Proceedings 5th World Rabbit Congress, 25-30 July 1992, Corvallis – USA, 274-286.

EVALUATION OF CALIFORNIAN, CHAMPAGNE D'ARGENT, NEW ZEALAND WHITE AND PALOMINO AS POTENTIAL SIRE BREEDS: I. POSTWEANING LITTER TRAITS

J.D. Roberts and S.D. Lukefahr

International Small Livestock Research Center
Department of Food Science and Animal Industries
Alabama A&M University, P. O. Box 264,
Huntsville, AL 35762, USA

Abstract

Postweaning trait data were collected on 584 weanling rabbits from 92 litters representing four sire breeds: Californian (CAL), Champagne D'Argent (CHA), New Zealand White (NZW) and Palomino (PAL)). All sires (s=34) were mated to NZW does (d=58). Postweaning litter traits included litter size, and growth and feed related characters. The general model consisted of sire breed (SB), season of weaning, month within season, and litter size and estimated milk yield covariates as fixed effects, and sire nested within SB, dam within sire and the random residual as random effects. Litter trait performance was similar ($P>.10$) for CAL X NZW crossbred vs NZW purebred and for PAL X NZW crossbred vs NZW purebred comparisons. The CHA X NZW crossbreds tended ($P<.10$) to have heavier litter weaning weights, consumed more feed ($P<.05$), and had numerical (but non-significant) advantages in average and total litter market weights at 70 days of age, compared to NZW purebred litters. A gross margin analysis suggested higher potential net returns from CHA X NZW crossbred litters than from purebred NZW litters.

Introduction

Litter performance (e.g. litter size and total litter market weight) is of economic importance to commercial producers, whereas carcass traits (e.g. dressing percentage) are especially relevant to rabbit meat processors. Meat qualities such as meat-to-bone ratio and fat content are of primary interest to the consumer. While both producers and processors should strive to produce or purchase the most economical rabbit, attractiveness to the consumer is the ultimate test in determining long term economic viability of the meat rabbit industry.

The New Zealand White (NZW) is currently the industry breed standard. The NZW has scientifically proven merit for nest building behavior, milk production, litter size and survival (Lukefahr et al., 1983b,c, 1984; Szendro and Kustos, 1988; McNitt and Lukefahr, 1990; Hamilton and Lukefahr, 1991). In contrast to these findings for maternal traits, U.S. studies have demonstrated inferiority of the NZW breed for certain postweaning growth and carcass traits (Lukefahr et al., 1982, 1983a,d, 1984; Ozimba and Lukefahr, 1991a,b). Hence, the NZW can be appropriately classified as a dam breed resource. This statement implies that a different breed of sire should be used with the NZW doe to produce the most economical, highest quality meat animal.

Evaluation of the extent to which the sire breed might influence certain postweaning litter traits - as compared to conventional purebred NZW litter performance - was the objective of this breeding experiment. The alternate sire breeds chosen were the Californian (CAL), the Champagne D'Argent (CHA), and the Palomino (PAL). The CAL is currently the second most popular breed in the U.S., and was originally developed to improve carcass traits (American Rabbit Breeders Association, 1984). The CHA is also a breed that has been shown in several European studies to have good carcass and lean yield characteristics (Rouvier, 1970; Masoero, 1982; Trojan and Mach, 1982; Auxilia and Masoero, 1986). However, this breed has not, to date, been investigated in the U.S. The PAL is a fairly recently developed breed of U.S. origin. Limited reports (Grobner et al., 1985; McNitt and Moody, 1989; McNitt and Lukefahr, 1990, 1991) have appraised this breed but only with respect to its purebred merits.

The objectives of this investigation were to evaluate the postweaning litter performance traits of CAL-, CHA- and PAL-sired crossbred litters reared by NZW dams compared to conventional New Zealand White purebred litters.

