Genetic Parameters Of Leg Weakness In The Blue Fox

R. Kempe[1], N. Koskinen[2] and I. Strandén[1]

Introduction

Over the past years the leg structure in the farmed blue fox has deteriorated and increased animal size has been suspected to be one predisposing factor. Leg weakness may incur economic losses to producers through reduced selection intensity. Ethical aspects should also be considered, since it may reduce fox's wellbeing. Leg weakness appears to have a negative phenotypic correlation (-0.58) with animal weight (Korhonen *et al.* 2005, Keski-Nisula, 2006). Korhonen *et al.* (2005) observed leg weakness in blue foxes aged from 1.7 to 3.6 months. Besides leg weakness, a large proportion of these blue foxes had osteochondrosis (OC) in their carpal and/or elbow joints at the age of 5 months (Korhonen *et al.*, 2005). It was concluded that high energy content in the diet and high body weight may increase leg weakness and OC (Korhonen *et al.*, 2005). Similar flexural leg deformities have been reported in dogs, foals and farm animals (e.g. Vaughan, 1992; Love *et al.*, 2006). It has been suggested that flexural leg deformities in blue foxes and dogs are hereditary (Vaughan, 1992; Korhonen *et al.*, 2005). Hence, the main purpose of this study was to estimate the genetic parameters for leg weakness in the Finnish blue fox and also to determine the potential for selection against leg weakness. Genetic correlations between leg weakness, body condition score and production traits were also examined.

Material and methods

The experiment was carried out at the fur animal research station of MTT Agrifood Research Finland in Kannus. Data were collected during growth periods in 2005 and 2006 from altogether 2076 blue foxes. The foxes were classified into four birth classes by their time of birth: 104-129, 130-144, 145-160 or 161-180 days from the beginning of the year. Pups from the same litter were divided into full-sib pairs as follows: male-male, male-female, or female-female pairs. They were housed in traditional wire mesh cages in open-sided two-row sheds or in a hall, one full-sib pair per cage. The foxes were fed according to normal farming practice with a feeding machine controlled by a Farm Pilot (Tved Maskinbyg, Denmark). The thickness of subcutaneous fat was assessed by a subjective body condition scoring

[1] MTT Agrifood Research Finland, Biotechnology and Food Research, Biometrical genetics, FI-31600 Jokioinen, Finland

[2] MTT Agrifood Research Finland, Animal Production Research, Monogastric Research, Tervamäentie 179, FI-05840 Hyvinkää, Finland

(BCS) method on a scale of 1 to 5, where 1=very thin and 5=extremely fat (Kempe *et al.*, 2009). Body weight (BW) was recorded six times during the study period: at the beginning of the study (Aug 15) and from then on every three weeks (Sept 5, Sept 26, Oct 17, Nov 7) until pelting time (BW_{Fin}). For animal grading size (gSI) the score 1 was the smallest and 5 the largest. LEG, which describes carpal hyperextension, was evaluated on a scale of 1 to 5 based on the poorer of the forelegs. In the worst case (score 1) the carpal joint was bended to a 90 degree angle compared to a normal, only slightly angled carpal joint (score 5). If the fox mainly remained sitting or lying still in the cage, even when shooed off its MOVE level was graded at 1 or 2. If the fox was sometimes moving about and was somehow capable of jumping on the shelf its MOVE was evaluated at 3. Finally, if the animal was actively moving and was able to jump easily on the shelf, its MOVE was evaluated at 4 or 5. Dry matter intake (DMI), daily gain (DG) and feed efficiency (FE) were determined for the growth period from Aug 15 to Oct 18 based on previous results on the same data (Kempe *et al.*, 2008). DMI (g/d) was measured as the cage average for each full-sib pair. Individual DG (g/d) was calculated as the difference between BW at the end of a period and BW at its beginning divided by the number of days in the period. FE of a full-sib pair was calculated as the ratio of total DG (g) to total DMI (kg dry matter) of a cage for the same period as DMI.

