COMPARISON OF RABBIT BREED TYPES FOR POSTWEANING LITTER GROWTH, FEED EFFICIENCY, AND SURVIVAL PERFORMANCE TRAITS

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ABSTRACT

Postweaning data on 643 rabbits from 122 litters representing four breed types, New Zealand White (NZW) and Californian (CAL) purebreds, CAL × NZW (CxN), and Flemish Giant (FG) crossbreds (the latter group was a collection of FG × CAL, FG × Champagne D'Argent [CHA], and 1/2 FG × 1/4 CAL × 1/4 CHA), were gathered over five seasons and compared for growth, feed efficiency, and survival-related performance traits. Evaluation criteria included litter size and weight at weaning (28 d); 28- to 70-d litter feed intake, weight gain, feed efficiency, and mortality rate; and litter and average market weight (70 d). The least squares model included main effects of breed type, season of birth of the litter and parity of dam, litter size at weaning as a linear covariate, and the random error. Breed-type differences were not detected for litter size and weight at weaning and feed efficiency. Purebred NZW and CAL litter trait performances were comparable (P > .05). Purebred NZW litters consumed less feed than CxN and FG crosses, gained weight less rapidly than FG crosses, and weighed less per fryer at 70 d than CxN and FG crosses (P < .05). Feed intake was lower and average market weight was lighter for CxN crossbred litters than for CxN and FG crossbred litters (P < .05). The CxN and FG crossbreds only differed (P < .05) for average market weight (2,078 vs 2,192 g). Mortality rate was lower (P < .05) in CxN crossbred litters than in CAL purebred litters. Results of this study provide corroborative evidence in support of terminal crossbreeding using CAL sires mated to NZW dams or FG purebred or crossbred sires mated to CAL and CHA purebred or crossbred dams.

Key Words: Rabbits, Breed Differences, Crossbreeding, Growth, Mortality

Introduction

In contrast to common meat animal species, the rabbit has not been subjected to intense selection pressure for genetic improvement of commercial production traits. However, crossbreeding through selection among available breeds, whereby existing breed differences

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1This research project was supported by a grant from the Coop. State Res. Serv., USDA. Published as Paper No. 168T, Journal Ser., Agric. Exp. Sta., Alabama A&M Univ., Huntsville 35762.


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Received January 11, 1991.
Accepted April 5, 1991.


from a heterotic and complementary standpoint are utilized, has been extensively used in Europe (Masoero, 1982; Rochambeau, 1988). Rabbit production systems in North America traditionally involve purebred New Zealand White (NZW) and, to a lesser extent, Californian (CAL) breeds, which were originally developed in the United States (Lukefahr et al., 1983a). As such, the potential economic benefits associated with crossbreeding using optimal breed combinations has not been adequately investigated in North America. Moreover, to date, no crossbreeding publications are available involving breed lines common to the southeastern United States investigating postweaning litter traits of commercial importance.
LITTER TRAITS IN BREED TYPES OF RABBITS

TABLE 1. NUMBER OF SIRES, DAMS, LITTERS, AND KITS WEANED BY BREED TYPE

<table>
<thead>
<tr>
<th>Sire breeding</th>
<th>Dam breeding</th>
<th>Sires</th>
<th>Dams</th>
<th>Litters</th>
<th>Kits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZW</td>
<td>NZW</td>
<td>15</td>
<td>25</td>
<td>40</td>
<td>197</td>
</tr>
<tr>
<td>CAL</td>
<td>CAL</td>
<td>11</td>
<td>12</td>
<td>14</td>
<td>75</td>
</tr>
<tr>
<td>CAL</td>
<td>NZW</td>
<td>9</td>
<td>22</td>
<td>28</td>
<td>147</td>
</tr>
<tr>
<td>FG</td>
<td>CAL</td>
<td>7</td>
<td>10</td>
<td>11</td>
<td>54</td>
</tr>
<tr>
<td>FG</td>
<td>CHA</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td>FG × CAL</td>
<td>FG × CHA</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>36</td>
</tr>
<tr>
<td>FG × CHA</td>
<td>FG × CAL</td>
<td>8</td>
<td>10</td>
<td>14</td>
<td>111</td>
</tr>
</tbody>
</table>

NZW = New Zealand White, CAL = Californian, CHA = Champagne D’Argent, and FG = Flemish Giant.

