Evaluation of the South African small stock genetic resources for production and meat quality traits.

Jasper J. E. Cloete

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Supervisor: Dr L.C. Hoffman

Co-supervisor: Dr S.W.P. Cloete

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature :

Date: 23/2/2007

ABSTRACT

Title	: Evaluation of the South African small stock genetic resources for production and meat quality traits
Name	: Jasper J.E. Cloete
Study leader	: Prof L.C. Hoffman
Department	: Animal Sciences
University	: Stellenbosch
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The study includes separate papers, which are all linked by their emphasis on the evaluation of South African small stock genetic resources for production and meat quality. This abstract is intended to provide readers with a broad overview of the outcomes of the study.

Part 1: Comparison of breeds

Chapter 2 dealt with the slaughter and meat quality traits of wool (Merino), dual-purpose (Dohne Merino and South African Mutton Merino (SAMM)) and meat type (Dormer) sheep. The more expensive retail cut weights were higher in the meat type sheep but the latter breeds also had a thicker fat cover. Dormer and SAMM sheep had heavier but fatter carcasses than Merinos and Dohne Merinos, with no marked differences in meat quality among breeds.

Chapter 3 provides production parameters obtained from Merino, Dohne Merino and SAMM stud flocks. An economic simulation indicated differences in gross income per small stock unit between the breeds. Merinos generally outperformed the other two breeds in terms of income per small stock unit.

In Chapter 4, Dorper, Merino and Boer Goat breeds were compared on reproduction potential. Reproduction and growth of the three breeds were comparable with figures found in the literature. An economical analysis indicates that Merino ewes outperformed the other two breeds in terms of income per small stock unit.

Part 2: Assessment of Merino and Merino type ewe breeds as terminal dam lines

Chapter 5 details the production performance of ewes that originated from a terminal crossbreeding experiment that involved five Merino type dam lines and two terminal crossbreeding sire lines (Dormer and Suffolk). In Chapter 6 slaughter data and meat quality of the crossbred progeny were compared and discussed. Differences between progeny in slaughter age, marketing weight, dressing percentage and carcass weight could largely be attributed to the comparison of purebred Merino lines with dual-purpose lines. In Chapter 7 an economic simulation indicated large differences in gross income per small stock unit between ewe lines.

Chapter 8 provides details of slaughter traits of lambs born from a terminal crossbreeding experiment that involved Merino ewes crossed with Dormer, Ile de France, Merino Landsheep, Suffolk and Dorper rams, purebred Merinos were used as control. No conclusive advantages in favour of any of the terminal sire breeds were obtained.

Part 3: Importance of carcass quality using leaner sire breeds on early maturing Dorpers

In Chapter 9 Dorper ewes were crossed with Ile de France, Merino Landsheep and SAMM rams to produce lean carcasses without sacrificing growth performance. Terminal crossbred lambs were equal to or superior to purebred Dorpers with regard to quantitative and qualitative carcass parameters evaluated (Chapter 10). SM2000 economic simulation model was used to assess the economic output of the respective breed combinations and discussed in Chapter 11. No real differences were found for income per small stock unit between the different crossbred combinations and purebred Dorper lambs. Terminal crossbreeding could thus be implemented in commercial Dorper flocks, without compromising productivity and/or product quality.

Implications

The study revealed marked differences in the performance of the breeds contributing to the South African small stock genetic resource. As with other experiments with finite monetary and animal resources, animal numbers (and especially those of sires sampled to represent a breed) were relatively low. Further studies on the evaluation of the South African small stock genetic resource is indicated. Studies on the integration of sheep breeds in structured crossbreeding systems should have a high priority, since it appears to be a sustainable way to ensure economic viability of commercial small stock production.

OPSOMMING

Titel	: Die evaluasie van die genetiese bronne vir produksie- en vleiskwaliteitseienskappe van Suid-Afrikaanse kleinvee rasse
Naam	: Jasper J.E. Cloete
Studieleier	: Prof. L.C. Hoffman
Departement	: Veekunde
Universiteit	: Stellenbosch
Graad	: PhD. Agric

Die tesis bestaan uit aparte artikels wat almal verband hou met die belangrikheid van die evaluasie van Suid –Afrikaanse kleinvee genetiese bronne vir produksie en vleiskwaliteit. 'n Opsomming van die artikels het dus ten doel om die leser 'n breë perspektief oor die uitkomste van die studie te voorsien.

Deel 1: Vergelyking tussen rasse

Hoofstuk 2 handel oor die slag- en vleiseienskappe van wol (Merino), dubbeldoel (Döhne Merino en Suid-Afrikaanse Vleis Merino (SAVM)) en vleistipe (Dormer) skape. Die duurder snitte was swaarder in die vleistipe rasse en die vleistipes het ook meer onderhuidse vet gehad. Daar is gevind dat Dormer en SAVM skape swaarder en vetter as Merino's en Döhne Merino's was, met geen duidelike verskille in vleiskwaliteit tussen die rasse nie.

Hoofstuk 3 verskaf inligting oor produksie-eienskappe, afkomstig van Merino, Dohne Merino en SAVM stoetkuddes. 'n Ekonomiese ontleding het aangedui dat die inkomste per kleinvee-eenheid tussen die drie rasse verskil het. Merino's het in terme van inkomste per kleinvee-eenheid oor die algemeen 'n hoër inkomste as die ander twee rasse gelewer.

Hoofstuk 4 handel oor 'n vergelyking tussen Dorper, Merino en Boerbokke in terme van reproduksiepotensiaal. Reproduksie- en groeiresultate van die drie rasse is in ooreenstemming met syfers in die literatuur. 'n Ekonomiese ontleding het aangedui dat inkomste per kleinvee-eenheid van Merino-ooie hoër was as die ander twee rasse.

Deel 2: Ondersoek van Merino en Merino tipe ooie as 'n terminale moederlyn

Hoofstuk 5 handel oor die produksievermoë van ooie en lammers afkomstig uit 'n terminale kruisteeltproef met vyf Merinotipe ooilyne en twee terminale kruisteelt ram rasse (Dormer en Suffolk). In Hoofstuk 6 word slagdata en vleiskwaliteit van die kruisteeltnageslag vergelyk. Die nageslag van suiwer Merino- en dubbeldoellyne het in terme van slagouderdom, bemarkingsgewig, uitslagpersentasie en karkasgewig verskil. In Hoofstuk 7 dui 'n ekonomiese ontleding aan dat daar groot verskille tussen ooilyne is, i.t.v. inkomste per kleinvee-eenheid.

Hoofsuk 8 verskaf inligting oor slageienskappe van lammers van 'n kruistelingsproef waartydens Merino-ooie met Dormer-, Ile de France-, Merino Landskaap- , Suffolk- en Dorperramme gekruis is. Suiwer Merinoramme is as kontrole gebruik. Geen duidelike voordele ten gunste van enige van die terminale ramrasse is gevind nie.

Deel 3: Belangrikheid van karkaskwaliteit deur gebruik te maak van maerder ramrasse gekruis met vroegryp Dorperooie

In Hoofstuk 9 word Dorperooie in 'n terminale kruisteeltstelsel gepaar met Ile de France- , Merino Landskaap- en SAVM ramme om karkasse te produseer sonder om groei in te boet. Daar is gevind dat terminale kruisteeltlammers dieselfde of beter as suiwer Dorperlammers gevaar het met verwysing na kwalitatiewe en kwantitatiewe karkaseienskappe (Hoofstuk 10).

SM2000 ekonomiese simulasiemodel is gebruik om 'n ekonomiese uitkoms te verkry van die verskillende raskombinasies en word in Hoofstuk 11 bespreek. Geen betekenisvolle verskille is gevind vir inkomste per kleinvee-eenheid tussen die verskillende kruisteeltkombinasies en suiwer Dorperlammers nie. Terminale kruisteling kan dus gebruik word in kommersiële Dorperkuddes sonder om produktiwiteit of produkkwaliteit te beïnvloed.

Implikasies

Die studie toon duidelike verskille in die produksie- en reproduksievermoë van verskillende rasse om bydrae tot die genetiese materiaal van die Suid Afrikaanse kleinveebedryf te maak. Soos met ander proewe met beperkte geld en natuurlike hulpbronne was die aantal diere, veral ten opsigte van die aantal ramme wat gebruik is om 'n ras te verteenwoordig, relatief laag. Verdere studies oor die evaluasie van die Suid-Afrikaanse kleinvee genetiese hulpbronne is egter nodig. Studies oor die integrasie van verskillende skaaprasse in gestruktureerde kruistelingstelsels blyk 'n hoë prioriteit te wees, omdat dit voorkom of dit 'n manier is om volhoubaar en ekonomies met kleinvee te boer .

CONTENT

Language and style in this thesis are in accordance with requirements of the *South African Journal of Animal Science.* This thesis represents a compilation of manuscripts; each chapter is an individual entity and some repetition between chapters is therefore unavoidable.

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List of publications and congress contributions from this thesis:

Publications:

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Cloete, S.W.P., Cloete, J.J.E., Herselman M.J. & Hoffman, L.C., 2004. Relative performance and efficiency of five Merino-type dam lines in a terminal crossbreeding system with Dormer or Suffolk sires. S. Afr. J. Anim. Sci. 34, 135-143.

Cloete, J.J.E., Cloete, S.W.P. & Hoffman L.C., 2006. Carcass characteristics and meat quality of progeny of five Merino type lines, crossed with Dormer and Suffolk sires. S. Afr. J. Anim. Sci. (in press).

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Congress contributions:

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Cloete, J.J.E., Cloete, S.W.P. & Hoffman L.C. 2006. Comparative analysis of reproduction potential of Dorper, Merino and Boer Goat ewes under extensive production conditions in South Africa. Developing animal agricultural interest group, South African Society for Animal Science. Upington South Africa. 3-6 July. (Presentation)

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Cloete, J.J.E., Hoffman, L.C., Cloete, S.W.P. & Olivier J.J., 2004. Crossbreeding of Dorper ewes with Ile de France, SA Mutton Merino and Merino Landsheep rams. The 1st Joint Congress of the Grassland Society of Southern Africa and the South African Society of Animal Science. Christiana, South Africa. (Presentation)

Chapter 1

General Introduction

Background

In South Africa there are 29 million sheep and four of the most popular sheep breeds are the Merino, Dohne Merino, SA Mutton Merino (SAMM) and Dorper sheep (Campher *et al.,* 1998). The small stock industry has an overall gross turnover of approximately R 3.5 billion nationwide. The small stock industry was demonstrated over many decades to be very versatile and adaptable, being practiced in environments ranging from arid, low productivity regions to fairly intensive enterprises in the pasture–cropping regions and intensive horticultural areas. The Western Cape contributes approximately 15 % of small stock production to the national industries. Small stock farming is well adapted to complement the cropping, horticulture and viticulture that is typical to the region. The small stock industry has provided Western Cape farmers with a stable, reliable income over years, adding stability to the more capital and labour intensive plant industries. It is particularly well adapted to complement the cropping industry, utilizing crop residues and the by-products of ley-farming systems that are preferred at present. In years of crop failure, due to drought or disease, as well as during periods of unstable grain prices, farmers in the Swartland and Southern Cape regions of South Africa depend on small stock farming as their only means of providing a livelihood for their families and employees.

Another advantage of small stock is that they can enable sustainable production on low potential, extensive pastoral areas, where no alternative farming ventures can be practiced. Small stock farming is, in fact, the only viable farming enterprise in the vast extensive Karoo regions of the central part of South Africa. Many rural communities depend on small stock for their very existence, and for the maintenance of viable human societies. Without the money generated by small stock products, many rural towns would simply cease to exist. Most sheep are found in the Eastern Cape, where it provides a source of sustenance to many resource-poor farmers in the former Transkei and Ciskei regions. However, vast areas of the Karoo ecotype are also found within the boundaries of the Western Cape.

The primary sheep and wool industry also benefits all participants in the associated secondary industries, namely the slaughter, wool processing and tanning industries. Until recent years lamb (meat) production has been a by-product of the wool industry. At present 65-88 % of the total South African income from wooled sheep is derived from meat, contributions is even higher in the case of mutton and dual purpose sheep (Hoon *et al*., 2000).

In South Africa the genetic evaluation program for slaughter lamb production is not well structured. The National Small Stock Improvement Scheme (NSIS) captures data for a number of breeds, including terminal sire breeds with potential usage in commercial slaughter lamb production (Olivier *et al*., 2004). However, there is no formal structure to integrate the breed analyses emanating from the NSIS with commercial slaughter lamb production. No research has been done on a recording system that predicts an individual animal's ability to produce progeny that meet the requirements of the current and future markets for lamb products. Ideally seed stock breeders and slaughter lamb producers should work together to get simple, accurate and practical information on the genetic value of an animal, independent of non-genetic (environmental) influences on the animal's exhibited performance for a comprehensive range of product traits. All major terminal, maternal and dual-purpose breeds need to be comparable across flocks within breed for maternal and dual-purpose breeds. Across-breed evaluations have also become routine in other parts of the world (Fogarty, 2006). So far, nothing of this nature has been attempted in the South African small stock genetic resource.

South African scientists have a proud record of published research on various aspects of sheep and wool science, and genetic parameters and responses to selection of South African genetic resources are commonly available. However, most past research projects only involved wool-type or meat type animals with little attention to integration in production systems (see Schoeman & Burger, 1992; Olivier *et al.*, 2000; Cloete *et al.*, 2002; Fourie *et al.*, 2002; Cloete *et al.*, 2004). Crossing was mostly used for the development of composite breeds (Olivier *et al.*, 1984; Snyman *et al.*, 1998), while research on commercial crossbreeding is limited to a few studies (Erasmus, 1965; Erasmus *et al.*, 1983; Cloete & Durand, 2000). Research on crossbreeding has been discouraged in the 1970's and 1980's, owing to the importance of the then vibrant local wool industry to the economy, and perceptions that injudicious crossing may jeopardise the entire industry.

Comparison of breeds

Research involving breed comparisons is political by its very nature, and often discouraged because of vested interests. It is also fraught with complications, such as relatively small sample sizes and the possible misrepresentation of the sample population of the overall animal resources (Fogarty, 2006). Very few studies comparing small stock breeds in South Africa have been done, and the studies that were done are characterized by low numbers (Basson *et al.*, 1969; Webb & Casey, 1995). A study by Cloete *et al.* (1999) involving University of Stellenbosch Merino, Dohne Merino and South African Mutton Merino (SAMM) flocks is a possible exception, since fairly large flocks with several introductions from the local stud industry in each flock were used. Only a few studies involving breed effects on meat quality have been reported (Webb & Casey, 1995; Sheridan *et al.*, 2000; Cloete *et* al., 2004) in South Africa. The question also remains if breed comparisons published overseas could be extrapolated to South African conditions, given the unique animal resources and managerial practices in the local industry.

Assessment of Merino and Merino type ewe breeds as terminal dam lines

Merino and Merino type ewes are the bulk of the South African flock (11,7 million sheep vs. 6.2 million non wool sheep). At the present wool:meat price ratio, most of the financial income acquired in a wool sheep enterprise is derived from meat, and particularly from the marketing of lambs. Fluctuations in the ratio between wool and meat prices have resulted in the emphasis on the two products changing markedly over the past decade. This resulted in distinct changes in the South African Merino industry involving the adaptation of the breeding strategy for Merino sheep to enable an improved meat production capability

(Olivier, 1999). Given that changes in the breeding strategy are not likely to realise marked changes on the short term, alternative strategies also need to be considered on the commercial level. One such strategy is the production of commercial crossbred slaughter lambs where the crossbred lambs are expected to have a higher birth weight, and better growth performance (relative to the mean of the parent breed) up to the age of weaning and should reach the mature slaughtering weight in an intensive fattening system faster. Crossbred lambs are also expected to exhibit a better survival than purebred lambs.

Crossbreeding is a powerful tool for the animal breeder and is of critical importance to the meat sheep industry. Considerable improvement in efficiency can be achieved, increasing the total weight of lamb per ewe joined per year by the exploitation of maternal heterosis (Fogarty *et al.*, 2000). Crossbreeding of Merino type ewes with mutton type rams in a terminal crossbreeding system is often seen as an option to achieve gains from direct heterosis of crossbred lambs (Kleeman *et al.*, 1983). It is possible for commercial producers to spread risk over the meat and wool commodities by combining complementary sheep genetic resources in a structured crossbreeding system.

