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HETEROSIS IN MATERNAL TRAITS FROM CROSSBREEDING OF EXOTIC AND LOCAL BREEDS OF RABBITS

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Target Audience: Commercial rabbit producers, breeders, researchers.

ABSTRACT

Heterosis in maternal traits was estimated using least-squares mixed model methodology and records on 442 offspring from 114 litters produced in a reciprocal crossbreeding programme involving Local (LOC), New Zealand White (NZW) and Californian (CAL) rabbits at the Institute of Animal and Veterinary Research (IRZV), Mankon, Bamenda-Cameroon. For the NZW x LOC matings (main and reciprocal) the amount of heterosis expressed varied from -19.3% for litter weight at birth to 16% for litter size at 56 days. In the NZW x CAL matings (main and reciprocal), heterosis estimates ranged from -24% for percent stillbirth to 18.5% for average daily growth rate from 21 to 56 days. Differences in performance between crossbreds and purebreds were significant ($p<0.05$) for litter weight at birth in the NZW x LOC mating types and for individual weaning weights in the NZW x CAL matings. Average percent heterosis from the two types of crosses was negative for all early preweaning characters and positive for all late preweaning characters. These low to high heterosis estimates suggest a possible use of non-additive gene action for the improvement of some maternal traits through crossbreeding.

Key words: Heterosis, maternal traits, rabbits.

DESCRIPTION OF PROBLEM

Non-additive gene effect is one of the two components making up an individual's genotype. Through non-additive gene action, beneficial effects of heterosis considered as the better average breeding performance of crossbred animals than of their pure parent breeds (1), have been extensively studied in crosses of different livestock species. Heterosis when expressed in a cross has been used as a way of genetically improving characters that are subject to little additive gene action such as those related to fitness (e.g maternal traits). When and how a genetically built up heterosis expresses itself phenotypically in the life of a crossbred animal is a matter of great concern to the commercial

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breeder because an appropriate timing of the sales of animal is a guarantee of a profitable venture.

There is substantial information about heterosis in maternal traits involving crosses among exotic breeds of rabbits (1,2,3,4). On the contrary, no literature is available on heterosis values involving the crosses of local and exotic breeds. The objective of this study was to determine heterosis estimates in maternal traits in the crosses of New Zealand White x Local and New Zealand White x Californian (main and reciprocal) breeds of rabbits.

MATERIALS AND METHODS

Source of data

The data used in this study were collected on 442 offsprings from 114 litters obtained from a reciprocal crossbreeding programme involving 24 bucks and 67 does at the Institute for Animal and Veterinary Research (IRZV) Mankon, Bamenda-Cameroon. Two major seasons predominate in the area, namely, a five-month dry season (mid-October to mid-March) and a seven-month rainy season (mid-March to mid-October). The ambient tempera-tures average 21°C but fluctuate much during the dry season where maximum temperatures of 31.6°C are sometimes registered against mini-mum temperatures of 6.3°C. Humidity in general is high and reaches its peak during the rainy season with a value of 87%, the minimum recorded during the dry season being 53%.

Animal management

The three breeds of rabbits involved in a crossbreeding programme at the Institute were the Local (LOC), New Zealand White (NZW) and Californian (CAL). Reciprocal matings were practiced on each pair of the three breeds. However, due to small numbers, the LOC x CAL matings (main and reciprocal) were excluded from the study. Mating of animals was done early in the morning. Following a successful mating, pregnancy diagnosis was made by palpation of the lower abdomen 10 days later. Does found empty were returned to the corresponding buck for re-mating. Litters were evaluated on a weekly basis till weaning at 8 weeks (56 days) when individual weaning weights and sex were recorded. The rabbits were fed a concentrate ration with 18.6% protein given free choice and about 100g of fresh herbage. Fresh clean water was supplied at all times.

