Relationships between adult liveweights and velvet weights in farmed Red deer

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ABSTRACT

Deer farmers with velvetting herds are interested in: selection of stags for superior lifetime performance; selection of stags and hinds to produce improved sons; and management of the stag herd to increase returns from velvet. Knowledge of genetic and phenotypic relationships between weights of velvet harvested at different ages and between liveweights and velvet weights will allow benefits from selection and some management practices to be quantified. This paper reports estimates of these relationships from a study involving some 2,021 stags representing 92 sire progeny groups distributed over five farms.

Heritability estimates for velvet weight at successive ages from 2 to 8 year old stags ranged from 0.43 to 0.85. The average estimated genetic correlation between velvet weights in successive years was 0.97 but declined to 0.75 as the number of years between harvests increased. Phenotypic correlations were consistently lower than genetic correlations. Treating log-transformed velvet weight as a repeatable trait resulted in an estimated heritability of 0.36 with a repeatability of 0.64 and s.d. of 0.11 (log scale). Average velvet production in kg (Y) can be predicted from age in years (X) from the following equation: $\log_{10}(Y) = -0.37 + 0.33*X - 0.044*X^2 + 0.002*X^3$

Within a cohort of stags of the same age, heavier stags produced more velvet, with an average genetic correlation of 0.74 and phenotypic correlation 0.44. The genetic correlation between liveweight of hinds at 2 years of age and velvet weight at various ages averaged 0.5.

Comparing different cohorts of stags of the same age, there was no relationship between average liveweights and average velvet weights.

As stags aged, the average weights of velvet and liveweight increased. Describing velvet weight in kg (Y) as a non-linear function of weight in kg (X) the allometric equation was $Y = 0.21*X^{1.4}$, indicating velvet weight is later maturing than liveweight.

Keywords: Genetic parameters; heritability; selection.

INTRODUCTION

During the last 25 years of deer farming in New Zealand the number of animals and the age and sex composition of the national herd has been somewhat volatile depending upon relative returns for venison and velvet and on the profitability of alternative land uses such as sheep farming, beef cattle finishing and dairy grazing. Given a more stable industry, farmers will become increasingly interested in improving the profitability of their herds. Velvet herd profitability will be enhanced by: retaining only those young stags that will have the best lifetime velvet antler production; selecting breeding stags and hinds that will produce improved future crops of velvetting stags; and management (particularly nutritional manipulation) so as to increase per head production of velvet. Knowledge of appropriate model equations to describe velvet production and estimates of the relevant parameters pertaining to the models are required to determine the scope for increasing profitability by selection. This paper reports estimates of genetic and phenotypic relationships obtained from analysis of field records of performance for annual velvet harvests and adult stag and hind liveweights.

MATERIALS & METHODS

Performance records were obtained for Red deer born on five South Island deer farms from 1981 to 1987. No sires were used in common across the five farms. The animals represented 92 sire groups and included 2,021 stags with velvet weights recorded at their harvest as two year olds. Due to culling and natural losses between successive harvests, there were fewer records on older stags. A subset of the stags with velvet information also had body weight records, sufficient for analysis of two to five year old winter stag weights. Winter liveweights on half-sisters allowed estimation of genetic correlations between velvet weights on stags and winter weights for two, three and four year old hinds. Numbers of observations, raw means and estimated coefficients of variation are in Table 1.

Any progeny from Wapiti, Elk and any recently-imported European sires were discarded as were offspring from multiple sire joinings. Velvet weights were obtained at velvetting which followed normal farm practice. More details on the procedures followed are in Ball *et al* (1994) whose data comprised a subset of records from one of the farms reported in this paper.

Mixed linear models were assumed in order to estimate relevant parameters using restricted maximum likelihood (REML). The model equations are described as mixed because these include both fixed effects (such as

TABLE 1: Number of sires and dams, number of records (N), means and coefficients of variation (C.V.) of velvet weights, stag liveweights and hind liveweights for 2 to 5 years of age.

	velvet weight			stag liveweight			hind liveweight		
	No sires	92			67			55	
	No dams	1470			968			663	
age yrs	N.	mean kg.	C.V. %	N.	mean kg.	C.V. %	N.	mean kg.	C.V. %
2	2,021	1.34	23.6	1,499	109.9	9.5	889	86.87	8.5
3	1,454	1.91	21.9	749	134.9	8.8	549	92.58	7.6
4	969	2.46	22.3	255	146.9	8.1	120	91.21	8.1
5	590	2.78	22.6	119	147.3	8.0			

TABLE 2: Parameter estimates including phenotypic standard deviations (s.d.) and coefficients of variation (CV) for velvet weight by stag age from 2 to 8 years of age. Phenotypic correlations above the diagonal, heritabilities on the diagonal, genetic correlations below the diagonal.