Materials and Methods

Research Herd Management. The four sire breeds included in the study were each represented by eight or nine bucks. These bucks, sampled at random (regardless of pedigree or performance records), were donated by Southeastern regional commercial and(or) fancy breeders and one institution (see Acknowledgements). Each buck was mated at random to one or two NZW does of the commercial Ozark strain maintained at Alabama A&M University. In turn, each doe produced one to two litters to the experiment, resulting in a total of 92 litters surviving to 70 days of age. Table 1 provides a summary of the number of sires, dams, litters and fryers represented in each sire breed subset.

The study was initiated with does representing several parity or age classes so as not to contribute later to a potential parity by time (season or month) confounding problem in the statistical analyses. Breedings occurred in two-week intervals with each mating replication involving a composite of virgin does (5 month-old), does with litters 2 to 4 weeks of age, and does not successfully impregnated from the previous mating replication. Does were palpated 2 weeks post-mating, open does being immediately rebred. Two weeks later, this process was repeated and the previous group of pregnant does were given nest boxes supplied with wood shavings and fine-stemmed hay. Litters were born in each of the three production seasons of 1989 (spring, summer and fall) when the breeding experiment was conducted.

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Table 1. Number of sires, dams, litters and kits weaned by sire breed

Sire breed	Sires	Dams[a]	Litters	Kits
Californian	9	16	24	149
Champagne D'Argent	8	11	19	140
New Zealand White	9	15	23	143
Palomino	8	16	26	152
Total	34	58	92	584

[a] All dams were of the New Zealand White breed.

Litters were weaned at 28 days of age. Total litter weights were recorded. Each kit was individually weighed, sexed and ear-tagged. Each litter was then moved to an adjacent growing facility and placed in a cage (76.2 x 91.4 x 45.7 cm, LWH) as an intact litter. Daily feed intake was recorded for each litter. The feed used was a commercially prepared pelleted rabbit diet (Nutrena Rabbit Pellets, Cargill-Nutrena Feeds Div., Florence, AL). The chemical composition of the diet was 13.6% moisture, 16.5% protein, 3,511 kcal gross energy/kg DM, 26.2% ADF, 54.1% NDF, 4.62% lignin, 5.45% ether extract and 8.2% ash. The litters were provided feed ad libitum. Water was continuously provided through an automatic watering system.

Postweaning litter traits studied included: 28 and 70 day total litter and average weights, litter sizes at 28 and 70 days, 28 to 70 day total feed consumption, litter gain and feed efficiency, and litter survival rate, proportion of marketable fryers weighing at least 1,700 g (3.75 lb) by 70 days of age and within-litter uniformity. Litter feed efficiency was calculated as litter feed intake divided by gain. Litter survival was calculated as the proportion of fryers surviving to 70 days. The proportion of marketable fryers attaining at least 1,700 g body weight by 70 days of age was calculated on a within-litter basis. Uniformity was measured as the coefficient of variation among siblings for individual 70-day body weight, times 100.

Statistical Methods. Data were analysed (Harvey, 1990) according to the following general mathematical model:

$$
\begin{aligned}
Y_{ijklmn} = {} & \mu + SB_i + s_{ji} + d_{kji} + Seas_l + Mo_{ml} \\
& + \beta_1(\overline{LSW}\text{-}LSW) + \beta_2(\overline{LSW}\text{-}LSW)^2 \\
& + \beta_3(\overline{MP}\text{-}MP) + \beta_4(\overline{MP}\text{-}MP)^2 + \epsilon_{ijklmn}
\end{aligned}
$$

where,

Y_{ijklmn}	=	observation on the nth litter weaned in the mth month of the lth season to the kth dam mated to the jth sire of the ith sire breed;
μ	=	overall mean;
SB_i	=	fixed effect of the ith sire breed;
s_{ji}	=	random effect of the jth sire nested within the ith sire breed, assumed to be NID $(0, \sigma^2_s)$;
d_{kji}	=	random effect of the kth dam nested within the jth sire nested within the ith sire breed, assumed to be NID $(0, \sigma^2_d)$;
$Seas_l$	=	fixed effect of the lth season of weaning;
Mo_{ml}	=	fixed effect of the mth month nested within the lth season;
β_1 and β_2	=	partial linear and quadratic regressions due to litter size at weaning (LSW);
β_3 and β_4	=	partial linear and quadratic regressions due to estimated milk yield (21-day litter weight (MP), and
ϵ_{ijklmn}	=	random error, assumed to be NID $(0,\sigma^2_\epsilon)$.