(Co)variance components for the different traits were estimated with animal model restricted maximum likelihood (REML) using the DMU sofware (Madsen and Jensen, 2000). The statistical model was: $Y_{ijklmnop} = \mu + hy_i + sy_j + sh_k + p_l + ty_m + dy_n + l_o + a_p + e_{ijklmnop}$, where $Y_{ijklmnop}$ is observation of the trait (BCS, DG, BW, gSI, LEG or MOVE) in the single-trait analyses, hy_i is the fixed effect of house and year (i=1-6), sy_j is the fixed effect of sex and year (j=1-4), sh_k is the fixed effect of sex and house (k=1-6), p_l is the fixed effect of pair (l=1-3), ty_m is the fixed effect of time of birth and year (m=1-7), dy_n is the fixed effect of age of dam and year (n=1-5), l_o is the random effect of litter which accounts for the common litter environment of full-sibs born in the same litter, a_p is the additive genetic effect of the animal and $e_{ijklmnop}$ is the residual effect. Because FE and DMI were cage averages, the model for FE and DMI was the same as above except that the interactions of sex were excluded from the model, whereas the fixed effect of pair (3 classes: male-male, male-female, female-female) was included and the random effect of the animal was replaced by the sib group. Multi-trait animal model was used to calculate the genetic and phenotypic correlations between the different traits. The model was the same as used for FE and DMI, as all the traits were converted to be cage averages.

Results and discussion

Estimated genetic parameters for the studied traits are in Table 1. The heritability estimates for LEG, MOVE and BCS were moderate: 0.25, 0.22 and 0.30, respectively, suggesting that leg weakness and fatness in the blue fox have a genetic background. Further, moderate heritability was found for DG. Body weight showed a lot of genetic variation and moderate to high heritability. The effects of litter on BCS, LEG and MOVE were small (0.11-0.15). Litter variation was highest in BW_{Oct} (0.25). In DG, gSI, BW_{Fin} and gSI, the litter effect varied between 0.14 and 0.19. Litter variation was lowest in FE (0.09). The litter had a clear influence on all of the studied traits, which justifies the environmental effects common to litter-mates in the model.

LEG had moderate unfavourable negative genetic correlations (-0.40 to -0.53) with gSI, BW_{Oct}, DG and BCS. Phenotypic correlations between the traits were also negative, although lower. BW_{Oct} showed a slightly higher genetic correlation with LEG than BW_{Fin} perhaps due to the time of grading, which was closer to the measuring time of BW_{Oct} than of BW_{Fin}. Early October is also the period when foxes are growing fastest and their DG is high. BW in Sept and Oct seemed to have a slightly higher genetic correlation (-0.40±0.19 to -0.44±0.18) with LEG than BW measured in Aug (-0.26±0.20) or at the end of growth period in Nov/Dec (-0.33±0.18 to -0.39±0.19). The results indicate that large size, fatness and fast growth rate on early growth, increase leg weakness and impaired ability to move in blue foxes under the age of six months.

There was a high genetic correlation between LEG and MOVE, which means that these two traits have the same genetic background. Their phenotypic correlation was fairly high as well. Thus, fox with good leg structure also has good ability to move and jump in the cage. On the other hand, DG, BW_{Oct} and gSI showed quite high unfavourable genetic correlations with MOVE, while BCS, BW_{final} and DMI had moderate unfavourable correlations with MOVE. The corresponding phenotypic correlations were negative, indicating that large size, fatness and fast growth rate to some extent impair the fox's ability move about in the cage. In a study by Korhonen *et al.* (2001), foxes on an earthen floor enclosure received higher scores for LEG than foxes in traditional wire-mesh cages. The authors concluded that the higher MOVE in pen conditions had a positive impact on LEG through lower BW.

Phenotypic and genetic correlations between DMI and LEG and MOVE were negative. Thus, foxes with the highest feed consumption had the poorest legs and lowest ability to move about in the cage. All genetic correlations between DMI, BW_{Oct}, BW_{final}, BCS, gSI and DG were high, except between BCS and gSI, which showed a moderate correlation. Also, the corresponding phenotypic correlations were moderate to high. Consequently, selection and breeding for large gSI and heavy animals will favour fast-growing individuals. And, because the genetic correlations between DMI and size traits were unfavourable, ranging from 0.76 to 0.95, selection for big, heavy, fast-growing animals will simultaneously increase DMI and, thus, feeding costs. Genetic correlations between LEG and FE were fairly low and did not differ significantly from zero. This result gives weak support for the conclusion that selection for better FE will not predispose animals to fatness or leg weakness. However, FE did show a moderate genetic correlation with DG, and so selection for better FE will favour fast-growing animals. On the other hand, DG had high positive genetic correlations between the size traits and BCS. This antagonistic connection should be taken into account in the blue fox breeding programme. Thus, it may be possible to increase FE and still keep the blue fox's size at the current level, although this will lower response to selection.