Key aims and indicators of success in a structured crossbreeding enterprise:

- To maximize the effect of heterosis and production performance, direct heterosis is measured as the extra performance of the crossbreds over the weighted average of their parents. The percentage increase in performance ranges from about 3-10% for growth traits (Piper & Ruvinsky, 1997; Fogarty, 2006). Estimates of individual heterosis are higher for survival (0.10), while maternal heterosis for lamb production traits are estimated at 0.10 to 0.40 (see review by Fogarty, 2006).
- A good crossbreeding system aims to use breeding ewes that are small as well as prolific. When a large breed of ram is used the proportion of total feed directed to growing animals is increased and the production system benefits accordingly (Dickerson, 1978; Roux, 1992; Schoeman *et al.*, 1995).
- Choice of crossbreeding system – the best crossing system depends to a large extent on the characteristics of the breeds that are available (Kirton *et al.*, 1995).
- Crossbreeding systems can be driven largely by the supply/demand situation for parental stock and are quite prevalent in the overseas meat sheep industries (Teixeira *et al.*, 1996; Piper & Ruvinsky, 1997; Doloksaribu *et al.*, 2000; Freking *et al.*, 2000; Snowder & Duckett, 2003). In the Western Cape province of South Africa, Merino and Merino type ewes are generally available for crossbreeding with specialist sire breeds.

Importance of carcass quality using leaner sire breeds on early maturing Dorpers

The Dorper is a composite breed derived in South Africa from a cross between the Dorset Horn and the Blackheaded Persian (Milne, 2000). The Dorper has grown to be the second largest sheep breed in South

Africa, and it accounts for the vast majority of meat sheep. With approximately 6 million breeding ewes, it is also one of the largest commercial breeds in South Africa. Breeding stock has also been exported to other countries. Dorper sheep are regarded as early maturing and therefore tend to put on fat at a relatively early age. The propensity of Dorper lambs to put on more localised fat at lower live weights than late maturing breeds is seen as a disadvantage (Greeff *et al.*, 1988). It is generally accepted that modern consumers demand leaner cuts of lamb, resulting in leanness becoming an important breeding objective for slaughter lamb production (Gilmour *et al.*, 1994). The terminal crossbreeding of Dorper ewes with rams of relatively lean breeds could be considered, with the aim of improving the carcass value of the crossbred offspring and enhancing consumer satisfaction. Using later-maturing breeds as sire breeds may have the advantage of producing carcasses with optimal fat thickness and distribution at a heavier live weight compared to purebred Dorpers (Schoeman, 2000). The Dorper has never been used as a dam line for terminal crossbreeding studies in South Africa, although ewe numbers allow for a proportion of the ewes to be mated to specialist terminal sires.

Objectives

Within the South African scenario, very little research has been conducted on the benchmarking of small stock genetic resources for the production of alternative commodities. Very little information on the meat quality of these breeds are generally available. There is also a lack of crossbreeding systems that utilise local sheep resources, while the meat quality of such crosses has also not been evaluated. In this study meat quality and production level of some of the most popular local small stock breeds were compared, as well as crossbreeding systems using these breeds as dam and / or sire lines. The overall aim of the study was not to detract from possible niche markets and commodities produced by each of these breeds, but rather to identify systems that are more profitable for the farmer in the Western Cape area of South Africa. It was also attempted to identify circumstances where the desired properties of some of these breeds could be combined in structured crossbreeding systems on the commercial level.

References

Basson, W.D., Van Niekerk, B.D.H., Mulder, A.M. & Cloete, J.G., 1969. The productive and reproductive potential of three breeds mated at 8-monthly intervals under intensive feeding conditions. Proc. S. Afr. Soc. Anim. Prod. 8, 149-154.

Campher, J.P., Hulun, C. & Van Zyl, G.J., 1998. South African Livestock Breeding. South African Stud Book and Livestock Improvement Association. PO Box 270. Bloemfontein 9300, South Africa.

Cloete, J.J.E., Cloete, S.W.P., Hoffman, L.C. & Fourie, J.E., 2004. Slaughter traits of Merino sheep divergently selected for multiple rearing ability. S. Afr. J. Anim. Sci. 34, 189-196.

Cloete, S.W.P., Coetzee, J., Schoeman, S.J., Morris, J. & ten Hoope J.M., 1999. Production parameters for Merino, Dohne Merino and South African Mutton Merino. Proc. Assoc. Advmt. Anim. Breed Genet. 13, 181-184.

Cloete, S.W.P. & Durand, A., 2000. The crossing of commercial Merino ewes with South African (SA) Meat Merino rams for an increased lamb output. Aust. J. Exp. Agric. 40, 11-16.

Cloete, S.W.P., Scholtz, A.J. & Taljaard, R., 2002. Lambing behaviour of Merino ewes from lines subjected to divergent selection for multiple rearing ability from the same base population. S. Afr. J. Anim. Sci. 32, 57-64.

Dickerson, G.E., 1978. Animal size and efficiency: basic concepts. Anim. Prod. 27, 367-379.

Doloksaribu, M., Gatenby, R.M., Subandriyo, S.T. & Bradford, G.E., 2000. Comparison of Sumatra sheep and hair sheep crossbreds. III. Reproductive performance of F_2 ewes and weights of lambs. Small Rum. Res. 38, 115-121.

Erasmus, L.S., 1965. Slaglamproduksie met die Merino as moederooi. M.Sc. Agric. thesis, University of Stellenbosch, South Africa.

Erasmus, L.S., De Kock, J.A. & Grobler, J.W., 1983. Slaglamproduksie in die Suid-Kaap. Els. J. 7, 13-32.

Fogarty, N.M., 2006. Utilization of breed resources for sheep production. 8th World Congress on Genetics Applied to Livestock Production, Belo Horizonte, MG, Brasil.

Fogarty, N.M., Hopkins, D.L. & Van de Ren, R., 2000. Lamb production from diverse genotypes 2. Carcass characteristics. Anim. Sci. 70, 147-156.

Fourie, P.J., Neser, F.W.C., Olivier, J.J. & van der Westhuizen, C., 2002. Relationship between production performance, visual appraisal and body measurements of young Dorper rams. S. Afr. J. Anim. Sci. 32, 256-262.

Freking, B.A., Leymaster, K.A. & Young L.D., 2000. Evaluation of Dorset, Finnsheep, Romanov, Texel, and Montadale breeds of sheep: I. Effects of ram breed on productivity of ewes of two crossbred populations. J. Anim. Sci. 78, 1422-1429.

Gilmour, A.R., Luff, A.F., Fogarty, N.M. & Banks, R., 1994. Genetic parameters for ultrasound fat depth eye muscle measurements in live Poll Dorset sheep. Aust. J. Agric. Res. 45, 1281-1291.

Greeff, J.C., Hofmyer, J.H., Wyma, G.W. & Van Deventer, J.F.P.J., 1988. Preliminary results on heterosis and breed transmitted effects of fertility and survival rate of Romanov and Dorper crossbreds. 19-23 June 1988, Institut National de la Recherche Agronomique, Paris, France. Proc. 3rd World Cong. Sheep Beef Cattle Breed 673-675.

Hoon, J.H., Herselman, M.J., Van Heerden, M. & Pretorius, A.P., 2000. The effect of bypass protein supplementation on the reproductive performance of Merino sheep grazing mixed Karoo veld. S. Afr. J. Anim. Sci. 30, 60-61.

Kirton, A.H., Carter, A.H., Clarke, J.N., Sinclair, D.P., Mercer, G.J.K. & Dunganzich, D.M., 1995. A comparison between 15 ram breeds for export lamb production 1. Liveweights, body composition, carcass measurements and composition. N. Z. J. Agric. Res. 38, 347-360.

Kleeman, D.O., South, M.H.L., Dolling, C.H.S. & Ponzoni, R.W., 1983. Survival, growth and wool production of South Australian strong-wool Merino and first-cross Merino lambs from birth to 16 months of age. Aust. J. Exp. Agric. Anim. Husb. 23, 271-279.

Milne, C., 2000. The history of the Dorper sheep. Small Rumin. Res. 36, 99-102.

Olivier, J.J., 1999. The South African Merino performance testing scheme. In: Premium Quality Wool Symposium. Proc. Advmt. Anim. Breed. Genet. 13, 199-124.

Olivier, J.J., Bezuidenhout, A.G., Greyling, A.C. & Cloete S.W.P., 2000. Evaluation of genetic fine and fine x strong wool Merinos on irrigated pastures. S. Afr. J. Anim. Sci. 30, 113-120.

Olivier, J.J., Marais, P.G. & Cloete, J.A.N., 1984. Die evaluering van verskillende raskruisings in die ontwikkeling van 'n witwolvleisras: Die Afrino. S. Afr. Tydskr. Veek. 14, 105-109.

Olivier, J.J., Rautenbach, L. & Taylor, R.F., 2004. Efficiency of selection in some South African sheep and goat breeds. *Book of Abstracts – 2nd Joint Congress of the Grassland Society of Southern Africa and the South African Society of Animal Science*, 28 June – 1 July 2004, Goudini, 100.

Piper, L. & Ruvinsky, A. 1997. The Genetics of Sheep. CAB International, Wallingford, Oxon OX10 8DE, UK.

Roux, C.Z., 1992. Maximum herd efficiency in meat production III. Feeder-breeder dimorphism. S. Afr. J. Anim. Sci. 22, 11-15.

Schoeman, S.J., 2000. A comparative assessment of Dorper sheep in different production environments and systems. Small Rumin. Res. 36, 137-146.

Schoeman, S.J. & Burger, R., 1992. Performance of Dorper sheep under an accelerated lambing system. Small Rumin. Res. 9, 265-281.

Schoeman, S.J., de Wet, R., Botha, M.A. & van der Merwe, C.A., 1995. Comparative assessment of biological efficiency of crossbred lambs from two Composite lines and Dorper sheep. Small Rumin. Res. 16, 61-67.

Sheridan, R., Ferreira, A.V., Hoffman, L.C. & Schoeman, S.J., 2000. Effect of diet energy levels on efficiency of SA Mutton Merino lambs and Boer goat kids under feedlot conditions. S. Afr. J. Anim. Sci. 30, 122- 129.

Snowder G.D. & Duckett S.K., 2003. Evaluation of the South African Dorper as a terminal sire breed for growth, carcass, and palatability characteristics. J. Anim. Sci. 81, 368-375

Snyman, M.A., Erasmus, G.J., van Wyk, J.B. & Olivier, J.J., 1998. Genetic and phenotypic correlations among production and reproduction traits in Afrino sheep. S. Afr. J. Anim. Sci. 28, 74-80.

Teixeira, A., Delfa, R. & Treacher, T., 1996. Carcass composition and body fat depots of Galego Bragançano and crossbred lambs by Suffolk and Merino Precoce sire breeds. Anim. Sci. 63, 389-394.

Webb, E.C. & Casey, N.H., 1995. Genetic differences in fatty acid composition of subcutaneous adipose tissue in Dorper and SA Mutton Merino wethers at different live weights. Small Rumin. Res. 18, 81-88.

Part 1

Comparison of breeds

Chapter 2

A comparison between slaughter traits of Merino, Dohne Merino, SA Mutton Merino and Dormer sheep

A comparison between slaughter traits and meat quality of Merino, Dohne Merino, SA Mutton Merino and Dormer sheep

Abstract

The slaughter and meat quality traits of similarly aged (20 months) wool (Merino), dual purpose (Dohne Merino and South African Mutton Merino (SAMM) and meat (Dormer) type sheep were compared in this study. The sheep were kept on the same pasture and were subjected to the same level of husbandry care for five months. Average live weight of SAMM and Dormer sheep were 23% heavier than those of Dohne Merinos. Dohne Merinos were correspondingly 28% heavier than Merinos. SAMM and Dormer sheep had higher dressing percentages than the other two breeds. Adjustment for the higher slaughter weight of Dormer and SAMM sheep resulted in most of breed differences being eliminated. The more expensive retail cut weights remained higher in the meat type sheep but the latter breeds also had a thicker fat cover. The pH measurement taken 45 minutes *post mortem* from Dohne Merino (6.66±0.08) and SAMM (6.86±0.06) sheep differed. Fat depths at the 13th rib and lumbar region of Merino and Dohne Merino sheep were lower than those of SAMM and Dormer sheep. The cooking loss, drip loss and shearing value from the *longissimus dorsi* muscle did not differ between breeds. With regard to colour measurements, the average L* value of meat from Merino sheep were higher than that of Dormer sheep. The initial juiciness and sustained juiciness of meat from Merinos were rated lower by trained sensory panel analysis, compared to meat from the other breeds. Meat from Dohne Merino sheep was rated higher for the attribute first bite (ease of penetration) compared to the other breeds. It was demonstrated that Dormer and SAMM sheep had heavier but fatter carcasses than Merinos and Dohne Merinos, with no marked differences in meat quality among breeds.

Keywords: Carcass, meat colour, pH, sensory analysis, shear force

Introduction

In South Africa there are 29 million sheep. Four of the most popular sheep breeds in the Western Cape are the Merino, Dohne Merino, SA Mutton Merino (SAMM) and the Dormer (Campher *et al.,* 1998). The Merino is a wool-type sheep that originated from Europe. Merino sheep compose 40% of the total sheep population in South Africa (Campher *et al.,* 1998). The Dohne Merino is a synthetic dual-purpose (wool and mutton) Merino developed by the South African Department of Agriculture using Merino ewes and former German Mutton Merino sires (Kotzé, 1951).

The South African Mutton Merino (SAMM) is also a dual-purpose sheep breed that was developed from the imported German Merino. The SAMM has a high growth rate and produces a lamb suitable for slaughter at a relatively early age with good meat characteristics (Neser *et al.,* 2000). The Dormer breed was developed on the Elsenburg experimental farm from crosses between Dorset Horn sires and German Mutton

Merino dams (Van der Merwe, 1976). The principal objective with the development of the Dormer was to provide a terminal sire breed for crossbreeding on Merino ewes (Van der Merwe, 1976).

The Dormer is regarded as an early maturing breed and the SAMM as a late maturing breed with the Merino and the Dohne Merino being intermediate maturing breeds. Early-maturing animals reach maximum potential for fat growth at a younger and lighter live weight than late-maturing animals (Lawrie, 1998). Dormer sheep would thus tend to put on fat at an earlier age than SAMM sheep (Cloete *et al.* 2004a).

No results pertaining to comparative slaughter traits at the same age in these four South African breeds were found in the literature. This paper examines the effect of breed and sex on the carcass composition, yield of retail cuts, fat depth and sensory evaluation of the meat from similar aged Merino, Dohne Merino, SAMM and Dormer sheep reared on the same pasture.

Material and Methods

Data were obtained from similarly aged (20 months) wool (Merino (n=22)), dual purpose (Dohne Merino (n=13) and South African Mutton Merino (n=24; SAMM)) and meat (Dormer (20)) type sheep. All the ewes of the different sheep breeds were maintained in the same flock for five months, while the rams were maintained in another flock. The sheep were shorn at the initiation of the trail period and again before slaughter. Both groups were subjected to the same level of husbandry care (e.g. parasite control, etc) during this period. All sheep were kept on irrigated pasture consisting of clover and kukuyu. Live weight was determined 24 hours prior to slaughtering. A few hours before slaughter the rams and ewes were lairised together so that the sheep could be slaughtered at random. The sheep were slaughtered at a commercial abattoir using standard South African techniques. Treatment (transport, handling, etc.) were similar for all the groups. After being electrically stunned (4 seconds at 200 Volts) the sheep were exsanguinated and the carcasses hung to bleed out before dressing. No electrical stimulation was applied. The dressed carcasses were then hung in a cooler at 2°C for 24 hours.

Recordings on the carcass included the weight of carcass components, cold carcass weight (after 24 hours in a cooler at 2°C), the weight of different retail cuts and backfat depth. The latter was measured at a site 25 mm off the midline at the 13th rib and between the 3rd and 4th lumbar vertebrae (Cloete *et al.*,2004a). Carcass components that were weighed included the head, trotters and skin. Carcass length was measured on the hanging carcass from the pubis bone to the front of the first rib. The leg circumference was measured at two points; the first leg circumference (1) was taken at the maximum circumference of a line passing over the distal end of the iliac wings of the pelvis and the most caudal point on the median line between the legs (Stanford *et al.*, 1997), and the second leg circumference (2) was taken at the stifle (Oman *et al.*, 1999). Hind leg length was measured from the inner edge of the proximal end of the tibia to the anterior tip of the pubis (Enright, 1990).