In preliminary analyses, parity effects (i.e. primiparous vs multiparous records) and two-way interactions among fixed effects were never significant, so these sources were not included in the final model above. The only exception was a sire breed X season interaction ($P<.05$) for litter weaning weight.

Multiple regression analysis was used in order to adjust or standardize traits to a constant litter size and milk production basis. The regression variable of litter size at weaning was not considered, of course, in the analysis of litter size at weaning. Litter size at 70 days was included as a regression variable in the model for the analysis of the 28 to 70 day and 70 day endpoint traits except for litter size at 70 days, survival rate and proportion of marketable fryers. In preliminary analyses, non-significant partial linear or quadratic regressions were eliminated from the model using backstep multiple regression procedures. Weighted least squares analyses were performed for litter survival, average weight and proportion of marketable fryers at 70 days. The weighting criteria used were the litter size at 28 days for the first trait and litter size at 70 days for the last two traits.

Preplanned contrasts included all possible pair-wise comparisons between sire breed groups (e.g. NZW vs CAL X NZW and CHA X NZW vs PAL X NZW) for average performance in each trait used as evaluation criteria. Contrast comparisons were tested ($P<.10$) for statistical significance using the Student's t-test. Despite non-orthogonality, these contrasts were deemed most meaningful for conducting gross marginal analyses to draw economical inferences to make potential recommendations to commercial producers. Contrast differences would evaluate sire breeds on the basis of additive genetic merit if heterosis for these postweaning traits can be assumed to be of minor importance (Carregal, 1980; Lukefahr et al., 1983d; Masoero et al., 1985; Brun and Ouhayoun, 1989).

Results and Discussion

Analysis of Variance. Sire breed group differences will be discussed in the next section. Sire within sire breed was significant only for litter size at market age (70 days), 28 to 70 day survival rate, and uniformity among littermates in individual 70-day body weight. The dam effect (nested within sire) significantly influenced all litter traits measured at weaning age (28 days), 28 to 70 day total feed consumption, litter size at market age, average and total 70-day litter market weights, and proportion of marketable fryers. In rabbits, dams generally influence litter traits more so than sires (Rollins et al., 1963; Rouvier et al., 1973; McReynolds, 1974; Khalil et al., 1986).

Season or month within season of weaning had significant effects on all characters studied except litter size at market age. Basically, performance was poorest during the summer season, in agreement with previous domestic reports (Casady et al., 1962; Sittmann et al., 1964; Lukefahr et al., 1983d; Ozimba and Lukefahr, 1991b). Season or month results had no particular bearing on sire breed results; however, a sire breed X season interaction was detected ($P < .05$) for litter weaning weight. The nature of the latter interaction followed no clear trend and is open to question.

The number of kits (litter size) at weaning significantly affected average and total litter weaning weights, 28 to 70 day litter gain, feed consumption, and feed efficiency, average litter market weight, and proportion of marketable fryers by 70 days of age. These results are consistent with previous reports (Johnson et al., 1988; Lukefahr et al., 1983d). Of interest, litter size at weaning was not an important ($P > .23$) factor on total litter market weight. Also, the litter size at market age influenced ($P < .05$) 28 to 70 day litter gain, feed consumption, feed efficiency, and litter market weight. In general, the linear or linear and quadratic regression(s) involving litter size at weaning tended to reflect negative relationships, whereas litter size at market age had positive relationships with the litter traits and in models containing both litter size covariates. The linear or linear and quadratic regression(s) for milk production was highly significant for all litter weaning traits, for 28 to 70 day litter feed consumption, feed efficiency, litter size, and proportion of marketable fryers by market age (70 days). In all cases, the relationships were positive, confirming the importance of milk production on postweaning litter trait performances (Leplege, 1970; Rouvier et al., 1973; Lukefahr et al., 1990).

