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Impacts of animal genetic gain on the profitability of three different grassland farming systems producing red meat

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A B S T R A C T

Animal productivity has increased rapidly in the latter half of the 20th century through the selection of desirable traits using genetics. Evaluating the impact of genetic gain on the profitability of farm systems has relied primarily on the use of economic indices valuing the extra production per unit of feed required. The impact on the performance of the whole farm system, however, is often overlooked. In this study the impact of genetic gain in sheep, beef and deer on the performance of three different livestock farming systems (sheep & beef, mixed sheep, beef and deer, and deer only) in four distinct climatic regions of New Zealand is investigated. A whole farm system optimisation model that maximises farm profit by optimising the allocation of feed to livestock was used for the analysis. Scenarios are replicated using climatic variability over a ten year period within each region. Animal genetic gain is predicted to increase profitability in all of the farming enterprises and climatic environments investigated except during winter cold, high summer soil moisture deficit environment. The increase in profitability is the result of a combination of interactions occurring on-farm, including the need for fewer capital animals to utilise the fixed feed resource at the same time as prime animals that grow faster and are sold earlier at a heavier live weight. This farm system analysis indicates that there is considerable scope for the expansion of the deer industry and that other than a pasture management tool, beef cattle will play less significance in the future as they are a less profitable livestock species than sheep and deer.

1. Introduction

Livestock practitioners have selected on phenotypic traits that are desirable since the domestication of livestock began around 10,000 years ago (Hayes et al., 2013). Advancements in technology in the latter half of the 20th century have allowed for a rapid increase in genetic gain (Garrick et al., 2000). The genetic merit of animals being farmed has a significant impact on whole farm profitability (Archer, 2003; Byrne et al., 2012). Future gains in productivity from genetic improvement are predicted to continue (Archer and Amer, 2009; Byrne et al., 2010; Wickham et al., 2012), but how that fits within a farm system with a finite feed resource is not well understood.

Intensive livestock production systems in New Zealand are characterised by in situ grazing of pasture with profitability depending heavily on matching animal demand with the seasonal pattern of growth of the pasture resource (McCall and Sheath, 1993). Red meat production from sheep, beef and red deer comes from a diverse range of topography and climatic zones (Daly, 1990). Within farm there can also be considerable variation in landscape units and micro-climates. Increasing competition from more profitable land uses has displaced the traditional red meat livestock finishing systems from highly productive cultivatable low land environments into uncultivable hill land. In these environments, finishing of livestock is more challenging (Copland and Stevens, 2012) because of reduced options for manipulating forage supply (Grant et al., 1983; Lambert et al., 2003). Consequently profitability is also highly variable (Hawkins and Wu, 2011).

Farm enterprises that produce red meat invariably have a range of livestock enterprises. For example, New Zealand hill country farms may produce mutton, lamb, beef and venison. These mixed enterprises mitigate risk (Gray et al., 2011) and offer flexibility to maximise whole farm utilisation of the pasture resource (McCall and Sheath, 1993). This results in competition between livestock enterprises for the pasture resource in the search for maximum meat production and farm profitability. The balance between enterprises is likely to change over time if the competitive advantage of one enterprise exceeds another.

Indices to evaluate genetic gain in livestock have been developed for a number of traits. These traits are used to calculate economic indices to provide an indication of the value of the trait to the farm system (Amer et al., 1999; Archer and Amer, 2009). Economic indices are based largely on the extra production obtained per unit of feed required from the investment in genetic merit (e.g., Amer et al., 1999). They use a marginal costing approach (e.g., extra cost associated with the genetic gain) and

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more importantly rely on an estimate of the production gains from the new genetic merit in on-farm environments which are inherently highly variable (Archer and Amer, 2009). This is confounded further by the fact that the profitability of the whole farm system is highly dependent on the fit of animal demand to seasonal pasture supply. Any mismatch in the utilisation of feed will reduce farm profitability and as a consequence the calculation of genetic merit. To these limitations, must be added the fact that each livestock species has separate economic indices (e.g., sheep – Amer (2000); beef – Johnston (2007); red deer Archer and Amer (2009)). This raises the question about the configuration of existing farm systems and whether they capture all the benefit from genetic gain.

This is complicated further by the variation introduced by climate both between years and across regions, as it impacts on both the livestock policy and performance and farm profitability (Li et al., 2012), through its influence on pasture growth (Radcliffe and Baars, 1987). Assessing the economic merit of an investment in one versus another animal trait with this uncertainty represents an additional challenge to the farmer.

This paper investigates the impact of potential genetic progress in 10 years on the productivity of sheep, beef and red deer in a range of livestock farm systems. A whole farm optimisation model is used to determine optimal livestock enterprise configurations to maximise the benefits of predicted genetic gain and the profitability of farms in four contrasting climatic zones.

