# BREED TYPE COMPARISONS FOR POSTWEANING LITTER TRAITS IN RABBITS

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**Abstract** - Purebred and crossbred litters were compared for postweaning traits of economic importance. A total of 3,233 weanling rabbits from 460 litters, 162 sires and 182 dams were produced during a two-year breeding experiment (1990-1991). Dam breeds included CAL and NZW purebreds, and CAL♂ X NZW♀ crossbred does. Sire lines were Californian (CAL) and New Zealand White (NZW) purebreds and two terminal sire lines (control and select). Data were subjected to mixed-model procedures. Total litter market weight at 70-d (adjusted for litter size) was lighter ($P<.05$) by .5 kg in CAL- than in NZW-sired litters, whereas litters from terminal sires were heavier (P,.01) by .5 kg as compared to average CAL and NZW sire performance. NZW dams had the larger and heavier litter sizes and weights at weaning and at 70 d than CAL dams ($P<.01$); also, litter feed intake was higher ($P<.05$). Economic heterosis in crossbred dams was observed, whereby litter sizes and weights at weaning and at 70 d were significantly larger and heavier, respectively, and gross feed efficiency was improved. Individual heterosis in litters was not important ($P>.05$), although CAL X NZW reciprocally crossbred litters tended to have higher postweaning survival and proportion of marketable fryers litters (mean differences of 2.7 and 10.5%). These results support the adoption of crossbreeding practices in the U.S. commercial meat rabbit industry.

## INTRODUCTION

In the U.S. meat rabbit industry, producers traditionally practice purebreeding for commercial fryer production. The New Zealand White (NZW) and Californian (CAL) breeds are the most popular breeds utilized. Major reasons for traditional purebreeding include limited domestic research on breed evaluation and(or) crossbreeding systems, and ignorance among producers.

Globally, scientific knowledge has advanced on the role of heredity on commercially important traits of meat rabbits. Specific reports on crossbreeding parameters (e.g., breed additive and heterotic effects) that influence performance traits have been published (LUKEFAHR *et al.*, 1983a,b; BRUN and OUHAYOUN, 1989; OZIMBA and LUKEFAHR, 1991; BRUN, 1993; KHALIL *et al.*, 1995). However, certain U.S. breeds (e.g., Californian) are primarily bred for show exhibition with little emphasis on production trait selection. U.S. studies have demonstrated, for example, that the CAL has high carcass dress out and lean cutability but has relatively inferior maternal ability aspects, whereas the NZW has excellent maternal ability, but poor carcass dress out and lean cutability. In Europe, these same breeds have been more intensely selected for commercial production. Paradoxically, there is often a contradiction among reports between countries that involve the same breeds. Hence, recommendations as to the judicious choice of breeds utilized in crossbreeding systems may need to be specific to the country breed populations.

Our main research objective was to compare purebred and crossbred litters for postweaning performance traits of economic importance to the commercial meat rabbit industry. Another objective was to compute estimates of crossbreeding parameters (e.g., direct breed additive and individual heterotic effects) for postweaning litter performance traits.

## MATERIAL AND METHODS

### Population Background

This study involved three dam breed types: Californian (CAL) and New Zealand White (NZW) purebreds and a CAL♂ X NZW♀ crossbreds. Four sire lines were CAL and NZW purebreds and terminal sire control and select lines (TSC and TSS, respectively). The terminal sire lines were developed at Alabama A&M University (AAMU) and originated from CAL, Champagne D'Argent (CHA) and Flemish Giant (FG) breeds. The terminal synthetic

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sire lines originally inherited genes for rapid growth from the FG (LUKEFAHR *et al.*, 1983b, 1984) and genes for meat-type conformation and high lean cutability yield from the CAL and CHA breeds (OZIMBA and LUKEFAHR, 1991; ROBERTS and LUKEFAHR, 1992). FG was used as the sire breed whereas CAL and CHA breeds were used as dam breeds. The second filial generation ($F_2$) had the composition: 1/2 FG X 1/4 CAL X 1/4 CHA. The $F_2$ animals were randomly differentiated on a within-litter basis to establish TSC and TSS lines. The TSC was a non-selected, random mating line, whereas TSS was mass selected based on phenotypic 70-d body weight.

Approximately ten bucks from each sire line (CAL, NZW, TSC and TSS) were used in each of four, six-month cycles of breeding, involving a 2-year experiment (1990-1991). A new cycle was represented by the former sire group being replaced by another ten bucks (male progeny) from within the same breed or line population. In turn, these bucks were used in the next cycle of breeding. The number of experimental animals is shown in Table 1.

