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## Industry use of the Inverdale gene (FecX)

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### ABSTRACT

The Inverdale gene (FecX) offers the sheep industry the potential to markedly increase production at little cost. However, the characteristics of the gene mean that appropriate breeding structures are essential. The recommended structure is a stratified crossbreeding system. The three tier breeding structure consists of: (1) a ram breeder producing rams known to carry the Inverdale gene; (2) a ewe breeder producing carrier ewes by mating carrier rams across dual purpose breed ewes; and (3) a lamb producer who mates a meat breed ram with carrier ewes to produce lambs for slaughter. Some farmers may choose to have two, or all three tiers on a single property. If the gene was used to the maximum extent possible in Romney and Romney derived breeds, some 40% of all breeding ewes would contain a single copy of the gene and these would produce 31% more lambs for sale per ewe mated. Conservative estimates of the benefits to the New Zealand farmer are approximately \$29 m per annum.

**Keywords:** sheep; Inverdale; breeding structure; genetic; economic benefit.

### INTRODUCTION

The Inverdale prolificacy gene (FecX), located on the X-chromosome, was recently discovered in Romney sheep (Davis *et al.*, 1991a). Its release to the industry has been held in abeyance until further evaluation of its effects on animal production. Recent work has included an examination of the gene's effects on traits such as growth, ultrasonic fat depth, wool production and reproductive rate in animals carrying a single copy of the gene (Davis *et al.*, 1993; McEwan *et al.*, 1992; Gray and Davis, 1995). Infertility in all females which have two copies of the gene has been determined by Davis *et al.* (1992) and other sources of the gene in the existing populations have been identified (Davis *et al.*, 1994), as well as its localisation to a specific region of the X-chromosome (Galloway *et al.*, 1995). While more information is required, we can now make a preliminary evaluation of the potential benefits of the Inverdale to the New Zealand sheep industry. Similarly, the structural alterations in present farming systems required for its effective utilisation are described.

#### Effects of the Inverdale on productive traits

A single copy of the Inverdale gene resulted in an increase in ovulation rate of 1 extra egg shed per ewe ovulating (Davis *et al.*, 1991a). When these animals are mated, about 0.58 extra lambs are born per ewe lambing (Davis *et al.*, 1993). The difference between eggs shed and lambs born is partly a result of embryonic losses, which increase with ovulation rate, and studies of sheep carrying the Inverdale gene have shown that the gene has no effect on embryonic survival other than the effects directly associated with higher ovulation rates (Davis *et al.*, 1993). No difference has been detected in ewes carrying a single copy of the Inverdale gene for ewe survival or proportion that are barren (Davis *et al.*, 1993; McEwan *et al.*, 1992). Neonatal mortality increases with birth rank, but no additional effect of the Inverdale gene was detected by Davis *et al.* (1993) and this result is consist-

ent with more extensive data collected since that date (G.H. Davis pers. comm.). In contrast, McEwan *et al.* (1992) reported an increased neonatal mortality in lambs from ewes carrying the Inverdale gene, but the result was based on small numbers of ewes lambing under extremely adverse conditions and the results are now thought to be atypical. The large change in prolificacy in ewes containing a single copy of the Inverdale gene results in extra lambs tailed per ewe mated, but its magnitude depends on management, ewe parity, and weather at lambing. Increases in lambs tailed per ewe mated have ranged from 0 to 55%. A weighted mean of the published results of McEwan *et al.* (1992) and the summary of Gray and Davis (1995), which included information from Davis *et al.* (1993), indicates an average of 31% increase in lambs tailed per ewe mated.

Other than its effect on prolificacy, studies have not detected any effect of the Inverdale gene on economically important traits. Davis *et al.* (1993) reported a comparison in female progeny containing nil or one copy of the Inverdale gene. Greasy fleece weights at 13 months of age and mating weights at 1.5 years of age were compared and no significant difference between genotypes was detected. McEwan *et al.* (1992) found no significant differences when they compared female non-carriers with those carrying one copy of the Inverdale gene for liveweights at birth, weaning, 8, 12, 18 and 27 months of age, greasy fleece weights at 12 and 27 months of age and ultrasonic fat depths at 8 months of age.

