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Direct and maternal additive effects and heterosis in productivity traits at weaning in rabbits.

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ABSTRACT: Evaluation of F_1 combinations in an environment with hot climate and nutritional limitations is required in order to establish an effective genetic improvement program. A complete diallel cross was realized between 2003-2005 involving 3662 weaning of four rabbit breeds (California, Chinchilla, New Zealand and Semigiant White) to determine direct and maternal additive effects and heterosis in productivity traits: weaning interval, weaned litters/year, numerical and ponderal productivity. Genetic effect estimations were done applying linear contrasts after the Dickerson model. Direct additive effects were more important than maternal. Direct additive effects were favorable for Chinchilla breed, while maternal effects of the Californian were consistently superior to Chinchilla's. Heterosis averaged 6.3, 6.5, 6.1 and 3.7% for the four traits and was significant in 50% of the analysis. Maximum heterosis (6-22%) was found for the reciprocal pairs of crosses: CCh, ChS and CS. Results indicate that useful F_1combinations can be identified for increasing productivity.
Keywords: rabbits; productivity; genetics parameters; diallel cross

Introduction

In animal production, the achievements of a crossbreeding program depend on the magnitude of heterosis and on the productive potential of the breeds involved in the crosses (Magofoke y Garcia (2001)). In rabbit breeding there are several forms to determine productivity. One of them is the preweaning numerical productivity that indicates the number weaned/doe/year or per reproduction cage/year (Camps (1976)). The other one is the ponderal productivity that informs the kilograms of live weight produced/doe/year or per reproduction cage/year (Alpizar (2006)). Despite the importance of productivity, as a global indicator of a population performance, few works appear in the scientific literature that treats genetic aspects of this complex trait. It is necessary to execute more studies that deal with the determination of genetic parameters of crossbreeding of these integrator traits and not only of individual ones.

Material and methods

Data. A complete diallel crossbreeding trial involved 3662 weaning records of four rabbit breeds: California (C), Chinchilla (Ch), New Zealand (N) and Semigiant White (S). The experiment was developed between May/2003 and April/2004 in the rabbitry "26 de Julio", located at San Jose de Las Lajas, Mayabeque province.

Diet. A non conventional diet was administrated, that covered around 75% of rabbit requirements which generate nutritional limitations that qualify as harsh conditions. It consisted in a commercial meal ration with 17% crude protein, 10-10.8 MJ of digestible energy and 10-11 % of crude fiber mixed daily with 20% of wheat bran and supplemented with green forage of King grass (*Pennisetum purpureum*) offered *ad libitum*.

Climate. Another condition that affects rabbit performance are the climate characteristics. Cuba is situated below the Tropics of Cancer with a moderated subtropical climate with two seasons: rainy (May Set) and not rainy (Oct-Apr) seasons. The climate features during the experimental work are shown in table 1.

Table 1. Climate parameters during the experimental work.

Season	Temp., ^{0}C			Precipitation, mm	Humidity, %
	Average	Min	Máx		
Rainy 5-9/2003	26.7	21.9	31.5	184.5	84.8
Dry 10/2003-4/2004	22.4	17.3	27.5	54.2	79.9

The combination of high humidity and high temperatures, very frequent during the rainy season, reduces consumption, retards growth rate and reproductive activity. Climate conditions united to nutritional limitations create sources of stress for this species.

The productivity traits at weaning considered were: weaning interval (WI= weaning date- next weaning date), weaned litters per year (WL/Y=365/WI), numerical productivity (NUMPROD=no. weaned/litter*WL/Y) and ponderal (PONPROD=litter weaning weight* WL/Y) productivity. The values for the traits: no.weaned /litter and litter weaning weight for each record were taken from original files analyzed in previous reports of the same population (García (2014)). Records corresponded to weaned litters with at least one weaned kid. Records that did not have the correspondent weaning interval to the next litter were filled with the average interval of its cross. The mating design accomplished the assumptions of a complete diallel cross (4*4). The animals were allocated in open sided buildings following a completely random design. Male and female breeders were selected from the genetic population and fulfilled the phenotypic characteristics of each breed.

Statistical analysis. A generalized linear mixed model (macro for GLIMMIX of SAS (2007)) was applied, which considered the fixed effects of genotype (16 classes) and experiment (3 trials) and the random effect of parity (5 levels). The same model was used for the four traits, and the link function ascribed to each was *log*.

Dickerson's (1969) model was used to estimate the genetic parameters of crossbreeding: direct (g^I) and maternal (g^m) additive effects and the individual heterosis (h^I). Linear contrasts between means of the genetic groups were used to estimate the genetic parameters. The contrasts were constructed following the definition of each parameter and the coefficient determined by the same author for each type of cross.

Results and discussion

Differences between genotypes. Significant differences were detected (P<0.001) among genotypes. The significance pattern for WI and WL/Y were similar and it was found that SC and ChC crosses excel NCh cross. In the other hand, for numerical and ponderal productivity traits the ChC cross presented superiority over the Semigiant pure breed. The rest of the genotypes did not differ from the extremes. However, some genotypes as CCh, CS, ChN, ChS and SCh exhibited excellent performances, but with high SE.

