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GENETIC COMPONENTS OF LITTER PERFORMANCE IN A DIALLEL CROSS INVOLVING FOUR RABBIT BREEDS

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ABSTRACT

New Zealand White (NZW), Californian (CA), Chinchilla (CH) and Criollo (CR) rabbits were utilized in a diallel cross to evaluate general and specific combining abilities, as well as maternal and reciprocal effects on litter size and weight at birth and weaning. Data were collected from 66 litters and a total of 502 kits. Statistical analysis was performed by least-squares procedures. Breed differences in general combining ability for litter size indicated that NZW and CA does had better performance at birth and weaning than CH and CR does. Analysis for specific combining ability showed that the best combinations for litter size at both birth and weaning were NZW-CA, NZW-CH and CA-CH. Results of maternal effects showed that litters from NZW and CA does had better performance for litter size and weight at birth and litter weight at weaning than litters from CH and CR does. Differences attributed to reciprocal effects indicated the possibility of an advantage in litter size at birth and weaning when using NZW does in the mating.

Key words: diallel cross, combining ability, litter traits.

INTRODUCTION

The performance of all crosses that derive from one strain is designated the general combining ability (GCA) of this strain, while the specific combining ability (SCA) is a joint attribute of two strains and signifies the deviation of a cross from the sum of the GCA's of its parent strains (PIRCHNER, 1983). In addition, maternal ability implies the influence of the dam on her progeny other than through the genes she transmits to them, while reciprocal effects (sex-linked effects) measures the residual differences between reciprocal crosses after taking general, specific and maternal ability effects into account (AFIFI and EMARA, 1990).

A diallel cross is a very useful tool to evaluate the performance of breeds in their various combinations, especially for the evaluation of breeds already indigenous to a region or for a limited number of breeds chosen on the basis of prior topcross evaluation (DICKERSON, 1993). In addition, analysis of diallel crosses enables the breeder to partition total genetic variation into additive (GCA) and non additive (SCA) genetic variance (NAGPURE et al, 1991).

In Mexico, there are several breeds of rabbits available to the producers; however, diallel crosses with rabbits to evaluate their performance in various combinations have not been carried out so far. The objective of this study was to estimate the general and specific combining abilities, as well as maternal and reciprocal effects for litter size and weight at birth and weaning in a 4 x 4 diallel cross in rabbits.

MATERIALS AND METHODS

This study was carried out in the Experimental Rabbitry at Montecillo, Colegio de Postgraduados. The climate is classified as temperate subhumid, with rains during the summer months. Average annual temperature and rainfall are 15.2 ^{o}C and 636.5 mm, respectively (GARCÍA, 1988).

Data for this study were collected from 502 kits born to 66 does from the New Zealand White, California, Chinchilla and Criollo (native) breeds, from December 15, 1997 to March 15, 1998. Rabbits were kept indoors, in individual wire cages that were equipped with a nipple drinker and an outside placed feeder. The rabbits had *ad libitum* access to feed and water. They were fed a commercial pelleted diet with 14 % CP and 16 % CF, offered twice a day. Common sanitary practices allowed the control of health status of rabbits. Kits were weaned at an average of 35 days of age.

Statistical analysis was performed by means of the IML procedure of SAS (MARTÍNEZ-GARZA, 1983, 1991). Dependent variables were litter size and weight at birth and weaning, whereas independent variables were the progenitor breeds, where the model used was as follows:

$$Y_{ijk} = \mu + g_i + g_j + s_{ij} + m_i - m_j + r_{ij} + e_{ijk}$$

where: Y_{ijk} : variable analyzed; μ: overall mean; g_i: effect of the general combining ability of the ith breed; g_j: effect of the general combining ability of the jth breed; s_{ij}: effect of the specific combining ability of the cross $_{(i,j)}$; m_i: maternal effect of the ith breed; m_j: maternal effect of the jth breed; r_{ij}: reciprocal (sex-linked) effect of the cross $_{(i,j)}$; e_{ijk}: random error, assumed to be independently randomly distributed ($0,\sigma^2_e$). All effects were considered statistically as fixed effects.

RESULTS AND DISCUSSION

Results of the analysis of variance for birth traits showed that litter size was influenced ($P<0.01$) by general combining ability, specific combining ability, maternal effects and reciprocal effects, whereas litter weight was influenced only by maternal effects ($P<0.05$). For weaning traits, litter size was influenced ($P<0.01$) by general combining ability, specific combining ability, maternal effects and reciprocal effects, while litter weight was not influenced by any of the sources of variation.