Characters studied

The traits studied were gestation length (GL), live birth number (LBN), percent stillbirth (PSB), litter size at birth (LSB), litter weight at 21 days (LW21) and at 56 days (LW56), average daily growth rate from birth to 21 days (ADG21), average daily growth rate from 21 to 56 days (ADG56) and individual weaning weight (IWW), where:

$$ADG21 = (LW21-LWB)/(21 \times LS21)$$
$$ADG56 = (LW56-LW21)/[(56-21) \times LS56]$$
$$KWV = (LS56/LBN) \times 100$$

Statistical analyses

The data were analyzed by least-squares procedures as described by Harvey (5) Corrections were made for important environmental effects such as season of birth of the litter, age and weight of doe at kindling and sex of rabbit. The traits PSB(%) and KWV(%) were transformed to the log scale to homogenize the variances and normalize the distribution in order to meet the ANOVA assumptions. Initial analyses showed generally nonsignificant breed group x season, breed group x sex and season x sex interaction effects. These interactions were therefore excluded from the two final fixed effect models as follows:

For litter traits:

$$Y_{ijk} = m + C_1 + G_j + b_1A_{ij} + b_2W_{ij} + \in_{ijk}$$

For individual weaning weights:

$$Y_{ijk} = m + C_1 + G_j + X_k + b_3A_{ijk} + b_4W_{ijk} + \in_{ijk}$$

where Y_{ijk} (Y_{ijk}) = a single observation on a rabbit (litter)

m = the overall mean

C_1 = the effect of the ith season of birth of the litter (dry vs rainy)

G_j = the fixed effect of the jth breed group of litter (j = 1,2,...,9)

X_k = the fixed effect of the kth sex of rabbit (male vs female)

b_3A_{ijk} (b_1 A_{ij}) = the partial linear regression of a trait on age of doe at kindling

b_4W_{ijk} (b_2W_{ij}) = the partial linear regression of a trait on weight f doe at kindling

$\in_{ijk\ 1}$($\in_{ijk}$) = the random error assigned to each record. $\in_{ijk1}$ ($\in_{ijk}$) ~iind $(0,\sigma^2)$.

Least-squares means (LSM) for each breed group derived from least-squares ANOVA were used in the computation of heterosis. For each pair of breeds AA and BB crossed, the heterotic effect was measured as the deviation of the average of the main and reciprocal crosses from the mid-parent average expressed as a percentage of the average of the parental breeds. Thus,

$$\% \text{ Heterosis} = \frac{(LSM_{AB} + LSB_{BA}) - (LSM_{AA} + LSM_{BB}) \times 100}{(LSM_{AA} + LSM_{BB})}$$

The significance of these deviations was tested by T-test.

RESULTS AND DISCUSSION

Heterosis estimates from the two types of crosses (main and reciprocal in each case), are presented in Tables 1 and 2. For the matings of NZW X LOC (man and reciprocal), the amount of heterosis expressed was substantial, ranging from -19.3% for LWB to 16% for LS 56 (Table 1). Performance differences between crossbreeds and purebred were nonsignificant for all characters, except for LWB ($P \leq 0.05$). There was a noticeable disadvantage in crossing NZW and LOC breeds as regards early preweaning characters such as LBN, PSB, LSB, LWB, LW21 and ADG21 which had negative percent heterosis estimates of -7.8, 8.1, -8.2, -19.3, -6.1 and -0.7, respectively. This indicates a general poor mothering ability in these crosses. In fact this is an expected result because of all four parents involved in this reciprocal crossing, only NZW sires showed good mothering ability, the effect which might have been masked by dominant genes governing poor mothering ability from local does in the cross NZW X LOC. In addition, indirect heterosis effect stemming from genotype X environment interaction effect due to adaptability hassles encountered by the newly imported exotic breeds used in this study might have further inflated negative maternal effects on the performance of their litters. Rao *et al* (6) reported a similar indirect heterotic effect. Consequently, crossbreeding is not advocated for the improvement of these traits. Rather, improvement could be sought by a simple amelioration of management standards of the purebred.

