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HERITABILITY AND REPEATABILITY OF LITTER TRAITS BASED ON DAM RECORDS FROM A TROPICAL RABBIT POPULATION IN TRINIDAD, WEST INDIES

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ABSTRACT

Data on litter production traits of does, involving 1120 litters, was collected over a 10-year period (1984 to 1994) and analyzed to estimate heritability and repeatability. Locally adapted does and bucks of predominantly New Zealand White breeding were involved. Traits studied were total litter size born and born alive, and litter size and weight at 21 d, 28 d (weaning) and 84 d (marketing). A doe repeatability model was employed which included a fixed contemporary environmental group effect (year-season-doe parity) and litter size at the corresponding age as a linear covariate (for litter weight traits only), and random animal (additive maternal genetic), permanent (non-additive maternal genetic plus permanent environmental), service sire, and residual effects. Heritability (repeatability) estimates for total litter size born and born alive, and litter size at 21 d, 28 d, and 84 d were 0.09, 0.12, 0.06, 0.09, and 0.07 (0.30, 0.32, 0.26, 0.25, and 0.19), respectively. For litter weight at 21 d, 28 d, and 84 d, heritability (repeatability) estimates were 0.08, 0.09, and 0.02 (0.18, 0.19, and 0.09), respectively. In conclusion, litter production traits tended to be lowly heritable and lowly to moderately repeatable.
Keywords: Rabbits; Heritability; Maternal effects; Litter traits

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INTRODUCTION

Limited rabbit genetic studies have been conducted in tropical countries where climate, diet, management, and stock sources can differ markedly from those in temperate countries. Genetic parameter estimates (e.g., heritability and breeding value) are especially needed from tropical rabbit populations in order to provide quality breeding stock to farmers. Reports from Ghana (Lukefahr *et al.,* 1992) and Brazil (Ferraz and Eler, 1994) tend to indicate higher heritabilities for production traits than is generally reported from temperate environments. In tropical environments, rabbit populations often have a heterogeneous history involving multiple breed introductions and crossings which could explain the higher heritability values reported.

The objectives of this study were to estimate maternal heritability and repeatability for several litter production traits of the doe for application in selection or culling programmes in an experimental herd of predominantly New Zealand White rabbits raised in the humid-tropical environment of Trinidad (West Indies).

MATERIALS AND METHODS

Rabbit type, climate and housing
Data on doe performance traits were collected over a ten-year period (1984 to 1994) from a small experimental rabbitry, established in March 1983, at the UWI, Trinidad. Locally adapted rabbits of mixed breeding (including contributions from New Zealand White, Californian, Checkered Giant, etc.), purchased from pet keepers and a few small rabbitries, served as the foundation stock. The herd was closed by the end of 1983 with ten does and three bucks. However, the herd continued to expand to reach a total of 35 breeding does by the end of 1994.

The Trinidad climate is humid-tropical with average relative humidity varying between 80 - 85%. Daily temperature inside the rabbitry varied between 25^0 and $36^{\circ}C$. There is a major dry season from January to May and a short one in October. The mean annual rainfall is 1700 mm. Animals were housed in a well ventilated building with all-wire cages and had access to automatic waterers and feeders.

Breeding management
An eleven to fourteen day remating schedule was followed. A group rotation breeding scheme was practiced whereby each doe was randomly assigned to the same buck for the entire period of her reproductive life. This scheme used together with pedigree information helped to avoid matings among closely related animals. Does were palpated for pregnancy 14 d after service. If not pregnant, the doe was immediately rebred. On d 28 of gestation, the nest box was presented. Cross-fostering of kits among does was not practiced so that a doe's own producing ability could be assessed. Does were culled for poor fertility and productivity (i.e., failure to wean at least a total of twelve kits during the first three consecutive matings). Male replacements were selected for post-weaning growth until breeding age of six months, whereas doe replacements were selected at weaning from dams with larger than average litters over the first three kindlings and with below average inter-kindling period.

Traits studied
Total litter size born and born alive, and litter size and weight at 21 d, 28 d (weaning), and 84 d (marketing) were measured. Obviously, litter traits measured on day 84 after kindling can not be strictly regarded as doe performance traits. Nonetheless, our interest was in determining the degree of maternal influence. Of the recorded litters, those which did not survive to weaning (<4%) were eliminated from the data set. Descriptive statistics for all traits studied are presented in Table 1.

