SHORT COMMUNICATION

Genetic analysis of velvet antler yield in farmed elk (*Cervus elaphus*)

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Wang, Z., Yang, R-C., Goonewardene, L. A. and Huedepohl, C. 1999. **Genetic analysis of velvet antler yield in farmed elk (*Cervus elaphus*)**. Can. J. Anim. Sci. **79**: 569–571. Data from the Alberta Agriculture Food and Rural Development data base, which keeps inventories of elk producers and velvet production information (*n* = 12 724), were used to estimate genetic and phenotypic variances, heritability and repeatability estimates for velvet antler using REML methods. The heritability based on the animal models I and II was 0.27 ± 0.03 and the repeatability ranged from 0.31 ± 0.02 to 0.35 ± 0.03 depending on the animal model used. Antler yield is expected to respond to selection as the heritability is medium, but non-additive and environmental effects can also influence production.

Key words: Elk, heritability, repeatability, antler production

Wang, Z., Yang, R-C., Goonewardene, L. A. et Huedepohl, C. 1999. **Analyse génétique du rendement en bois de velours du cerf d'élevage (*Cervus elaphus*)**. Can. J. Anim. Sci. **79**: 569–571. Nous avons utilisé les données de la base de données du ministère de l'Agriculture, de l'Alimentation et du Développement rural de l'Alberta, laquelle conserve les effectifs des élevages de cerfs et les renseignements sur la production de bois de velours (*n* = 12 724), pour calculer les variances génotypiques et phénotypiques, l'héritabilité et la répétabilité du rendement, selon les méthodes de vraisemblance maximale restreinte (REML). Les valeurs d'héritabilité basées sur les modèles animaux I et II étaient de 0,27 ± 0,03, la répétabilité fluctuant entre 0,31 ± 0,02 à 0,35 ± 0,03 selon le modèle animal utilisé. Le rendement en bois de velours devrait pouvoir s'améliorer par sélection génétique, vu que l'indice d'héritabilité est modéré, mais des effets non additifs et des effets environnementaux pourraient également influer sur la production.

Mots clés: Cerf rouge (d'Amérique), héritabilité, répétabilité, production de bois de velours

Elk are farmed for the multiplication and sale of breeding stock, venison and the production of antler velvet. At present elk production is limited to producing breeding stock and velvet antler, and very little venison is commercially available (Alberta Agriculture Food and Rural Development [1999] unpublished data). It is estimated that the total number of elk in the province of Alberta in 1998 was 19 498 and the number of elk producers 307. In 1996 and 1997, the average velvet production per head was 4.7 and 4.5 kg, respectively (Alberta Agriculture, Food and Rural Development 1998), while the antler production among stags 5 yr and older in 1994, 1995 and 1996 was 7.9, 7.5 and 7.7 kg, respectively (Goonewardene et al. 1998). Velvet yield in one year was dependent on the velvet yield in the previous year and the age of the stag, and on average, at 7 yr of age, mature elk would be producing 91% of their lifetime capacity (Goonewardene et al. 1998). Presently elk production in Canada is driven primarily by the prospects for antler velvet in foreign markets (Alberta Elk Association-Personal Communication), but little is known about the genetics of antler yield in farmed elk. Although elk producers intuitively select high velvet producing sires for breeding, little is known about the inheritance of the trait. In the dairy cattle industry, milk production has been improved significantly by selecting sires on the basis of their estimated breeding values (Robinson and Chesnais 1988). Similarly, selecting sires on the basis of EBV for velvet antler yield can be useful in improving velvet production in their progeny. However, limits to the progress based on EBV are set by the heritability, repeatability and the accuracy of the estimates. The purpose of this study was to estimate genetic and phenotypic variances, heritability, repeatability of velvet antler yield using data from farmed elk in Alberta.

The data were obtained from the Alberta Agriculture, Food and Rural Development game farm database, which collects and keeps inventories of elk producers, sire and dam information, velvet antler yields and age. The elk were managed in a manner similar to the recommended code of practice for the care and handling of farmed deer (*Cervidae*) (Canadian Agri-Food Research Council 1996). Data editing,

Abbreviations: **DFREML**, derivative free restricted maximum likelihood; **EBV**, estimated breeding value; $\mathbf{h^2}$, heritability; **H**, herd; **r**, repeatability; **REML**, restricted maximum likelihood; σ^2, variance component

Table 1. Genetic, phenotypic variances, heritability and repeatability of velvet antler yield

Model	σ^2_s	σ^2_d	σ^2_e	σ^2_a	$\sigma^2 E_P$	σ^2_P	$h^2 \pm$ SE	$r \pm$ SE
Sire[z]	0.352	–	2.844	1.408		3.197	0.44 ± 0.05	–
Sire + dam[z]	0.333	0.225	2.681	1.116		3.238	0.34 ± 0.02	–
Animal I[z]	–	–	2.031	0.843	0.252	3.125	0.27 ± 0.02	0.35 ± 0.03
Animal II[y]	–	–	1.947	0.759	0.094	2.800	0.27 ± 0.03	0.31 ± 0.02