The pH of the *longissimus dorsi* muscle was also measured between the 11th and 13th rib at three different intervals post mortem, namely 45 minutes, 24 hours and 48 hours (McGeehin *et al.*, 2001). After 48 hours in the cooler the carcasses were partitioned into South African retail cuts, which were weighed separately. These cuts consisted of the neck, shoulder, chuck, flatrib, prime rib, loin and hindquarters. The neck was removed at the seventh cervical vertebrae (the point where the neck starts bending), the cut being made at right angles to the spine. Thereafter the hind legs were removed. This consisted of loosening the flanks on the inside of the legs (following the curve of the leg muscle) to an imaginary line perpendicular to the ilium (seen from the inside of the carcass). The leg was then removed by cutting along this line, just missing the ilium (through the last lumbar vertebrae). The rest of the carcass was then halved prior to separation into trade cuts. The shoulder was removed by sawing along an imaginary line from the elbow joint to a point below the spinal column, between the fifth and sixth ribs. The carcass was then swiveled so that the spinal column was sawn through at right angles. The flank was removed by sawing from the *obliquus abdominis internus* muscle parallel to the spine. The loin and rib were separated perpendicularly to the spinal column at the junction of the thoracic and lumbar vertebrae (Hoffman, 2000). All commercial cuts were weighed on a digital computing scale to the nearest gram.

The left loin retail cut were removed and taken to the laboratory for the determination of physical meat quality attributes. The *longissimus lumborum* muscle was dissected from the 1st to the 6th lumbar vertebrae and used for these analyses (Schönfeldt *et al.*, 1993). Two loin sub-samples (the first taken at the first lumbar vertebrae and the second caudally adjacent to it) were taken for the determination of cooking loss, drip loss, colour (after blooming for 30 minutes) and meat tenderness (Honikel, 1998). For drip loss determination one of the 1.5 cm loin sub-samples were weighed, placed in netting and suspended in an inflated plastic bag. After a storage period of 24 h at 4 °C, the samples were weighed again and the drip loss was calculated as weight loss expressed as a percentage of the original weight of the sample (Honikel, 1998).

For the cooking loss determination, the other sub-sample were weighed and placed in a thin-walled plastic bag in a water-bath at 75 °C. After 1 h the samples were removed from the water bath, cooled in cold water, blotted dry and weighed. Cooking loss was calculated as the difference in sample weight before and after cooking, expressed as a percentage of the initial sample weight (Honikel, 1998).

Tenderness of the meat (same sample as used for cooking loss) was measured in triplicate with a Warner-Bratzler shear head using 1.27 cm diameter samples in triplicate (Honikel, 1998). Samples were randomly removed from the center of each *longissimus lumborum* muscle sample. Maximum shear force values (N) required to shear a cylindrical core, perpendicular to the grain (at crosshead speed of 200.0 mm/min), were recorded for each case.

The colour of a loin sub-sample was evaluated (after blooming for 30 minutes) by using a Color-guide 45°/0° colorimeter (BYK-Gardner, USA) to determine: L*, a* and b* values (Commission International de l' Eclairage, 1976), with L* indicating brightness, a* the red-green range and b* the blue-yellow range.

The right loin retail (*longissimus lumborum muscle*) cut of five male and five female sheep of each breed, were deboned, coded, vacuum packed, and stored at −18 °C until further sensory analysis. The samples were defrosted for 48 h at a temperature of 3-4 °C, wrapped individually in cooking bags and placed on the rack of an open roasting pan. The samples were cooked at 160 °C in two electric Defy 835 ovens connected to a computerised electronic temperature control system to an internal temperature of 70 °C (AMSA, 1978). Immediately after cooking all visible subcutaneous fat was removed. Six 1.5 x 1.5 x 1.5 cm cubed samples were taken from the middle of each sample and wrapped immediately in aluminium foil marked with random three-digit codes. The samples were placed in preheated glass ramekins in a preheated oven at 100 °C and evaluated for sensory attributes within 10 minutes.

Descriptive sensory analyses were performed on the meat samples. Panel members were selected and trained in accordance with the guidelines of the American Meat Science Association (AMSA, 1978). A six-member panel evaluated the meat for the following sensory attributes: aroma intensity, initial impression of juiciness, sustained juiciness, tenderness (first bite) and lamb flavour by means of an eight-point structured line scale (Jeremiah & Phillips, 2000). Table 1 depicts the definitions of the attributes used in the sensory analyses.

Table 1 Definition of attributes for descriptive sensory analyses of meat from similarly aged Merino, Dohne Merino, SAMM and Dormer sheep

Attribute and scale	Definition
Lamb aroma 1 = Extremely bland; 8 = Extremely intense	Aroma associated with animal species
Initial juiciness 1 = Extremely dry; 8 = Extremely juicy	The amount of fluid exuded on the surface when pressed between fingers
Sustained juiciness 1 = Extremely dry; 8 = Extremely juicy	Degree/amount of water perceived during mastication
First bite 1 = Extremely tough; 8 = Extremely tender	Force needed to compress the sample of meat between molar teeth on the first bite
Lamb flavour 1 = Extremely bland; 8 = Extremely intense	Flavour associated with animal species

The panel members were seated in individual booths in a temperature-controlled and light-controlled room and received a set of six samples over four sessions, served in a completely randomised order. Crackers and distilled water were used to cleanse the palate between samples (AMSA, 1978).

The remainder of the left loin retail cuts was taken to the laboratory for the measurement of the proximate chemical analysis. All subcutaneous fat was removed before the meat samples were minced twice through a 2 mm screen, vacuum packed and stored at –18 °C for later chemical analysis. The proximate composition of the *M. longissimus lumborum* was done according to the AOAC (1997) methods. The analysis included determination of moisture, lipid, protein and ash. The protein was determined by a FP-428 Nitrogen and Protein Determinator (Leco). Ashing was done at 500 °C for five hours. The moisture content was determined by drying at 100 °C for 24 h. Lipid content was determined by solvent extraction, according to the method of Lee *et al.* (1996).

Prior to testing for differences of the various parameters between the four breeds and sexes, a least square analysis of variance was done to account for uneven subclasses. The ASREML programme was used for this purpose (Gilmour *et al.*, 1999). There was no significant interaction between sex and breed. The differences between the various parameters determined for the two breeds and between sexes were then tested separately by means of the null hypothesis (H_o) with $H_o : \mu=\mu_o$ and the alternative hypothesis (H_μ) being $H_\mu : \mu\neq\mu_o$. This was done by means of contrast analysis and estimated least square means (± SE) as reported in the tables. Differences between the variables were accepted as being significant if the possibility of rejection of H_o was equal to or less than 5% ($P\leq0.05$), for the four breeds and two sexes.

Preliminary factorial analysis of variance, with session (four levels), panel member (identity of 7 members) and breed combination (as defined previously) was performed on the sensory data, using SAS version 8.12 (SAS, 1990). This analysis indicated that means were influenced by session and the identity of the panel member. Prior to the final analyses, the sensory scores were transformed to ranks. These ranks were adjusted for the effects of panel member and session prior to analyses. The analyses were rerun (SAS, 1990) to obtain adjusted rank means (and standard errors) depicting the effect of breed combination.

Results

As there was no sex x breed interaction, least square means depicting the main effects of breed and sex were tabulated. The means (± SE) of the carcass traits measured are shown in Table 2. As expected, the mean slaughter and carcass weights of SAMM and Dormer sheep were higher ($P < 0.05$) than those of Dohne Merino and Merino sheep. Dohne Merinos were correspondingly heavier ($P < 0.05$) than Merinos. Dormer and SAMM sheep had a higher ($P < 0.05$) dressing percentage than Dohne Merino and Merino sheep (Table 2).

The mean skin weights of Dormer and SAMM sheep were heavier ($P<0.05$) than those of the Merinos, but after adjustment (Table 3) for the higher slaughter weights of the SAMM and Dormer sheep there were no differences in skin weight. The trotters of the Merino sheep were lighter ($P<0.05$) than those of the other three breeds, but after adjustment for slaughter weight, there were no breed differences (Table 3). The mean carcass lengths of SAMM and Dormer sheep were longer ($P<0.05$) than those of the Dohne Merino and Merino breeds, while the carcasses of Dohne Merinos were longer ($P<0.05$) than those of Merinos (Table 2). The hind legs of Merino and Dohne Merino sheep were longer ($P<0.05$) than those from SAMM and Dormer sheep. Hind legs of SAMM sheep were also longer ($P<0.05$) than those of Dormer sheep. Sex differences were consistent with the observed higher slaughter weight of the rams (Table 2).

Table 2 The means (± SE) of carcass characteristics from 20-month old Merino, Dohne Merino, SAMM and Dormer rams and ewes maintained in the same flock for five months

Trait	Breed				Sex	
	Merino (n=22)	Dohne Merino (n=13)	SAMM (n=24)	Dormer (n=20)	Ram (n=38)	Ewe (n=41)
Carcass characteristics						
Slaughter weight (kg)	$40.8^{a}\pm1.4$	$56.0^{b}\pm1.8$	$63.2^{c}\pm1.3$	$61.4^{c}\pm1.4$	$60.4^{x}\pm1.1$	$50.3^{y}\pm0.9$
Carcass weight (kg)	$16.0^{a}\pm0.7$	$22.4^{b}\pm1.0$	$27.3^{c}\pm0.7$	$27.1^{c}\pm0.8$	$23.9^{x}\pm0.6$	$22.5^{y}\pm0.4$
Dressing % [1]	$38.7^{a}\pm0.8$	$40.5^{a}\pm1.0$	$43.7^{b}\pm0.7$	$44.4^{b}\pm0.8$	$39.7^{x}\pm0.6$	$44.0^{y}\pm0.5$
Skin weight (kg)	$3.41^{a}\pm0.11$	$3.67^{ab}\pm0.15$	$3.84^{b}\pm0.11$	$4.05^{b}\pm0.16$	$3.79^{x}\pm0.09$	3.69 ± 0.08
Head (kg)	3.01 ± 0.07	3.02 ± 0.09	3.20 ± 0.06	3.10 ± 0.07	$3.58^{x}\pm0.05$	$2.58^{y}\pm0.05$
Trotters (kg)	$0.96^{a}\pm0.03$	$1.11^{b}\pm0.04$	$1.18^{b}\pm0.03$	$1.12^{b}\pm0.03$	$1.21^{x}\pm0.02$	$0.97^{y}\pm0.02$
Carcass length (cm)	$74.7^{a}\pm0.65$	$79.1^{b}\pm0.85$	$82.9^{c}\pm0.61$	$82.8^{c}\pm0.61$	$82.4^{x}\pm0.5$	$77.3^{y}\pm0.5$
Carcass depth (cm)	$28.8^{a}\pm0.36$	$31.8^{b}\pm0.47$	$32.3^{b}\pm0.34$	$32.1^{b}\pm0.37$	$32.3^{x}\pm0.3$	$30.2^{y}\pm0.3$
Carcass width (cm)	$21.7^{a}\pm0.46$	$25.3^{b}\pm0.60$	$27.8^{c}\pm0.43$	$28.3^{c}\pm0.47$	26.2 ± 0.4	25.8 ± 0.3
Leg length (cm)	$34.5^{a}\pm0.42$	$34.9^{a}\pm0.54$	$33.2^{b}\pm0.39$	$31.9^{c}\pm0.43$	$34.7^{x}\pm0.3$	$32.6^{y}\pm0.3$
Leg circumference 1 (cm)	$37.8^{a}\pm0.61$	$42.3^{b}\pm0.80$	$45.4^{c}\pm0.57$	$45.0^{c}\pm0.63$	42.9 ± 0.5	42.3 ± 0.4
Leg circumference 2 (cm)	$24.6^{a}\pm0.44$	$26.6^{b}\pm0.57$	$28.2^{c}\pm0.41$	$27.6^{bc}\pm0.45$	$27.3^{x}\pm0.4$	$26.2^{y}\pm0.3$
Fat depth 13^{th} rib (mm)	$0.97^{a}\pm0.30$	$1.68^{ac}\pm0.40$	$2.65^{bc}\pm0.30$	$3.19^{b}\pm0.30$	$0.95^{x}\pm0.20$	$3.29^{y}\pm0.30$
Fat depth 3^{rd} and 4^{th} lumbar vertebrae (mm)	$1.27^{a}\pm0.30$	$1.74^{a}\pm0.40$	$3.09^{b}\pm0.30$	$3.65^{b}\pm0.30$	$1.17^{x}\pm0.20$	$3.70^{y}\pm0.20$
Retail cuts						
Neck (kg)	$0.96^{a}\pm0.04$	$1.23^{b}\pm0.05$	$1.42^{b}\pm0.04$	$1.34^{b}\pm0.05$	$1.42^{x}\pm0.03$	$1.05^{y}\pm0.03$
Shoulder (kg)	$0.82^{a}\pm0.02$	$1.02^{b}\pm0.03$	$1.17^{c}\pm0.02$	$1.09^{b}\pm0.03$	$1.18^{x}\pm0.02$	$0.87^{y}\pm0.02$
Chuck (kg)	$4.69^{a}\pm0.31$	$6.42^{b}\pm0.41$	$7.93^{c}\pm0.31$	$8.13^{c}\pm0.34$	$7.11^{x}\pm0.20$	$6.47^{y}\pm0.24$
Flatrib (kg)	$1.43^{a}\pm0.09$	$2.24^{b}\pm0.13$	$2.90^{c}\pm0.10$	$2.92^{c}\pm0.10$	2.36 ± 0.08	2.38 ± 0.08
Prime rib (kg)	$1.12^{a}\pm0.06$	$1.58^{b}\pm0.07$	$2.00^{c}\pm0.06$	$2.08^{c}\pm0.07$	1.68 ± 0.05	1.71 ± 0.05
Loin (kg)	$1.45^{a}\pm0.08$	$1.99^{b}\pm0.10$	$2.42^{c}\pm0.08$	$2.62^{c}\pm0.09$	2.13 ± 0.06	2.11 ± 0.06
Hindquarters (kg)	$4.73^{a}\pm0.21$	$6.86^{b}\pm0.27$	$8.30^{c}\pm0.21$	$7.83^{c}\pm0.23$	$7.32^{x}\pm0.16$	$6.54^{y}\pm0.16$

^{abc} Means in the same row with different superscripts differ ($P < 0.05$) (breeds)

^{xy} Means in the same row with different superscripts differ ($P < 0.05$) (sex)

[1] Dressing % = (carcass weight / slaughter weight) X 100

Fat depths at both sites were thicker ($P < 0.05$) in Dormer sheep than in Merino and Dohne Merino sheep. As expected, ewes were fatter than rams (Table 2). Mean retail cut weights were generally higher ($P<0.05$) in Dormer and SAMM sheep compared to Dohne Merino and Merino sheep.

After adjustment for the higher slaughter weight of the Dormer and SAMM sheep by analysis of covariance, some of the carcass traits still differed ($P<0.05$) between the breeds (Table 3). The average head weight of Merino sheep was higher than those of the other three breeds. Rams also had heavier heads than ewes. The average fat depths at the 13^{th} rib and at the lumbar region of Dohne Merino sheep was lower

(P<0.05) than corresponding means for Dormer sheep. After adjustment for slaughter weight, the mean chuck, flatrib and primerib of Dormer sheep were heavier than those from Merino sheep. The chuck and flatrib of Dormer sheep were heavier after adjustment for slaughter weight, compared to Dohne Merino sheep. The mean loin retail cut weight of Dormer sheep was higher than that of the Dohne Merino breed after adjustment for slaughter weight. The average hindquarter weight of SAMM sheep were higher than that of Merino sheep after adjustment for slaughter weight. The difference in adjusted carcass weight remained in favour (P<0.05) of the rams for the head and neck weights. The fat depth of ewes was thicker and the other retail cut weights were heavier for the ewes, compared to those of rams after adjustment for slaughter weight (Table 3).