General combining ability (GCA)

The New Zealand and Californian does showed the highest averages for litter size at birth (Table 1), followed by the Chinchilla and Criollo does. Ponce de León and Menchaca (1974) found significant differences (P<0.01) in GCA for litter size at birth, where the Semi-giant White does had the highest litter size, followed by the Chinchilla, New Zealand White, and Californian does. GCA analysis of litter size at weaning showed that the New Zealand and Californian does kept their superiority, followed by the Chinchilla and Criollo does. Results by Afifi and Emara (1990) in Egypt indicated that breed differences in GCA for litter size at birth and weaning were non-significant. For litter weight at weaning, however, Afifi (1971), cited by Afifi and Khalil (1992), reported significant differences (P<0.01) among breeds of his study, where the Californian kits had the highest litter weight, followed by the Bouscat and Giza White kits. From these results it can be concluded that the maximum utilization of additive genetic variance could be made by using both New Zealand and Californian rabbits for a higher litter size at birth and weaning.

Table 1. Least-squares means (mean±S.E.) of litter size and weight at birth and weaning, according to the general (GCA) and specific combining ability (SCA) effects.

	Birth traits			Weaning traits		
	N	Litter size	Weight (g)	N	Litter size	Weight (g)
GCA:						
NZW[1]	21	7.9±0.29a	474.1±23.0a	14	7.6±0.32a	3769.0±243.7a
CA	23	7.8±0.27a	459.5±22.2a	15	7.6±0.31a	3586.8±235.5a
CH	18	7.5±0.31b	444.9±24.8a	11	7.1±0.36b	3458.7±275.3a
CR	18	7.3±0.31b	415.3±24.8a	10	6.8±0.38b	3324.5±288.4a
SCA:						
NZW-CA[2]	3	7.8±0.76ab	475.3±60.9a	2	7.5±0.85ac	3649.4±646.4a
NZW-CH	4	7.9±0.66a	452.3±52.7a	2	7.7±0.85a	3746.8±646.4^{a}
NZW-CR	3	7.4±0.76cd	441.8±60.9a	2	7.1±0.85b	3460.0±646.4a
CA-NZW	3	7.5±0.76bd	447.5±60.9a	2	7.2±0.85b	3508.2±646.4^{a}
CA-CH	4	7.9±0.66a	486.4±52.7a	2	7.6±0.85a	3710.1±646.4^{a}
CA-CR	4	7.4±0.66cde	435.8±52.7a	3	7.1±0.69b	3448.7±526.8^{a}
CH-NZW	3	7.5±0.76 bd	443.8±60.9a	2	7.3±0.85 bc	3556.3±646.4 a
CH-CA	4	7.8±0.66ab	457.2±52.7a	2	7.6±0.85a	3717.2±646.4a
CH-CR	3	7.3±0.76c	433.4±60.9a	2	7.0±0.85b	3228.3±646.4a
CR-NZW	4	7.3±0.66c	435.8±52.7a	3	7.1±0.69b	3438.1±526.8a
CR-CA	3	7.5±0.76be	448.2±60.9a	2	7.3±0.85bc	3542.2±646.4a
CR-CH	2	7.4±0.94ce	420.7±74.8a	1	7.1±1.20b	3410.7±911.5a

[1]: NZW: New Zealand White, CA: Californian, CH. Chinchilla, CR: Criollo. [2]: In each combination the breed of sire is listed first. N: number of litters.

Specific combining ability (SCA)

Results for SCA indicated that the combinations NZW-CA, NZW-CH, CA-CH and CH-CA were superior for litter size at both birth and weaning, while there was no advantage regarding the use of male or female lines for any of these breeds to exploit non-additive genetic variance in litter weight at birth or weaning. CARREGAL (1980) and AFIFI and EMARA (1990) reported non-significant differences due to SCA for kit body weight at several ages and litter size at birth or weaning, respectively. However, EMARA (1982), cited by Afifi and KAHLIL (1992), found a significant effect for litter weight at birth attributable to SCA, when utilizing Bouscat, Giza White, White Flander and Baladi Red rabbits.