**Table 1 : Experimental design and distribution of breed types, sires, dams, litters and progeny weaned**

| Sire breed | No of sires | Dam breed type | No of dams | No of litters | No of progeny |
|---|---|---|---|---|---|
| CAL | 39 | CAL | 19 | 32 | 192 |
| | | NZW | 13 | 42 | 294 |
| | | (CALXNZW)♀ | 13 | 33 | 237 |
| NZW | 42 | CAL | 8 | 24 | 156 |
| | | NZW | 19 | 49 | 370 |
| | | (CALXNZW)♀ | 15 | 48 | 362 |
| TSC | 41 | CAL | 15 | 31 | 208 |
| | | NZW | 14 | 43 | 287 |
| | | (CALXNZW)♀ | 19 | 43 | 310 |
| TSS | 40 | CAL | 17 | 31 | 177 |
| | | NZW | 14 | 44 | 317 |
| | | (CALXNZW)♀ | 15 | 40 | 323 |
| Totals | 162 | | 181 | 460 | 3,233 |

Housing, diet and management aspects were previously reported by OZIMBA and LUKEFAHR (1991). All animals were fed a commercial pelleted diet. A 14-day breeding regime was practiced. A doe was randomly assigned for mating to a buck within only one sire line, but never repeating matings to the same buck. Closely related (half- or full-sib) matings were avoided. Does were culled from the study for poor health and infertility. Reproductive failure and(or) inability to wean at least one kit after three successive matings resulted in the doe being culled. A doe was culled after one full year of reproduction (8 litters per year) to balance parities within the breed and season groups. There was no crossfostering of kits at birth to equalize litter size. The study was initiated with does representing various parity classes.

### Traits Measured

Litters were weaned at 28 days of age, being randomly transferred to separate cages after individual kit weighing, sexing and ear tagging. The 28 to 70 d survival rate, total litter size and weight at 28 d and market age (70 d) were recorded. Litter market weight at 70 d was also adjusted for litter size weaned (on a within-doe breed group basis). Feed intake per litter was recorded on a bi-weekly basis. Litter feed efficiency (feed consumed per unit litter gain) was calculated from a 28 to 70 d. Proportion of marketable rabbits (1.8 kg minimum weight by 70 d) was also determined. A weighted least squares analysis was performed for litter survival rate and proportion of marketable rabbits, based on the number of rabbits in the litter.

### Statistical Analysis

Litter trait data were subjected to statistical analyses using the General Linear Mixed Models (GLMM) package (BLOUIN and SAXTON, 1990), according to the mixed-model:

$$Y_{ijklmnop} = \mu + SL_i + Cycle_j + (SL \text{ X } Cycle)_{ij} + s_{kij} + DB_l + (SL \text{ X } DB)_{il} + d_{mil} + Seas_{nj} + Parity_o + (DB \text{ X } Seas)_{lnj} + (DB \text{ X } Parity)_{lo} + (Seas \text{ X } Parity)_{njo} + \varepsilon_{ijklmnop}$$

where $\mu$ = an unknown constant (overall population mean); $SL_i$ = fixed effect of the $i^{th}$ sire line (SL = 1,2,3 and 4); $Cycle_j$ = fixed effect of the $j^{th}$ 6-month cycle (Cycle = 1,2,3 and 4); $(SL \text{ X } Cycle)_{ij}$ = fixed effect of the sire line by cycle interaction $s_{kij}$ = random effect of the k^th^ sire nested within the i^th^ sire line by j^th^ cycle subclass, assumed to be NID (0, $\sigma^2_s$); $DB_l$ = fixed effect of the l^th^ doe breed type (DB = 1,2 and 3); $(SL\ X\ DB)_{il}$ = fixed effect of the sire line by doe breed type interaction; $d_{mil}$ = random effect of m^th^ doe nested within the i^th^ sire line by l^th^ doe breed type subclass, assumed to be NID (0, $\sigma^2_d$); $Seas_{nj}$ = fixed effect of the n^th^ season of weaning nested within j^th^ cycle (Seas = 1,2,3 and 4); $Parity_o$ = fixed effect of the o^th^ parity class (classes = 1 (first),2 = (2nd through 5th) and 3 = (6th through 8th parities); $(DB\ X\ Season)_{lnj}$ = fixed effect of the doe breed type by season interaction; $(DB\ X\ Parity)_{lo}$ = fixed effect of the doe type by parity class interaction; $(Seas\ X\ Parity)_{njo}$ = fixed effect of season by parity class interaction, and $\varepsilon_{ijklmnop}$ = random residual, assumed to be NID (0, $\sigma^2_\varepsilon$). Second and higher order interactions were assumed to be negligible. Restricted maximum likelihood (REML) estimates for random sire, doe and residual (litter) effects as observational components of variance for litter traits were computed by iterative procedures using GLMM. The REML variance components were applied using mixed-model techniques to derive best linear unbiased estimates (BLUE) for model fixed effects.