Table 3 Mean (± SE) weights of carcass components after adjusting for slaughter weights that differed statistically between 20-month old Merino, Dohne Merino, SAMM and Dormer rams and ewes maintained in the same flock for five months

Trait	Breed				Sex	
	Merino (n=22)	Dohne Merino (n=13)	SAMM (n=24)	Dormer (n=20)	Ram (n=38)	Ewe (n=41)
Carcass characteristics						
Head (kg)	3.45^{a}±0.08	3.00^{b}±0.07	2.95^{b}±0.06	2.90^{b}±0.05	3.42^{x}±0.05	2.72^{y}±0.04
Skin (kg)					3.53^{x}±0.08	3.92^{y}±0.08
Fat depth 13th rib (mm)	2.00^{ab}±0.50	1.67^{b}±0.40	2.04^{abc}±0.36	2.71^{c}±0.37^{c}	0.55^{x}±0.28	3.66^{y}±0.27
Fat depth 3rd and 4th lumbar vertebrae (mm)	2.26^{ab}±0.45	1.73^{a}±0.36	2.51^{ab}±0.33	3.20^{b}±0.34	0.79^{x}±0.26	4.06^{y}±0.25
<u>Retail cuts</u>						
Chuck (kg)	6.68^{a}±0.44	6.42^{a}±0.33	6.79^{ab}±0.33	7.26^{b}±0.31	6.37^{x}±0.24	7.19^{y}±0.24
Neck (kg)					1.34^{x}±0.03	1.13^{y}±0.03
Flatrib (kg)	2.15^{a}±0.17	2.24^{a}±0.10	2.49^{ab}±0.09	2.61^{b}±0.09	2.09^{x}±0.07	2.64^{y}±0.07
Prime rib (kg)	1.57^{a}±0.08	1.58^{a}±0.06	1.73^{ab}±0.06	1.88^{b}±0.06	1.51^{x}±0.04	1.87^{y}±0.04
Loin (kg)	2.10^{ab}±0.10	1.99^{a}±0.07	2.05^{ab}±0.07	2.34^{b}±0.07	1.89^{x}±0.05	2.35^{y}±0.05
Hindquarters (kg)	6.54^{a}±0.22	6.86^{ab}±0.16	7.26^{b}±0.17	7.03^{ab}±0.16	6.65^{x}±0.11	7.20^{y}±0.12

^{abc} Means in the same row within breeds with different superscripts differ (P < 0.05) (breeds)

^{xy} Means in the same row within sex with different superscripts differ (P < 0.05) (sex)

The pH values measured 45 minutes after slaughter were lower (P<0.05) in the Dohne Merino breed than in SAMM sheep. No differences at pH_{45} was found between the other breeds. Twenty four and forty eight hours after slaughter the pH of meat from Merino and Dohne Merino sheep were higher (P<0.05) than meat from SAMM sheep. Although the initial pH did not differ between sexes, pH measurements of meat from rams were lower 24 and 48 hours after slaughter than those of the ewes (Table 4).

Drip loss and cooking loss of the respective breeds did not differ significantly. The mean cooking loss of meat from rams was higher ($P<0.05$) than that of ewes. The drip loss was not affected by sex. There were no breed differences in meat tenderness, but meat from rams was significantly ($P < 0.05$) tougher than meat from ewes. The only colour difference was for the L* reading where meat from Merino sheep was higher than meat from Dormer sheep, while meat from ewes were darker and situated more towards saturated red (Table 4).

Table 4 The means (± SE) of meat-quality parameters from similar aged Merino, Dohne Merino, SAMM and Dormer rams and ewes kept in the same flock for five months

Trait	Breed				Sex	
	Merino (n=22)	Dohne Merino (n=13)	SAMM (n=24)	Dormer (n=20)	Ram (n=38)	Ewe (n=41)
Meat-quality parameters						
pH_{45}	6.70 ^{ab}±0.06	6.66 ^{a}±0.08	6.86 ^{b}±0.06	6.80 ^{ab}±0.06	6.78±0.05	6.73±0.05
pH_{24}	5.84 ^{a}±0.73	5.89 ^{a}±0.96	5.54 ^{b}±0.69	5.67 ^{ab}±0.76	5.94 ^{x}±0.58	5.53 ^{y}±0.54
pH_{48}	5.83 ^{a}±076	5.89 ^{a}±0.96	5.54 ^{b}±0.69	5.67 ^{ab}±0.76	5.96 ^{x}±0.60	5.51 ^{y}±0.55
Drip loss %	0.96±0.08	0.82±0.10	0.96±0.09	0.88±0.09	0.92±0.06	0.89±0.07
Cooking loss %	32.0±1.1	29.6±1.4	30.1±1.1	29.3±1.2	31.9 ^{x}±0.8	28.6 ^{y}±0.9
Tenderness (N)	112.2±5.9	100.1±7.7	111.5±6.3	116.2±6.4	114.8 ^{x}±4.6	105.2 ^{y}±5.7
Colour L*	34.9 ^{a}±0.5	33.2 ^{ab}±0.6	34.2 ^{ab}±0.5	32.8 ^{b}±0.5	34.4 ^{x}±0.4	33.2 ^{y}±0.4
a*	12.5±0.3	12.4±0.4	13.4±0.3	12.8±0.3	12.3 ^{x}±0.2	13.3 ^{y}±0.2
b*	8.95±0.35	8.78±0.46	9.19±0.37	9.19±0.38	9.08±0.28	8.98±0.28
Croma	15.4±0.4	15.4±0.5	16.1±0.4	15.7±0.4	15.3±0.3	16.0±0.3
Hue	35.1±0.9	35.0±1.3	34.4±1.0	35.3±1.1	35.9 ^{x}±0.7	34.0 ^{y}±0.8

abc Means in the same row within breed different superscripts differ ($P < 0.05$)

xy Means in the same row within sex different superscripts differ ($P < 0.05$)

There were no differences in the sensory attributes of the meat from rams and ewes. The initial juiciness and sustained juiciness of meat from Merinos were rated lower ($P < 0.05$) compared to meat from the other breeds. Meat from Dohne Merino sheep was rated higher for first bite (tenderness) than that of the other breeds. No breed differences were found for aroma and flavour (Table 5).

According to Table 6, there were no differences between the breeds for moisture, protein and ash concentrations of the meat from the *M. longissimus*. The only proximate chemical component that differed between breeds was the lipid concentration, where meat from the SAMM sheep were fatter ($P<0.05$) on average than meat from Dohne Merino and Merino sheep. The lipid concentration of meat from Dormer and Dohne Merino sheep were also higher than meat from Merino sheep. The moisture concentration of the meat of rams was higher ($P<0.05$) than that of ewes, and the lipid and protein content of meat from ewes were higher ($P<0.05$) compared to rams.

Table 5 Means for the sensory quality characteristics of the *longissimus lumbaren* muscle between similar aged Merino, Dohne Merino, SAMM and Dormer rams and ewes kept in the same flock for five months

	Breed				Sex	
	Merino (n=10)	Dohne Merino (n=10)	SAMM (n=10)	Dormer (n=10)	Ram (n=20)	Ewe (n=20)
Aroma	6.36±0.08	6.52±0.89	6.43±0.83	6.48±0.93	6.40±0.08	6.49±0.08
Initial juiciness	5.64^b±1.10	6.50^a±0.69	6.55^a±0.79	6.55^a±0.93	6.12±010	6.51±0.08
Sustained juiciness	5.16^b±1.19	6.39^a±0.93	6.27^a±1.07	6.19^a±1.13	5.69±0.11	6.31±0.10
First Bite	5.46^a±1.54	6.64^b±1.18	5.88^a±1.64	5.91^a±1.56	5.46±0.16	6.48±0.12
Flavour	6.21±0.73	6.54±0.99	6.42±0.78	6.23±1.19	6.17±0.10	6.57±0.08

^{ab} Means in the same row within breed with different superscripts differ (P < 0.05)

Table 6 Mean (± s.e.) proximate chemical composition (g/100 g muscle) of the 11/13th –rib cut (*longissimus lumbaren* muscle) between similar aged Merino, Dohne Merino, SAMM and Dormer rams and ewes

	Breed				Sex	
	Merino (n=20)	Dohne Merino (n=12)	SAMM (n=18)	Dormer (n=18)	Ram (n=35)	Ewe (n=35)
Moisture	73.3±0.6	72.0±0.8	70.4±0.6	71.1±	73.9±0.5	69.5±0.5
Protein	22.9±0.5	23.1±0.6	23.5±0.5	23.8±0.5	22.2^x ±0.04	24.4^y±0.4
Lipid	2.19^a±0.26	3.03^b±0.35	3.97 ^{c}±0.27^c	3.19 ^{bc}±0.28	2.29^x ±0.2	3.9^y±0.20
Ash	1.07±0.07	1.06±0.09	1.21±0.07	1.10±0.07	1.04±0.05	1.18±0.05

^{abc} Means in the same row within breeds different superscripts differ (P < 0.05)

^{xy} Means in the same row within sex different superscripts differ (P < 0.05)

Discussion

Higher slaughter and carcass weights of the meat type animals were expected as indicated by Campher *et al.* (1998). Dressing percentage is affected by the stomach content and skin (wool) weight when live weights are recorded. Dressing percentage is known to increase with animal weight and degree of fatness (Kirton *et al.*, 1995). Dormer and SAMM sheep were fatter and heavier than Merino and Dohne Merino sheep, the latter resulting in a higher dressing percentage.

Head weights of rams were higher after adjustment for slaughter weight as expected from the sexual dimorphism commonly experienced for the forequarters. The differences in carcass measurements and retail cut weights before adjustment for slaughter weight in favour of the Dormer and SAMM sheep is a result of their higher carcass weight.

The higher head weights of Merinos after adjustment for slaughter weight were because of the horns of the rams and some of the ewes. The differences in fat depth between rams and ewes were as expected (Cloete *et al.,* 2004b; Teixeira *et al.*, 1996). The higher fat cover after adjustment for live weight of the Dormers is due to the fact that Dormers are an early maturing breed, and were physiologically more developed at the same age compared to the other breeds which are later maturing breeds. Early maturing animals tend to put on fat at an earlier age than later maturing contemporaries (Campher *et al.*, 1998; Cloete *et al.,* 2004b). It is reasonable that these breeds would have already deposited substantial amounts of subcutaneous fat when slaughtered at 20 months.

Cloete *et al.* (2004b) and Fahmy *et al.* (1999) found that ewes had heavier loin and hindquarter retail cuts than rams. Jeremiah *et al.* (1997) and Cloete *et al.* (2004b) reported similar results as found in this study, that rams had heavier neck retail cuts than ewes. This phenomenon of heavier forequarters in rams is typical of sexual dimorphism, and is expected when sheep are slaughtered after attaining sexual maturity.

The higher pH_{24} and pH_{48} of the meat from the rams could be because the rams and ewes were lairised together a few hours pre slaughter, causing the rams to be more restless. This restlessness of the rams would have caused lower energy levels in the muscle which would have resulted in higher pH values 24 and 48 hours post mortem. However, no meat from the rams sampled would have been classified as Dark Firm and Dry (DFD) in this study. Although statistically there were colour differences in the meat between rams and ewes, it is debatable whether the industry would have discriminated between sexes based on these differences. None the less, the meat from the rams was tougher ($P < 0.05$) than that of ewes (Table 4). The sensory panel noted a tendency in the same direction, but this trend did not reach statistical significance. It could be argued that if more meat samples were subjected to sensory evaluation, the panel may possibly have found the differences to be significant. Freezing of the sample could also have caused the differences to become negligible.

According to Dryden & Marchello (1970), juiciness is related to both the capacity of the muscle to release its constitutive water (initial juiciness) and the infiltrated fat content (sustained juiciness). In combination with water, the melted lipid constitutes a broth that, when retained in the meat, is released upon chewing. This broth may also stimulate the flow of saliva and thus improve the meat's apparent juiciness. The higher juiciness and sustained juiciness scores of the dual purpose and mutton breeds compared to Merinos could be related to their thicker fat depots and higher average fat percentages (Tables 2 and 6). This argument may also apply to the sex differences. Rams tended to have lower juiciness scores (albeit not significant). It could be argued that the panel may have found these differences to be significant if more samples were evaluated.

The higher lipid content of meat from the SAMM and Dormer sheep are due to the fact that they are both earlier maturing breeds. Cloete *et al.* (2004b) and Teixeira *et al.* (1996) stated that ewes were fatter than rams at the same age. Similar results were found in this study, as was reflected by a higher ($P < 0.05$) average lipid concentration in the proximate chemical analysis. Meat from rams contained a higher percentage of moisture in the *M. longissimus* than ewe carcasses, which agrees with the results of Kemp *et al.* (1976).

Conclusion

The differences in retail cut weights after adjustment for slaughter weight in favour of Dormers indicated a higher percentage of the more valuable meat cuts in this breed. This would be an advantage in a terminal sire breed. This study emphasised the fact that early maturing breeds are generally fatter at the same age than late maturing breeds. Meat sensory evaluation indicated that meat from Merino sheep had lower scores for juiciness, as dictated by their lower fat cover, although there were no differences in flavour. Further studies are necessary to ascertain whether there are differences in cooking loss, drip loss and sensory evaluation if carcasses of these four breeds were slaughtered at the same fat content.

References

AMSA, 1978. Guidelines for cookery and sensory evaluation of meat. American Meat Science Association, National Livestock and Meat board, Chicago, IL.

AOAC, 1997. Official methods of analysis of the Association of Official Analytic Chemists (16th ed.) Arlinton, Virginia, USA, AOAC International.

Campher, J.P., Hulun, C. & Van Zyl, G.J., 1998. South African Livestock Breeding. South African Stud Book and Livestock Improvement Association. PO Box 270. Bloemfontein 9300, South Africa.

Cloete, J.J.E., Hoffman, L.C., Cloete, S.W.P. & Fourie J.E., 2004(a). A comparison between the body composition, carcass characteristics and retail cuts of South African Mutton Merino and Dormer sheep. S. Afr. J. Anim. Sci. 34, 44-50.

Cloete, J.J.E., Hoffman, L.C., Cloete S.W.P & Fourie J.E., 2004(b). Slaughter traits of Merino sheep divergently selected for multiple rearing ability. S. Afr. J. Anim. Sci. 34, 189-196.

Commision International De L' Eclairage, 2nd, 1976. Commision Internationale De L' Eclairage, 18th session, London, England. September 1975. CIE publication no. 36.

Dryden, F.D. & Marchello, J.A., 1970. Influence of total lipid and fatty acid composition upon the palatability of three bovine muscles. J. Anim. Sci. 31, 36-41.

Enright, W.J., Quirke, J.F., Gluckman, P.D., Breier, B.H., Kennedy, L.G., Hart, I.C., Roche, J.F., Coert, A. & Allen, P., 1990. Effects of long-term administration of pituitary-derived bovine growth hormone and estradiol on growth in steer. J. Anim. Sci. 68, 2345-2350.

Fahmy, M.H., Gariepy, C. & Fortin, J., 1999. Carcass quality of crossbred lambs expressing the callipyge phenotype born to Romanov purebred and crossbred ewes. Anim. Sci. 69, 525- 533.

Hoffman, L.C., 2000. The yield and carcass chemical composition of impala (*Aepyceros melampus*), a southern African antelope species. J. Sci. Food Agric. 80, 752-756.

Honikel, K.O., 1998. Reference methods for the assessment of physical characteristics of meat. Meat Sci. 49, 447-457.

Gilmour, A.R., Cullis, B.R., Welham, S.J. & Thompson, R., 1999. ASREML – Reference manual. NSW Agricultural Biometric Bulletin No. 3. NSW Agriculture, Orange Agricultural Institute, Forest Road, Orange 2800, NSW, Australia.

Jeremiah, L.E., Jones, S.D.M., Tong, A.K.W., Robertson, W.M. & Gibson, L.L., 1997. The influence of lamb chronological age, slaughter weight and gender on yield and cutability. Int Sheep Goat Res. J. 13, 39-46.

Jeremiah, L.E. & Phillips, D.M., 2000. Evaluation of a probe for predicting beef tenderness. Meat Sci. 55, 493-502.

Kemp, J.D., Johnson, A.E., Stewart, D.F., Ely, D.G. & Fox, J.D., 1976. Effect of dietary protein, slaughter weight and sex on carcass composition, organoleptic properties and cooking losses of lamb. J.Anim. Sci. 42, 575-583.

Kirton, A.H., Carter, A.H., Clarke, J.N., Sinclair, D.P., Mercer, G.T.J.K. & Duganzich, D.M., 1995. A comparison between 15 ram breeds for export lamb production 1. Liveweights, body composition, carcass measurements and composition. N.Z.J. Agric. Res. 38, 347-360.

Kotzé, J.J.J., 1951. The development of a mutton-woolled sheep for the sour-grassveld area. Farm. S. Afr. April 1951, 110-113.

Lawrie, R.A., 1998. Lawrie's Meat Science. 6th ed. Woodhead Publ. Ltd. Cambridge, England.

Lee, C.M., Trevino, B. & Chaiawat, M., 1996. A simple and rapid solvent extraction method for determining total lipids in fish tissue. J. AOAC Intern 79, 487-492.

McGeehin, B., Sheridan, J.J. & Butler, F., 2001. Factors affecting the pH decline in lamb after slaughter. Meat Sci. 58, 79-84.

Neser, F.W.C., Erasmus, G.J. & Van Wyk, J.B., 2000. Genetic studies on the South African Mutton Merino: growth traits. S. Afr. J. Anim. Sci. 30, 172-177.

Oman, J.S., Waldron, D.F., Griffin, D.B. & Savell, J.W., 1999. Effects of breed-type and feeding regimen on goat carcass traits. J. Anim. Sci. 77, 3215-3218.