Sire Breed Comparisons. Sire breed means and contrasts for postweaning litter traits are shown in Tables 2 and 3. As expected, sire breed effects were not significant for litter weaning traits; moreover, these characters were influenced strongly by maternal effects, as previously discussed. However, litter weaning weight tended ($P < .10$) to be heavier for CHA X NZW crossbred compared to purebred NZW litters. Despite the similar medium-sized mature weights of the four breeds, significant sire breed contrast differences were observed for 28 to 70 day total litter gain, feed consumption, and average and total litter market weights, and proportion of marketable fryers by 70 days of age. Varying rates of physiological maturation among breeds, as opposed to absolute body weight differences at maturity, may best explain these results.

Table 2. Least squares sire breed means and contrasts for litter performance traits[a]

Item	LSW	AWW, g	LWW, g	Gain, g	Feed, g	FE
Californian (CAL)	6.44	514	3,346	7,429	27,991	3.75
Champagne D'Argent (CHA)	6.47	531	3,559	8,023	28,967	3.84
New Zealand White (NZW)	6.50	517	3,275	7,554	26,586	3.60
Palomino (PAL)	6.45	518	3,368	7,073	26,463	3.78
CAL - NZW	-.07	-4	71	175	1,405	.15
CHA - NZW	-.03	13	284†	469	2,381*	.24
PAL - NZW	-.06	0	94	-481	-124	.18
CAL - CHA	-.03	-17	-213	-294	-976	-.09
CAL - PAL	-.01	-4	-22	656*	1,528	-.03
CHA - PAL	.02	13	191	950**	2,505*	.06
SE[b]	.55	25	160	260	1,140	.17

[a] Trait abbreviations: LSW = litter size weaned (28 d); AWW = average weaning wt, g; LWW = litter weaning wt, g; GAIN = litter market wt - litter weaning wt, g; Feed = 28 to 70 d total feed consumption, g, and
FE = Feed/gain.

[b] Average standard error for the sire breed means.

† $P<.10$, *$P<.05$, **$P<.01$.

Specifically, CAL X NZW and CHA X NZW crossbred litters gained significantly more weight from 28 to 70 days of age than PAL X NZW crossbred litters. The CHA X NZW also consumed more feed than NZW and PAL X NZW litters ($P<.05$). However, no sire breed differences were found ($P>.10$) for litter feed efficiency from 28 to 70 days. In addition, average and total litter weights were heavier for CHA X NZW crossbred than PAL X NZW litters. CAL X NZW crossbred litters tended ($P<.10$) to weigh more at 70-day market age than PAL X NZW crossbred litters. The proportion of fryers attaining 1,700 g (3.75 lb) body weight by 70 days of age was 14.9% lower ($P<.05$) in CAL X NZW than in CHA X NZW fryers, while 20.6% more CHA X NZW fryers were marketable than PAL X NZW fryers ($P<.01$).

Table 3. Least squares sire breed means and contrasts for litter performance traits[a]

Item	LSM	SR, %	AMW, g	LMW, g	CV, %	PMF, %
Californian (CAL)	5.04	79.1	1,948	10,960	7.97	74.0
Champagne D'Argent (CHA)	5.20	81.8	1,975	11,393	2.18	88.9
New Zealand White (NZW)	5.17	81.5	1,913	10,754	6.16	79.1
Palomino (PAL)	5.58	87.8	1,855	10,195	6.04	68.3
CAL - NZW	-.13	-2.4	35	205	1.81	-5.1
CHA - NZW	.03	.2	63	639	-3.99	9.8
PAL - NZW	.41	6.2	-58	-559	-.11	-10.8
CAL - CHA	-.16	-2.6	-27	-434	5.80	-14.9*
CAL - PAL	-.54	-8.6	93	765†	1.93	5.7
CHA - PAL	-.38	-6.0	120†	1,198*	-3.87	20.6**
3						
SE[b]	.66	6.3	62	383	2.9	7.2

[a] Trait abbreviations: LSM = litter size at market age (70 d); SR = 28 to 70 d survival ((LSW - LSM)/LSW), %; AMW = average market wt (70 d), g; LMW = total litter market wt (70 d), g; CV = among-sibling coefficient of variation for individual 70 d wt, %, and PMF = proportion of siblings weighing at least 1,700 g by 70 d, %.