The CAL × NZW specific cross has shown promise because NZW does have been reported to exhibit outstanding maternal qualities as related to behavior, fecundity, and lactation (Rouvier, 1980; Lukefahr et al., 1983a,b; Szendro and Kustos, 1988). A prospective terminal sire line involves the Flemish Giant (FG) a breed noted for rapid growth (Ouhayoun, 1978; Lukefahr et al., 1983c, 1984), mated to the CAL and Champagne D’Argent (CHA) breeds, the latter recognized for high carcass dress-out and lean yield rates (Rouvier, 1970; Jensen and Tuxen, 1982; Lukefahr et al., 1983d; Ozimba and Lukefahr, 1991).

One simple approach might be for industry to use terminal crossbreds with higher trait productivity as opposed to conventional purebreds. Accordingly, the objectives of this study were to compare specific breed types, purebred and crossbred, for postweaning litter growth, feed efficiency, and survival traits.

Materials and Methods

Population Management. A total of 643 rabbit kits from 122 litters and representing four breed-types, NZW and CAL purebreds and CAL sire × NZW dam (C×N) and FG crossbreds (the latter group being a collection of FG sire × CAL dam, FG sire × CHA dam and 1/2 FG × 1/4 CAL × 1/4 CHA), were compared for postweaning litter growth, feed utilization, and survival performances (Table 1). The NZW and CAL breeds were initially obtained from commercial sources in the southeastern United States and were managed as randomly mated stocks at Alabama A&M University. The FG crossbreds were produced to develop a synthetic terminal sire line with an initial 1/2 FG × 1/4 CAL × 1/4 CHA breed composition; all litters had in common a one-half fraction of breed additive inheritance from the FG breed. The investigation covered five seasons of data collection starting in the winter (January) of 1988.

Litters were weaned at 28 d of age by removing the litter from the dam’s cage. At time of weaning, each kit was individually ear-tagged, sexed, and weighed. Littermates were then placed together in the same cage (914 x 762 x 457 mm) to 70 d of age. All litters were given ad libitum access to a pelleted commercial diet over the course of the experiment. The chemical composition of the diet consisted of 3,511 kcal GE, 16.5% CP, 26.2% ADF, 54.1% NDF, 4.62% lignin, 5.45% ether extract, and 8.2% ash per kilogram of DM. Water was supplied through an automatic system. The photoperiod was controlled to a daily 14:10 h light:dark cycle.

Traits Studied. Evaluation criteria on which breed-type comparisons were based included 28-d litter size and total weaning weight; 28- to 70-d litter feed intake, weight gain (70-d minus 28-d litter weight), feed efficiency (litter feed intake divided by weight gain), and total litter and average market weight per fryer at 70 d; and litter mortality rate. Feed weights were recorded on a daily basis. Litter feed intake was calculated as total feed consumed during the 28- to 70-d growth period. Litter mortality rate was expressed as the proportion of kits that died between 28 and 70 d of age divided by litter size at weaning.

Statistical Methods. Data were analyzed through least squares ANOVA procedures as described by Harvey (1987). Fixed effects in...
the model included breed type, season of birth of the litter and parity of dam, the linear covariate of litter size at weaning, and the random error. Season classes were on a 3-mo consecutive basis (i.e., season class 1 = January, February, and March). Because the photoperiod was controlled, seasonal fluctuations were due, presumably, to variations in temperature and humidity. The season source had five consecutive classes. Parity classes were first, second, third, and fourth through eighth parity records. In preliminary analyses of the data, all first-order interactions between breed type, season, and parity did not \( (P > .20) \) approach significance and so were eliminated from the model.

A within-breed-type regression of the given dependent variable on litter size at 28 d was performed (with the exceptions of litter size at weaning, litter mortality rate, and average market weight per fryer). The litter size adjustment (arithmetic mean of 5.27 and a range from 1 to 11 kits weaned), therefore, transformed all relevant dependent variables from an observed to an adjusted basis. Litter size was anticipated to be an important source of explained variation within breed types, which otherwise would have existed, in part, as among-litter residual variation.

The random error consisted of within-subclass variation among litters, assumed to be normally and independently distributed \( (0, \sigma^2) \).

A hierarchical design of dams nested within sires within breed type was not followed. In addition, certain CAL sires and CAL and NZW dams produced both purebred and crossbred litters (Table 1). Nonetheless, the among-litter variation source (nested within main effects) was deemed most appropriate in adequately describing the data and as the random error term \( (df = 107) \) for testing all fixed effects in the model.

