The Influence Of Sexual Dimorphism On The Feed Efficiency Of Lamb Production

B. Gudex[*], B. Walmsley[†], C. Gondro[*] and J. van der Werf*

Introduction

A review of the literature reporting mature weights of ewes and rams from the same flock revealed that the range of sexual dimorphism (ram/ewe weight) varies between 1.0 (no difference between rams and ewes) and 1.5 (rams 50% heavier than ewes). Furthermore, Gudex *et al.* (2009) demonstrated that it is possible to alter the magnitude of sexual dimorphism in sheep via genetic selection. Studies in other species have shown that sexual dimorphism can alter the feed efficiency of meat production systems. Jaap (1969) found that the use of a known recessive, sex linked dwarfism gene in chickens reduced the size of female parents by 30% and their feed requirements by 33%. Roux *et al.* (1992) found that bulls 60% larger than cows could increase feed efficiency by up to 16% depending on the percentage of heifers required as replacements. No such studies have been conducted in sheep. This study evaluates the effect that genetic selection on sexual dimorphism could have on the feed efficiency of lamb production by comparing the nutritional requirements of each sex in the presence of sexual dimorphism varying between 1.0 and 1.5.

Material and methods

Production System Simulated. A self replacing sheep flock producing one lamb per ewe per year was simulated. The amount of sexual dimorphism present was varied between 1.0 and 1.5 around an average mature weight of 65 kg for both sexes (see Figure 1). The 65kg mature weight was chosen as it is the average ewe mature weight given in the November 2008 1st cross ewe gross margin budgets for New South Wales (Industry & Investment NSW, 2009). The age structure of the flock and the number of replacements required per year was determined by 4.0% adult mortality per year, a ram requirement of 1 to 50 ewes and each ewe lambing for the first time at 2 years of age and for the last time at 5 years of age. During their lifetime, an average ewe would have 4 lambs, 2 of which (assuming a 50:50 sex ratio) will be ewes and 2 will be rams. Of the 2 ewe lambs, 1 will be required to replace the ewe and of the 2 ram lambs, 0.02 will be required to replace her ram requirement. It was assumed that all lambs not required as replacements were sold upon reaching a 21kg carcass weight (44.7kg live weight). The value given to these lambs was AU$85.10 (Industry & Investment NSW, 2009).

[*] School of Environmental and Rural Science, University of New England, Armidale 2351, NSW, Australia
[†] Industry & Investment NSW, Beef Industry Centre, University of New England, Armidale 2351, NSW, Australia

Growth and Nutritional Model. The growth and body composition model of Amer and Emmans (1998) was used to predict the growth and nutritional requirements of both sexes. This model is based on a Gompertz function ($u_t = exp(-exp(G_0 - B \cdot t))$ and estimates the unconstrained growth of protein, fat, water and ash in the body as a function of protein maturity, with the empty body weight being the sum of these components. The daily energy requirements were estimated from the energy required for maintenance and the energy required for the retention of protein and lipid during growth. The energy content of pasture (10.5 MJ/kg DM) given by Amer and Emmans (1998) was then used to convert the energy requirements (MJ) into pasture (feed) requirements (kg). The overall feed efficiency was defined as the amount of pasture consumed per weight of carcass sold.

Model Parameters. The chemical composition of mature ewes and rams reported by Thompson and Butterfield (1985) was used to derive the mature protein weight (P_m), lipid to protein ratio (Q), water to protein ratio (R) and ash to protein ratio (S) parameters required by the Amer and Emmans (1998) model. A rate parameter of 0.023 was taken from Jones *et al.* (2004). Lamb birth weights of 4.71kg for ewes and 5.01kg for rams were obtained from the average of the maternal breeds on the Sheep Genetics database (Daniel Brown *pers. comm.* 16/9/2009). The chemical composition of newborn lambs reported by Blaxter (1985) was used to derive the initial protein weight (P_m) and initial condition (G_0) required in the model.

Results and discussion

Growth curves for ewes and rams simulated using the Amer and Emmans (1998) model with sexual dimorphism at maturity set to 1.0 and 1.5 are presented in Figure 1. Mature weight for rams was 25.96kg or 49.9% higher than ewes when sexual dimorphism at maturity was set at 1.5.

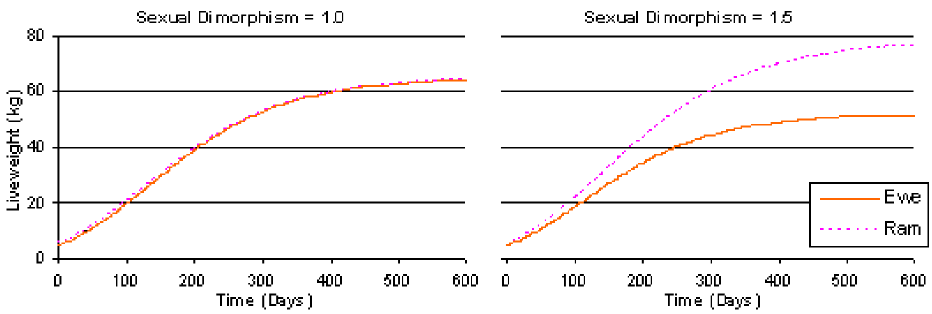

Figure 1: Simulated ewe and ram growth curves where sexual dimorphism was set at 1.0 and 1.5.