Doe breed type and sire line generalized least squares means were separated using single degree of freedom contrast comparisons. Control and select terminal sire lines (TSC and TSS) were combined (TS) in computation of the generalized least squares means since only 2 generations of selection (cycles 3 and 4) in the TSS line had been applied. All contrast differences were tested using the Student's t-test at the P <.05 probability level. Genetic component expectations: breed additive, maternal breed additive, grand-maternal breed additive, and individual and maternal heterotic effects (recombination loss, linkage and maternal cytoplasmic effects were assumed to be nil) are shown in Table 2.

**Table 2 : Coefficients for fractions of breed additive (A), maternal breed additive (M), genetic (g), and individual (I) and maternal (M) heterotic (h) effects according to breed group[a]**

| Breed group | $\overset{A}{g_{TS}}$ | $\overset{A}{g_{CAL}}$ | $\overset{A}{g_{NZW}}$ | $\overset{M}{g_{CAL}}$ | $\overset{M}{g_{NZW}}$ | $\overset{GM}{g_{CAL}}$ | $\overset{GM}{g_{NZW}}$ | $\overset{I}{h_{CXN}}$ | $\overset{M}{h_{CXN}}$ |
|---|---|---|---|---|---|---|---|---|---|
| CAL purebred | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| CAL♂ X (CALXNZW)♀ | 0 | ¾ | ¼ | ½ | ½ | 0 | 1 | ½ | 1 |
| CAL♂ X NZW♀ | 0 | ½ | ½ | 0 | 1 | 0 | 1 | 1 | |
| NZW♂ X CAL♀ | 0 | ½ | ½ | 1 | 0 | 1 | 0 | 1 | 0 |
| NZW♂ X (CALXNZW) ♀ | 0 | ¼ | ¾ | ½ | ½ | 0 | 1 | ½ | 1 |
| NZW purebred | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| TS♂ X CAL | ½ | ½ | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| TS♂ X NZW | ½ | 0 | ½ | 0 | 1 | 0 | 1 | 1 | 0 |
| TS♂ X (CALXNZW)♀ | ½ | ¼ | ¼ | ½ | ½ | 0 | 1 | 1 | 1 |

[a]Expectations for contrasts are as follows:

1) (CAL - NZW)/3 sires = $[½(\overset{A}{g_{CAL}} - \overset{A}{g_{NZW}})]$

2) (2(TS) - (CAL+NZW))/6 sires = $[½(\overset{A}{g_{TS}} - (\overset{A}{g_{CAL}} + \overset{A}{g_{NZW}}))]$

3) (NZW - CAL)/3 dams = $[(½(\overset{A}{g_{NZW}} - \overset{A}{g_{CAL}})) + (\overset{M}{g_{NZW}} - \overset{M}{g_{CAL}}) + (\overset{GM}{g_{CAL}} - \overset{GM}{g_{NZW}})]$

4) (2(CALXNZW) - (CAL+NZW))/6 dams = $[½(\overset{GM}{g_{NZW}} - \overset{GM}{g_{CAL}}) + \overset{M}{h_{CXN}}]$

5) ((CALXNZW + NZWXCAL) - (CAL+NZW))/2 litters = $\overset{I}{h_{CXN}}$

## RESULTS AND DISCUSSION

A total of 3,233 weanling rabbits from 460 litters of 12 breed types were involved. Generalized least squares means for postweaning litter traits (litter size and weight at weaning and litter postweaning survival rate and litter size at market age [70 d]) are presented in Table 3. Concerning only significant contrasts, litter size weaned was larger by .84 kits in purebred NZW compared to CAL dams. This finding is in agreement with the report by LUKEFAHR *et al.* (1983a) in which a difference of 1.06 kits at weaning was detected in NZW *vs* CAL dams. However, BRUN and ROUVIER (1988) and BRUN (1993) reported non-significant direct, maternal and grandmaternal breed effects for litter size at weaning involving the same breeds. Further supporting our view of unique country breed populations, BRUN and ROUVIER (1984) observed more favorable direct and maternal breed additive effects, but poorer grand-maternal breed additive effects, for CAL than NZW litters for litter size weaned. Economic heterosis was detected (difference of .69 kits [10.4%]) in CAL X NZW crossbred dams compared to average purebred dam results for litter size weaned, in agreement with the literature (LUKEFAHR *et al.*, 1983a; COUDERT and BRUN, 1989).

