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GENETIC COMPONENT ESTIMATIONS AND DIETARY INFLUENCE FOR AND ON MILK PRODUCTION AND ASSOCIATIVE CHARACTERS IN RABBIT BREEDS AND SPECIFIC CROSSBREDS

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INTRODUCTION

The biological phenomenon of lactation, a joint achievement of genetic and environmental influences, ensures that the progeny receive essential postnatal nourishment to survive and reproduce in ensuing generations. One major postnatal component of net maternal productivity in the doe rabbit is milk production. The economic aspect of milk production has been well demonstrated by the strong positive relationship shown to exist between this character and litter growth response (Lebas, 1969; de Blas and Galvez, 1973; Niehaus and Kocak, 1973).

Venge (1963) reported differences in milk production among dam breeds varying in adult body weight. Breed differences have also been demonstrated by Cowie (1969), who found New Zealand White does to surpass Dutch-belted does in total milk yield over a 6 week period. Selection of existing genetic diversity among maternally suitable breeds for milk production and other vital reproductive characters is one potential approach towards increasing bioeconomic returns to the commercial meat rabbit enterprise. To make logical recommendations as to utilization of such genetic diversity among breeds, or formation of hybrid maternal lines of rabbits, it is imperative that information on genetic components of performance (s) be estimated and reported.

The objectives of the experiment (results published in the Journal of Animal Science, In Press, 1983,) were to quantity differences among straightbred and reciprocal crossbred doe groups into genetic components due to additive plus maternal breed and individual heterotic effects and differences among sire breeds of litters in milk production and associative traits and (2) to estimate intra-class correlations based on repeated doe record performances for milk production and associative traits.

MATERIALS AND METHODS

Two-hundred-twenty-five lactation and litter production records from eighty-two does representing four genetic groups and two diet sources were collected to determine the biological importance of specific genetic and environmental effects for milk production and related characters. Genetic groups evaluated were New Zealand White (NN) and Californian (CC) straightbred and Californian X New Zealand White (CN)and New Zealand White X Californian reciprocal crossbred does. Does of each genetic group were randomly alloted at standard breeding age (154d) to one of two diets. Complete pelleted rations fed to does and litters were either a commercial control[3] or a diet consisting of 74% alfalfa (IFN I-00-III), 21% soybean meal (IFN 5-04-604), 3% molasses (IFN 4-04-696), 1.25% tallow (IFN 4-00-375), .5% trace mineralized salt and .25% dicalcium phosphate.

[3]Carnation Albers Milling CO., Portland, OR, U.S.A. (Commercial Family Ration).

Control vs 74% alfalfa diets had 18.8 vs 22.1% crude protein, 22.8 vs 26.5% acid detergent fiber, 32.9 vs 34.8% cell wall constituents and 2,605 vs 2,527 kcal digestible energy per kg of dry matter. The rationale for developing the latter diet was to limit the amount of soluble carbohydrates reaching the hindgut and thereby to prevent excessive microbial fermentation leading to diarrhea and subsequent death in weanling rabbits, according to the carbohydrate- overload hypothesis of Cheeke and Patton (1980).

Sire breeds of litters included NN, CC and Flemish Giant (FG) straightbreds. Fifteen NN, 16 CC and 11 FG bucks were involved. All bucks received the commercial control diet. Doe genetic group, diet and sire breed of litters were cross-classified in a factorial arrangement consisting of twenty-four treatment classes.

Population management and housing were previously discussed by Lukefahr et al. (1983). Doe management consisted of a 14-day intensive breeding schedule following the first and all subsequent parturitions, allowing for a maximum of eight litters per annum. At day 28 of gestation, pregnant does were provided with a front-loading subterranean nest box containing sanitized wood shavings.

The data set consisted of 225 doe records, collected from day of kindling to 21 days of age of the litter, for the following characters: total milk production (1-21 days), litter 21 d weight, litter milk efficiency (to be defined), litter size at 21 d (number of young), doe weight at kindling and doe feed intake and efficiency (to be defined). Milk production was estimated daily from 1-21 d using the weigh-suckle-weigh method. Unlike other mammalian livestock species, the normal nursing behavior of the rabbit involves a single daily nursing period (Venge, 1963; Zarrow et al., 1965). Therefore, the experimental nursing method was consistent with the natural one in regards to suckling frequency. Access of the doe to the litter for nursing was controlled by opening a gate that otherwise separated the nest box from the doe cage. Nursing generally lasted only 3-4 min and ended abruptly when the doe vacated the nest box. Fostering of kits between litters was not practiced so as to assess a given does' own rearing ability of the young. Litters subsisted solely on milk until day 21 when they were removed from the nest box and placed in the does cage. Weaning of litters occurred one week later at 28 d of age.

