

GENETIC AND PHENOTYPIC RELATIONSHIPS BETWEEN KID SURVIVAL AND BIRTH WEIGHT IN AUSTRALIAN MEAT GOATS

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SUMMARY

The Australian goat industry would like to improve reproductive rate by increasing kid survival. Parameter estimates for kid survival and correlated traits are yet to be reported. A preliminary analysis of birth weight and survival was conducted using 16,050 records from industry herds. The heritability for birth weight (0.32 ± 0.029) was similar to previous reports, but the heritability for kid survival (0.29 ± 0.024) was higher than expected in comparison to other breeds of goats and sheep. The phenotypic variance for birth weight is similar to those previously reported for Boer goats. For a binomial trait there was moderate variation in kid survival with a phenotypic deviation of 0.288, birth weight had a moderate amount of variation with a standard deviation of 0.599kg. The lowest kid survival rates occur in animals less than 2.5kg with survival rates between 67% and 85%, while animals over 2.5kg had survival rates between 92% and 98%, the overall mean for survival was 85%. The phenotypic correlation estimate of 0.16 is low but positive for birth weight and survival. The genetic correlation was also positive and high at 0.54 ± 0.068 . Improving survival could potentially be achieved either with direct selection or indirect selection with birth weight.

INTRODUCTION

The Australian goat industry was valued at \$146m AUD in 2012/13 (MLA 2012). The majority of production is achieved by harvesting feral goats from the Australian rangelands but genetic improvement is focused on the domestic Boer goat population. While there is limited genetic research on goats in Australia, reproductive rate has been identified as a trait requiring improvement (MLA 2012). Goats are moderately fertile (does kidding/doe joined = 0.82, Walkden-Brown and Bocquier 2000) and highly fecund (kids born / doe joined = 1.76, Zhang *et al.* 2009). Instead of focusing on fertility and fecundity, increasing kid survival between birth and weaning could increase the net reproductive rate.

Australian sheep research has made recent progress on survival traits much of which is yet to be replicated in Australian goats. Sheep have been shown to display low to moderate genetic correlations between birth weight and survival but with curvilinear phenotypic relationships between these traits (Brien *et al.* 2014).

This paper reports a preliminary analysis using the KIDPLAN national genetic evaluation database to estimate the genetic and non-genetic relationships between kid survival and birth weight. This is part of a larger project which aims to determine whether correlated traits can be exploited to achieve genetic improvement of kid survival in Australian production systems.

MATERIALS AND METHODS

Data analysed for this study was submitted to the national performance recording scheme KIDPLAN and included records on 16,280 individuals born from 1991 to 2014. 973 duplicate records were removed during data cleaning. The animals are progeny of 574 sires and 3,669 dams. The median number of progeny per sire was nine and per dam was three. The key traits of interest

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were birth weight and kid survival. Birth weight was recorded by the breeder. Kid survival was generated using birth and rearing type records, 743 dead tags were added when multiple litter sizes did not have data submitted on the dead kid. Ideally breeders would submit data for all dead kids, from the calculated survival 2404 kids did not survive to weaning and of these 507 dead kids had a birth weight recorded. Due to the low number of quadruplets (480 kids) and quintuplets (60 kids), litters of 3 or greater were analysed as a single category termed ‘multiples’. Fixed effects in the analysis were date of birth, sex, dam age and site in addition to birth type and rearing type. The data was submitted from 40 herds.

Means, phenotypic variances, heritabilities and correlations were estimated using ASREML-R (Butler *et al.* 2009) for both kid survival and birth weight. Univariate analysis of birth weight and kid survival was conducted with fixed effects for sex, site, year of birth, site by year of birth interaction, dam age and birth type included in the models. The animal model included the following random effects; direct genetic effect fitted as a trait of the kid, a permanent environmental and maternal genetic component and a sire by flock by year interaction. Predictions for birth weight and survival were also estimated with birth type as it had significant effect on both traits.

A bivariate analysis for birth weight and survival was conducted to estimate phenotypic variance, heritability, genetic and phenotypic correlations. The full model included the fixed effects birth type, sex, flock, year of birth, flock by year of birth interaction and dam age. The sire by flock by year interaction was removed from the random effects as it was not estimable in the bivariate model, leaving the random effects as direct genetic, permanent environmental and maternal genetic components.

RESULTS AND DISCUSSION

The mean birth weight (\pm SD) for goats in this data set was 3.5kg \pm 0.6 and was normally distributed. Kid survival rates for different birth weight categories are illustrated in Figure 1 and shows a trend for lower birth weights to be associated with lower survival rates. It also appears that high birth weight was not associated with lower survival as seen in other species due to dystocia (Brown *et al.* 2014). The survival rate for goats between 1.0 and 1.4kg was 67%, 1.5 to 1.9kg was 70% and goats 2 to 2.4kg was 85%. The mean survival rate for goats was 85%, which was higher than a mean Merino lamb survival rate of 72% from a sample with a similar mean birth weight of 3.63kg (Hatcher *et al.* 2014).