Maternal effects (ME)

For litter size and weight at birth, and also for litter size at weaning, litters from New Zealand and Californian does had better performance than those from Chinchilla and Criollo does (Table 2). Carregal (1980) found significant differences for body weight of kits at 28 and 70 days of age attributable to maternal ability in favor of New Zealand and Californian does, when compared to Dutch and Blanc du Bouscat does. AFIFI and EMARA (1990) reported that the best maternal ability was exhibited by White Flander and Baladi Red does at birth and at weaning, respectively. AFIFI (1971) and EMARA (1982), cited by AFIFI and KHALIL (1992), reported significant differences for litter weight at weaning due to breed of doe. BRUN *et al*. (1992) found differences for litter size between strains of rabbits attributable to maternal effects. Moreover, KROGMEIER *et al.* (1994) found that New Zealand does had significantly higher averages for litter traits at birth and weaning than Helle Grossilber does. The superiority that some breeds of doe show for maternal ability can be attributed to increased milk production, maternal behaviour and care of the litter. The maternal superiority of New Zealand does, as compared to other standard breeds, has been demonstrated in various studies (PARTRIDGE *et al*., 1981; LUKEFAHR *et al*., 1983; ROUVIER and BRUN, 1990; OZIMBA and LUKEFHAR, 1991; KHALIL *et al*., 1995).

Reciprocal effects

Significant differences ($P<0.01$) in litter size at birth and weaning attributed to reciprocal effects were found in the matings NZW-CH, CA-NZW and CH-NZW (Table 2). These results seem to indicate an advantage when using New Zealand White does in the mating. PONCE de LEÓN and MENCHACA (1974) found a significant effect for litter size at birth attributable to reciprocal effects; the highest averages in their study were found where the Semi-giant breed was included as the sire in the mating. NAGPURE *et al.* (1991) concluded from their study that the use of new Zealand White males on White Giant females can be made to exploit reciprocal effects (maternal and sex-linked) in obtaining higher body weights from birth to 6 months of age. CARREGAL (1980) found that the use of Dutch males on New Zealand, Californian and Bouscat does produced the highest individual kit body weight at 28 days of age. EMARA (1982), cited by AFIFI and KHALIL (1992) reported a significant effect ($P<0.01$) on litter weight at birth attributed to reciprocal effects. Contrary to the above findings, AFIFI and EMARA (1990), found non-significant differences in litter size attributed to reciprocal effects.

It is concluded that additive genetic variance can be exploited by using New Zealand and Californian rabbits for a higher litter size at birth and weaning. To exploit non-additive genetic variance, the matings New Zealand White x Californian, New Zealand White x Chinchilla, Californian x Chinchilla, and Chinchilla x Californian can be made for a higher litter size at birth and weaning. To take advantage of maternal effects, New Zealand and Californian does can be used for higher averages in litter size and weight at birth and also for litter size at weaning, while for reciprocal effects there is an advantage when New Zealand White does are used in the mating.

Table 2. Least-squares means (mean ± s.e.) of litter size and weight at birth and weaning, according to the maternal (ME) and reciprocal effects (RE).

	Birth traits			Weaning traits		
	N	Litter size	Weight (g)	N	Litter size	Weight (g)
ME:						
NZW[1]	24	7.9±0.27a	487.3±21.5a	15	7.6±0.31a	3703.1±235.5a
CA	29	7.8±0.24a	478.1±19.6a	18	7.5±0.28a	3465.0±214.9a
CH	15	7.4±0.34b	415.8±27.2b	9	7.1±0.40b	3580.9±303.8a
CR	12	7.4±0.38b	412.6±30.5b	8	6.9±0.42b	3390.0±323.2a
RE:						
NZW-CA[2]	3	7.6±0.76b	448.3±60.9a	2	7.3±0.85b	3547.3±646.4a
NZW-CH	4	7.8±0.66a	461.4±52.7a	2	7.7±0.85a	3625.7±646.4a
NZW-CR	3	7.4±0.76b	432.2±60.9a	2	7.2±0.85b	3498.1±646.4a
CA-NZW	3	7.9±0.76a	453.1±60.9a	2	7.8±0.85a	3562.4±646.4a
CA-CH	4	7.5±0.66b	471.6±52.7a	2	7.3±0.85b	3650.5±646.4a
CA-CR	4	7.4±0.66b	448.4±52.7a	3	7.2±0.69b	3485.7±526.8a
CH-NZW	3	7.9±0.76a	451.5±60.9a	2	7.8±0.85a	3552.1±646.4a
CH-CA	4	7.5±0.66b	467.1±52.7a	2	7.3±0.85b	3615.4±646.4a
CH-CR	3	7.4±0.76b	438.7±60.9a	2	7.2±0.85b	3502.8±646.4a
CR-NZW	4	7.5±0.66b	442.6±52.7a	3	7.2±0.69b	3510.7±526.8a
CR-CA	3	7.3±0.76cb	433.2±60.9a	2	7.0±0.85c	3415.2±646.4a
CR-CH	2	7.4±0.94b	435.7±74.8a	1	7.1±1.20cb	3448.6±911.5a

[1]: NZW: New Zealand white, CA: Californian, CH: Chinchilla, CR: Criollo. [2]: In each combination the breed of sire is listed first. N: number of litters.