Table 1: Heterosis for Maternal Traits[a] in the crosses between NZW and LOC breeds[b]

Traits	Average of NZW and LOC (purebred)	Average of NZW x LOC (main and reciprocal)	Difference	% Heterosis
GL (days)	32.04	31.6	-0.44	-1.4
LBN	6.67	6.15	-0.52	-7.8
[c]PSB(%)	1.36	1.47	0.11	8.1
LSB	6.82	6.26	-0.56	-8.2
LS21	5.57	5.77	0.2	3.6
LS56	5.01	5.81	0.8	16.0
[c]KWV(%)	74.87	90.82	5.95	7.9
LWB(g)	367.5	296.5	-71	-19.3
LW21(g)	1261.5	1184.5	-77	-6.1
LW56(g)	3882.5	4246.5	364	9.4
ADG21(g/d)	8.08	8.02	-0.06	-0.7
IWW(g)	15.2	15.6	0.4	2.6
	765.5	756.7	-8.8	-1.2

[a]GL = Gestation length, LBN = Live birth number, PSB = Percent stillbirth, LSB = Litter size at birth, LS21 = Litter size at 21 days, LS56 = Litter size at 56 days, KWV = Kindling to weaning viability, LWB (LW21, LW56) = Litter weight at birth (at 21 days, at 56 days), ADG21 = Average daily growth rate from birth to 21 days; ADG56 = Average daily growth rate from 21 to 56 days, IWW = Individual weaning weight.

[b] NZW = New Zealand White, LOC = Local.

[c]Values given are re-transformed estimates to the original scale.

*P<0.05.

GL, ADG21, ADG56 and IWW showed little or no heterosis, ranging from -1.4% for GL to 2.6% for ADG56. This is an indication of important additive, or little non-additive gene action on these traits and therefore, purebreeding and selection rather than crossbreeding might be the solution to the improvement of these traits. Other late preweaning characters on the contrary gave encouraging results from the crossing of NZW and LOC breeds. In fact, LS56, LW56 and KWV all showed positive percent heterosis estimates of 16, 9.4 and 7.9 respectively. Systematic crossbreeding would therefore be advocated for their improvement. No literature values were available for comparison.

Table 2 shows that heterosis estimates in the matings NZW + CAL (main and reciprocal) were also substantial, but with a wider range (from -24% for PSB to 18.5% for ADG56) than for the crosses NZW X LOC (main and reciprocal). Differences in performance between crossbreds and purebreds were not significant except for IWW (P<0.05). LS21, KWV, LW21, LW56 and ADG21 all showed negative heterosis. Lukefahr *et al* (7) obtained similar heterosis estimates for litter size at 28 days (4.3%) and litter weight at 28 days (7.5%), while Partrige *et al* (3) reported an estimate of -4.29% for KWV. Improvement of these traits could be sought by amelioration of management techniques of the purebreds. Heterosis esimates for GL, LBN LSB and LS56 were small ranging from -0.9% for GL to 2.0% for LS56. Coudert and Brun (8) similarly reported the value 3.07% for LS56. The little non-additive gene action on these traits calls for improvement by purebreeding and selection. The traits LWB, ADG56 and IWW showed a positive heterosis of 4.8, 18.5 and 9.3%, respectively; for PSB, the estimate was negative (-24%). Partridge *et al* (3) also reported a high negative heterosis estimate (-31.05%) for PSB, using these same breeds. It should be noted here that a decrease of 0.42 kitten in stillbirths per generation and a cross advantage in ADG56 of 2.5g amounting to 87.5g weight gain per crossbred kit from 21 to 56 days of age (Table 2) are of great economic significance. Systematic crossbreeding should make use of heterosis through non-additive gene action and is therefore advocated for the improvement of LWB, ADG56, IWW and PSB.