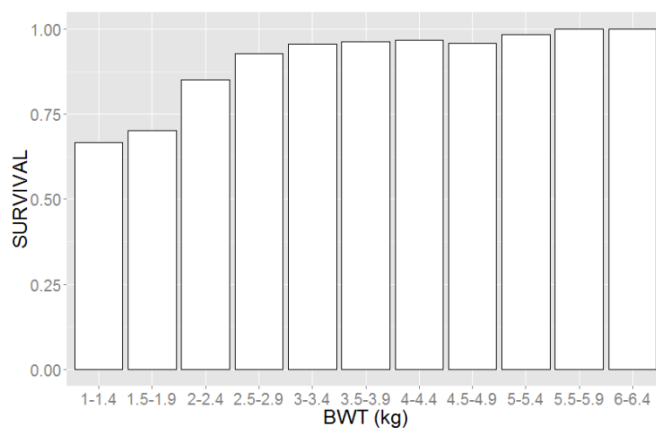


Figure 1. Survival rate of goats plotted against birth weight groups of 0.5kg

Predicted means for birth weight and kid survival rates for each birth type class were made using the univariate model. Birth type had a significant effect on both kid survival ($P < 0.01$) and birth weight ($P < 0.01$). Singles had the largest birth weight (3.88kg), twins (3.49kg) and multiples the lowest (3.16kg) (Table 1). There was no significant difference in kid survival between singles and twins (83% and 82% respectively) but multiples had a lower survival rate (71%).

Table 1. Predicted means (\pm se) of Boer kid survival rates for each birth type class and birth weight

Birth Type	Number of records for birth type	Survival	Birth Weight (kg)	Number of records for birth weight
1	3,510	0.83 (0.0075)	3.88 (0.019)	1,971
2	8,841	0.82 (0.0068)	3.49 (0.016)	6,301
≥ 3	3,699	0.71 (0.0084)	3.16 (0.020)	2,373

A summary of the heritability, phenotypic and genetic correlations, and phenotypic variances are summarised in Table 2. The heritability for birth weight was 0.32 and similar to other estimates for birth weight in Boer goats which have been reported between 0.19 and 0.39 (Ball *et al.* 2001, Zhang *et al.* 2008, Zhang *et al.* 2009). No studies are yet to publish heritability of survival in Boer goats however, the estimate of the current study of 0.29 was much larger than those reported for other breeds and species. Previous goat studies have reported heritabilities of 0.10 (Singh *et al.* 1990) and studies in sheep ranged between 0.01 and 0.03 (Brien *et al.* 2014). It is important to note that the phenotypic variance reported for birth weight is consistent with that of the Boer goat at 0.36 previously reported between 0.31 and 0.57 which allows for selection to be undertaken successfully (Ball *et al.* 2001, Zhang *et al.* 2008). Though the phenotypic variance of survival was low (0.08) there is variation in the trait, in comparison to sheep it is within the range of 0.05 and 0.19 as reported by Hatcher *et al.* (2014).

The genetic and phenotypic correlations between birth weight and kid survival are 0.54 and 0.16 respectively. The phenotypic correlation between birth weight and kid survival has previously been reported to be a curvilinear relationship (Snyman 2010). The genetic correlation has not yet been reported for goats and appears to be high. The genetic correlation for sheep has been reported between not different to zero and 0.45 (Brien *et al.* 2014).

Table 2. Estimates of, phenotypic variance (σ_p^2), permanent environmental variance (PE), maternal genetic variance (σ_m^2), heritability (h^2) and genetic (r_g) and phenotypic (r_p) correlations for birth weight and survival from a bivariate analysis of goats (\pm se).

Trait	Birth Weight(kg)	Survival
σ_p^2	0.36 (0.01)	0.08 (0.001)
PE	0.037 (0.01)	0.0034 (0.001)
σ_m^2	0.027 (0.01)	0.0008 (0.001)
h^2	0.32 (0.03)	0.29 (0.02)
Birth Weight	-	$r_p = 0.16$ (0.01)
Survival	$r_g = 0.54$ (0.07)	-

As the majority of losses occur in kids under 2.5kg, the results of this study suggest that selection to increase birth weight, to reduce mortalities, can be undertaken successfully though

caution must be taken not to develop dystocia problems. The preliminary results also suggest that improved survival could be achieved by direct selection for the trait.

The high heritability for survival was unexpected, and may be a consequence of the larger variation in birth type observed in the current study compared to sheep. Additionally the survival data is yet to be analysed using a more appropriate model for binomial data. The results could also be a function of the data if breeders did not submit complete kid mortality records.

The predictions for survival (Table 1) indicate that increasing survival could be accomplished by reducing litter size but this could have unfavourable consequences for weaning rate (as number of kids per doe joined). Future work will examine the relationship of birth weight with litter size and how selection to change these may influence weaning rates. Finally the results of this study suggest that kid survival in single, twin and multiple birth classes should be considered as separate traits and will also be investigated in future work.

CONCLUSIONS

The higher than expected heritability for kid survival reported in this study suggests that if measurements of kid survival are collected, and the trait is given priority in the breeding objective, breeders will be able to improve the trait by selection. The genetic and phenotypic correlation between kid survival and birth weight has implications for future indirect selection, but with a risk of increasing the chance of dystocia. The results also indicate that litter size could contribute to kid survival and birth weight which will be further investigated.

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