[z]Proc MIXED (SAS Institute, Inc. 1992)
[y]DFREML analysis (Meyer 1998). σ^2_s, sire variance; σ^2_d, dam variance; σ^2_e, environmental variance; σ^2_a, additive variance; $\sigma^2 E_P$, permanent environmental variance; σ^2_P, phenotypic variance; h^2, heritability; r, repeatability; SE, standard error.

checking for outliers, normality and data structure were done using SAS (SAS Institute, Inc. 1992). Genetic, phenotypic variances, heritability and repeatability of velvet antler yield were obtained using PROC MIXED of the SAS Institute, Inc. (1992) and DFREML (Meyer 1998). The data were collected from 1992 to 1998 and contained 12 724 records from 232 herds, with 361 sires, 1360 dams and 6687 animals. Herd of origin (H) was a fixed effect and age in months included as a covariate in all the models. The following models were used to estimate variance components:

Sire model: $Y = H + S + bX + e$ (PROC MIXED-SAS 1992)

Sire and dam model: $Y = H + S + D(S) + bX + e$ (PROC MIXED-SAS 1992)

Animal model I: $Y = H + AN + Ep + bX + e$ (PROC MIXED-SAS 1992)

Animal model II: $Y = H + AN + Ep + bX + e$ (DFREML-Meyer 1998)

where, Y = antler yield, H = herd, S = sire, D = dam(sire), X = age, AN = animal, Ep = permanent environment and e = residual error. The heritability based on the sire variance component was estimated as $4(\sigma^2_s)/\sigma^2_p$, and the heritability based on the sire and dam was estimated as $2(\sigma^2_s + \sigma^2_d)/\sigma^2_p$ (Becker 1984), where σ^2_s = sire variance component, σ^2_d = dam variance component and σ^2_p = phenotypic variance component. Repeatability was estimated as $(\sigma^2_a + \sigma^2_{Ep})/\sigma^2_p$ (Meyer 1998), where σ^2_a = additive variance component and σ^2_{Ep} = permanent environment variance component.

Variance components, additive-genetic and phenotypic variances, heritability and repeatability estimates based on four models are shown in Table 1. In general, the h^2 for velvet antler was medium (0.27 to 0.44), which suggests that it is partly under the control of additive genes much like in milk production of dairy cows. However, the non-additive and environmental effects accounted for approximately 60 to 70% of the variation in antler yield. We perceive that dominance and epistasis can influence antler production, and that the trait may therefore respond to improvement by cross breeding. The h^2 based on the sire component was higher than that based on either the sire and dam or the two animal models. The overestimation was probably because there were 9971 half sibs, 8884 full sibs and 6131 animals identified as both half and full sibs in the data. It has been shown that in mixed half- and full-sib populations, the additive variance and heritability estimates based on the sire component can be over estimated (Yang et al. 1998), and it was suggested that $\sigma^2_a = 3\sigma^2_s$ (Old et al. 1986) instead of $\sigma^2_a = 4\sigma^2_s$ (Becker 1984). The repeatability of antler yield was between 0.31 and 0.35 in this data set, suggesting that the effect of the permanent environment was small, and non-genetic factors such as feed supply and nutrition (temporary environment) have an influence on antler yield.

The total number of females that are 1 yr and older available for breeding in Alberta in 1998 was estimated to be 8255 (Alberta Agriculture, Food and Rural Development 1998). Assuming that all females are bred and the calf weaning rate is 78% (Alberta Agriculture, Food and Rural Development, unpublished data), and 50% of the calves are males, the number of males available as potential breeding sires would be 3220. If 5% (161), 10% (322), 15% (483) and 20% (644) of the males are selected as breeding sires for the next generation, then the intensities of selection (i) adjusted for sample size would be 2.062, 1.754, 1.553 and 1.400, respectively (Becker 1984; Falconer and Mackay 1996). Thus the response (R) to selection per generation, assuming that all females are bred is $R = i(0.5\sigma^2_a)$ where, σ^2_a is the genetic variance (0.759 from Table 1). Thus if 5, 10, 15 and 20% of the males are selected for breeding on the basis of EBV then the expected responses to selection would be 0.782, 0.666, 0.589 and 0.531 kg antler per generation, respectively. This study identifies that there is sufficient additive gene variance to warrant the use of individual selection and EBV for the continued improvement of elk antler production. The use of EBV has proved to be successful in improving the traits of many livestock species (Robinson and Chesnais 1988; Kennedy et al. 1996) and the elk industry should seriously consider adopting a similar genetic evaluation system.

The heritability of velvet antler in farmed elk based on the two animal models was 0.27 and the repeatability ranged from 0.31 to 0.35 depending on the model used. Although antler yield is expected to respond to selection, non-additive and environmental effects also influence production. Selection based on estimated breeding values would assist in progressively improving elk antler yield.

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