Genetic parameters of crossbreeding. **Additive effects.** Direct additive effects were more consistent than maternal ones, as significant effects were found in all traits except for PONPROD, while maternal effects were found significant only for WI and WL/Y (table 2). Direct effects were favorable for the Chinchilla breed over the rest, except for NUMPROD where it did not differ from the New Zealand. The use of these two breeds as paternal lines assures an increment of 6.4weaned/doe/year respect the California or Semigiant breeds. Maternal additive effects were found for WI and WL/Y where Californian does had shorter WI in 11 days and one more weaning than the Chinchilla's. It is well known the importance of maternal effects in preweaning individual traits (Ponce de Leon (1988)), but in the present work they are also encountered for the compound productivity traits. These results avail also the expected negative correlation between direct and maternal additive effects (Blasco et al. (1982); Garreau et al. (2004)), aspect that should be taken into account when designing a correct breed utilization policy. On the other hand, results assume potential advantages for the Chinchilla breed as paternal line and the California as maternal line and justify the excellence of the ChC cross already mentioned.

Heterosis. All the heterosis estimates of the reciprocal pair of crosses for WI were found negative and significant, except for the ChN combination, indicating real superiority of the majority of the crosses with a mean heterosis of 8% (table 2). Additionally 67% of the crosses exhibited a significant positive heterosis for WL/Y with a mean value of 9.4%, while ChN and NS crosses average only 1%. Surprisingly few significant heterosis values were found for NUMPROD and PONPROD which correspond to ChC and ChS reciprocal pairs with an average of 16% for both traits. Although the CS cross had heterosis between 6.2-8.6% it did not attain significance. In fact, there is a correspondence between the best crosses for these traits and the heterosis estimates for the pair of its reciprocals.

Although scarce literature is devoted to productivity traits, null information is obtained when productivity is analyzed from individual records and no estimations of additive nor of heterosis could be found. Obtaining high levels of heterosis for productivity traits in some of the crosses indicates that crossbreeding could be an option even using all medium size breeds after conscious studies of its different variants had been analyzed.

Conclusions

The genetic parameters of crossbreeding estimated from a diallel cross for four productivity traits up to weaning identified superiority for direct additive effects of the Chinchilla breed, as well as superior performance of California for maternal additive effects. The pair of reciprocal crosses CHC-CCh were found to exhibit exceptional performance for numerical and ponderal productivity with heterosis of 22%.

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Table 2. Direct and maternal additive effects and heterosis for prolificacy traits at weaning in diallel crosses

		Weaning interval (days)		Weaned litters/year (No.)		NUMPROD weaned/doe/year (No.)		PONPROD weaned/doe/year (kg.)	
		Estimator	SE±	Estimator	SE±	Estimator	SE±	Estimator	SE±
Direct additive effects	$\bar{g}^{I}_{C}$	0,04[b] (2,7)	0,04	-0,05[b] (-0,3)	0,03	-0,13[b] (-3,1)	0,09	-0,07 (-1,0)	0,09
	$\bar{g}^{I}_{CH}$	-0,12[a] (-8,9)	0,04	0,12[a] (0,6)	0,04	0,16[a] (3,8)	0,09	0,11 (1,59)	0,10
	$\bar{g}^{I}_{N}$	0,03[b] (2,8)	0,04	-0,32[b] (-0,1)	0,04	0,11[ab] (2,6)	0,09	0,09 (1,2)	0,10
	$\bar{g}^{I}_{S}$	0,04[b] (3,5)	0,04	-0,04[b] (-0,2)	0,03	-0,14[b] (-3,3)	0,09	-0,13 (-1,9)	0,09
Maternal additive effects	$\bar{g}^{M}_{C}$	-0,08[a] (-5,6)	0,04	0,09[a] (0,5)	0,03	0,08 (1,8)	0,09	0,11 (1,5)	0,09
	$\bar{g}^{M}_{CH}$	0,08[b] (5,7)	0,04	-0,09[b] (-0,5)	0,03	-0,06 (-1,4)	0,08	-0,12 (-1,8)	0,09
	$\bar{g}^{M}_{N}$	0,02[ab] (1,3)	0,04	-0,01[b] (-0,0)	0,03	-0,06 (-1,5)	0,09	-0,09 (-1,3)	0,10
	$\bar{g}^{M}_{S}$	-0,02[ab] (-1,3)	0,04	0,01[b] (0,0)	0,03	0,04 (1,01)	0,09	0,11 (1,6)	0,09
Individual Heterosis	h^{I}_{CCH}	-0,09*** (-6,6)	0,02	0,10*** (0,5)	0,02	0,18*** (5,0)	0,05	0,20*** (3,2)	0,05
	(%)	-8,8		10,8		21,0		22,0	
	h^{I}_{CN}	-0,07** (-5,1)	0,03	0,06** (0,3)	0,02	-0,03 (-0,5)	0,06	-0,08 (-1,1)	0,06
	(%)	-6,9		6,6		-2,3		-7,5	
	h^{I}_{CS}	-0,12*** (-8,6)	0,02	0,12*** (0,6)	0,02	0,08(1,9)	0,05	0,06 (0,9)	0,05
	(%)	-11,3		12,6		8,6		6,2	
	h^{I}_{CHN}	0,02 (1,3)	0,02	-0,02 (-0,1)	0,02	-0,05 (-1,1)	0,06	-0,09 (-1,2)	0,06
	(%)	1,7		-2,0		-4,7		-8,4	
	h^{I}_{CHS}	-0,08*** (-6,2)	0,02	0,08*** (0,4)	0,02	0,10* (2,5)	0,05	0,09 (1,3)	0,05
	(%)	-8,1		7,7		10,7		9,0	
	h^{I}_{NS}	-0,05* (-3,6)	0,02	0,04 (0,2)	0,02	0,03 (0,7)	0,05	0,01 (0,1)	0,05
	(%)	-4,6		3,9		3,11		1,0	

[ab]Parameters with different letters in the same column difffer at P<0,05. *P<0,05 *P<0,05 ** P<0,01 *** P<0,001 (Kramer 1956). () Retransformed estimators .