FACTORS AFFECTING LITTER SIZE AND BIRTH WEIGHT IN RABBITS

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SUMMARY
Dam breed, sire breed and parity showed no significant effect on total number born per litter (NB), number born alive per litter (NBA), total litter birth weight (TLBWT), live litter birth weight (LLBWT) and average birth weight of kittens (ABWT). Month of birth was significant for ABWT. Between doe differences were significant for all the traits. Mean NB, NBA, TLBWT, LLBWT and ABWT were 8.5, 6.9, 468g, 391g and 57g, respectively. Low repeatability estimates were observed for all traits (0.13 to 0.24). Significant negative correlations were found between litter size traits and birth weight.
Key words: Rabbits, litter size, birth weight.

INTRODUCTION
In the early 1990s, over 2.7 million wild rabbits per annum were sold for meat in Australia (Foster 1999). But with the release of rabbit haemorrhagic disease as a biological control agent in 1996, the population of wild rabbits has reduced (Bowen and Read 1998) with just over 100,000 per annum now being harvested for meat. Owing to this decrease in availability of rabbit meat, rabbit farming started to grow as a rural industry to cater for strong domestic demand for rabbit meat. In 1998, the Australian farmed rabbit industry produced around 106 tonnes of rabbit meat compared to world rabbit meat production of 1 million tonnes. Research to support this growing industry was initiated by CSIRO Livestock Industries and in late 1999, a 100 doe rabbitry was established at the Pastoral Research Laboratory, Armidale, NSW, with the aim to define a breeding objective for a rabbit enterprise. Litter size at birth has been identified as one of the main traits affecting the profit function in a rabbit farm (Eady and Prayaga 2000). Several overseas studies have identified the factors affecting litter traits as breed (Lukefahr *et al.* 1983), year of birth (Ferraz *et al.* 1991) and season of birth (Khalil *et al.* 1995). This paper aims to identify factors, both genetic and environmental, affecting litter size at birth and average birth weight of kittens under Australian farming conditions.

MATERIALS AND METHODS
Does and bucks were housed in individual cages ($0.6m^2$) and fed an *ad libitum* diet of commercial rabbit pellets (crude protein 18%). Matings were conducted once a week and does were provided with nest boxes 3-4 days before kindling. Does were first re-mated 10 to 12 days after giving birth. Nest boxes were checked daily to record newborn kittens and mortalities. Traits analysed (ASREML, Gilmour *et al.* 2001) were total number born/litter (NB), number born alive/litter (NBA), total litter birth weight (TLBWT), live litter birth weight (LLBWT) and average birth weight of kittens/litter (ABWT). Data on 307 litters from 117 does and 47 bucks, produced between March 2000 and December 2000 were included in the study. Tests of significance were performed fitting the doe effect as fixed, while least squares means were estimated fitting the doe effect as random. The model for estimating least square means was:

$$Y_{ijklmn} = \mu + DB_i + BB_j + DB.BB_{ij} + P_k + M_l + d_{ijm} + e_{ijklmn}$$

where, Y_{ijklmn} is the observation for the trait; μ is the common mean; DB_i is the fixed effect of doe breed; BB_j is the fixed effect of buck breed; $DB.BB_{ij}$ is the fixed effect of the interaction of doe and buck breed; P_k is the fixed effect of parity of the dam; M_l is the fixed effect month of birth; d_{ijm} is the random effect of doe and e_{ijklmn} is the random error. Phenotypic variances and repeatability estimates were calculated for NB, NBA, TLBWT, LLBWT and ABWT. Phenotypic correlations between NB, NBA and ABWT were also estimated to study the relationship between these traits.

RESULTS AND DISCUSSION

Although there was a large spread in the means of different traits for breeds (Table 1); the high within-breed variability precluded the means from being significantly different. Interactions of doe and buck breed were not significant.

Table 1. Least square means (standard error) and number of observations (N) for total number born/litter (NB), number born alive/litter (NBA), total litter birth weight (TLBWT), live litter birth weight (LLBWT), average birth weight (ABWT) by dam, sire breed and month of birth