Table 2: Heterosis for Maternal Traits[a] in the Crosses Between NZW and CAL Breeds[b]

Traits	Average of NZW and CAL (purebred)	Average of NZW x CAL (main and reciprocal)	Difference	%Heterosis
GL (days)	32.03	31.74	-0.29	-09
LBN	5.86	5.96	0.1	1.7
[c]PSB(%)	1.75	1.33	-0.42	-24
LSB	6.08	6.04	-0.04	-0.7
LS21	5.12	4.87	-0.25	-4.9
LS56	4.48	4.57	0.09	2.0
[c]KWV(%)	76.9	72.79	-4.11	-5.3
LWB(g)	334.5	350.5	16	4.8
LW21(g)	1154.5	1069	-85.5	-7.4
LW56(g)	3441	3259	-182	-5.3
ADG21(g/d)	8.37	7.45	-0.92	-11.0
ADG56(g/d)	13.5	16	2.5	18.5
IWW(g)	735	803.7	68.7*	9.3

[c]Refere to Table 1.
NZW = New Zealand White, CAL = Californian
P<0.05.

On the whole, all early-preweaning characters (Table 3) showed a negative average percent heterosis ranging from -8.0 for PSB to -0.6 for LS21. On the contrary, all late - preweaning traits (i.e LS56, KWW, LW56 and IWW) expressed a positive average heterosis grading from 2.0% for LW56 to 10.6% for ADG56. It does appear that the vigour apparently depressed in the early stages of development of the crossbred kits was not only recovered, but improved later in life. This finding advocates the sale of crossbred broiler rabbits by 8 weeks of age irrespective of how early they were weaned, in order to allow for full heterosis expression and to achieve greater economic returns in a commercial production venture.

Table 3: Average Percent Heterosis Over the Two Types of Matings (NZW and LOC, NZW AND CAL Breeds[a]) for maternal traits

Traits	Average % heterosis
Gestation length (days)	-1.1
Live birth number	-3.1
Percent stillbirth(%)	-8.0
Litter size at birth	-4.4
Litter size at 21 days	-0.6
Litter size at 56 days	9.0
Kindling to weaning viability(%)	1.3
Litter weight at birth(g)	-7.3
Litter weight at 21 days(g)	-6.8
Litter weight at 56 days(g)	2.0
Average daily growth rate from birth to 21 days (g/d)	-5.9
Average daily growth rate from 21 days to 56 days (g/d)	10.6
Individual weaning weight(g)	4.1

[a]NZW = New Zealand White, LOC = Local, CAL = Californian.

CONCLUSIONS AND APPLICATIONS

1. Heterosis estimates for NZW and LOC matings in the early preweaning characters namely LBN, PSB, LSB, LWB, LW21 and ADG21 were negative, indicating poor mothering ability of the crosses. Improvement in these characters could be sought by a simple amelioration of management standards of the purebreds.
2. The pattern of heterosis in GL, ADG21, ADG56 and IWW in NZW and LOC matings suggests that additive gene action was important for these traits. Purebreeding and selection are suggested as improvement pathways for these traits.
3. For LS56, LW56 and KWV (other late preweaning characters) heterosis estimates were substantial in the NZW and LOC crosses. Systematic crossbreeding is recommended as an improvement strategy for the traits.
4. In the NZW x CAL (main and reciprocal) crosses the estimates of heterosis suggest an improvement programme for LS21, KWV, LW21, LW56 and ADG21 based on improved levels of management for the purebreds. The traits GL, LBN, LSB and LS56 would be improved by purebreeding and selection. For LWB, ADG56 and

IWW, the recommended breeding method would be crossbreeding to make use of heterosis.

5. On the whole most of the differences between crossbreds and purebreds were not significant. This could have arisen from a narrow genetic diversity between the breeds. For instance, the local breed was derived *a priori* from many previous crosses while the NZW and CAL have been classified as average breeds, with adults of the former weighing only slightly more than the latter.
6. Although the breed group effects were not significant for most of the traits, the data was free of interactions which would have interfered with the meaning of effects.

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