SAS., 1990. SAS/STAT User's guide, Version 6 (4th ed.). Cary, NC: SAS Institute Inc.

Schönfeldt, H.C., Naudè, R.T., Bok, W., Van Heerden, S.M. & Smit, R., 1993. Flavour- and tenderness-related quality characteristics of goat and sheep meat. Meat Sci. 34, 363-379.

Stanford, K., Woloschuk, C.M., McClelland, L.A., Jones, S.D.M. & Price, M.A., 1997. Comparison of objective external carcass scores for prediction of lamb carcass quality. Can. J. Anim. Sci. 77, 217-223.

Teixeira, A., Delfa, R. & Treacher, T., 1996. Carcass composition and body fat depots of Galego Bragnançano and crossbred lambs by Suffolk and Merino Precoce sire breeds. Anim. Sci. 63, 389-394.

Van der Merwe, C.A., 1976. Genetiese en nie-genetiese faktore wat die produksie en reproduksie eienskappe van die Elsenburg Dormer Skaapkudde beïnvloed. Ph.D. (Agric)-Thesis. University of Stellenbosch.

Chapter 3

Production performance and efficiency of Merino, Dohne Merino and South African Mutton Merino sheep

Production performance and efficiency of Merino, Dohne Merino and South African Mutton Merino sheep

Abstract

Production parameters were obtained from Merino, Dohne Merino and South African Mutton Merino (SAMM) stud flocks maintained at the Mariendal experimental farm of the University of Stellenbosch. Average lamb production (kg of lamb weaned per ewe lambed) over three lambings were higher in SAMM ewes than in Dohne Merinos, while Dohne Merino ewes in turn outperformed Merino ewes in this respect. Yearling SAMM lambs were heavier than Dohne Merinos, which were heavier than Merinos. Merinos produced more clean wool than Dohne Merinos, which produced more clean wool than SAMM yearlings. Average fibre diameter of Merino and Dohne Merino yearling sheep was similar, but SAMM wool was slightly coarser. An economic simulation indicated differences in gross income per small stock unit between the three breeds. Merinos outperformed the other two breeds with regard to wool production traits, and were generally the most profitable under a range of wool and meat prices.

Keyword: Income, small stock unit, sheep, woolled breeds

Introduction

The Dohne Merino and South African Mutton Merino (SAMM) breeds make an important contribution in numbers to the wool sheep population of South Africa. The SAMM was derived from the German Merino, which was imported from Germany (Campher *et al.*, 1998). The SAMM has a favourable growth rate and produces a lamb suitable for slaughter at an early age with good meat characteristics (Neser *et al.*, 2000). The Dohne Merino, developed from the Merino and the former German Merino, was originally intended for semi-intensive farming in the Eastern Cape grassland regions (Kotze, 1951), but since proved to be adaptable under widely divergent conditions. The adaptability of the breed resulted in a sustained growth for the breed and expansion to other areas in South Africa, and elsewhere in the world. Both these breeds have adapted well to South African conditions, and have now become the main dual-purpose (meat and wool) breeds. Yet there are limited comparative studies on their relative performance compared to the Merino, which can be considered as a true international sheep breed and the dominant South African sheep breed. This study reports production parameters for Merino, Dohne Merino and SAMM flocks under typical South African stud breeding conditions.

Material and Methods

Data recorded over a 15 year period (1980-1994) in stud flocks of Merino, Dohne Merino and SAMM were analysed to provide production parameters for the respective breeds. The studs consisted of 80-120 breeding ewes each, and were maintained on the Mariendal experimental farm of the University of

Stellenbosch. The climate at the experimental site is Mediterranean, with a mean annual precipitation of 605 mm. The ewes were maintained in separate flocks throughout the time. However, all flocks were rotated through irrigated kikuyu and dryland grass-clover paddocks. Cereal stubble was available seasonally. The pasture was supplemented with 0.5 to 1.0 kg per head per day of a complete diet (containing 14% crude protein and 9.7 MJ metabolizable energy per kg DM (or as fed) basis) during late pregnancy and lactation. Management programs were the same for all flocks. Lambing management was intensive, ewes being run on small (0.25 ha) paddocks. Lambs were identified with their dams at lambing and housed in individual interior pens of 1.5 X 1.2 m for 2-5 days. They were subsequently joined with other lambed ewes in groups of 20-30 ewes with their progeny on small paddocks. During this period, they received the same diet that was used to supplement the pastures *ad libitum*. Individual survival to weaning and weaning weights were recorded for all breeds. After weaning, at an average age (± SD) of 110±22 days, progeny of the respective breeds grazed together, separated according to sex. They were shorn as lambs at an age of approximately five months and selected for retainment into the flock according to breed standards. At the following shearing at 10-12 months age, greasy fleece weight was recorded for those lambs retained after initial lamb selection. A mid-side fleece sample was also taken for the determination of clean yield, fibre diameter and staple length. Fleece-free body weight was recorded after shearing. Clean fleece weight was calculated individually. Fleece weight and staple length were adjusted to a constant growth period of 183 days. Yearling live weight and fleece traits were recorded for 826 Merino, 1607 Dohne Merinos and 1535 SAMM sheep. Selection procedures in all three studs were consistent with practices in the stud industry and in cooperation with the respective breed societies.

Lamb survival data were compared among breeds, using Chi-square procedures (Siegel, 1956). Mean litter size at birth was expressed per ewe lambed, and compared for the breeds by the method described by Brown (1988). This statistical tests based on the chi-squared distribution are given for testing the homogeneity of lambing rates (the number of lambs born per ewe joined) and survival rates. Continuous variables were analyzed by least squares (Harvey, 1990). The fixed model employed included the effects of breed, year, sex, age of dam (2-7 years), birth type (single, twin or pooled triplets and quadruplets) and significant two-factor interactions for yearling traits. Weaning age was included as a linear regression in the analysis on weaning weight. The objective of the investigation was the comparison of the three breeds, and these results are emphasized. Results pertaining to the other fixed effects were consistent with the literature on environmental influences in sheep, and were excluded from the results and discussion. Exceptions were made when such fixed effects interacted ($P < 0.05$) with breed.

Data obtained from the study were entered into the SM2000 economic simulation model as described by Herselman (2002). Information on the details required by SM2000 for an economic simulation is provided in the latter literature source. Feeding cost is considered as a major cost item for commercial sheep production systems (Schoeman *et al.*, 1995). In the simulation, live weight and growth rates were used as an indication of the energy requirements of ewes and lambs, using the standards compiled by the ARC

(1980). Energy requirements were used for calculation of small stock units (SSU), where 1 SSU is considered to be equivalent to 11.25 MJ ME/day. The average wool weight of lambs (of all breeds) was assumed to be 50% of adult performance. Results were thus expressed on a gross income per small stock unit (SSU) basis. Average wool and meat prices used for the simulation were obtained from the industry. Average wool weight of the yearlings of all breeds was assumed to be 85% of adult ewe performance. In order to provide a robust outcome, a range of average wool and meat prices obtained from industry were considered over a 16 year period from 1990 to 2006.

Results and Discussion

The number of lambs born per ewe lambed were 30 and 7% higher (P < 0.05) in SAMM ewes than in Merino and Dohne Merino ewes respectively (Table 1). Dohne Merino ewes correspondingly outperformed Merino ewes in this respect. Birth weights of SAMM lambs were higher (P < 0.05) than those of Dohne Merinos, which in turn had heavier (P < 0.05) birth weights than Merinos. Overall, Merino and Dohne Merino lambs were more (P < 0.05) likely to survive to weaning than SAMM lambs. The average survival of lambs to weaning was high in all breeds, compared to previous values for SA Mutton Merinos (Cloete, 1992) and Merinos (Cloete & Scholtz, 1998), and considering the high percentage of multiples. Dohne Merino lambs weighed 16.4% more (P < 0.05) than Merino contemporaries at weaning (Table 1). The differences for weaning weight between these breeds were previously reported to be 19.4% (Basson *et al.*, 1970). SAMM lambs weighed 24.3% more than Merinos, and 6.6% more than Dohne Merinos at weaning (P < 0.05).

Table 1 Lambs born, birth weight, survival and weaning weight (± SE) of Merino, Dohne Merino and SA Mutton Merino lambs

	Breed			
	Merino	Dohne Merino	SAMM	Chi^{2*}
Number of ewes with lambing records	1171	1558	1528	
Lambs born per ewe lambed	1.525^a	1.757^b	1.827^c	208.25
Birth weight (kg)	$4.73^2 \pm 0.02$	$4.65^3 \pm 0.02$	$4.92^1 \pm 0.02$	
Survival				
Number of lambs	1786	2740	2790	
Lambs weaned per lamb born	0.825^a	0.851^a	0.794^b	31.074
Weaning weight	$25.9^1 \pm 0.4$	$30.2^2 \pm 0.2$	$32.2^3 \pm 0.2$	

* Critical Chi^2-value for 2 degrees of freedom = 5.99
abc Proportions with different superscripts differ (P < 0.05) in rows
123 Means with different superscripts differ (P < 0.05) in rows

The total weight of lamb weaned by ewes over three consecutive production seasons (lambing at 2, 3 and 4 wears of age) was considered next. Merino ewes (n = 169) produced an average (±SE) of 31.1±1.1 kg of lamb per season over that period. Total weight of lamb weaned correspondingly averaged 28.8 kg in the

Merino breed analysis reported by Olivier *et al.* (2001). The lamb output of 260 Dohne Merino ewes was 33.5% higher (41.8±0.9 kg of lamb per season; P < 0.01). Means derived from data of Basson *et al.* (1969) suggested a 20.3% advantage of Dohne Merino ewes compared to Merino ewes. A further improvement (P < 0.05) of 6.9% was observed in 237 SAMM ewes, which produced 44.7±1.0 kg of lamb per season. The lamb output of SAMM ewes was previously reported to be 14.5% higher than from Dohne Merinos (Schoeman 1990). The derived means for the respective breeds were in general accordance but slightly higher than corresponding means derived for commercial Merino ewes (that were selected for fleece weight), Dohne Merino ewes and SAMM ewes in a pasture-based terminal crossbreeding situation (Cloete *et al.*, 2003; 2004). It needs to be considered that the latter study reported means on a per ewe mated basis under pastoral conditions, possibly contributing to this difference.

Table 2 Least squares means (± SE) for yearling production traits in Merino, Dohne Merino and SA Mutton Merino yearlings across sexes

Trait	Breed		
	Merino	Dohne Merino	SA Mutton Merino
Yearling weight (kg)	$51.3^c \pm 0.2$	$60.1^b \pm 0.2$	$67.4^a \pm 0.2$
Yearling clean fleece weight (kg)	$3.28^a \pm 0.02$	$2.18^b \pm 0.01$	$1.63^c \pm 0.02$
Yearling clean yield (%)	$72.5^a \pm 0.3$	$66.7^b \pm 0.3$	$61.2^c \pm 0.3$
Yearling fibre diameter (μm)	$21.9^b \pm 0.05$	$21.8^b \pm 0.04$	$23.7^a \pm 0.05$
Yearling staple length (mm)	$59.1^a \pm 0.7$	$56.6^a \pm 0.3$	$49.4^c \pm 0.6$

^{abc} Means with different superscripts differ (P < 0.05) in rows

For yearling traits, the interaction of breed with sex was significant (P < 0.05) in most instances. Results in Table 2 stems from the overall analysis, to provide a basis for comparison with results derived from South African breed specific analyses in the literature. The South African breed analysis for traits in Merinos of both sexes yielded means of 27.8 kg for weaning weight (see Table 1), 45.7 kg for yearling weight, 3.82 kg for clean fleece weight and 19.2 μm for fibre diameter (Olivier *et al.*, 2001). Results are broadly comparable if it is considered that clean fleece weight was probably recorded after a presumably longer, but unspecified growth period. Overall means from a recent Dohne Merino breed analysis amounted to 50 kg for yearling live weight, 3.12 kg for clean fleece weight and 19.4 μm for yearling fibre diameter (Van Wyk *et al.*, 2006). In this instance the stud breeding practices at Mariendal appeared to be more favourable than in the breed analysis, as reflected by an approximately 10 kg difference in yearling live weight. The lower fibre diameter means in the more recent breed analyses were expected, given the emphasis placed on the production of finer wool in the recent years.

Means for the respective sexes are in Table 3 for ewes and Table 4 for rams. In general, SAMM yearlings were heavier (P < 0.05) than Dohne Merinos, which in turn were heavier (P < 0.05) than Merinos as was also reported in Table 2. Breed differences were larger in ewes than in rams, resulting in the interaction mentioned previously. Dohne Merino and SAMM ewe yearlings were 17.1 and 32.6% heavier (P < 0.05) than Merino contemporaries, respectively. The corresponding differences for ram yearlings amounted to 13.4 and 26.5%, respectively.

Yearling clean fleece weight and clean yield decreased ($P < 0.05$) from Merinos to Dohne Merinos and further ($P < 0.05$) to SAMM sheep (Table 2). In this case, breed differences were generally smaller in ewes than in rams. Clean fleece weight of Dohne Merino and SAMM ewes (Table 3) amounted to respectively 70.1 and 52% of that recorded in Merinos. Corresponding values for rams were 66.5 and 48.9%, respectively. The clean wool production of mature Dohne Merino ewes was previously reported to amount to 69.7% of that of Merino ewes (Basson *et al.*, 1969). Greeff (1990) reported that the respective fleece weights of Dohne Merino and SAMM amounted to 64.3 and 51.8% of that of Merinos.

Table 3 Least squares means (± SE) for yearling production traits in Merino, Dohne Merino and SA Mutton Merino ewe yearlings

Trait	Breed		
	Merino	Dohne Merino	SA Mutton Merino
Birth weight (kg)	$4.61^{b}±0.03$	$4.48^{c}±0.02$	$4.79^{a}±0.03$
Yearling weight (kg)	$42.9^{c}±0.3$	$51.2^{b}±0.2$	$57.9^{a}±0.9$
Yearling clean fleece weight (kg)	$2.96^{a}±0.02$	$2.00^{b}±0.02$	$1.52^{c}±0.02$
Yearling clean yield (%)	$73.3^{a}±0.4$	$68.5^{b}±0.3$	$63.6^{c}±0.4$
Yearling fibre diameter (μm)	$21.9^{b}±0.06$	$21.7^{b}±0.05$	$23.7^{a}±0.06$
Yearling staple length (mm)	$58.6^{a}±0.7$	$55.9^{b}±0.3$	$49.4^{c}±0.3$

^{abc} Means with different superscripts differ ($P < 0.05$) in rows

Mature Dohne Merino ewes produced 4.3 kg of greasy wool in the study of Schoeman (1990), compared to 2.9 kg in SAMM sheep. The clean yield of Dohne Merino and SAMM ewe yearlings was respectively 93.5 and 86.6% of the corresponding value for Merinos (Table 3). The corresponding values were 89.5 and 81.5% in ram yearlings (Table 4). The fibre diameter of Merinos and Dohne Merinos of both sexes was similar, while SAMM fleeces were approximately 8% coarser ($P < 0.05$). Yearling average staple length means of Dohne Merino and particularly SAMM sheep were shorter ($P < 0.05$) than those of Merinos.

Table 4 Least squares means (± SE) for yearling production traits in Merino, Dohne Merino and SA Mutton Merino ram yearlings

Trait	Breed		
	Merino	Dohne Merino	SA Mutton Merino
Birth weight (kg)	$4.85^{b}±0.03$	$4.83^{c}±0.02$	$5.05^{a}±0.02$
Yearling weight (kg)	$59.6^{c}±0.3$	$68.9^{b}±0.9$	$76.9^{a}±0.2$
Yearling clean fleece weight (kg)	$3.61^{a}±0.02$	$2.36^{b}±0.02$	$1.74^{c}±0.02$
Yearling clean yield (%)	$71.7^{a}±0.5$	$65.0^{b}±0.4$	$58.5^{c}±0.3$
Yearling fibre diameter (μm)	$21.9^{b}±0.07$	$22.0^{b}±0.06$	$23.7^{a}±0.06$
Yearling staple length (mm)	$59.6^{a}±0.7$	$57.3^{b}±0.3$	$49.5^{c}±0.4$

^{abc} Means with different superscripts differ ($P < 0.05$) in rows

Economic data used in the simulation is provided in Table 5. No grading/classification results of individual carcasses were available, for that reason the same average meat price were used for the three breeds. This mode of action was motivated by the relatively good growth rates of all sheep under the prevailing conditions, while it was also supported by previous results involving terminal crossbred lambs that were produced by ewes from the respective breeds (Cloete *et al.*, 2004). Results reported in Chapter 11 on Dorper and Dorper crossbred lambs also suggest that meat prices are relatively stable for genotypes differing in qualitative slaughter traits in the present South African grading system. Wool prices obtained from industry for the Merino and Dohne Merino breeds were somewhat higher that those obtained for SAMM wool. This trend is consistent with earlier results, with estimated prices of R37 to R39 for Merino wool, R37 for Dohne Merino wool and R29 for SAMM wool (Cloete *et al.*, 2004).