[b] Average standard error for the sire breed means.

† $P<.10$, *$P<.05$, **$P<.01$.

Previous reports (Rouvier, 1973; Bednarz and Frindt, 1975; Niedzwiadek, 1979; Lukefahr et al., 1983d; Masoero et al., 1985; Brun and Ouhayoun, 1989; Ozimba and Lukefahr, 1991b) have demonstrated comparable or even increased postweaning growth- and feed-related performances for CAL X NZW crossbred compared to purebred NZW fryers or litters. Present results showed no significant differences between these two groups, perhaps due to the limited number of litters. Masoero et al. (1985) observed CHA X NZW fryers to have more rapid average daily gains (37.0 vs 33.0 and 33.3 g) and convert feed more efficiently (4.08 vs 4.38 and 4.30) than CAL X NZW crossbred and purebred NZW fryers. Only the investigations by Grobner et al. (1985) and McNitt and Lukefahr (1991) compared purebred NZW and PAL fryers for similar postweaning traits. Both studies showed numerically poorer trait performances in purebred PAL compared to NZW rabbits.

Gross Margin Analysis. Gross margin analysis is a basic economic tool commonly used to project the comparative profitability of alternative farm ventures. Specifically, a comparison of alternative farming activities is made based on gross income (revenue) vs operating (variable) costs. A gross margin analysis was conducted to compare sire breed groups of rabbit, based on the following set of assumptions:

1) Litters had the same average litter size at market age;
2) Fryers were marketable by 70-days of age;
3) Feed costs represented the major variable cost, and
4) Costs of producing litters were similar to weaning age across sire breed groups.

The first assumption is supported by the lack of differences among sire breeds in litter size at 70 days of age (Table 3). The assumption that all fryers were marketable by 70 days has been made for convenience so that the production figures obtained from this study could be used. Sire breed groups having a lower proportion of marketable fryers (Table 3) would tend to be discounted further as additional feed, labor and cage space would be expended. The major operating cost of fryer production was feed, while other costs (e.g. debt service, depreciation, supplies, utilities and veterinary) were assumed to be constant. Similar production costs to weaning age for all sire breeds is assumed because all litters were raised by NZW does. Also, the cost of purchasing a buck of any of the four breeds would be approximately the same. The gross margin analysis was conducted on a per litter basis, as follows:

	Sire breed			
	CAL	CHA	NZW	PAL
Gross Revenue ($):				
- Litter 70-day market weight, kg	10.960	11.393	10.754	10.195
- X market price, $1.54/kg	$16.89	$17.55	$16.56	$15.70
Variable costs ($):				
- Feed consumption, kg	27.991	28.967	26.586	26.463
- X feed cost, $.29 $/kg	$8.12	$8.40	$7.71	$7.67
Gross Margin ($):				
Gross revenue - feed costs	$8.77	$9.15	$8.85	$8.03

The above figures were based on the following calculations:

Gross Margin = (LMW X MP) - (FEED X FC),

where LMW = total litter 70-day market weight (kg);
FEED = total 28 to 70 day litter feed intake (kg);
MP = price of rabbit on a live weight basis ($/kg), and
FC = cost of rabbit feed ($/kg).

Values for LMW and FEED were taken from Tables 3 and 2, respectively. Of course, other variable costs in addition to feed would reduce the above gross margin values. In Table 4, ranges in market prices and feed costs are provided so that the reader might better project economic returns for the alternate sire breed groups. The gross margins in the table are expressed as deviations from the purebred NZW. Because variable costs other than feed were assumed to be constant, the gross margins should reflect additional net returns. Comparison of CAL X NZW crossbreds to purebred NZW litters revealed minor differences, ranging from -.13 to .10 dollars, regardless of market price or feed cost. No difference between CAL X NZW crossbred to NZW purebred litters was projected at the 1.98 $/kg market price and .29 $/kg feed cost range values.