REFERENCES

AFIFI E. A., EMARA M. E.. 1990. Analysis of litter size in rabbits in a diallel crossing scheme involving four local Egyptian and exotic breeds. J. Appl. Rabbit Res. 12:256-258.

AFIFI E. A., KHALIL M. H.. 1992. Crossbreeding experiments of rabbits in Egypt: Synthesis of results and overview. *In*: Rabbit Production and Genetics in the Mediterranean Area. *Série A: Séminaires. Options Méditerranéennes*. 17:35-52.

BRUN J. M., BOLET G., OUHAYOUN J. 1992. The effects of crossbreeding and selection on productive and reproductive traits in a triallel experiment between three strains of rabbits. J. Appl. Rabbit. Res. 15:181-189.
CARREGAL R. D. 1980. Evaluation of heterosis, combining ability and the maternal and reciprocal effects in rabbits (In Spanish). Proc. 2nd World Rabbit Congress. Barcelona, Spain. pp:213-222.
DICKERSON G. E. 1993. Evaluation of breeds and crosses of domestic animals. Animal Production and Health Paper 108. FAO. Rome. Italy. 47 p.
GARCIA E. 1988. Modificaciones al sistema de clasificación climática de Kppen. 4a. Ed. Instituto de Geografía, Universidad Nacional Autónoma de México. México, D.F. 217 p.
KHALIL M. H., AFIFI E. A., YOUSSEF Y. M. K., KHADR A. F. 1995. Heterosis, maternal and direct genetic effects for litter performance and reproductive intervals in rabbit crosses. Wld. Rabbit Sci. 3:99-105.
KROGMEIER D., DZAPO V., MAO I. L.. 1994. Additive genetic and maternal effects on litter traits in rabbits. J. Anim. Breed. Genet. 111:420-431.
LUKEFAHR S., HOHENBOKEN W. D., CHEEKE P. R., PATTON N. M.. 1983. Doe reproduction and preweaning litter performance of straightbred and crossbred rabbits. J. Anim. Sci. 57:1090-1099.
MARTÍNEZ-GARZA A. 1983. Statistical Designs and Analysis of Experiments of Diallel Crosses (In Spanish). Colegio de Postgraduados. Montecillo, Edo. México. 252 p.
MARTÍNEZ-GARZA A. 1991. Analysis of diallel experiments by means of the IML procedure of SAS (In Spanish). Comunicaciones en Estadística y Cómputo. Centro de Estadística y Cálculo. Colegio de Postgraduados. Montecillo, Edo. México. 36 p.
NAGPURE N. S., KOTHEKAR M. D., GORE A. K., DESHMUKH S. N. 1991. Estimation of general and specific combining ability variances from a 4 x 4 diallel cross in rabbits. J. Appl. Rabbit Res. 14:38-43.
OZIMBA C. E., LUKEFHAR S. D. 1991. Comparison of rabbit breed types for postweaning litter growth, feed efficiency and survival performance traits. J. Anim. Sci. 69.3494-3500.
PARTRIDGE G. G., FOLEY S., CORRIGAL W. 1981. Reproductive performance in purebred and crossbred commercial rabbits. Anim. Prod. 32:325-331.
PIRCHNER F. 1983. Population Genetics in Animal Breeding. 2nd. Ed. Plenum Press, New York, NY. 414 p.
PONCE DE LEON R., MENCHACA D. 1974. Study of genetic factors of variation in a triple crossbreeding (In Spanish). 1st. World Congress on Genetics Applied to Livestock Production. Madrid, Spain. Vol. 3. pp:455-463.
ROUVIER R., BRUN J. M. 1990. Crossbreeding and selection experiments with rabbits: An overview from studies in France about litter traits. *Options Mediterraneennes, Serie Séminaires*. 8:29-34.