A weighted least squares analysis was conducted for litter mortality rate (28 to 70 d) in a model consisting of breed type, season, and parity main effects. A transformation of this trait to a logit basis and employment of litter size at weaning as the weighting factor was made. For analysis of average market weight per fryer, breed type, season, and parity classes were combined and the among-litter random source was nested as a main effect within breed-type \( \times \) season \( \times \) parity subclasses to permit the inclusion of sex of rabbit as a fixed effect, fitted on a within-litter variation basis. The potential interaction effect involving sex of rabbit was assumed to be nonsignificant.

The combined breed-type \( \times \) season \( \times \) parity effect was tested by the among-litter variation (within subclass) source \( (df = 73) \), and the sex effect was tested by the residual source \( (df = 485) \). Least squares breed-type means were separated using the Bonferroni \( t \)-test method (Gill, 1978).

**Results and Discussion**

**Analysis of Variance.** The main effect of breed type was an important \( (P < .05) \) source of variation for all postweaning litter traits except litter size and weight at weaning (28 d) and litter feed efficiency. Discussion of breed-type comparisons will be made in the next section. The effect of season of birth influenced \( (P < .01) \) all traits examined. Season mean values for growth and feed traits declined dramatically in the summer period, apparently in response to high temperature fluctuations, as reported by Casady et al. (1962), Sittmann et al. (1964), and McNitt and Lukefahr (1983). Conversely, the parity class of dam effect was never a significant source of variation. In contrast to the present results, Rollins et al. (1963) found parity class of dam to influence litter size and total weight at 56 d. Rouvier et al. (1973) reported parity effects for litter size, survival rate, and total litter and average fryer weight at 56 d. In addition, Lukefahr et al. (1983c) reported parity influences on litter feed intake, feed efficiency, and litter weight at 56 d. The 70-d end-point trait performances reported in the present study, as opposed to 56-d performances reported in the literature, may have been less influenced by residual maternal effects of parity. For average market weight per fryer, the sex effect approached significance \( (P < .13) \), with males tending to weigh more than females (2,063 vs 2,028 g).

The overall linear covariate of litter size at weaning was related \( (P < .01) \) positively to litter weaning weight, total feed intake, weight gain, and market weight at 70 d and negatively to litter feed efficiency (Tables 2 and 3); however, within-breed-type regressions were never significantly different. Rao et al. (1977), Lukefahr et al. (1983c, 1990), and Johnson et al. (1988) have similarly reported significant relationships between litter size and weight.
TABLE 2. LEAST SQUARES BREED-TYPE MEANS FOR LITTER SIZE AND WEANING WEIGHT AT 28 DAYS AND 28- TO 70-DAY LITTER FEED INTAKE AND WEIGHT GAIN AND OVERALL REGRESSIONS ATTRIBUTABLE TO LITTER SIZE AT WEANING

<table>
<thead>
<tr>
<th>Item</th>
<th>Item</th>
<th>Item</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter size weaned, no.</td>
<td>Litter weaning wt, g</td>
<td>Litter feed intake, g</td>
<td>Litter wt gain, g</td>
</tr>
<tr>
<td>Overall mean</td>
<td>5.092</td>
<td>2,817</td>
<td>22,232</td>
</tr>
<tr>
<td>Breed-type mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand White (NZW)</td>
<td>4.867</td>
<td>2,838</td>
<td>20,945&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Californian (CAL)</td>
<td>5.029</td>
<td>2,790</td>
<td>20,051&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CAL × NZW</td>
<td>5.114</td>
<td>2,860</td>
<td>24,076&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flemish Giant cross</td>
<td>5.357</td>
<td>2,781</td>
<td>24,257&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Regression, litter size</td>
<td>ND&lt;sup&gt;b&lt;/sup&gt;</td>
<td>391**</td>
<td>206**</td>
</tr>
<tr>
<td>Residual SD</td>
<td>2.414</td>
<td>556</td>
<td>4,097</td>
</tr>
</tbody>
</table>

<sup>a,b</sup>Means within trait columns bearing different superscripts are different (P < .05).
<sup>c</sup>Regression analysis not performed for this trait.

**P < .01.

postweaning characters in rabbits. Of relevance, the overall least squares mean for 28-d litter size of 5.09 kits is in good agreement with the mean value of 5.47 kits weaned (averaged over four breeds) reported in Louisiana (McNitt and Lukefahr, 1990). However, these values are lower than those reported by Lukefahr et al. (6.80 and 8.01 kits; 1983c, 1984) from studies conducted in the northwestern United States using comparable breed types.