Table 5 Average meat and wool prices used in the economical analysis.

Year	Meat price use for all three breeds (R/kg carcass weight)	Merino and Dohne Merino clean wool price (R/kg)	SAMM clean wool price (R/kg)
1990	R5.81	R12.68	R8.62
1991	R6.39	R12.77	R8.68
1992	R6.87	R10.49	R7.13
1993	R7.74	R12.11	R8.23
1994	R10.48	R20.28	R13.79
1995	R10.47	R17.29	R11.76
1996	R11.12	R22.28	R15.15
1997	R12.53	R22.16	R15.07
1998	R12.16	R17.71	R12.04
1999	R12.36	R19.41	R13.20
2000	R14.06	R22.91	R15.58
2001	R14.59	R33.19	R22.57
2002	R16.86	R43.26	R29.42
2006	R24.52	R24.27	R16.50

Figure 1 depicts the trends in income per SSU, with the highest income consistently derived from Merino sheep, an intermediate income from Dohne Merino sheep and the lowest income from SAMM sheep. The drop in income from 2002 to 2006 for the Merino sheep was due to a markedly lower wool price (R24 vs. R43). The relative success of the Merino breed seems to stem from three factors, namely their higher expected income from wool, there smaller body size and the fact that the ewes used were capable of achieving a relatively high reproduction rate. The lower income from SAMM could be attributed to the lower wool production and lower wool price. Comparable results were reported by Cloete *et al.* (2004) where Merino ewes outperformed Dohne Merino and SAMM ewes in terms of income per small stock unit, using these three breeds in a terminal crossbreeding system. Snyman & Herselman (2005) accordingly reported that the income from wool producing Merino sheep exceeded that derived from dual-purpose Afrino sheep, with the lowest income being derived from meat producing Dorper sheep. These results were shown to be quite robust over a range of simulated wool and meat prices, and the authors concluded that Merino ewes with a good average reproduction rate is likely to outperform other breeds in economic terms.

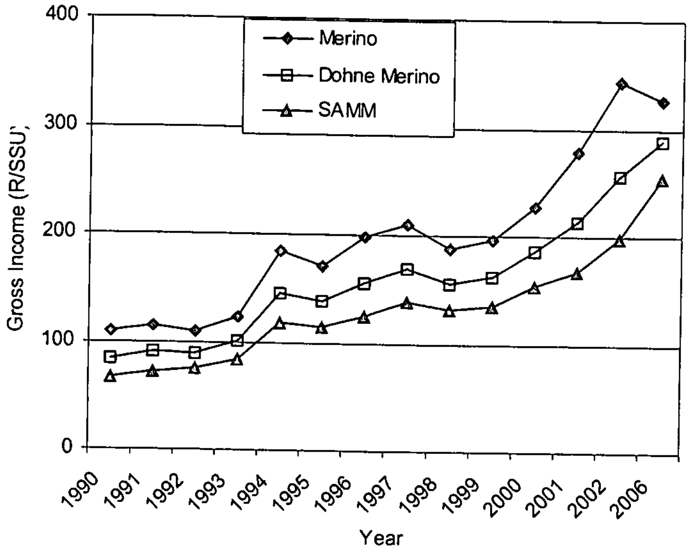

Figure 1 Gross income per small stock unit (SSU) for Merino, Dohne Merino and SAMM sheep when assessed at the reigning wool and meat prices for the period 1990 – 2006

Conclusion

It was evident that the dual-purpose Dohne Merino and SAMM breeds outperformed the Merinos as far as lamb output was concerned. Weaning and yearling weights followed a similar pattern. However, Merinos outperformed the other two breeds with regard to wool production traits, and were generally the most profitable under a range of wool and meat prices. However, results from the literature have indicated that economic differences between individuals within breed often surpasses differences between breeds (Fogarty, 2006). A breeding program for maximum economic gains is expected to make use of both variation between and within breeds.

References

ARC, 1980. The nutrient requirements of farm livestock. No 2: Ruminants. Agricultural Research Council, Commonwealth Agricultural Bureaux, London.

Basson, W.D., Van Niekerk, B.D.H., Mulder, A.M. & Cloete, J.G., 1969. The productive and reproductive potential of three breeds mated at 8-monthly intervals under intensive feeding conditions. Proc. S. Afr. Soc. Anim. Prod. 8, 149-154.

Basson, W.D., Van Niekerk, B.H.D. & Mulder, A.M., 1970. Growth and puberty of lambs raised under intensive conditions. Proc. S. Afr. Soc. Anim. Prod. 9, 171-175.

Brown, G.H., 1988. The statistical comparison of reproduction rates for groups of sheep. Aust. J. Agric. Res. 39, 899 - 905.

Campher, J.P., Hulun, C. & Van Zyl, G.J., 1998. South African Livestock Breeding. South African Stud Book and Livestock Improvement Association. PO Box 270. Bloemfontein 9300, South Africa.

Cloete, S.W.P., 1992. Observations on litter size, parturition and maternal behaviour in relation to lamb mortality in fecund Dormer and South African Mutton Merino ewes. S. Afr. J. Anim. Sci. 22, 214-221.

Cloete, S.W.P., Cloete, J.J.E., Durand, A. & Hoffman, L.C., 2003. Production of five Merino type lines in a terminal crossbreeding system with Dormer or Suffolk sires. S. Afr. J. Anim. Sci. 23, 223-232.

Cloete, S.W.P., Cloete, J.J.E., Herselman, M.J. & Hoffman, L.C., 2004. Relative performance and efficiency of five Merino dam lines in a terminal crossbreeding system with Dormer or Suffolk sires. S. Afr. J. Anim. Sci. 34, 135-143.

Cloete, S.W.P. & Scholtz, A.J., 1998. Lamb survival in relation to lambing and neonatal behaviour in medium wool Merino lines divergently selected for multiple rearing ability. Aust. J. Exp. Agric. 38, 801-811.

Fogarty, N.M., 2006. Utilization of breed resources for sheep production. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 04-10.

Greeff, J.C., 1990. The Merino and modern production systems. Proc. World. Merino Conf. Volume 1, 3.2,1-33. 2-4 May, 1990, Pretoria, South Africa. (Merino Studbreeders' Society of South Africa, P.O. Box 109, Graaff-Reinet 6280, South Africa.)

Harvey, W.R. 1990. User's guide for LSMLMW and MIXMDL. PC-2 version, Mimeograph.

Herselman, M.J., 2002. The role of simulation models in agricultural extension. Proc. 1st Joint Cong. Grassl. Soc. S Afr. Soc. Anim. Sci., 13-16 May 2002, Christiana Aventura, pp 46a-46c

Kotzé, J.J.J., 1951. The development of a mutton-woolled sheep for the sour-grassveld area. Farm. S. Afr. Reprint 26, 110-113.

Neser, F.W.C., Erasmus, G.J. & Van Wyk, J.B., 2000. Genetic studies on the South African Mutton Merino: growth traits. S. Afr. J. Anim. Sci. 30, 172-177.

Olivier W.J., Snyman, M.A., Olivier, J.J., van Wyk J.B. & G.J. Erasmus, G.J., 2001. Direct and correlated responses to selection for total weight of lamb weaned in Merino sheep. S. Afr. J. Anim. Sci., 3, 115 121.

Schoeman, S.J., 1990. Productivity of purebred Dohne Merino, SA Mutton Merino and Dorper sheep under an intensive accelerated lambing system. Proc. 4th Wrld Cong. Genet. Appl. Livest. Prod., Edinburgh, UK. 15, pp. 373-376.

Schoeman, S.J., De Wet, R., Botha, M.A. & Van der Merwe, C.A., 1995. Comparative assessment of biological efficiency of crossbred lambs from two composite lines and Dorper sheep. Small Rumin. Res. 16, 61-67.

Siegel, S., 1956. Non Parametric Statistic for the Behavioral Sciences. McGraw-Hill, New York.

Snyman, M.A. & Herselman M.J., 2005. Comparison of productive and reproductive efficiency of Afrino, Dorper and Merino sheep in the False Upper Karoo. S. Afr. J. Anim. Sci., 35, 98-107.

Van Wyk, J.B., Swanepoel, J.W., Delport, G.J. & Cloete, S.W.P., 2006. Estimates of genetic parameters for yearling body weight and fleece traits in the South African Dohne Merino population. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 04-10.

Chapter 4

Comparative analysis of reproduction potential of Dorper and Merino ewes as well as Boer Goat does under extensive production conditions in South Africa

Comparative analysis of reproduction potential of Dorper and Merino ewes as well as Boer Goat does under extensive production conditions in South Africa

Abstract

Three of the most important small stock breeds in South Africa, namely the Dorper, Merino and Boer Goat were compared on their production potential for seven years under extensive conditions on Nortier experimental farm. Approximately 80 Dorper ewes, 45 Merino ewes and 40 Boer Goat does were used each year. The sheep were mated from middle December for six weeks and the Boer Goat does from middle January for six weeks. At birth, birth weight, sex of the lamb and the birth status (singles or multiples) were recorded. Survival to weaning was recorded for all lambs. Slaughter weight and age at slaughter and cold carcass weight were recorded. Reproduction, expressed as lambs/kids born per ewe lambed was 1.24 for Merino ewes, 1.57 for Dorper ewes and 1.98 for Boer Goat does. The survival rate of the lambs from the Dorper and Merino ewes were almost 10 % higher than the Boer Goat kids (0.90 and 0.87 vs. 0.77 respectively). Birth weight of lambs born from Dorper ewes was respectively 7 % and 12 % higher than lambs born from Merino ewes and kids produced by Boer Goat does. At weaning, the Dorper lambs were heavier than the other two breeds, while the Boer Goat kids also had a heavier weaning weight than the Merino lambs. Slaughter weight and dressing percentage of Dorper lambs were higher than those of Merino lambs and Boer Goat kids. Reproduction and growth of the three breeds were comparable with figures found in the literature. Dorpers were able to produce a quality slaughter lamb, at an early age from natural pasture under extensive conditions. The Merino is not traditionally a breed known for slaughter lamb production, but the lambs performed relatively well under the experimental conditions. The Boer Goat showed an ability for high meat production but low survival rates restricted this potential. An economical analysis indicates that the Merino ewes outperformed the other two breeds in terms of income per small stock unit under these experimental conditions.

Keywords: Slaughter age, slaughter weight, reproductive performance, survival rate

Introduction

The Dorper is a composite breed derived in South Africa from a cross between the Dorset Horn and the Blackheaded Persian. The Dorper is well adapted to thrive under arid and hot conditions. Dorper sheep are typically maintained in divergent environments and under a variety of managerial regimes. They are capable of fairly high levels of reproduction i.e. 90-150% lambs weaned per ewe joined, as reviewed by Cloete *et al.* (2000). The Merino on the other hand is a wool-type sheep that originates from Europe. Merino sheep compose 40% of the total sheep population in South Africa. Lambing percentage of the Merino is between 75-120% (Campher *et al.*, 1998). In a study by Fourie & Cloete (1993) the mean number of lambs marketed as a percentage of ewes joined, was 87% for Merino ewes. The Boer Goat has its origin in the Eastern Cape Province of South Africa and was developed from indigenous African and introduced

European stock (Casey & Van Niekerk, 1985). Goats have the ability to survive and reproduce under adverse environmental conditions. The Boer Goat is also capable of fairly high reproduction rates, with percentages of 210% kids born per number of ewes kidded, and 165% kids weaned per ewe kidded having been recorded (Campher *et al.,* 1998).

All three breeds are frequently farmed under extensive pastoral conditions such as Strandveld Succulent Karoo (Low & Rebelo, 1996). As the grazing (veldt) requirements of the breeds overlap, farmers are frequently faced with the choice of which breed is most suitable for their specific environment. There is also uncertainty of which breed would perform the best in a specific environment as far as economic yield is concerned.

Almost 80% of the financial income acquired from Merino sheep production is from the meat production which is mostly obtained from lambs, whereas 100% of the financial income acquired in Dorper and Boer Goat production comes from the meat production. No data is available in South Africa regarding the comparison of the reproduction potential of Dorper, Merino and Boer Goat ewes under extensive conditions. The objective of this study was therefore to compare the reproduction rate of Dorper, Merino and Boer Goat ewes kept on the same farm with a low input management system for seven breeding seasons.

Materials and Methods

The experiment was carried out on the Nortier experimental farm in the West Coast Strandveld area of the Western Cape, South Africa from 1978 till 1984. A paper by Cloete & De Villiers (1987) provides a description of the location and vegetation of the experimental farm. The dominant vegetation type is Strandveld Succulent Karoo vegetation (Low & Rebelo, 1996). The climate at the experimental site is Mediterranean, with 76 % of the total long-term annual precipitation of 221 mm being recorded during winter (April to September). The experimental site is characterised by dry, hot summers and cooler winters with an unpredictable and variable rainfall.

Dorper and Merino ewes as well as Boer Goat does were kept on the farm for seven years from 1978 – 1984 and their reproduction compared. Approximately 80 Dorper ewes, 45 Merino ewes and 40 Boer Goat ewes were used each year. Normal farming practices were followed each year, with the oldest age group being cast for age and young ewes selected and introduced into the breeding flock. The experimental flock grazed on natural pasture throughout the production cycle. From January till the first winter rain, all the animals received an urea-molasses lick. A problem in the experimental layout was that the ewes could not be maintained in a single flock throughout the year. However, the flocks were rotated between four different paddocks throughout the year on a monthly basis.

Dorper and Merino ewes were joined from middle December for six weeks and the Boer Goat ewes from middle January for six weeks, this joining dates are in accordance with what is normal farming practices in that region of South Africa. The sheep lambed during May and June and the goats during June and July. Birth weight, birth type (single or multiple) and sex of the lamb, or kids were recorded within 24 hours after birth. All the ram lambs and male kids were castrated after reproduction ceased for a specific season. The lambs were weaned at four months of age and the kids were weaned at a mean age of seven months. Survival to weaning was recorded for all lambs. During 1978 there was not sufficient feed available for the animals on the farm and all the lambs/kids were weaned early. The Dorper lambs and Boer Goat kids weight 16 kg at 60 and 90 days respectively and the Merino lambs weighed 11 kg at 60 days. These lambs were placed in a feedlot, to keep them alive and to ensure that the ewes survived.

All the wether lambs and surplus ewes and does (not selected for further breeding purposes) were slaughtered. Dorper lambs were slaughtered at approximately four and a half months, just after weaning. Merino lambs were slaughtered at 18 months after being subjected to phenotypic selection on type. Under commercial conditions in South Africa, lambs are commonly shorn as lambs and two-tooth or yearling age for the extra wool income from the young animals prior to slaughter. Merino ewes were shorn each year during spring. Boer Goat kids were weaned and slaughtered at seven months. Slaughter weight was determined prior to slaughter and age at slaughter was recorded. Cold carcass weights were recorded after 24 hours and used for the calculation of dressing percentage. Only the slaughter data for two breeding seasons (1978 and 1980) is used since the relevant data were not recorded during the other years.

Normally distributed birth and weaning weight data as well as slaughter data were analysed according to a 3 (breed) X 2 (birth type; singles and pooled multiples) X sex (male and female) X age of dam (maiden and mature) factorial analysis. Year was also added as a fixed effect in these analysis. Least squares procedures were used to account for uneven subclasses (Harvey, 1990). Since interactions were not significant in the vast majority of cases, only relevant main effect means were tabulated. Interaction effects are also provided in cases where significant ($P < 0.05$).

A linear regression on weaning age was also fitted for weaning weight for each of the breeds and weaning weight corrected to a hundred days of age were used for further analysis. Binomially distributed lamb mortality data were assessed by standard Chi-squared procedures (Siegel, 1956). Ewe reproduction was compared between breeds by the no-parametric method of Brown (1988).

Data obtained from the study were entered into the SM2000 economic simulation model (Herselman, 2002). Information on the details required by SM2000 for an economic simulation is provided in the latter literature source. All the data required for the economic analysis were not recorded in this study. This typically involved fleece traits in the case of the Merinos. Mean levels of performance for traits not recorded individually were obtained from De Villiers (1987).