Table 1

Means, standard deviation and range for maternal performance traits analyzed

Trait	Mean	SD	Range min.	max.
Total litter size born	5.3	1.52	1	12
Litter size born alive	5.2	1.55	1	12
Litter size at 21 d	4.6	1.48	1	9
Litter size at 28 d (weaning)	4.6	1.48	1	9
Litter size at 84 d (marketing)	4.2	1.52	1	9
Litter wt. at 21 d, g	958	168	120	2410
Litter wt. at 28 d, g	1304	222	180	2870
Litter wt. at 84 d, g	6455	846	1100	17200

Statistical procedures

A repeatability animal model was employed to estimate genetic and environmental variances for litter production traits of the doe by AIREML (Average Information Restricted Maximum Likelihood) as developed by Johnson and Thompson (1995). The model terms included the fixed effect of year-season-doe parity to represent contemporary environmental subgroups, random doe (additive maternal genetic), permanent maternal (non-additive maternal genetic plus permanent environmental), service sire of the litter, and residual (temporary maternal environmental and possible genetic contribution of the litter) effects. For litter weight traits, the model also included litter size at the corresponding age as a linear covariate. Within each year, two seasons were considered (dry=January to May, wet= June to December). There were three doe parity classes (first, second through fifth, and sixth through 12th). Additive maternal genetic, non-additive maternal genetic plus permanent environmental, service sire of the litter, and residual effects were assumed to be normally and independently distributed with mean 0 and variances $A\sigma^2a$, $I\sigma^2p$, $I\sigma^2s$, and $I\sigma^2e$, respectively.

Maternal heritability was computed by expressing σ^2a as a proportion of the total phenotypic variance ($\sigma^2t = \sigma^2a + \sigma p^2 + \sigma e^2$). To estimate repeatability, variance components due to additive maternal genetic and permanent effects were summed together ($\sigma^2a + \sigma p^2$) and expressed as a proportion of the total phenotypic variance. Standard errors for ratios of σa^2 and σ^2p to σt^2 were computed from AIREML analyses, however standard errors for repeatability could not be directly obtained from the analysis.

RESULTS AND DISCUSSION

Heritability estimates for maternal performance traits

In general, maternal heritabilities for all litter traits investigated were low and non-significantly different from zero ($0.02 \leq h^2 \leq 0.12$, Table 2). For litter size at various ages, heritability estimates varied between 0.06 for litter size at 21 d and 0.12 for litter size born alive. At present, consensus exists that heritability of litter size in rabbits (and other prolific species) is generally around 0.1 (Afifi *et al.,* 1992; Baselga *et al.,* 1992; Ferraz *et al.*, 1992; Blasco *et al.,* 1993; Ayyat *et al.*, 1995; Blasco, 1996; Lukefahr, *et al.*, 1996a; Lukefahr and Hamilton, 1997; Rochambeau, 1997).

Low heritability of litter size is further reflected in low response to direct selection ($\approx$0.11 rabbits per litter per generation; Baselga *et al.,* 1992; Poujardieu *et al.*, 1994; Rochambeau *et al.*, 1994; Gomez *et. al.*, 1996). However, other studies (Khalil *et al.*, 1987, 1988; Krogmeier *et al.*, 1994) reported moderate to high heritability values, but these estimates were associated with rather high standard errors.

Maternal heritability values for litter weight at 21 d, 28 d, and 84 d were 0.08, 0.09, and 0.02, respectively. These estimates, except that for litter weight at 84 d, correspond well with those of Afifi *et al.*, 1992; Lukefahr *et al.*, 1996b, and Lukefahr and Hamilton, 1997. Other researchers have reported a broad range of heritability estimates (0.03 to 0.57) for litter weight at weaning (Khalil *et al.*, 1987; Moura *et al.*, 1991; Ferraz *et al.*, 1992; Krogmeier *et al.*, 1994; Ayyat *et al.*, 1995). Litter weight at 84 d, having the lowest maternal heritability of 0.02, may best be explained by the expected increasing importance of the genetic contribution of the progeny in conjunction with the diminishing influence of the dam. It is also possible that a negative covariance between direct and maternal genetic effects may explain the low heritability. McNitt and Lukefahr (1996) reported a negative correlation of .12 between direct and maternal genetic effects for postweaning average daily gain in New Zealand White rabbits.