Litter milk efficiency was calculated as the ratio of litter gain (litter 21 d weight - litter birth weight) to total milk intake from 1-21 days. Doe feed intake was recorded from 1-21 d, and doe feed efficiency was calculated as the ratio of total milk production to doe feed intake.

Data were analyzed through least-squares procedures as described by Harvey (1975). Fixed effects included dam genetic group, diet, sire breed of litter, age of doe (as a covariate), month of experiment and two-factor interactions involving the first three sources. Random effects in the model were among-doe variation within breed X diet subclass and the random error.

A pre-planned set of orthogonal linear comparisons was made to quantify differences according to doe genetic group, diet and sire breed of litters. Specific genetic component estimations of additive plus maternal breed and individual heterotic effects on milk production and related characters were derived through the selected contrasts. Each single degree of freedom contrast was tested for significance by the Students' t-test.

Repeatabilities for milk production and related traits were estimated as the intra-class correlation between repeated records of the same doe, using among and within doe variance components obtained from analyses of variance, as described above. Approximate standard errors of the repeatabilitity estimate were calculated by the method of Swiger et al. (1964).

RESULTS AND DISCUSSION

Doe Genetic Group and Diet Comparisons. Least-squares genetic group and diet means and selected contrasts for milk production and associative traits are shown in table 1. Straightbred NN does were superior ($P<.01$) to CC does for milk production (3.97 vs 3.06 kg). Bartelli and Altomonte (1968), using litter 21 d weight as a reflection of milk production, similarly reported NN does to exceed CC does in milking ability. In the present experiment, NN does were heavier than CC does, a significant difference of .54 kg, which could have caused the greater milk production. Venge (1963) and Cowie (1969) reported that milk production level closely paralleled mature doe weights across breeds.

In the present study, 21 d litter weights corresponded with the genetic group rankings for milk production. Litter milk efficiency (litter gain/ milk intake) was slightly improved in litters reared by NN vs CC dams, although the difference was not significant. Cowie (1969) reported litter milk efficiency values of .45 and .38 for NN and Dutch-belted straightbreds, from day 9 to 31 of lactation. Although moderate breed differences between NN and CC does where shown for litter size at 21 d and for doe feed intake (NN does having the larger means), significance was not detected. The NN doe breed was more efficient ($P<.01$) compared to the CC doe breed in converting feed into milk during the three week post-partum period.

Positive heterosis was observed ($P<.05$) for milk production and litter size and weight at 21 d age. Although heterosis for milk production has been documented in several laboratory and livestock species, studies involving rabbits are not available for comparison. Heterosis for litter milk efficiency, doe weight at kindling and doe feed intake and efficiency was small ($P>.05$).

Reciprocal differences existed for milk production, litter milk efficiency, litter size at 21 d and doe feed intake (all $P<.08$). Greater milk production, a larger litter size and an increase in feed consumption of CN does reared by NN dams were observed, compared to NC does reared by CC dams. Thus, important maternal breed effects may exist for the above characters. Litters from NC vs CN does were more efficient ($P<.05$) in converting milk to weight gain. Reciprocal differences were not significant for litter 21 d weight, doe weight at kindling or doe feed efficiency.

Does receiving the 74% alfalfa ration produced more milk and reared larger and heavier litters by day 21. The higher protein content in the 74% alfalfa ration (22.1 vs 18.8% in the control diet) may explain the above trend. However, since diets also differed in content of other nutrients (e.g. energy concentration and / or fiber level), specific dietary effects on performances cannot be ascertained. Partridge and Allan (1982) demonstrated that lactational yield in does correspondingly increased as dietary protein levels rose from 13.5 to 17.5 and to 21.0%, respectively. Conversion of feed to milk production was nearly identical for each diet, even though does fed the 74% alfalfa ration consumed more feed (P<.01). A greater lactational demand due to rearing a larger litter and the lower caloric density of the 74% alfalfa ration may have stimulated greater appetite of does on that diet. Litter milk efficiency and doe weight at kindling were not influenced (P>.05) by diet.

Single degree of freedom contrasts for doe genetic group X diet interactions, for sire breed of litter effects (involving the comparisons between litters sired by NN vs CC medium weight breeds and the comparisons between litters sired by the large FG breed vs the combined average of NN and CC medium weight breeds) and for all possible remaining two and three-factor interactions were never found to be significant.