	N	NB	NBA	TLBWT (g)	LLBWT (g)	ABWT (g)
Dam breed						
New Zealand White (NZ)	187	8.0 (0.3)	6.4 (0.3)	452 (17)	370 (19)	58.4 (0.9)
Californian (CAL)	47	6.8 (0.7)	5.3 (0.9)	350 (37)	285 (51)	52.2 (2.6)
Flemish Giant (FG)	37	7.7 (0.6)	6.3 (0.7)	473 (31)	386 (43)	62.0 (2.1)
CAL x NZ	26	9.8 (0.8)	8.8 (0.9)	505 (39)	453 (54)	53.1 (2.7)
FG x NZ	10	9.9 (1.5)	7.9 (1.9)	562 (78)	460 (109)	58.9 (5.5)
Sire breed						
New Zealand White	88	8.9 (0.5)	7.8 (0.6)	486 (26)	435 (36)	56.3 (1.8)
Californian	90	8.1 (0.4)	6.5 (0.5)	448 (21)	368 (29)	56.8 (1.5)
Flemish Giant	129	8.5 (0.4)	6.4 (0.5)	471 (20)	370 (28)	57.6 (1.4)
Month of birth						*$P < (0.05)$*
March 2000	42	8.6 (0.7)	7.1 (0.9)	454 (37)	379 (51)	53.3^{a} (2.6)
April 2000	29	8.9 (0.7)	6.0 (0.9)	475 (37)	341 (51)	55.7^{ab} (2.6)
May 2000	47	9.4 (0.6)	6.6 (0.8)	518 (32)	373 (44)	56.5^{ab} (2.2)
June 2000	39	9.0 (0.6)	6.8 (0.7)	497 (30)	382 (42)	56.3^{ab} (2.1)
July 2000	28	8.3 (0.6)	7.5 (0.8)	488 (30)	449 (43)	60.3^{b} (2.2)
August 2000	30	7.3 (0.6)	6.9 (0.7)	437 (28)	413 (39)	62.0^{b} (2.0)
September 2000	22	8.3 (0.6)	6.9 (0.8)	471 (32)	388 (45)	57.7^{ab} (2.3)
October 2000	28	7.7 (0.6)	6.8 (0.7)	415 (29)	364 (40)	56.3^{ab} (2.0)
November 2000	26	8.1 (0.6)	6.9 (0.7)	461 (28)	407 (39)	56.7^{ab} (2.0)
December 2000	16	9.0 (0.7)	7.9 (0.9)	467 (35)	413 (49)	54.3^{a} (2.5)
Overall mean	307	8.5 (0.3)	6.9 (0.4)	468 (18)	391 (24)	56.9 (1.2)

* means with the same superscript do not differ significantly

Californian does appear to have a poor reproductive performance compared to the other breeds. Lukefahr *et al*. (1983) reported breed superiority of New Zealand does over Californian does for all pre-weaning traits and noted that crossbred does kindled and reared larger litters than pure-bred does. In the present study also crossbred does appeared to have produced larger litters than the purebred does, though not statistically significant. Parity of the doe had no significant effect on the traits measured. Month of birth had a significant effect ($P<0.05$) on average birth weight of kittens and the kittens born in winter months (July and August) were observed to have heavier birth weights. Khalil *et al.* (1995) also observed heavier weights in winter kindlings. Between doe differences were found to be significant for NB, NBA, TLBWT, LLBWT and ABWT, indicating there may be genetic variation which can be exploited by selection.

The phenotypic variances and the repeatability estimates for various traits under study are presented in Table 2. Phenotypic variance of 7.4 and repeatability of 0.17 for NB were consistent with the results presented in the literature (Baselga *et al.* 1992). Lower repeatability estimates were given by Ferraz *et al*. (1991) for NB (0.09), NBA (0.10) and TLBWT (0.12). As repeatability sets the upper limit of heritability, it is likely that these traits are lowly heritable. However, high phenotypic variances and coefficients of variation indicate that there is plenty of scope for response through selection. Low repeatability values for these litter traits suggest that there is less correlation between the repeated measures of the same individual and hence the selection decisions on these traits should be based on multiple litter measurements.

Table 2. Phenotypic variances (standard error), coefficient of variation and repeatability estimates (standard error) for total number born/litter (NB), number born alive/litter (NBA), total litter birth weight (TLBWT), live litter birth weight (LLBWT) and average birth weight (ABWT)

Trait	Phenotypic variance	Coefficient of variation	Repeatability
NB	7.4 (0.6)	32.0	0.17 (0.07)
NBA	11.9 (1.0)	50.0	0.16 (0.06)
TLBWT(g)	19098.1 (1708.0)	29.5	0.24 (0.07)
LLBWT(g)	36792.1 (3209.0)	49.0	0.19 (0.06)
ABWT(g)	93.5 (8.0)	20.0	0.13 (0.07)

Negative phenotypic correlations were observed between litter size traits (NB, NBA) and ABWT (Table 3). This distinct negative relationship between litter size traits at birth and the average birth weight of kittens indicates that kittens from larger litters have lower birth weights. As expected, there was a high positive phenotypic correlation between NB and NBA. Argente *et al.* (1999) also observed that total number of young rabbits born and number of young rabbits born alive were negatively correlated with average birth weight of kittens (-0.69 and -0.61, respectively). From these results it can be deduced that selection for increased litter size should always be done with caution, as it may decrease the birth weights. This in turn may decrease the survival rates (Argente *et al*. 1999). Hence it may also be necessary to address birth weight in the development of breeding objectives.

Table 3. Phenotypic correlations (standard errors) between total number born/litter (NB), number born alive/litter (NBA) and average birth weight of kittens (ABWT)

Traits	NB	NBA
NBA	0.82 (0.02)	
ABWT	-0.53 (0.05)	-0.37 (0.06)

While it would be wise for Australian farmers to reserve their decision on breed merit until additional data are collected, it may still be noticed from the present study that crossbred does may offer advantages in terms of litter size, compared to purebred does. It can also be concluded that the selection decisions on litter size should be based on multiple litter measurements.

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