Table 2
Estimates of heritability, permanent effects, and repeatability for maternal performance traits

Trait	$h^2 \pm$ SE	Statistic[a] $p^2 \pm$ SE	R	$\sigma s^2 \pm$ SE	σp
Total litter size born	.09 ± .07	.22 ± .06**	.30	.02 ± .02	1.85
Litter size born alive	.12 ± .07	.21 ± .07*	.32	.01 ± .01	1.90
Litter size at 21 d	.06 ± .07	.20 ± .07*	.26	.02 ± .02	1.75
Litter size at 28 d (weaning)	.09 ± .07	.16 ± .07*	.25	.01 ± .02	1.73
Litter size at 84 d (marketing)	.07 ± .06	.12 ± .06*	.19	.03 ± .02	1.72
Litter wt. at 21 d, g[b]	.08 ± .06	.10 ± .05*	.18	.10 ± .03**	198.09
Litter wt. at 28 d, g[b]	.09 ± .06	.10 ± .06	.19	.08 ± .03*	260.95
Litter wt. at 84 d, g[b]	.02 ± .04	.06 ± .04	.09	.03 ± .02	901.90

[a]Symbols: h^2 = heritability (additive genetic variance as a proportion of phenotypic variance), p^2 = permanent effects (non-additive genetic plus permanent environmental effects variance as a proportion of phenotypic variance), R = repeatability (sum of h^2 and p^2), σs^2 = variance due to random effect of service sire, σp = phenotypic standard deviation.
[b]Adjusted for linear covariate of litter size at the corresponding age.
*P<0.05; **P<0.01.

Repeatability estimates for maternal performance traits
Repeatabilities for litter size at various ages were generally moderate, ranging from 0.19 for litter size at 84 d to 0.32 for litter size born alive (Table 2). There was a slight tendency for repeatability of litter size to decline with age of the litter. Repeatability values for litter size in this study tended to be close to or above the maximum of the range of values reported in the literature from temperate as well as tropical rabbit populations (Khalil *et al.,* 1988; Moura *et al.*, 1991; Afifi *et al.,* 1992; Khalil, 1994; Ayyat *et al.,* 1995; Lukefahr and Hamilton, 1997).

The estimates of repeatability for litter weight at various ages ranged from low (0.09 for litter weight at 84 d) to moderate (0.19 for litter weight at 28 d), being relatively lower than those estimates for litter size (Table 2). In contrast, Afifi *et al.* (1992) reported that repeatability for litter weight at various ages was relatively higher than that for litter size. This contrast may be explained in part due to differences in statistical methodology, being more up to date in this study, and in part due to differences in population, being more heterogeneous in this study compared to New Zealand White and Californian breeds involved in the report by Afifi *et al.* (1992). Repeatabilities of litter weights in this study were somewhat lower than values reported in the literature (Moura *et al.,* 1991; Afifi *et al.,* 1992; Ferraz *et al.,* 1992; Khalil, 1994; Ayyat *et al.,* 1995; Lukefahr *et al.,* 1996b; Lukefahr and Hamilton, 1997) for reasons that cannot be explained.

Results from our investigation certainly warrant further research. In other tropical environments, higher direct heritabilities for individual fryer and litter traits have been reported than those from temperate countries. If true, this may be attributable, in part, to the relatively more heterogeneous nature of rabbit populations in tropical environments. Nonetheless, the challenging environment indeed offers opportunities to genetically characterize rabbit populations to help determine appropriate breeding programmes to meet farmer's demand for quality breeding stock.

REFERENCES

AFIFI, E.A., YAMANI, K.A., MARAI,I.F.M., EL-MAGHAWRY, A.M. 1992: Environmental and genetic aspects of litter traits in New Zealand White and Californian rabbits under the Egyptian conditions. In: Proc. 5th World Rabbit Congress, Oregan State Univ., Corvalis, USA. July 1992, Vol. A, 335 - 351.

AYYAT, M.S., MARAI, I.F.M., EL-SAYIAD, G.H.A. 1995: Genetic and non-genetic factors affecting milk production and preweaning liter traits of New Zealand White does under Egyptian Conditions. World Rabbit Sci. 3, 119 - 124.

BASELGA, M., GOMEZ, E., CIFRE, P., CAMACHO, J. 1992: Genetic diversity of litter size traits between parities in rabbits. In: Proc. 5th World Rabbit Congress, Oregon State Univ., Corvallis, USA, July 1992, vol. A, 198 - 205.