2. Materials and methods

2.1. General

For the purposes of this study four climatic environments within New Zealand were chosen. These four environments include 70% of all red meat producing farmers in New Zealand (Beef and Lamb, 2014). The environments included are a winter cold, summer moist environment represented by the Southland region, winter cold, summer dry environment represented by the Canterbury region, winter cool, summer dry environment represented by the Hawkes Bay region and a winter warm, summer moist environment represented by the Waikato region. Farms in each environment include two topographies, flat to rolling land (cultivatable) making up 30% of total area and moderate to steep (uncultivable) land making up the remaining 70% of total farm area with a total land area equal to 500 ha. The exception to the topographies was the winter cold summer dry environment (Canterbury) where an irrigated area (30% land area) and a dryland area (70% land area) are used. The cultivatable or irrigated areas represented a more fertile or lower moisture deficit area that has a higher pasture growth rate than the uncultivatable hill or dryland areas. These topographies are represented as Land Management Units (LMUs) in the model.

Three livestock enterprise mixes were chosen, sheep & beef (S&B), sheep, beef and deer (Mixed) and deer only (Deer only). The S&B and Deer only enterprises consisted of two LMUs each, one cultivatable and one uncultivable. In the Mixed enterprise deer were restricted to half of the farm area by using four LMUs, two for sheep and beef animals only and two for all livestock species. Each half of the farm had one cultivatable LMU and one uncultivatable LMU at the 30:70 split. The two animal performance scenarios explored are the current genetic merit of sheep, deer and cattle (current) and the future performances in 10 years (future) based on predictions from current trends obtained from Sheep Improvement Ltd., DEERSelect, and the NZ Angus Breeders Association, respectively.

The rainfall, temperature and soil moisture deficit parameters are represented in Fig. 1. Each environment also has specific soil physical and chemical characteristics (Table 1). The combination of these attributes was used to develop pasture growth curves using the simulation model Agricultural Production System Simulator (APSIM version 7.5; Keating et al., 2003). The AgPasture module (Li et al., 2011) in APSIM calculates daily pasture growth rates utilising climatic data (Tait et al., 2006), and soil data (Table 1) which is then aggregated into two weekly periods (Fig. 2). The grazing regimes used in the APSIM model are defined in Li et al. (2011). The APSIM model occasionally generated negative net growth rates that appeared to be extreme, so is restricted to a minimum net growth rate of negative 5 kg DM/day. Pasture growth is based on perennial ryegrass/white clover. Pasture covers are constrained between 1200 and 2500 kg DM/ha in the optimisation model to ensure that both quality and growth rates are practical.

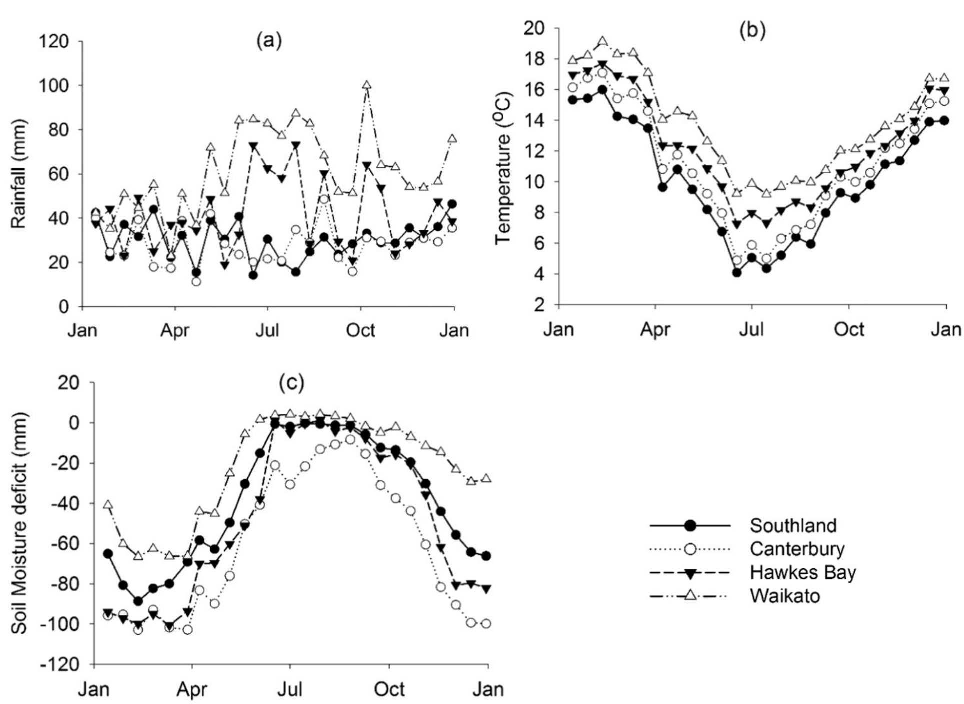

Fig. 1. Average rainfall, temperature and calculated potential soil moisture deficit profiles (using the years 2000–2009) for four climatic environments around New Zealand.