**Table 3 : Generalized least squares breed type means for postweaning litter traits and selected contrasts**$^{a}$

| Item | LSW$^{b}$ | LWW | LS70 | SR |
|---|---|---|---|---|
| CAL purebred | 5.88 | 2.90 | 5.41 | 91.8 |
| CAL♂ X NZW♀ | 6.75 | 3.46 | 6.33 | 93.7 |
| CAL♂ X (CAL X NZW) ♀ | 6.93 | 3.36 | 6.28 | 90.6 |
| NZW♂ X CAL♀ | 6.31 | 3.11 | 5.74 | 91.1 |
| NZW purebred | 7.36 | 3.79 | 6.47 | 88.2 |
| NZW♂ X (CAL X NZW) ♀ | 7.29 | 3.85 | 6.88 | 94.5 |
| TS♂ X CAL♀ | 6.14 | 3.02 | 5.59 | 90.9 |
| TS♂ X NZW♀ | 7.43 | 3.68 | 6.81 | 91.6 |
| TS♂ X (CAL X NZW)♀ | 6.73 | 3.86 | 6.34 | 93.9 |
| Se$^{c}$ | .37 | .16 | .37 | 2.1 |
| *Contrasts* | | | | |
| CAL - NZW sires | -.46 | -.34$^{*}$ | -.35 | .8 |
| TS - CAL+NZW sires.02.11 | .06 | .5 | | |
| NZW - CAL dams | .84$^{**}$ | .69$^{**}$ | .80$^{**}$ | .7 |
| CAL X NZW - CAL+NZW dams | .69$^{**}$ | .27$^{*}$ | .68$^{**}$ | .6 |
| Individual heterosis | -.09 | -.06 | .09 | 2.4 |
| (Percentage heterosis) | (-1.36) | (-1.79) | (1.52) | (2.7) |

| Item (Cont.) | LFI$^{b}$ | GFE | ADJLMW | LMW | MKT |
|---|---|---|---|---|---|
| CAL purebred | 26.4 | 3.92 | 10.5 | 10.0 | 57.0 |
| CAL♂ X NZW♀ | 31.2 | 4.11 | 12.4 | 12.0 | 64.6 |
| CAL♂ X (CAL X NZW) ♀ | 29.9 | 3.62 | 12.9 | 11.8 | 57.0 |
| NZW♂ X CAL♀ | 29.4 | 3.84 | 10.8 | 11.0 | 69.8 |
| NZW purebred | 31.0 | 3.73 | 12.6 | 12.4 | 64.5 |
| NZW♂ X (CAL X NZW)♀ | 32.3 | 3.61 | 13.8 | 13.7 | 67.5 |
| TS♂ X CAL♀ | 28.7 | 3.82 | 10.9 | 10.8 | 63.8 |
| TS♂ X NZW♀ | 33.0 | 3.61 | 13.5 | 13.3 | 65.4 |
| TS♂ X (CAL X NZW) ♀ | 32.4 | 3.62 | 13.5 | 13.1 | 73.2 |
| Se$^{c}$ | 1.6 | .15 | .2 | .7 | 4.7 |
| *Contrasts* | | | | | |
| CAL - NZW sires | -1.7 | .15 | -.5$^{*}$ | -1.1$^{\dagger}$ | -7.7$^{\dagger}$ |
| TS - CAL+NZW sires | 1.3 | -.12 | .5$^{**}$ | .6 | 4.1 |
| NZW - CAL dams | 3.4$^{*}$ | -.04 | 2.1$^{**}$ | 2.0$^{**}$ | 3.9 |
| CAL X NZW - CAL+NZW dams | 1.9$^{\dagger}$ | -.23$^{*}$ | 1.6$^{**}$ | 1.4$^{**}$ | -2.2 |
| Individual heterosis | 1.6 | .15 | .1 | .2 | 6.4 |
| (Percentage heterosis) | (5.6) | (3.92) | (.1) | (1.8) | (10.5) |

[a] Breed type codes are defined in text.

[b] Trait abbreviations: LSW and LWW= litter size and weight (kg) at weaning; LS70 and SR = litter size at 70 d and litter survival rate from 28 to 70 d, %; LFI = litter 28 to 70 d feed intake, kg; GFE = gross feed efficiency (LFI/litter gain); ADJLMW and LMW = litter 70 d weight (adjusted and not adjusted for LSW), kg, and MKT = proportion of marketable fryers within litter at 70 d, %.