	2 yo	3 yo	4 yo	5 yo	6 yo	7 yo	8 yo
2 yo	**0.43**	0.70	0.64	0.61	0.50	0.61	0.57
3 yo	0.98	**0.51**	0.74	0.73	0.65	0.70	0.71
4 yo	0.93	0.97	**0.56**	0.77	0.73	0.81	0.75
5 yo	0.88	0.93	0.96	**0.74**	0.78	0.81	0.77
6 yo	0.73	0.80	0.91	0.94	**0.57**	0.87	0.84
7 yo	0.79	0.85	0.93	0.98	0.98	**0.74**	0.87
8 yo	0.76	0.82	0.89	0.96	0.97	0.99	**0.85**
sd (kg)	.32	.42	.54	.62	.70	.80	.96
CV (%)	24	22	22	23	23	25	29

herd or birth year) and random effects (such as animal genetic and permanent environmental influences). Random effects were assumed to follow a multivariate normal distribution. The algorithm used to maximise the restricted likelihood was based on second derivatives of the likelihood function as approximated using the so-called average information matrix (AIREML, Johnson and Thompson 1995). Although animal models were fitted, there were only a minority of dams with more than one offspring (Table 1) such that most information used to estimate variance components arose from half-sib relationships.

Analysis 1: Velvet weights were analysed assuming each velvet harvest represented a different trait. This model allows for changes in the phenotypic variance of velvet weights by age and enables estimation of the heritability at each age and the genetic correlations between ages.

Analysis 2: Velvet weights were log-transformed to standardise the phenotypic variation by age. Relatively constant coefficients of variation by age provide some confidence that a $\log_{10}$-transformation will standardise the variance. A repeatability model was then fitted, partitioning the $\log_{10}$-transformed records into genetic effects and permanent environmental effects (common to production at all ages) and uncorrelated temporary environmental effects. A cubic function of stag age in years was included to model the effects of stag age on velvet production.

Analysis 3: A multivariate model was fitted which included as different traits, velvet weights at each age along with stag weights at each age. For each trait, a fixed contemporary group effect was defined for each birth year nested within farm. This model includes parameters that can be used to describe the genetic and phenotypic regressions of velvet weight on liveweight and vice versa.

Analysis 4: A multivariate model was fitted including as different traits velvet weights at each age along with hind weights at each age. This model allows for indirect selection for velvet weight using hind liveweights.

Analysis 5: Environmental (contemporary group) effects for stag liveweights and stag velvet weights from analysis 3 were compared in two ways. First, estimates of these contemporary group effects were used as data to fit an allometric equation using non-linear least squares to relate velvet production to liveweight production as stags mature. Second, estimates of contemporary group effects for velvet weight were regressed on estimates of contemporary group effects for liveweight within stag age to identify non-genetic influences of management affecting winter weight on velvet weight.

RESULTS & DISCUSSION

Velvet weight inheritance by stag age (Analysis 1).

Estimates of variance components are in Table 2. These results show that the phenotypic standard deviations of velvet weight increase with age in years from 0.32 at two years of age to 0.96 at eight years of age. However, the coefficient of variation is somewhat more stable at 20 to 25%. The heritability is high (0.43 to 0.85) at all ages, indicating that perhaps one-half of the observed variation within a group of similarly managed contemporary stags results from genetic differences among the stags. Genetic correlations were close to unity between successive harvests, but these correlations reduced when comparisons were made among harvests that were several years apart. For example, the genetic correlation estimate was only 0.76 between stags aged two and eight years old. Nevertheless, these estimates support the finding that most of the genes affecting mature velvet production are common to all ages and that selection at any one age would improve production at all ages. Phenotypic correlations followed the same pattern but were always somewhat lower than corresponding genetic correlations.

No comparative results are available from published sources. Various authors report heritability estimates for one age but these estimates tend to be based on small numbers of animals and other species of deer (e.g., Williams *et al.*, 1994; reported heritability estimates between 0.71 and 0.86 for antler weight in white-tailed deer at 18 months of age). Moore *et al.* (1988), reported phenotypic relationships between the weights of velvet harvested from spiker, two and three year-old Red deer.

Repeatability results for log-transformed velvet weight (Analysis 2).

Log_{10}-transformed velvet weight had a heritability of 0.36, repeatability of 0.64 and phenotypic standard deviation (log_{10}-scale) of 0.11. These results support the findings of the previous analysis by age, confirming that velvet production is highly repeatable and a useful proportion of the variation is available to be exploited by selection. The estimated cubic function relating age of a stag (X) in years to average velvet performance (Y in kg), is given by:

$$Y = 10^{(-0.37 + 0.33X - 0.044X^2 + 0.002X^3)}$$

Similar curvilinear functions relating phenotypic antler characteristics to age have been reported by Scribner *et al.* (1989) for white-tailed deer; Zhou and Wu (1979) for sika deer; and Ludwig and Vocke (1990) for Red deer.