<u>Repeatabilites</u>. Estimates of repeatability (effective number of repeat doe records of 2.4, from a total of 225 records) pooled across doe genetic groups, for milk production and associative traits were obtained in the study. Repeatability of milk production was estimated to be - .02±.08. This may reflect the presence of a negative environmental covariance between adjacent records of the same doe. However, separate genetic group estimates for repeatability of milk production of -.04, .47, .55 and .46 for NN, CC, CN and NC does indicated that the negative environmental component, if real, was breed specific. A possible explanation for the negative repeatability in NN does is an increased lactational stress associated with the intensive 14-d breeding schedule in does with an otherwise above-average lactational capacity.

Repeatabilities of litter 21 d weight and litter milk efficiency, traits closely related to milk production, were estimated to be -.03 ±.08 and -.19±.07. In a separate experiment involving FG and NN straightbreds and Florida White X NN crossbred does, Lukefahr (1983) reported a pooled repeatability estimate of .25 for litter 21 d weight. Rouvier et al. (1973) found repeatabilities for the same trait to be .13 and .24 in NN and Fauve de Bourgogne doe populations.

Repeatability of litter size at 21 d was estimated to be .23±.08, consistent with repeatability estimates of .13 and .25 reported by Rouvier et al. (1973).

Repeatabilities for doe weight at kindling, doe feed intake and doe feed efficiency were estimated to be .72±.04, .27±.08 and .17±.09, respectively. The high repeatability for doe weight at kindling may be indicative of considerable additive genetic variation for the character. Lukefahr (1983) obtained a larger estimate of repeatability for doe feed intake of .58, while a more comparable estimate of .27 was found for doe feed efficiency.

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SUMMARY

Lactation and litter performance records (N=225) from eighty-two does representing four genetic groups and two diet regimes were analyzed to quantify additive plus maternal breed, heterotic and dietary effects for milk production and associative traits. Doe genetic groups were New Zealand White (NN) and Californian (CC) straightbreds and Californian X New Zealand White (CN) and New Zealand White X Californian (NC) reciprocal crossbreds. Pelleted diets fed to does and litters were either a commercial control or a 74% alfalfa ration. The sire breeds of litters included NN, CC and Flemish Giant (FG) straightbreds. Straightbred NN does were heavier at kindling, yielded more milk, reared a heavier litter by 21 d and were more efficient in converting feed into milk that were straightbred NN does ($P<.01$). Significant heterosis was detected for milk production and for litter size and weight at 21 d. Reciprocal differences between crossbred doe groups were observed (approaching significance at $P<.08$) for milk production and litter size at 21 d and for litter milk efficiency (litter gain/milk intake) and doe feed intake ($P<.05$). The 74% alfalfa ration was superior to the commercial control diet for effects on milk production and litter size and weight at 21 d, although doe feed intake was increased. The sire breed of litter effect did not indirectly influence ($P>.05$) lactational performance of does nor associative traits. Significant estimates of doe repeatability were obtained for litter size at 21 d, doe feed intake and efficiency and doe weight at kindling. Separate genetic group estimates of repeatability for milk production were -.04, .47, .55 and .46 for NN, CC, CN and NC does. Experimental results suggest the utilization of CC as the sire and NN as the dam breeds of choice to increase maternal productivity as expressed in hybrid does.

RESUME

L'analyse porte sur les performances de lactation et de prolificité enregistrées dans 225 portées de quatre vingt deux femelles de quatre types génétiques recevant deux types de rations. Le but de l'experience était de quantifier les effects des races de méres, du types de ration et d'heterosis sur la production laitiére et des caractéres associés. Les types génétiques de femelles étaient: Néozelandaise blanche (NN) et Californien (CC) de lignées pures et les deux croisements réciproques Néozelandais x Californien (NC) et Californien x Néozelandais (CN). Les mâles péres des portée etaient de lignées pures NN, CC et Geant des Flandre (FG). Les rations distribuées sous formes de granulés aux lapines et à leurs portées etaient, soit un aliment commercial pris comme témoins, soit un aliment renfermant 74% de luzerne. Les femelles NN, plus lourdes à chaque mise bas produisaient plus de lait, élevaient une portée plus lourdes à 21 jours et s'averaient plus efficientes dans la transformation de leur nourriture en lait que les femelles CC (P<.01). La production laitiére, la taille et le poids de portée à 21 jours bénéficiaient d'un hétérosis significatif. La production laitiére et la taille de portée à 21 jours des deux types de femelles métis differaient presque significativement (P<.08); ces deux types de femelles métis présentaient des consommations d'aliment différentes et des différences d'efficacité de la transformation du lait par la portée (poids de la portée / lait consommé) (P<.05). La ration à 74% de luzerne entrainait une consommation des méres, une production laitiére, une taille et un poids de portée à 21 jours, supérieurs à ceux de la ration témoin. La race du pére de la portée etait sans influence sur les caractéres études (P .05). Les répétabilités de la taille de protée à 21 jours, de la consommation, de l'aptitude à la transformation alimentaire et du poids à la mise bas des lapines étaient significativement non nulles. Les valeurs estimées pour la production laitiére étaient de -.04, .47, .46, .55 selon le type génétiques de la mére NN, CC, NC, ou CN.