**Breed-Type Mean Comparisons.** Breed-type means did not (P > .05) differ for either litter size or litter weaning weight (Table 2). Strong maternal effects of litter size and milk production, more so than direct genetic effects, may have influenced kit weights at 28 d. Lukefahr et al. (1983a) and McNitt and Lukefahr (1990) observed no significant differences in litter size at 28 d between CAL and NZW does; however, the former study found total weaning weights to be lighter in CAL vs NZW litters, whereas the latter study reported no difference. Carregal and Lui (1984) and Lukefahr et al. (1984) reported significant average kit weight differences at birth but not at 28 d of age in purebred progeny comparisons of NZW and large breeds (e.g., Gigante de Bouscat and FG).

The CxN and FG crossbred litters consumed more (P < .05) feed than purebred litters, whereas differences did not exist between crossbreds or between purebreds (Table 2). This finding may reflect increased appetite in favor of crossbreds, because weaning weights were similar among breed types. Purebred NZW litters had the slowest gains from 28 to 70 d (5,969 g) but significantly differed only from FG crossbred litters, which had the most rapid gains (7,630 g). However, litter-gain means did not differ between CAL, CxN, and FG groups. Breed-type mean differences for litter feed efficiency were not significant. Nonetheless, the numerically poorest vs the best feed efficiency performances were displayed by CAL purebred vs FG crossbred litters, a trend consistent with patterns of physiological maturity (Ouhayoun, 1978).

Heckmann et al. (1971) reported poorer feed efficiency values and slower BW gains for purebred NZW than for the German Riesen Grey (GRG) × NZW and GRG × (Blue Viennese × NZW) crosses; however, reciprocal matings were not made to distinguish between specific genetic effects. Ouhayoun (1978) observed similar feed efficiency values between purebred NZW vs medium- and large-sized breeds comparable to the present study; however, ADG and market weight performances were poorer relative to FG and Gigante de Bouscat breeds. Lukefahr et al. (1983c) reported that NZW-sired litters consumed less feed, achieved slower gains, and converted feed to gain less efficiently than litters sired by CAL and FG breeds (averaged over NZW and CAL purebred and NZW × CAL reciprocally crossed dam genetic groups).

For total and average market weights at 70 d, NZW litters had the numerically lowest mean values (8,839 and 1,951 g) relative to the other breed-type groups (Table 3). Of signifi-
vs medium-sized breeds. Transmission of direct heterosis accounted for heavier market weights, differences were detected for total market crossbred litters. Although no other breed-type the experimental crosses could have been lighter for large- superior genes from large-sized NZW purebreds; however, Regression, litter size: 141** 1.807** NDe NDe (less than .01.)(1984) reported comparable results for wean-
ing and 70-d weights involving similar large-

feed to gain at a similar rate relative to marketed earlier, potentially representing more efficient use of management and facility

Niedzwiedek (1979) reported that CxN crossbreds reached 2,500 g earlier by 3 d and converted feed to gain at a similar rate relative to mean purebred values. Brun and Ouhayoun (1989) observed that CxN crossbreds outweighed CAL and NZW purebreds at 79 d by 181 g, on average. This is comparable to the present 119-g CxN crossbred advantage. Favorable breed maternal effects on litter growth and feed efficiency values in the same specific cross were documented by Lukefahr et al. (1983c). Direct heterosis for rate of litter postweaning gain, however, seems to be low (less than 5%), according to previous studies (Lukefahr et al., 1983c; Brun and Ouhayoun, 1989). Ouhayoun (1978) and Carregal and Lui (1984) reported comparable results for weaning and 70-d weights involving similar large- vs medium-sized breeds. Transmission of superior genes from large-sized FG may have directly accounted for heavier market weights, assuming negligible heterotic effects existed.

Mortality rate from 28 to 70 d in CxN crossbreds was lower (P < .05) than in CAL purebreds (.066 vs .154); no other breed-type comparisons were significant (Table 3). Over the 42-d growth period of the experiment, CxN litters had the lowest mean value for mortality rate, .066. Lukefahr et al. (1983c) obtained a direct heterosis estimate of -21% for total mortality rate in litters from 28 to 56 d of age involving the same cross. The mortality reduction alone could explain the increased feed intake and market weight performances of CxN crossbred litters.