Relationships between stag liveweights and their velvet production (Analysis 3).

Genetic and phenotypic correlations between stag liveweights and their velvet weights at two, three and four years of age are in Table 3. The average genetic correlation between velvet production and liveweight for stags of the same age was 0.74. The corresponding average phenotypic correlation was 0.44. These parameter estimates indicate that animals with superior velvet production tend also to be superior both genetically and phenotypically for liveweight. The estimates can be used to calculate the regression of velvet production on two year old liveweights. The resultant coefficients for predicting velvet superiority of two, three and four year old stags are 138, 178 and 190 g velvet per 10 kg two year old bodyweight superiority. These coefficients apply to superiority of two year old stags in comparison to contemporary stags of the same age (two years) on the same farm.

Velvet performance in stags related to hind liveweights (Analysis 4).

Genetic correlations between hind liveweight and stag velvet weight are in Table 4. These results along with the

TABLE 4: Genetic correlations between hind liveweight (Lwt) and stag velvet weight (Velv) for 2 to 4 year old deer.

	2 yo Lwt	3 yo Lwt	4 yo Lwt
2 yo Velv	0.49	0.24	0.29
3 yo Velv	0.50	0.24	0.30
4 yo Velv	0.51	0.25	0.30

results in table 3 confirm that liveweight could be used as an indirect indicator of velvet performance for selection of both males and females in velvet breeding herds. Similarly, selection for increased velvet production is likely to have a correlated impact on liveweight. The estimated correlations are somewhat higher between two year old hind liveweights and all velvet weights, suggesting that indirect selection on hind weight at this age would have greater affects on velvet merit than indirect selection on hinds at older ages. The reduction in genetic correlations between velvet production and hind liveweights beyond two years of age may be a reflection of the effects of genes related to pregnancy and lactational conditions in the hinds.

Increases in velvet production with liveweight. (Analysis 5).

The allometric equation fitted to relate the velvet production (Y) to liveweight (X) as stags mature was estimated as $Y = 0.21 X^{1.4}$

The allometric coefficient estimate of 1.4 exceeds unity which may be interpreted as implying that velvet is somewhat later maturing than liveweight. It is important that this allometric equation is not misinterpreted in order to predict the increase in velvet weight that results with increases in liveweight. The allometric equation demonstrates that as animals age, they both increase in liveweight and in velvet weights. Furthermore, the increase in velvet weight is at a greater rate than the increase in liveweight. Ball *et al.* (1994) reported estimates of allometric coefficients of 2.4 and 1.7 for each of two birth years from analysis of a subset of the data used in this study.

Analysis of the effects of liveweight on velvet production between farms and birth years for stags of the same age produced the following results

two-year old stags $Y=0.73 X^{0.14}$
three-year old stags $Y=0.77 X^{0.20}$
four year old stags $Y=0.86 X^{0.22}$
five year old stags $Y=0.49 X^{0.35}$

These coefficients have values close to zero indicating that farm and year effects (presumably including level of nutrition) that resulted in increased average mob

TABLE 3: Genetic and phenotypic correlations between stag liveweight (Lwt) and velvet weight (Velv) for 2 to 4 year old stags.

	Genetic correlation			Phenotypic correlation		
	2 yo Lwt	3 yo Lwt	4 yo Lwt	2 yo Lwt	3 yo Lwt	4 yo Lwt
2 yo Velv	0.67	0.69	0.73	0.45	0.38	0.37
3 yo Velv	0.66	0.68	0.73	0.44	0.43	0.43
4 yo Velv	0.78	0.80	0.86	0.36	0.41	0.44

liveweights had very little affect on average mob velvet production. Within any age group, differences of 40 kg in average liveweight were associated with negligible increases in average velvet weight. Furthermore, between farms and years, there were as much as 0.5 kg difference between mob average velvet weights without any associated differences in average liveweight.

CONCLUSION

Velvet weight exhibits considerable variation between individual stags and a significant proportion of this variation is genetic in origin. Selection of stags that are superior for velvet weight at any adult age, relative to their similarly-managed contemporaries, will result in increased velvet production at all ages. Stags selected for superior velvet production will tend to be above-average liveweight. Selection for velvet weight in a breeding herd will indirectly increase liveweight in both sexes. The inclusion of liveweight information on both sexes along with velvet weights on stags would lead to increased rates of progress for velvet weight than would selection using only velvet weight as the selection criterion.

As stags mature, they get heavier and produce more velvet. However, management to increase mature mob liveweight will not necessarily be associated with increased average velvet weights.

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