[c] Average standard error for breed type trait means in column.

$^{\dagger}$P<.10; $^{*}$P<.05; $^{**}$P<.01.

The CAL sires had lighter (P<.05) litter weaning weights by .34 kg than NZW sires. LUKEFAHR *et al.* (1983b) reported a .10 kg decrease in litter weaning weight involving the same sire comparison. As expected, litter weaning weights were significantly heavier in NZW *vs* CAL dams, due in part to the larger litter size. Likewise, crossbred dams had heavier litter weaning weights by .27 kg compared to the mid-parent breed performances. The litter size at weaning advantage in purebred NZW over CAL was maintained to market age at 70 d (difference of .80 kits at P<.01). In crossbred *vs* purebred dams, litter size at market age was significantly larger by .68 kits, suggestive of grand-maternal breed additive and(or) maternal heterotic effects.

Postweaning litter trait breed type means and contrasts for total 28 to 70 d feed intake and gross feed efficiency, litter market weight (adjusted or not adjusted for litter size at weaning), and proportion of fryers marketable within litter are also presented in Table 3. Total litter feed intake was increased by 3.4 kg (P<.01) in litters reared by NZW compared to CAL dams. No difference was found for litter feed efficiency in this same comparison, in agreement with LUKEFAHR *et al.* (1983b) and OZIMBA and LUKEFAHR (1991). Litters reared by crossbred dams consumed 1.9 kg more feed than litters reared by purebred dams (P<.10). These differences are probably directly related to the larger litter size. LUKEFAHR *et al.* (1983b) also observed higher feed intake by 3.6 kg in litters reared by crossbred *vs* purebred dams. In addition, gross feed efficiency in litters reared by crossbred dams was improved (difference of .23 [6.0%]).

NZW sires had the heavier litter market weight by 1.1 kg than CAL sires. Litters from NZW *vs* CAL dams were heavier at market age by 2.0 kg. LUKEFAHR *et al.* (1983b) reported a 1.27 kg difference in litter 56-d weight in NZW *vs* CAL dams, in agreement with present results, whereas OZIMBA and LUKEFAHR (1991) observed no significant difference. Litters from crossbred dams were heavier by 1.4 kg than litters from purebred CAL and NZW dams (P<.01). For litter market weight (adjusted for litter size at weaning), CAL-sired litters were lighter by .5 kg than NZW-sired litters, and terminal sires produced heavier litters by .5 kg than medium-sized sire breeds (P<.05). The latter contrast would mainly reflect a ¼ fraction difference due to FG breed inheritance. Despite the litter size adjustment, market weights of litters were heavier in NZW *vs* CAL dams (P<.05), presumably because of the breed difference in litter size and(or) heavier individual kit weights. Crossbred dams maintained a significant advantage over mid-parental dam performance in litter market weight as a result of the litter size adjustment. Proportion of marketable fryers within litter, was higher in NZW- *vs* CAL-sired litters by 7.7%, in agreement with the 4.0% purebred difference reported by MCNITT and LUKEFAHR (1993). ROBERTS and LUKEFAHR (1992) observed NZW vs CAL X NZW litters to have higher marketability rate by 5.1%.

Individual heterosis was not significant for any of the litter traits investigated; however, CAL X NZW reciprocally crossbred litters tended to have higher postweaning survival and proportion of marketable fryers within litters (mean differences of 2.7 and 10.5%). ROLLINS and CASADY (1964) found that reciprocal CAL x NZW crosses outperformed purebreds by 29 and 25% for litter size and weight at 56 d, respectively. YAO and EATON (1954) reported that mean $F_1$ line crosses yielded 7% heavier weaning weights in rabbits. LUKEFAHR *et al.* (1983b) observed positive but small individual heterosis (less than 10%) for postweaning litter size and weight traits. In CAL X NZW crosses, BRUN and OUHAYOUN (1989) reported individual heterosis values of 12.3, 3.9 and 6.3% for individual weaning weight (30-d), average daily gain and market weight (79-d).

In conclusion, the U.S. CAL breed population appears to be inferior in respect to the sum of breed additive components for litter traits, as compared to NZW. Economic heterosis displayed by CAL X NZW crossbred does was major; however, individual heterosis in litters was negligible. Our results suggest potential benefits from adoption of crossbreeding in the U.S. meat rabbit industry.

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