TABLE 1 . LEAST-SQUARES GENETIC GROUP AND DIET MEANS AND STANDARD ERRORS FOR MILK PRODUCTION AND ASSOCIATIVE TRAITS, AND SELECTED ORTHOGONAL COMPARISONS

Item	Milk production, kg	Litter 21 d wt, kg	Litter milk efficiency	Litter size at 21 d	Doe wt at kindling, kg	Doe feed intake, kg	Doe feed efficiency
Doe genetic group mean[a]							
NN	3.97 ± .16	2.72 ± .11	.519 ± .02	7.05 ± .55	3.98 ± .11	8.51 ± .44	.455 ± .02
CC	3.06 ± .19	2.07 ± .13	.503 ± .02	6.17 ± .58	3.43 ± .10	7.66 ± .46	.393 ± .02
CN	4.03 ± .17	2.72 ± .11	.508 ± .02	8.19 ± .58	3.91 ± .13	9.30 ± .47	.441 ± .02
NC	3.65 ± .24	2.52 ± .16	.543 ± .03	7.08 ± .81	3.76 ± .16	8.11 ± .64	.442 ± .03
Straightbred contrast							
NN-CC	.91** ± .18	.64** ± .12	.016 ± .02	.88 ± .55	.54** ± .09	.85 ± .44	.062** ± .02
Heterosis contrast							
1/2{(CN+NC)-(NN+CC)}	.32* ± .13	.23* ± .09	.014 ± .01	1.02* ± .42	.13 ± .07	.61 ± .33	.018 ± .01
(heterosis percentage)	(9.2)	(9.6)	(2.7)	(15.4)	(3.5)	(7.5)	(4.2)
Reciprocal contrast							
CN-NC	.38 ± .20	.20 ± .14	-.036* ± .02	1.12 ± .63	.15 ± .11	1.19* ± .50	-.002 ± .02
Diet mean							
Commercial control	3.42[b] ± .22	2.32[b] ± .15	.512 ± .02	6.27[b] ± .67	3.79 ± .13	7.55[b] ± .54	.436 ± .02
74% alfalfa	3.94[c] ± .17	2.70[c] ± .11	.525 ± .02	7.98[c] ± .59	3.76 ± .12	9.24[c] ± .47	.430 ± .02

[a] Doe genetic group abbreviations are New Zealand White (NN), Californian (CC), Californian sire x New Zealand White dam (CN) and New Zealand White sire x Californian dam (NC).

[b,c] Diet column means bearing unlike superscripts differ (P<.01).

*P<.05.

**P<.01.

APPENDIX 1. RESIDUAL CORRELATIONS AMONG MILK PRODUCTION AND ASSOCIATIVE TRAITS

Trait:	2[a]	3	4	5	6	7	8	9
(1) Milk production, kg	.48[b]	.64	.99	.52	.78	.10	.63	.81
(2) Total number born[c]		.81	.45	-.03	.68	-.12	.32	.39
(3) Litter birth wt[c], g			.62	.00	.72	-.01	.49	.46
(4) Litter 21 d wt, kg				.58	.80	.11	.63	.79
(5) Litter milk efficiency					.38	.14	.27	.53
(6) Litter size at 21 d						.11	.51	.65
(7) Doe wt at kindling, kg							.07	.04
(8) Doe feed intake, kg								.11
(9) Doe feed efficiency								

[a]Numbers in column headings correspond to row-numbered traits.

[b]Correlations greater than .19 and greater than .25 in absolute value are different from zero at $P<.05$ and $P<.01$, respectively.

[c]Analyses of variance results and breed and diet means for number born and litter birth weights have been reported elsewhere (Lukefahr et al., 1983).

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