Table 1: Estimated genetic parameters in the Finnish blue fox [α].

	BCS	$FE_{Aug-Oct}$	$DG_{Aug-Oct}$	$DMI_{Aug-Oct}$	BW_{Oct}	BW_{Fin}	gSI	LEG	MOVE
BCS	.30±.08	.29±.20	.85±.07	.78±.10	.84±.07	.86±.06	.57±.14	-.40±.19	-.61±.14
$FE_{Aug-Oct}$	.17	.28±.06	.51±.17	-.16±.23	.09±.22	.27±.20	-.09±.23	-.10±.25	-.24±.23
$DG_{Aug-Oct}$	.53	.46	.28±.09	.76±.10	.89±.05	.94±.03	.66±.14	-.42±.21	-.65±.15
$DMI_{Aug-Oct}$	.47	-.26	.73	.23±.05	.95±.02	.88±.05	.82±.09	-.41±.21	-.55±.16
BW_{Oct}	.58	.11	.84	.83	.37±.09	.96±.02	.85±.08	-.45±.19	-.65±.13
BW_{Fin}	.68	.14	.76	.72	.86	.49±.10	.74±.10	-.38±.20	-.58±.15
gSI	.37	.07	.46	.47	.59	.55	.32±.09	-.53±.20	-.66±.14
LEG	-.28	-.04	-.28	-.27	-.32	-.35	-.31	.25±.08	.94±.06
MOVE	-.31	-.01	-.34	-.37	-.41	-.40	-.37	.62	.22±.07

[α]Heritabilities (±s.e.) on the diagonal, phenotypic and genetic correlations below and above the diagonal, respectively.

Conclusion

There is a high incidence leg weakness and fatness in the farmed Finnish blue fox population. The genetic parameters estimated for LEG and BCS in this study indicate that genetic improvement through selection may reduce leg weakness and fatness in the animals. Our results show that high body weight, fatness and fast growth rate at early growth all have a non-zero genetic correlation to leg weakness and impaired ability to move. However, single-trait selection for LEG and BCS is expected to decrease DG and size traits like gSI and BW slightly due to a correlated response to selection. The current Finnish blue fox breeding programme is not targeted at increasing animal size or fatness, since size and fertility are known to have an antagonistic genetic correlation. Also the management of big foxes and pelts in the present production facilities is a challenging task.

Environmental factors like nutrition may also play a major role in LEG and BCS in less than six-month-old blue foxes. High DMI and/or high energy intake may be among the main environmental factors affecting leg weakness in the blue fox through accelerated growth and high BW. A moderate growth rate would be particularly desirable for large foxes inclined to leg weakness.

References

Kempe, R., Koskinen, N., Peura, J. *et al*. (2009). *Acta Agr. Scand.,* 59:85-92.

Kempe, R., Strandén, I., Koivula, *et al*. (2008). *Scientifur,* 32:47-52.

Keski-Nisula, S. 2006. *Helsingin yliopiston kotieläintieteen laitoksen julkaisuja* 82. 37 pp.

Korhonen, H., Happo, M., Rekilä, T. *et al*. (2005). *Anim. Sci.,* 80:325-331.

Korhonen, H.T., Jauhiainen, L., Niemelä, P., *et al.* (2001). *Anim. Sci*., 72: 375-387.

Love, S., Wyse, C.A., Stirk, A.J. *et al.* (2006). *Equine Vet. J.,* 38:597-603.

Madsen, P. and Jensen, J. (2000). *Users guide to DMU.* 22 p.

Vaughan, L.C. (1992). *J. Small Anim. Pract.,* 33:381-384.