Figure 2 shows the variation in feed requirements that occur as a consequence of variation in sexual dimorphism. Both graphs clearly show the higher feed requirements of ewes when at the same weight as rams. This is due to the higher fat content of the ewe body and the greater energy cost of depositing fat compared with protein (Amer and Emmans, 1998). The slower growth to a 21kg carcass weight of ewes when sexual dimorphism is present (305 days for ewes with sexual dimorphism of 1.5) compared to rams (208 days for rams with sexual dimorphism of 1.5) also increases the cumulative feed requirements for maintenance. The time taken to reach a 21kg carcass weight when sexual dimorphism is absent was 236 days in both sexes. Although not tested in this study, the time taken to reach a 21kg carcass weight for each sex is important when the availability of pasture and the prices received for lamb vary throughout the year. The lower feed requirements of rams to reach the same carcass weight also demonstrates the potential feed efficiency benefits of single sex production systems that use advanced reproductive technologies, e.g. sexed semen.

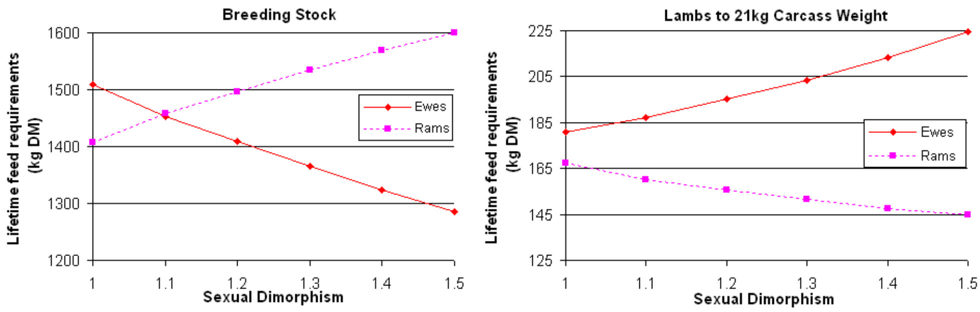

Figure 2: The relationship between sexual dimorphism and the cumulative lifetime feed requirement of breeding stock and sale lambs slaughtered at 21kg carcass weight.

Figure 3 shows the benefits in feed efficiency that can be gained by increasing sexual dimorphism via genetic selection. It should be noted that the increase in efficiency with sexual dimorphism is not linear; suggesting that as sexual dimorphism increases above that tested in this study, there may be no further benefits and at some level of sexual dimorphism, detrimental effects may develop though no detrimental effects were observed in the beef cattle study of Roux (1992) who evaluated sexual dimorphism up to 2.0 (bulls twice the weight of cows). The increase in feed efficiency found in this study would allow a farm that traditionally carried 1000 ewes with no sexual dimorphism to carry an extra 106 production units (ewes with their associated lambs and ram requirement) if sexual dimorphism reached 1.5 (10.6% increase). This translates to an extra AU$6,755.11 income from lamb sales for a 1000 ewe flock once the extra replacement requirements are taken into consideration.

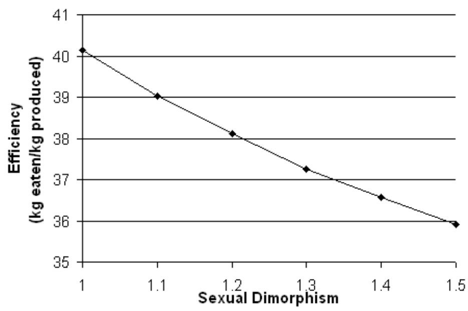

Figure 3: Graph of the relationship between feed efficiency and sexual dimorphism

The simplified representation of the production system used in this study is a constraint of the current approach. For example, the nutritional costs of pregnancy, lactation and wool growth were not included in the current model and some economic factors known to influence the profitability (e.g. per animal costs (shearing, drenching) and the value of wool and salvage ewes) were also omitted. Of these factors, the weight and subsequent salvage value of the breeding stock is directly affected by sexual dimorphism. The influence of sex dimorphism on feed efficiency is also likely to be sensitive to variation in fertility and longevity as these factors will influence the number of replacements required and consequently the number of lambs available for sale (Roux 1992). Increased longevity also places more emphasis on the maintenance component of feed requirements, potentially making smaller ewes more valuable.

Conclusion

These results clearly show that the presence of sexual dimorphism in a flock is valuable and that sexual dimorphism is an important consideration when formulating selection objectives where feed efficiency is considered desirable. However, there are additional factors that need to be incorporated into the model before definitive economic values can be estimated.

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