Feeding cost is considered as a major cost item for commercial sheep production systems (Schoeman *et al.*, 1995). In the simulation, live weight and growth rates were used as an indication of the energy requirements of ewes and lambs (ARC, 1980). Energy requirements were used for calculation of small stock units (SSU), where 1 SSU is equivalent to 11.25 MJ ME/day. Average wool weight of the Merino lambs was assumed to be 50% of adult ewes' performance. No grading/classification of carcasses was undertaken. The same average meat price was thus used for Merino and Dorper lambs. Unfortunately no average prices were available for goat meat on the local market from 2000 (Table 5). A second economical analysis was done with on-farm prices for goat meat instead of using average abattoir prices (Table 6). Only prices for the last three years were available to conduct this analysis. Expenses were not broken down further, but it was assumed that all three breeds were subjected to the same level of husbandry and health care. Results are thus expressed on a gross income per small stock unit (SSU) basis. Average wool and meat prices used for the simulation were obtained from the industry. In order to provide an outcome, a range of average wool and meat prices were considered over a 15 year period from 1990 - 2004.

Results

As there were interactions between breed and lambing year, the main effects of breed and birth type and sex are discussed first. The average reproduction, defines as number of lambs/kids born per ewe/doe lambed/kidded amounted to 1.60 for Dorper ewes, 1.24 for Merino ewes and 1.98 for Boer Goat (Chi^2 = 229.9; Table 1). The survival rate of the lambs from Dorper and Merino ewes were nearly 10% higher than that of the Boer Goat kids. The survival rate of multiples born from Dorper ewes were also approximately 10% higher than survival rates recorded for multiples born both to Merino ewes and Boer Goat does (Table 1).

Table 1 Number of lambs born as well as survival rate of the lambs. Lambing rate is expressed in relation to ewes that lambed

	Breed		
	Dorper	Merino	Boer Goat
Number of ewes lambed	573	243	231
Lambs born /ewe lambed	1.60^b	1.24^a	1.98^c
Number of lambs or kids born	917	302	495
Survival rate			
All lambs or kids	0.90^a	0.87^a	0.77^b
Singles	0.92^a	0.91^a	0.74^b
Multiples	0.89^a	0.79^b	0.77^b

[abc] Means in the same row with different superscripts differ ($P < 0.05$)

Lambs born to Dorper ewes were heavier ($P < 0.05$) at birth than lambs and kids born to Merino ewes and Boer Goat does (Table 2). Merino lambs also had heavier ($P < 0.05$) birth weights than Boer Goat kids. The Dorper lambs were the heaviest at weaning, while the Boer Goat kids also had a heavier ($P < 0.05$) weaning weight than the Merino lambs (Table 2). Even though the Dorper lambs were slaughtered at an earlier age, their slaughter weights were significantly ($P < 0.05$) heavier than those of Merino lambs and Boer Goat kids (Table 2). Boer Goat kids were slaughtered at an earlier age than Merino lambs ($P < 0.05$). Carcass weight followed the same pattern as slaughter weight with the Dorper lambs been heavier ($P < 0.05$) than the lambs and kids from the other two genotypes (Table 2). The dressing percentage of Dorper lambs was also significantly higher ($P < 0.05$) than the dressing percentage of the Merino lambs and Boer Goat kids.

Table 2 Least squares means (±SE) for lamb birth weight, weaning weight, slaughter age, slaughter weight and dressing percentage of Dorper, Merino and Boer Goat lambs

	Breed		
	Dorper	Merino	Boer Goat
Birth weight (kg)	$3.94^{a} \pm 0.03$	$3.64^{b} \pm 0.06$	$3.45^{c} \pm 0.05$
Weaning weight (kg)	$36.7^{a} \pm 0.3$	$23.8^{b} \pm 0.5$	$28.8^{c} \pm 0.9$
Slaughter age (days)	$144^{b} \pm 2$	$535^{a} \pm 8$	$215^{c} \pm 5$
Slaughter weight (kg)	$36.0^{a} \pm 0.7$	$30.9^{b} \pm 0.9$	$29.2^{b} \pm 1.4$
Carcass weight (kg)	$15.8^{a} \pm 0.3$	$11.6^{b} \pm 0.5$	$10.9^{b} \pm 0.7$
Dressing %	$43.4^{a} \pm 0.5$	$37.2^{b} \pm 0.8$	$37.6^{b} \pm 1.1$

^{abc}Means in the same row with different superscripts differ ($P < 0.05$)

Birth weights and weaning weights of wethers or castrated male goats were heavier ($P < 0.05$) than those of ewe lambs or kids. Singles were correspondingly heavier than multiples. No differences in slaughter weight and carcass weight were found between single and multiples, but wethers and castrated male goats had higher ($P < 0.05$) slaughter and carcass weights than ewe lambs or kids. Dressing percentage was not affected significantly by birth type, but the wethers and castrated male goats had a higher ($P < 0.05$) dressing percentage than ewe lambs and kids. These results are consistent with expectations from the literature and will therefore not be presented in detail.

The significant interactions between breed and lambing year are given in Table 3. Dressing percentage of Merino lambs and Boer Goat kids were not affected by slaughter year but Dorper lambs had a 5.1% higher ($P < 0.05$) dressing percentage in 1980 than in 1978 when the drought occurred.

Table 3 Least squares means (±SE) for the dressing percentage and slaughter age depicting significant ($P<0.05$) interactions between breed and lambing year, breed and birth type, breed and sex

	Breed		
	Dorper	Merino	Boer Goat
Breed X Year			
Dressing percentage	**	**	**
1978	43.2±0.5	38.2±1.1	38.6±1.1
1980	45.4±0.7	37.9±0.8	38.2±1.1
Breed X Birth type			
Slaughter age	**	**	**
Singles	141±3	543±9	234±8
Multiples	146±2	529±7	197±3
Dressing percentage	*	ns	ns
Singles	45.0±0.6	36.7±0.8	37.0±1.8
Multiples	43.5±0.5	39.4±1.4	39.7±0.7
Breed X Sex			
Dressing percentage	*	*	*
Wether	44.7±0.6	40.5±1.1	38.6±1.1
Ewes	43.8±0.6	35.6±0.9	38.2±1.1

** – Significant ($P<0.01$) * – Significant ($P<0.05$), ns – not significant

There was also a significant interaction between breed and birth type for slaughter age and dressing percentage (Table 3). Singles born from Dorper ewes had a higher dressing percentage and a younger slaughter age than multiples (P < 0.05). In the case of Merino lambs and Boer Goat kids, dressing percentage was unaffected by birth type (P < 0.05). In the latter two breeds, singles were accordingly slaughtered at a higher age than multiples.

Dressing percentage was also affected by a significant (P < 0.05) interaction between breed and sex (Table 3). Dressing percentage of wethers was independent of sex for Dorper lambs and Boer Goat kids. However, Merino wethers had a significantly (P < 0.05) higher dressing percentage than the ewes.

The significant interaction between breed and birth year for birth weight is depicted in Figure 1. The birth weights of Dorper lambs were generally higher (P < 0.05) than those of lambs from Merino ewes and kids from Boer Goat does, with a few exceptions (Fig 1). During 1978 and 1979 there were no differences (P > 0.05) in the birth weights of Merino and Dorper lambs. Also, in 1979 and 1984 there were no differences (P > 0.05) in birth weights of Dorper lambs and Boer Goat kids. Significant differences (P < 0.05) between birth weights of Merino lambs and Boer Goat kids were only found in 1978 and 1982. Although the recorded birth weights of Merino lambs were higher (P < 0.05) than those of Boer Goat kids in three years, the absolute differences favoured Boer Goat kids in other years. However, these differences were of a small magnitude, and not significant (P > 0.05).

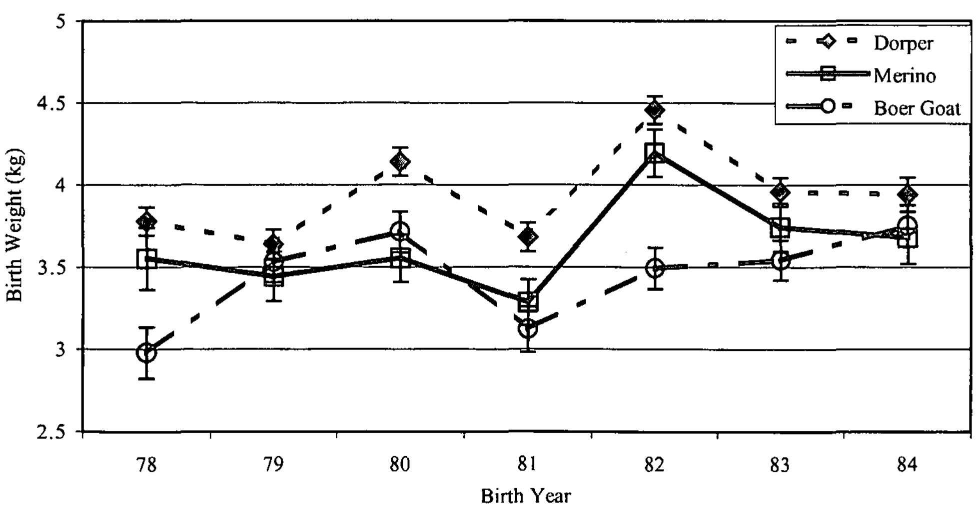

Figure 1 The effect of birth year on birth weight of Dorper and Merino lambs, as well as Boer Goat kids

In Figure 2 all the data were pooled to show the effect of ewe age on birth weight of the lambs. The lambs produced by two-year-old ewes were the lightest (P < 0.05). Birth weight steadily increased as ewe age increased to reach a maximum at age six years (3.94 kg). At an ewe age of seven years, the birth weight of the lambs started to decline again.

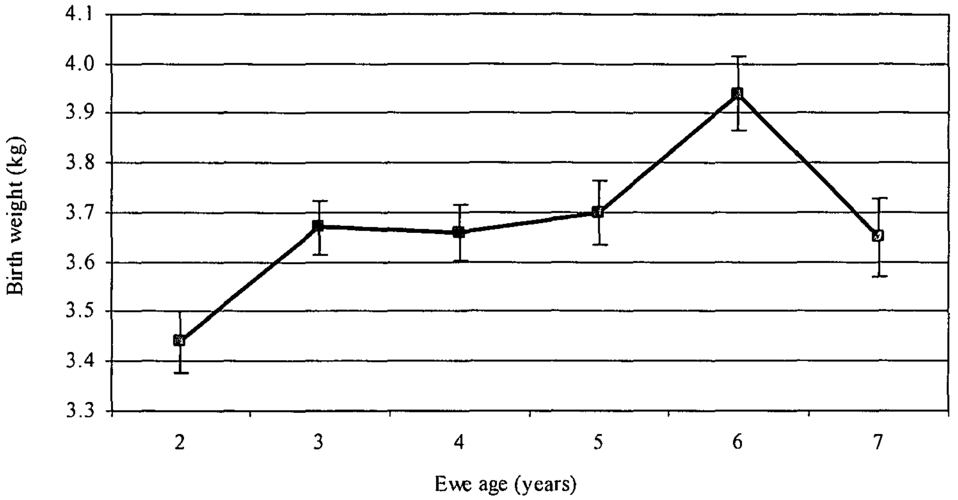

Figure 2 The effect of ewe age on birth weight of Dorper and Merino lambs, as well as Boer Goat kids

This study demonstrated substantial differences in the gross income of Merino and Dorper sheep, as well as Boer Goats. Figure 3 depicts the trends in income per SSU, with the highest income derived from the Merino sheep. The sharp drop in income from 2002 to 2006 for the Merino sheep was due to a lower wool price (Table 5). A higher income was generated from Dorpers than from the Boer Goats when the average abattoir prices over a 10 year period were entered in the simulation (Figure 3).

Table 5 Average meat and wool prices used in the economical analysis.

Year	Lamb meat price (R/kg carcass weight)	Merino clean wool price (R/kg)	Goat meat price (R/kg slaughter weight)
1990	R5.81	R12.68	R4.23
1991	R6.39	R12.77	R4.42
1992	R6.87	R10.49	R5.08
1993	R7.74	R12.11	R5.51
1994	R10.48	R20.28	R7.76
1995	R10.47	R17.29	R7.53
1996	R11.12	R22.28	R7.01
1997	R12.53	R22.16	R8.42
1998	R12.16	R17.71	R7.93
1999	R12.36	R19.41	R7.85
2000	R14.06	R22.91	R9.09
2001	R14.59	R33.19	
2002	R16.86	R43.26	
2006	R24.52	R24.27	

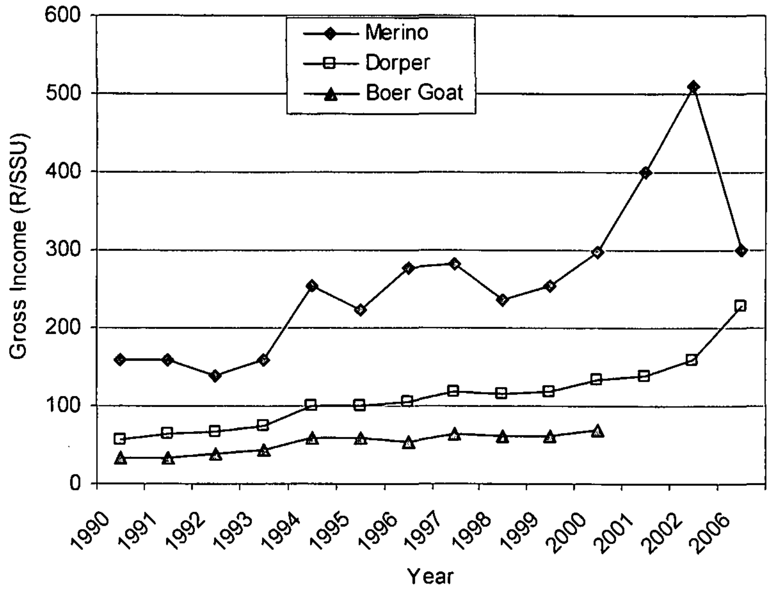

Figure 3 Gross income per small stock unit (SSU) for the three breeds when assessed at the reigning wool and meat prices for the period 1990 - 2006

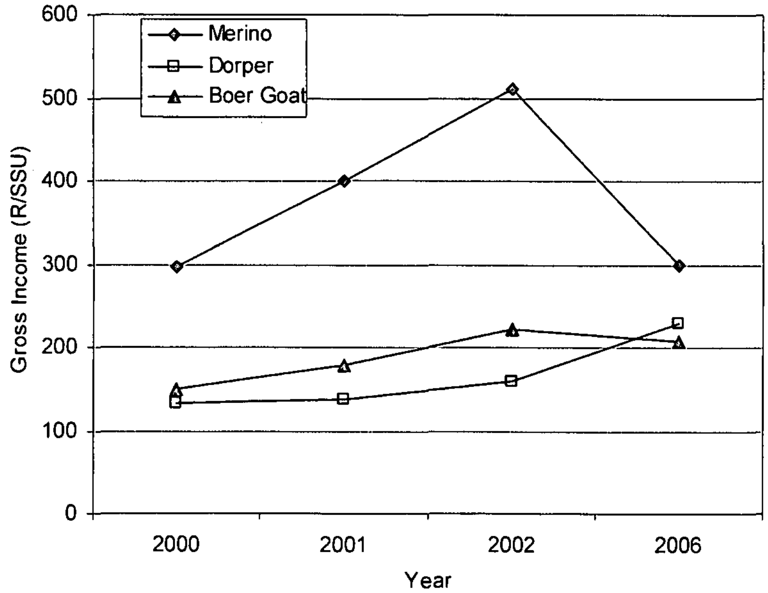

Figure 4 Gross income per small stock unit (SSU) for the three breeds using live weight meat price for Boer Goats over the last six years

The second economical analysis included goat meat prices attained by farmers for on-farm sales. The Merino still generated the highest income in this simulation, but no apparent differences in income per SSU were found between the Dorper and Boer Goats (Figure 4).

Table 6 Average meat and wool prices used in the second economical analysis

Year	Lamb meat price (R/kg slaughter weight)	Merino clean wool price (R/kg)	Goat meat price (R/kg live weight)
2000	R14.06	R22.91	R12.50
2001	R14.59	R33.19	R14.50
2002	R16.86	R43.26	R17.50
2006	R24.52	R24.27	R15.00

Discussion

According to the Cloete *et al.* (2000), Dorper ewes are capable of fairly high levels of reproduction (90-150% lambs weaned per ewe mated). For this breed to reach such high reproduction levels they need to produce a high percentage of multiples, as was found in this study (71% multiples). In this study the Merinos have a lower proportion of multiples (37.7% multiples), which would result in a lower lambing percentage. According to Campher *et al.* (1998), Merinos have a lambing percentage of 75-120%, which is considered to be lower than that of Dorpers. Boer Goats are capable of reproduction rates up to 210% (Campher *et al.*, 1998). The very high proportion of multiples found in this study (89.8% multiples) were thus expected. Mean reproduction levels in Table 1 also accorded with expectations. In the only comparative study on Dorper and Merinos that we could access, Snyman & Herselman (2005) reported that Dorper ewes had a higher lambing percentage than Merino ewes at one property (140% vs. 107% respectively). No significant differences was found at another property, although the trend was in the same direction (130% vs. 110% respectively).