BLASCO, A. 1996: Genetics of litter size and does fertility in the rabbit. In: Proc. 6th World Rabbit Congr., Toulouse, France, July 1996, Vol. 2, 219 - 227.

BLASCO, A., SANTACREU, M.A., THOMPSON, R., HALEY, C.S. 1993: Estimates of genetic parameters for ovulation rate, prenatal survival and litter size in rabbits from an elliptical selection experiment. Livest. Prod. Sci. 34, 163 - 174.

FERRAZ, J.B.S., ELER, J.P. 1994: Use of different animal models in prediction of genetic parameters in 23 traits of Californian and New Zealand White rabbits raised in tropics and suggestion of selection criteria. In: Proc. 5th. World Congr. Genet. Appl. Livest. Prod. Guelph, Ontario, Canada, August, 1994, Vol. 20, 348 - 351.

FERRAZ, J.B.S., JOHNSON, R.K., VAN VLECK, L.D. 1992: Estimating genetic trends and genetic parameters for reproductive and growth traits of rabbits raised in subtropics with animal models. In: Proc. 5th World Rabbit Congr., Oregon State Univ., Corvallis, USA, July 1992, vol. A, 131 - 142.

GOMEZ, E.A., RAFEL, O., RAMON, J., BASELGA, M. 1996: A genetic study of a line selected on litter size at weaning. In: Proc. 6th World Rabbit Congr. Toulouse, France, July 1996, Vol. 2, 289 - 292.

JOHNSON, D.L., THOMPSON, R. 1995: Restricted maximum likelihood estimation of variance components for univariate animal models using spars matrix techniques and average information. J. Dairy Sci. 78, 449 - 456.

KHALIL, M.H. 1994: Lactational performance of Giza White rabbits and its relation with pre-weaning litter traits. Anim. Prod. 59, 141 - 145.

KHALIL, M.H., AFFIFI, .EA., EMARA, M.E., OWEN, J.B. 1988: Genetic and phenotypic aspects of doe productivity in four breeds of rabbits. J. Agric. Sci. 110, 191 - 197.

KHALIL, M.H., OWEN, J.B., AFIFI, E.A. 1987: A genetic analysis of litter traits in Bauscat and Giza White rabbits. Anim. Prod. 45, 123 - 134.

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.D., HAMILTON, H.H. 1997: Heritability and repeatability estimates of maternal performance traits in purebred and crossbred does. World Rabbit Sci. 5(3), 99 - 105.

LUKEFAHR, S.D., ATAKORA, K.A., OPOKU, E.M. 1992: Heritability of 90-day body weight in domestic rabbits from tropical Ghana, West Africa. J. Heredity. 83 (2), 105 - 108.

LUKEFAHR, S.D., CHEEKE. P.R., PATTON, N.M. 1996a: Heritability of milk production and 21-day litter weight and litter size in purebred and crossbred rabbits using an animal model. In: Proc. 6th World Rabbit Congr. Toulouse, France, July 1996, vol. 2, 319 - 323.

LUKEFAHR, S.D., ODI, H.B., ATAKORA, J.K.A. 1996b: Mass selection for 70-day body weight in rabbits. J. Anim. Sci. 74, 1481 - 1489.

MCNITT, J.I., LUKEFAHR, S.D. 1996: Genetic and environmental parameters for postweaning growth traits using an animal model. In: Proc. 6th World Rabbit Congr. Toulouse, France, July 1996, vol. 2, 325 - 329.

MOURA, A.S.A.M.T., POLASTRE, R., NUNES, J.R.V. 1991: Genetic study of litter traits at weaning in Selecta rabbits. J. Appl. Rabbit Res. 14, 222 - 227.

POUJARDIEU, B., GUICHARD, F., ROCHAMBEAU, H. DE., ROUVIER, R. 1994: Le modéle animal, application au lapin et aux palmipédes. In: Proc. Sèminaire Modéle animal, September 1994, La Colle sur Loup, France. 143 - 150.

ROCHAMBEAU, H. de. 1997: Genetics of the rabbit for meat production: What is new since the World Rabbit Congress held in Budapest in 1988?: A Review. World Rabbit Sci. 5(2), 77 - 82.

ROCHAMBEAU, H. de, BOLET,G., TUDELA, F. 1994: Long term selection - comparison of two rabbit strains. In: Proc. 5th World Congress on Genetics Applied to Livestock Production, Guelph, Ontario, Canada, August 1994, vol. 19, 257 - 260.