CHA X NZW crossbred litters maintained a comparative advantage over all other sire breed groups suggestive of greater potential net returns. Rouvier (1973) projected net returns to be higher for CHA X NZW litters than for CAL X NZW and NZW litters (due to more rabbits per litter and improved feed efficiency). The PAL X NZW crossbred litters consistently had negative gross margins across market price and feed cost ranges in relation to NZW purebred results, indicative of lower potential net returns associated with usage of the PAL as a sire breed.

Conclusions

The results of this sire breed evaluation based on postweaning litter performances showed that CAL X NZW crossbred litters were comparable to purebred NZW litters. However, the results from the following companion paper (Lukefahr et al., 1992) clearly indicate better dressing percentage and lean-to-bone ratio in CAL X NZW crossbred vs purebred NZW fryers. Processors should provide an economic incentive to commercial producers (e.g. payment according to dress-out rate) to produce the meatiest rabbit possible to increase consumer demand and also make money.

Use of PAL bucks to produce commercial fryers is not presently encouraged because of the poorer gross margin results, and also the discouraging results from previous investigations conducted in Louisiana and Oregon. However, there were no significant differences between PAL X NZW crossbreds and purebred NZW litters in this postweaning litter trait investigation.

Table 4. Gross margin analysis: Projected producer net returns for CAL-, CHA- and PAL-crossbred compared as deviations from NZW purebred litter performances based on LMW and FEED results[a].

		Market price, $/kg ($/lb)			
		1.32 (.60)	1.54 (.70)	1.76 (.80)	1.98 (.90)
Feed cost, $/kg ($/lb)	SB				
.22 (.10)	CAL	-.04[b]	+.01	+.05	+.10
	CHA	+.32	+.46	+.60	+.74
	PAL	-.71	-.83	-.96	-1.08
.24 (.11)	CAL	-.07	-.02	+.02	+.07
	CHA	+.27	+.41	+.55	+.69
	PAL	-.71	-.83	-.95	-1.08
.26 (.12)	CAL	-.10	-.06	-.01	+.03
	CHA	+.21	+.36	+.50	+.64
	PAL	-.71	-.83	-.95	-1.08
.29 (.13)	CAL	-.13	-.09	-.04	+.00
	CHA	+.16	+.30	+.44	+.58
	PAL	-.70	-.83	-.95	-1.07

[a] Sire breed (SB) abbreviations: CAL = Californian; CHA = Champagne D'Argent; NZW = New Zealand White, and PAL = Palomino.

[b] For illustration, the first value of -.04 was calculated by [(+.205 kg)(1.32 $/kg) - (+1.405 kg)(.22 $/kg)], where contrast deviations (e.g. CAL - NZW) for LMW (total 70-d litter market wt) and FEED (total 28 to 70 day litter feed consumption) are taken from Tables 2 and 3.

The CHA X NZW crossbreds tended to have the numerically better litter trait performances (although in most cases mean differences were not significant) and had the higher gross margins. In a larger experiment, significant differences may have been more detectable. Superior carcass trait results were statistically demonstrated, however, as shown in the next paper. Processors generally discriminate on the basis of coat color. Interestingly, throughout the investigation, it was observed that several CHA purebred sires produced albino or Californian-marked offspring. Selection of future sires from this line might provide CHA bucks which would produce suitably colored terminal-crossbred fryers. Hence, the economic opportunity exists for CHA fanciers to develop such a commercial line to sell bucks to commercial producers. This venture could prove valuable to the meat rabbit industry.

Acknowledgements

This research project was supported by a grant from the Coop. State Res. Serv./USDA, and published as Paper No. 198T, Journal Ser., Agric. Exp. Sta., Alabama A&M Univ., Huntsville 35762. The authors extend gratitude to the following breeders and institution for the generous provision of purebred Californian, Champagne D'Argent and Palomino buck stock: Mrs. Ruby Battles (AL), Mr. Roger Banks (MS), Mr. Baron Cockrell (AL), Mr. John Cosby (AL), Dr. Robert Hudson (SC), Dr. James McNitt (LA), and Mr. Elwood Samuels (VA).

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