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Opportunities for breeding for disease resistance in British sheep[1]

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Introduction

Diseases of livestock receive increasing interest from both producers, who want to control costs, and policy makers interested in animal health and sustainability of livestock production. Current costs of diseases in sheep in Great Britain, and consequently opportunities to reduce costs are poorly documented.

In a survey among farmers, shepherds, veterinarians and others, the Moredun Foundation (1997) identified internal parasites, sheep scab and foot rot as the most important diseases in sheep. Various types of abortions also ranked high. Bennett *et al*. (1999a) estimated on-farm direct costs for seven contagious diseases, but excluded the top three diseases identified by the Moredun study. In their study, highest costs were estimated for abortions. Annual costs of enzootic abortions in ewes (EAE) were estimated as £9 to £41M, and for toxoplasmosis at £12 to £24M in Great Britain.

In Britain, sheep production is based on a stratification system, with the main commercial ewe and lamb populations being crosses of various breeds. A great number of breeding schemes exist, and their specific goals depend on their place in the stratification system. Roughly, one can distinguish terminal sire breeds, where focus is solely on improving the efficiency of lean growth, and maternal breeds where the breeding goal also includes traits affecting female reproduction and rearing ability.

The aim of this study is to estimate the benefits of reductions in disease incidence or severity for the major endemic diseases affecting the British sheep industry and to investigate what the important features of a breeding programme including disease resistance are. First the total costs of the three major diseases identified in the Moredun survey will be estimated and compared with costs estimated by Bennett *et al*. (1999a). Then, the benefits of reductions in disease incidence or severity will be estimated. Based on this marginal economic values for resistance, important for incorporation in an index, will be calculated, and applied in various scenarios, which mimic the current British breeding schemes.

Materials and Methods

Bennett *et al*. (1999b) developed a system to calculate costs of diseases based on actual probabilities of an animal contracting a disease and associated costs of prevention, treatment and reduced performance. The costs per animal are then multiplied by the number of animals at risk. The cost calculation framework is based on the formula:

$$C = L + T + P$$

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where: C = total costs per year
L = annual loss in expected output and wasted inputs
T = annual treatment costs
P = annual prevention costs

$L = p \times id \times ie \times e \times vl$
$T = p \times it \times vt$
$P = p \times ip \times vp$

and: p = population at risk (number of animals)
id = incidence of the infection as proportion of the population
ie = incidence of disease effects as proportion of infected population
e = physical effect of disease on input or output
vl = value per unit of input or output
it = proportion of population at risk treated (including healthy)
vt = costs of treatment per animal
ip = proportion of population at risk where preventive action is taken
vp = cost of preventive action per animal

The costs of three major sheep diseases, gastro-intestinal parasites, footrot and scab, in Great Britain were estimated and compared with costs for other diseases from another study. The above approach identifies the costs that are more or less fixed, regardless of the severity or incidence of a disease – preventive costs, and on the other hand costs that are directly affected by severity of infection or incidence – control/treatment costs and costs of lost production. The latter type of costs can be directly affected by a breeding programme that reduces disease severity in individuals of incidence in the population.

For diseases, like GI parasites, that affect all animals in a certain group (lambs in this case) and have an exponential distribution, the trait in the index would be a log-transformed measure of disease severity, and the marginal value of 1 unit disease reduction is equal to the costs per animal (but with opposite sign). For diseases where the main issue is affected or not, genetic selection would be on the underlying normal scale and the marginal value of disease resistance is equal to the costs per affected animal multiplied by the ordinate on the normal distribution corresponding with the incidence of the disease.
Discounting from Conington et al. 2001 is used to account for the time of expression.

Results
Disease costs
The most costly disease, of those studied, for the British sheep industry is infection with gastro-intestinal parasites, with estimated annual costs of £ 105 million (Table 1). Costs for the other two diseases are £ 32 M for footrot and £ 12 M for sheep scab. This compares to literature estimates of £ 25 M for enzootic abortion of ewes (EAE) and £ 18 M for toxoplasmosis. For EAE and sheep scab most costs are for preventive measures therefore, short of eradication, a reduction in incidence will have a limited effect on costs. For GI parasites and toxoplasmosis, costs are closer to linear with the severity or incidence and a reduction of the disease will have a proportional effect on the costs to the industry. For footrot about half the costs are for preventive measures,

the other half is for lost production and treatment. A reduction in the incidence of footrot has a proportional effect on the £18 M associated with infected animals.