While growth and wool production have a large effect on the economic return of New Zealand dual purpose sheep enterprises, there are many other traits which also contribute. These include wool quality parameters, meat colour and tenderness, and disease resistance. To date, the effect of the Inverdale gene for any of these traits has not been critically examined, although in most cases any large differences would have already been noted. Similarly, few data are available for production in male lambs, due to the difficulty in identifying their genotype.

## Structure of New Zealand sheep industry

In 1992 the New Zealand sheep industry consisted of 36.6 million ewes, 87% of which were Romney or Romney cross derived breeds such as the Perendale or Coopworth (Anon. 1993). The primary purpose of these breeds is the production of meat and wool, each contributing about one half to the average farmer's income.

Most New Zealand farmers change sheep breeds very infrequently and on a national basis any change tends to be spread over several decades (Carter and Cox, 1982). Similarly, most produce their own female breeding replacements, with the average farm purchasing less than 18% of its replacement stock (Anon., 1995a). Another characteristic of the New Zealand industry is that crossbreeding is not widely used. For example, terminal sire cross animals made up only 14% of the lambs slaughtered in 1993 (Anon., 1995b). The low interest in crossbreeding in sheep may result from the difficulty in obtaining replacement breeding stock, lower culling rates in female progeny when crossbreeding, and because it primarily increases lamb production, whereas within breed selection improves both wool and lamb production. As a consequence, production and identification of single copy Inverdale females must be simple as most farmers would produce their own female replacements. It is therefore extremely advantageous that the gene was discovered in the Romney breed, as most dual purpose sheep farmers can immediately utilise it without a change of breed.

## Breeding structure to utilise the Inverdale gene

The Inverdale gene would fit particularly well in a structured industry where, for example, surplus hill country ewes are mated to carrier rams and the prolific daughters sold to specialist meat producing lowland farmers who in turn mate them to terminal sire breeds, with all progeny sold for slaughter. While this structure requires an ongoing supply of carrier rams, the genotype of all female progeny is known and these can be identified by an appropriate eartag. The structure described does not need to involve crossbreeding, but not to do so would forgo additional advantages of hybrid vigour in the crossbred dams and the terminal sire progeny. Clarke (1982) estimated that such a three way crossing could improve total weight of meat produced by a further 24 percent. However, based on the present industry structure, farmers utilising the Inverdale would choose to have two or all three tiers of the proposed Inverdale breeding structure on a single property, and crossbreeding would be restricted. Large corporate farmers may be an exception, as they could vary both the breeds and properties grazed by the various Inverdale genotypes to maximise production. In the tiered breeding structure, the proportion of ewes with the Inverdale gene is dependent on the prolificacy of the base ewes, because sufficient ewes are needed to generate female breeding replacements for the base flock, and it is the surplus ewes that can be mated to Inverdale rams. Based on industry figures (Anon. 1995a) of 100% lambs weaned/ewe mated, a 25% replacement rate, and a culling rate of 20% of ewe lambs, then 40% of all ewes could be carriers of the Inverdale gene and all their progeny would be sold for slaughter. Such stratified breeding regimes result in less culling pressure for replace-

ment female commercial stock (i.e. 20% versus 50% in a traditional purebred flock) and any benefits would have to be balanced against this. Results from visual culling of replacement stock (Harvey *et al.*, 1989), suggest the reduced culling would result in 0.032 fewer lambs weaned per ewe mated and 0.073 kg less wool/ewe/year. Liveweight differences are not included, as we assume that extra product value from heavier sale stock would be balanced by their increased feed requirement.

## Production of rams containing the Inverdale gene

In a flock producing Inverdale carrier rams, mating would be determined by an individual's Inverdale genotype, but otherwise selection would be similar to a normal performance-recorded flock. Inverdale carrier rams would be mated to breeding ewes to introduce the gene into the ram breeding flock. All female progeny would have one copy of the Inverdale gene but it would not be present in male progeny.