**Conclusions.** Relative to purebred NZW mean performances for total litter 70-d weight (a composite trait of major economic value), CAL, CxN, and FG groups had mean deviations of +222, +1,104, and +1,714 g, respectively. Corresponding mean deviations in litter 28- to 70-d feed intake for CAL, CxN, and FG were -894, +3,131, and +3,312 g. Based on these deviations, market prices vs feed costs could readily be applied to assess marginal profitability values for each breed type. Because market prices will usually be at least four times greater than feed costs, all three breed types would seem to be more profitable than the NZW purebred. This comparison assumes the marketability of all fryers in the litter by 70 d of age. Such a simple economic comparison could be further validated if weanlings of comparable age were to be purchased at a constant market price, regardless of breed type.

### Table 3. Least Squares Breed-Type Means for 28- to 70-Day Litter Feed Efficiency and Mortality Rate, and Total and Average Market (70-Day) Weight and Overall Regressions Attributable to Litter Size at Weaning

<table>
<thead>
<tr>
<th>Item</th>
<th>Litter feed efficiency*</th>
<th>Litter market wt, g</th>
<th>Average market wt, g</th>
<th>Litter mortality rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall mean</td>
<td>3.528</td>
<td>9,599</td>
<td>2,047</td>
<td>.105</td>
</tr>
<tr>
<td>Breed-type mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand White (NZW)</td>
<td>3.295</td>
<td>8,839b</td>
<td>1,951b</td>
<td>.093bc</td>
</tr>
<tr>
<td>California (CAL)</td>
<td>3.918</td>
<td>9,061bc</td>
<td>1,968b</td>
<td>.154c</td>
</tr>
<tr>
<td>CAL x NZW</td>
<td>3.687</td>
<td>9,943bc</td>
<td>2,078c</td>
<td>.066b</td>
</tr>
<tr>
<td>Flemish Giant cross</td>
<td>3.210</td>
<td>10,553c</td>
<td>2,192d</td>
<td>.102bc</td>
</tr>
<tr>
<td>Regression, litter size</td>
<td>-1.141**</td>
<td>1,807**</td>
<td>NDg</td>
<td>NDg</td>
</tr>
<tr>
<td>Residual SD</td>
<td>.928</td>
<td>2,257</td>
<td>253</td>
<td>.008</td>
</tr>
</tbody>
</table>

*Litter feed efficiency calculated as 28- to 70-d litter feed intake divided by litter weight gain. Litter mortality rate calculated as litter size at weaning (28 d) minus litter size at market age (70 d) divided by litter size at weaning.

b,c,dMeans within trait columns bearing different superscripts are different (P < .05).

**Regression analysis not performed for this trait.

***P < .01.
In the present experiment the production of CxN crosses showed promise. Moreover, reports by Lukefahr et al. (1983d) and Ozimba and Lukefahr (1991) have indicated improved carcass and cutability yields in CxN vs NZW fryers. Because most North American commercial producers maintain purebred NZW stock, it would seem feasible simply to substitute the NZW for CAL bucks to improve overall meat production levels.

Overall, FG crossbred litters consumed more feed, gained weight more rapidly, utilized feed more efficiently, and weighed more at the 70-d market age than the three other breed types under comparison; however, this consistent pattern did not always lead to statistical differences in each of these traits. The FG, primarily selected as a fancy breed in North America, may be less efficient overall as a purebred than the NZW commercial purebred due to less favorable maternal abilities (e.g., higher preweaning kit mortality), as reported by Lukefahr et al. (1984). Hence, the more appropriate role of the FG seems to be that of a terminal sire breed, as a purebred or crossbred.

Despite the limited number of litter observations in this study, good agreement in numerical breed-type rankings for postweaning litter traits was confirmed with previous, although limited, domestic studies (Lukefahr et al., 1983c, 1984). Results of this study provide corroborative evidence in support of the adoption of terminal crossbreeding, via mating CAL sires to NZW dams or mating FG purebred or crossbred sires to CAL and CHA purebred or crossbred dams, as opposed to NZW and CAL purebreeding in the commercial rabbit industry in North America.

**Implications**

The New Zealand White rabbit breed is well recognized as a suitable dam breed based on favorable maternal qualities. Limited U.S. reports tend to demonstrate that the New Zealand White may not be the best breed type for postweaning litter and individual carcass traits. This study compared New Zealand White and Californian purebreds and Californian × New Zealand White and Flemish Giant terminal crossbreds for postweaning litter traits. Overall, although purebred differences were not significant, the terminal crossbreds were more productive, particularly for litter and/or average market weights. Terminal crossbreeding in the rabbit industry is suggested from this and other studies.

**Literature Cited**


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