Table 1 *Overview of the number of sheep affected by selected diseases, annual associated costs and opportunities for cost reductions in Great Britain*

	Disease				
	GI parasites	Footrot	Scab	EAE	Toxoplasmosis
Number of animals affected:					
Ewes (1,000)	0	1025	164	861	279
Lambs (1,000)	22960	689	69	0	0
Costs:					
Prevention costs (£M)	0	14	12	22	0
Treatment/control costs (£ M)	32	5	0	0	0
Lost performance costs (£ M)	74	13	0	3	18
Total costs (£ M)	105	31	12	25	18
Of which: treatment/control and lost performance costs (£ M)	105	18	0	3	18

based on Bennett *et al*. (1999a) but with 2003 ewe numbers
less than £ 0.5 M, § less than £ 0.05 M

Only for gastro-intestinal parasites, footrot and toxoplasmosis would a reduction of severity or incidence have a significant impact on costs of production in Britain.

Marginal values

Marginal values for the three diseases of interest are in Table 2, assuming incidences of 1.7% for Toxoplasmosis and for footrot 6.25% in ewes and 3% in lambs. It is assumed that resistance to footrot in ewes is genetically the same as in lambs, so that marginal values for the two can be added.

Table 2 *Marginal economic values for resistance to GI parasites, Toxoplasmosis and footrot in British sheep*

Disease	Costs/affected lamb (£)	Costs/ affected ewe (£)	Marginal costs (£)	Discounted (£)
GI parasites	4.57		4.57	7.39
Toxoplasmosis		64.56	2.71	3.62
Footrot	14.09	4.89	1.73 and 0.33	2.85

Breeding scenarios

Based on these results, general marginal costs of £2, 4 and 8 were used in terminal sire and maternal breeding schemes, also including weight at 20 weeks, and for the maternal scheme litter size reared, with relative economic values of £0.70/kg and £36.08/lamb respectively. Heritabilities for disease resistance of 0.1, 0.3 and 0.5 were investigated, and all genetic and phenotypic correlations were assumed to be 0. GI parasites were observed once in all animals, toxoplasmosis repeatedly (once per parity) in females and footrot in both lambs (once) and ewes (repeatedly). Selection intensity was 2 in males and 1 in females. Genetic progress was calculated using standard selection index theory and information from around 100 relatives (animal, parents, grandparents, sibs, aunts).

Analyses showed that it is very important to be able to observe disease resistance in lambs, since observations on ewes are only on a limited number of animals and a late stage in live. These results were then used to predict the benefits of one round of selection for the British sheep industry, assuming 100% penetration and heritabilities of 0.3 for GI parasites and footrot and 0.1 for resistance to Toxoplasmosis. Results in table 3 show that benefits would be £16.6M for GI parasites, £2.7 M for footrot and less than £1 M for Toxoplasmosis.

Table 3 *Economic benefits of one round of selection for resistance to GI parasites, footrot and toxoplasmosis based on the British sheep population. Based on a total ewe population of 16.4 M and a total lamb population 23.0 M and 100% penetration*

Disease	% ewes	% lambs	Genetic progress	£ M scenario	Benefits total £M
Scenario – animals measured					
GI parasites					
TS – lambs		39	17%[1]	7.0	
Maternal – lambs		61	15%[1]	9.6	
GI parasites total					16.6
Footrot					
TS – lambs	15	39	1.1 %[2]	0.9	
Maternal - females + lambs	85	61	0.7 %[2]	1.9	
Footrot total					2.7
Toxoplasmosis					
Maternal – females	85		0.1%[2]	0.9	
Toxoplasmosis total					0.9

[1] reduction in average FEC
[2] reduction in number of animals affected by the disease, as proportion of the total population

Conclusions

Infection with GI parasites is the most costly disease for the British sheep industry, with total estimated costs of £ 105 per annum. Benefits of breeding for resistance to GI parasites can be as high as £16.6 M for one round of selection. For footrot total costs are £31 M per annum, and selection for resistance can lead to cost reductions of £ 2.7 M from one round of selection. For both diseases, most benefits are realised through maternal breeds. For the other major diseases, potential for reduction through breeding are limited, even if moderate heritabilities were found to exist, because costs are preventive and therefore fixed (sheep scab, enzootic abortion in ewes) or measures are only available on lambs (Toxoplasmosis).

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