In subsequent matings ewes with one copy of the Inverdale gene would be joined with non-carrier rams (produced within or outside the flock). This mating produces four equal groups of progeny: namely rams and ewes each with or without one copy of the Inverdale gene. The Inverdale rams sold for breeding would be selected from the 50% of ram lambs containing one copy of the Inverdale gene. Normally one half of these animals would be sold for breeding. The best of the non-carrier ram lambs would be retained to mate Inverdale carrier ewes, with the rest sold for slaughter or as breeding rams to farmers not wishing to utilise the Inverdale gene. Only the best carrier female replacements would be retained. This would reduce selection pressure, but as the carrier ewes would have greater prolificacy the slightly reduced selection pressure would be concentrated on other traits. Breed Society flock book records show that dual purpose ram breeding flocks presently average 250 ewes. Inverdale ram breeding flocks retaining only carrier ewes would need to comprise 400 ewes to produce an equivalent number of rams. If five new rams are used per year and present flocks produce 120% lambs weaned to ewes mated, and ewes have a four year reproductive life, then the selection pressure would decline by 13% in Inverdale flocks. Inverdale ram production incurs additional costs, estimated at \$90 per ram sold if genetic tests cost \$10 each and recording costs \$5 per ewe.

Although this design is only one of several possibilities, all viable options for ram breeding flocks are dependent on an accurate and reasonably priced genetic test being available to determine the genotype of the progeny of carrier ewes. The advantages of the breeding programme described are that beneficial genes from outside the flock, e.g. semen from high ranking rams in sire referencing programmes, can be easily used. Secondly, no complicated mating designs are required as each sex contains only one Inverdale genotype. Disadvantages include the continuing costs of the genetic tests, increased flock size and therefore greater recording costs per ram sold, although this is partially compensated by extra sale lambs produced.

## Economic benefits from use of the Inverdale gene

Potential benefits of the Inverdale gene to the New Zealand industry are difficult to quantify because of assump-

tions about adoption rates, economic benefits, discount rates, and breed crosses used. For evaluation of the Inverdale gene, Animalplan relative economic values of \$13.80 per lamb and \$3.90 per kg wool have been used. These are calculated using a gross margin approach, adjusted for alterations in feed requirement, predictor trait measured, and expressed on a per ewe/year basis (Binnie and Clarke, 1992). They are not discounted. If the Inverdale gene was used to the maximum extent possible in Romney and Romney-derived breeds, some 40% of dual purpose ewes would contain a copy of the Inverdale gene, producing 31% more lambs for sale per ewe mated. The gross profit would be \$4.28 per Inverdale ewe per year or \$55 m per year for New Zealand farmers. However, additional costs of generating Inverdale rams and the reduction from lower culling proportions of female replacements need to be subtracted from this figure. If Inverdale rams were mated at average ram to ewe ratios of 1:80, and used for four years (Anon 1995a) with 20% of replacement females culled, each ram would produce 128 ewes. The extra \$90 required to produce an Inverdale ram is equivalent to 18 cents per Inverdale breeding ewe per year. Reduced culling of commercial female replacements would result in a loss of 73 cents per ewe per year for all ewes, or \$1.83 when expressed per Inverdale ewe per year. Thus the net benefits to New Zealand sheep farmers would be \$2.27 per Inverdale ewe per year or \$29 m. The benefit to the New Zealand economy in the form of increased farm export receipts would be several fold larger

than those received by the farmer. These figures do not include any benefits from cross breeding, either in Inverdale dams or the terminal sire progeny from these dams, which would contribute sizeable additional benefits.

### **The future**

Increased financial return is essential if new technology is to be adopted by the sheep breeding industry, but other aspects are also relevant. One of the most important is a lack of risk or variability in the returns. The Inverdale gene only increases the lamb output, so it is subject to variability in lamb prices and lamb survival. However, this is a normal risk for sheep producers, and existing farming structures should suit the adoption of new technology. The three tiered breeding structure required for efficient use of the Inverdale gene is readily understood and currently used in New Zealand, although not to the extent required to obtain maximum benefit from the introduction of the Inverdale gene. Farmers can have all three tiers present on a single property and within a single breed. The technology also has to be released in a package that can be simply implemented. The structures described are an example of such a package, but they depend on a DNA-based test to detect Inverdale carrier rams and ewes. This test is still under development. Meanwhile, the Inverdale gene is being evaluated under field conditions on three properties in South Otago and on Limestone Downs in South Auckland as a forerunner to its release to industry.