In a study by Notter *et al.* (2004), the pre-weaning losses of single and twin Dorper lambs were similar (10.9 ± 4.4 % and 10.8 ± 2.3%, respectively). Correspondingly figures for losses in Dorper lambs were found in this study. The overall survival rate of the Merino lambs did not differ from the Dorper lambs. In the study of Snyman & Herselman (2005), no differences was correspondingly found between Merino and Dorper lambs maintained on two properties. It should be noted that survival rates of Merino lambs in this study were slightly higher than comparable figures reported in the literature, 67.3 – 78.4% (Lax & Turner, 1965); 80.8%; (Hall *et al.*, 1995); 79 – 80.1% (Morris *et al.*, 2000). A study reported by Browning *et al.* (2006) indicates that Boer Goat does were not as fit or productive as Kiko and Spanish does. One of the limitations mentioned by the latter authors is a lower kid survival in Boer Goat kids compared to the other breeds. This result accords with findings from the present study.

The breed differences in weaning weight of Dorper and Merino lambs in the present study is supported by results published by Snyman & Herselman (2005). The latter authors reported weaning weights of respectively 31.0 and 30.7 kg for Dorper lambs at two properties, compared to 22.1 and 21.3 kg for Merino lambs. It is accepted that the Dorper is a meat type sheep with a mature body weight that should be higher than that of the Merino, which is a wool breed. These differences in live weight could have contributed in the differences in birth mass of the lambs between the two sheep breeds. From Figure 1 it could be seen that Dorper lambs had higher birth weights for almost all the years of the study. We did not find any results in the literature as far as a comparison of live weight traits between Merinos or Dorper and Boer Goats were concerned.

According to Schoeman (2000), the total weaning weights and efficiency of Dorper and Dorper crosses are higher than those of the Merino, Afrino, Dohne Merino and South African Mutton Merino, a result consistent with this study where the weaning weights of Dorper lambs were higher than that of Merino lambs. The Boer Goat kids had a higher weaning weight than the Merino lambs as they were weaned at an older age of 7 months.

Snyman & Herselman (2005) reported that Dorper lambs were slaughtered at respectively 248 and 236 days of age at two localities, compared to 337 and 348 days of age for Merino lambs. This result supports the higher slaughter age reported for Merino Lambs in the present study. Schoeman (2000) accordingly found that both Dorper and Dorper cross-bred lambs reached target slaughter weights of approximately 40kg, earlier than Merino, Afrino, Suffolk and Ile de France crosses. In this study Dorper lambs were also heavier at slaughter, although the lambs were slaughtered at an earlier stage than Merino lambs and Boer Goat kids. Merino lambs were slaughtered at such a late stage (18 months) because the two-tooth animals were shorn prior to slaughter for the extra wool income. The higher carcass weight of Dorper lambs could be related to their heavier slaughter weights.

Dressing percentage is known to increase with animal weight (Kirton *et al.,* 1995). The Dorper has a higher slaughter weight than the other two breeds and a hair cover on the skin instead of wool (as in the case of Merino lambs). The fact that all Boer Goat kids have horns (Campher, *et al.,* 1998) could have contributed to their low dressing percentage. Dressing percentage is also known to be influenced by gut weight when the animals were weighed. According to Sheridan (2001) goats have more intestinal fat, which would have been removed during the dressing procedures whilst sheep have more subcutaneous fat. This could also contributed to a lower dressing percentage for Boer Goats in the present study.

Gender effects in the present study are consistent with trends generally found in the literature, with ewe lambs being lighter than rams at birth, weaning and slaughter (Cloete *et al.*, 2005). The observed lower mean birth, weaning and slaughter weights in multiples were consistent with results from the study of Cloete *et al.* (2005), where data of Dorper crossbred lambs were reported.

During 1978, all the lambs were finished off in a feedlot due to a lack of grazing. The lambs were thus stressed (nutrition wise) in the earlier phase of their growth, when insufficient feed was available. When the lambs were in the feedlot, compensatory growth could have occurred which could have resulted in a higher fat deposition (Cloete *et al.*, 2005). Dressing percentage is known to be affected by slaughter weight, slaughter age, gut fill and fat depth. This could have caused the interaction between breed and year for dressing percentage, the animals being put in the feedlot with heavier gut content which could decrease dressing percentage. According to Cloete *et al.* (2005), ewes are expected to have higher dressing percentages than wethers. However, this was not the case for the Dorper and Merino ewes slaughtered in the present study. The reason for this finding is unclear, but it could be related to sampling, since the slaughter study did not involve very high animal numbers (n = 347 overall).

As the ewes off all breeds aged, their productivity in terms of lamb birth weight followed the expected pattern of increasing from two years of age to six years of age, before declining (Figure 2). The same trend was previously reported by Lax & Turner (1965).

The relative success of the Merino breed in economic terms seems to stem from two factors, their higher expected income from wool, and the fact that the ewes used were capable of achieving an acceptable high reproduction rate. The low inherent kid survival rate of Boer Goats compromised this breed in the economic analysis. The marketing of slaughter animals in the formal structure at abattoirs also seemed to have contributed in the first economic analysis with the lower income generated from Boer Goats. In the second economical analysis it was shown that if Boer Goat meat is marketed through informal outlets (which is the more common strategy in South Africa), the same income per SSU could be attained as from Dorper sheep in this specific environment.

Conclusion

The study reviewed production traits for three divergent livestock breeds in an extensive environment with limited resources. The average levels of performance of the animals were acceptable, and consistent with the objectives strived for. The populations used were relatively small and not well defined relative to overall population means (Fogarty, 2006). The obtained results will thus not necessarily be robust across a variety of environments. However, results of the economic evaluation in the present study are in accordance with those of Snyman & Herselman (2005) as far as the comparison between Dorper and Merinos are concerned. Further studies on larger and better-defined populations are required to test economic outcomes reported in this paper.

References

ARC, 1980. The nutrient requirements of farm livestock. No 2: Ruminants. Agricultural Research Council, Commonwealth Agricultural Bureaux, London.

Brown, G.H., 1988. The statistical comparison of reproduction rates for groups of sheep. Aust. J. Agric. Res. 39, 899 - 905.

Browning, R., Payton, Jr. T., Donnelly, B., Leite-Browning, M.L., Pandya, P., Hendrixson, W. & Byars, M., 2006. Evaluation of three meat goat breeds for doe fitness and reproduction performance in the South Eastern United States. 8th World Congress on Genetics Applied to Livestock Production, Belo Horizonte, MG, Brasil.

Campher, J.P., Hulun, C. & Van Zyl, G.J., 1998. South African Livestock Breeding. South African Stud Book and Livestock Improvement Association. PO Box 270. Bloemfontein 9300, South Africa.

Casey N.H. & Van Niekerk, W.A., 1985. Fatty acid composition of subcutaneous and kidney fat depots of Boer goats and the response to varying levels of maize meal. S. Afr. J. Anim. Sci. 15, 60-63.

Cloete, S.W.P. & De Villiers, T.T., 1987. Production parameters for a commercial Dorper flock on extensive pasture. S. Afr. J. Anim. Sci. 27, 121-127.

Cloete, S. W. P., Snyman, M.A. & Herselman, M.J., 2000. Productive performance of Dorper sheep. Small Rumin. Res. 36, 119-135.

Cloete J.J.E., Cloete, S.W.P., Olivier, J.J. & Hoffman, L.C., 2005. Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Ewe production and lamb performance. Small Rumin. Res. doi:10.1016/j.smallrumres.2005.12.005.

De Villiers T.T., 1987. Nortier – Boeredag, 12 Augustus. 20-42.

Fogarty, N.M., 2006. Utilization of breed resources for sheep production. 8th World Congress on Genetics Applied to Livestock Production, Belo Horizonte, MG, Brasil.

Fourie, A.J., & Cloete, S.W.P., 1993. Reproductive performance of commercial Merino, Dohne Merino and SA Mutton Merino flocks in the Southern Cape. S. Afr. J. Anim. Sci. (23) 104-110.

Harvey, W.R. 1990. User's guide for LSMLMW and MIXMDL. PC-2 version, Mimeograph.

Hall, D.G., Fogarty, N.M. & Gilmour, A.R., 1995. Performance of crossbred progeny of Trangie Fertility Merino and Booroola Merino rams and Poll Dorset ewes. 1. Lamb birth weight, survival and growth. Aust. J. Exp. Agric 35, 1069-1074.

Herselman, M.J., 2002. The role of simulation models in agricultural extension. Proc. 1st Joint Cong. Grassl. Soc. S Afr. Soc. Anim. Sci., 13-16 May 2002, Christiana Aventura, pp 46a-46c.

Kirton, A.H., Carter, A.H., Clarke, J.N., Sinclair, D.P., Mercer, G.T.J.K. & Duganzich, D.M., 1995. A comparison between 15 ram breeds for export lamb production 1. Liveweights, body composition, carcass measurements, and composition. N.Z. J. Agric. Res. 38, 347-360.

Lax, J. & Turner, T.H., 1965. The influence of various factors on survival rate to weaning of Merino lambs. I. Sex, strain, location, and age of ewe for single-born lambs. Aust. J. Agric. Res. 16, 981-995.

Low, A.B. & Rebelo, A.G., 1996. Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism. Pretoria. South Africa.

Morris, C. A., Hickey, S. M. & Clarke, J. N., 2000. Genetic and environmental factors affecting lamb survival at birth and through to weaning. N.Z. J. Agric. Res. 43, 515-524.

Notter, D.R., Greiner, S. P. & Wahlberg, M. L., 2004. Growth and carcass characteristics of lambs sired by Dorper and Dorset rams. J. Anim. Sci. 82, 1323-1328.

Schoeman, S.J., 2000. A comparative assessment of Dorper sheep in different production environments and systems. Small Rumin. Res. 36, 137-146.

Schoeman, S.J., De Wet, R., Botha, M.A. & Van der Merwe, C.A., 1995. Comparative assessment of biological efficiency of crossbred lambs from two composite lines and Dorper sheep. Small Rumin. Res. 16, 61-67.

Sheridan, R., 2001. A comparative analysis of nutrient utilisation and meat quality parameters of Boer Goats and South African Mutton Merinos. Msc thesis. University of Stellenbosch.

Siegel, S., 1956. Non parametric statistics for the behavioral sciences. McGraw-Hill Inc., New York.

Snyman, M.A. & Herselman M.J., 2005. Comparison of productive and reproductive efficiency of Afrino, Dorper and Merino sheep in the False Upper Karoo. S. Afr. J. Anim. Sci., 35, 98-107.

Part 2

Assessment of Merino and Merino type ewe breeds as terminal dam lines

Chapter 5

Production of five Merino type lines in a terminal crossbreeding system with Dormer or Suffolk sires

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Production of five Merino type lines in a terminal crossbreeding system with Dormer or Suffolk sires

Abstract

This study details the production performance of ewes and lambs that originated from a terminal crossbreeding experiment that involved five Merino type dam lines and two terminal crossbreeding sire lines from 1999 to 2002. Ewe lines were SA Mutton Merino (SAMM), SAMM rams crossed to Merino ewes (SAMM cross), Dohne Merino, as well as specialist Merino lines selected for clean fleece weight (FW+) and for an increased reproduction rate (Rep+). Dormer and Suffolk rams were used as sire breeds on these ewes. Data include 777 birth and 605 weaning records of lambs and 562 production year records of ewes. At birth the progeny of SAMM ewes were heavier than those of the other ewe lines, while FW+ ewes produced smaller lambs at birth than SAMM cross and Rep+ ewes. Lamb survival was not significantly affected by ewe line or sire breed. The progeny of the dual-purpose ewe lines (SAMM, SAMM cross and Dohne Merino) were heavier than those of Merino ewes (FW+ and Rep+) at weaning. No sire breed difference was found for birth or weaning weight. The joining weights of dual-purpose ewe lines were higher than those of Merinos. Although considerable variation was found between ewe lines in terms of lamb output (number or weight of lamb weaned per ewe joined), the only significant difference was for weight of lamb weaned between SAMM cross and FW+ Merino ewes. Means for weight of lamb weaned per joining (in kg) were 37.3 for SAMM ewes, 39.6 for SAMM cross ewes, 35.5 for Dohne Merino ewes, 28.9 for FW+ ewes and 34.6 for Rep+ ewes. No differences in ewe reproduction were found between ewes joined to Dormer or Suffolk rams. The clean wool production of SAMM ewes amounted to 46% of that recorded in FW+ ewes. Corresponding percentages were 68% for SAMM cross ewes, 74% for Dohne Merino ewes and 90% for Rep+ ewes. The wool of SAMM ewes was slightly coarser in diameter than those of SAMM cross and FW+ ewes, which in turn was coarser than those of Rep+ and Dohne Merino ewes. The economic viability of crossbreeding programs involving the respective ewe lines would depend on the ratio between the prices of wool and lamb. No conclusive advantage could be demonstrated in favour of any of the sire breeds.

Keywords: Fibre diameter, lamb growth, lamb output, reproduction, South African sheep breeds, wool yield

Introduction

Fluctuations in the ratio between wool and meat prices have resulted in the emphasis on the two products changing markedly over the past decade. This resulted in distinct changes in the South African Merino industry involving the adaptation of the breeding strategy for Merino sheep to enable an improved meat production capability (Olivier, 1999). Genetic change resulting from within-flock selection is comparatively slow, while it also takes time to filter through the structures of a breed. Commercial producers often seek other ways to exploit short-term benefits resulting from an increase in the price of meat without compromising the wool-producing capacity of their ewe flocks (Erasmus, 1965). Crossbreeding of Merino type ewes with mutton type rams in a terminal crossbreeding system is often seen as an option to achieve this goal (Kleeman *et al.*, 1983). In this way it is possible for commercial producers to spread risk over the meat and wool commodities, while it is also possible to exploit the advantage of sexual dimorphism between dam and sire lines (Roux, 1992). In the past, this practice has often been implemented injudiciously, resulting in wool contamination and the loss of genetic material needed for pure breeding (Erasmus, 1965).

The purpose of this study was to evaluate a range of Merino-type bloodlines as dam lines in a terminal crossbreeding system. Dam lines were SA Mutton Merino (SAMM), SAMM rams crossed to commercial Merino ewes (SAMM cross), Dohne Merino, as well as a specialist Merino line selected for clean fleece weight and a second line selected for an increased reproduction rate. The SAMM and Dohne Merino breeds are regarded as the most important dual-purpose genotypes available to the local industry. Both breeds produce white, apparel wool, free from undesirable fibres. SAMM rams are also used on Merino ewes in the Western Cape for the breeding of first-cross ewes for the commercial production of lambs and wool. This cross was recommended for a dam line in slaughter lamb production systems (Kotze, 1950). Anecdotal reports claim that this cross is highly successful in enhancing the mutton production capacity of ewe flocks (A.J. Fourie, Pers. Comm. Bredasdorp-Napier Co-operation, Swellendam Road, Bredasdorp 7280, South Africa, 1999). Advantages in lamb output that could be attributed to heterosis were found even when Australian Merino bloodlines were crossed (Mortimer & Atkins, 1997). The same reasoning would apply in the case of SAMM cross ewes. Data of the relative performance of such ewes in comparison to the parental breeds (SAMM and Merino) and the Dohne Merino breed (a synthetic derived from a cross between the SAMM and Merino breeds in the 1950s – Kotze, 1951) are scarce in the literature (Erasmus *et al.*, 1983; Cloete & Durand, 2000). All the genotypes that were mentioned above may play an important role in terminal crossbreeding systems, without seriously compromising wool quality.

Dormer and Suffolk rams were used as sire breeds on these ewes. The Dormer breed was developed for the purpose of providing a terminal crossbreeding sire breed for use on Merino ewes in the Western Cape (De Villiers & Cloete, 1984). Suffolk rams are commonly used for this purpose (Wang *et al.*, 1989: Nawaz *et al.*, 1992).

Against this background, the relative performance of the respective dam lines in a commercial, terminal crossbreeding system was studied, using Dormer and Suffolk rams as sires.

Material and Methods

The experiment was carried out on the Langgewens experimental farm in the Swartland area of the Western Cape. The site is situated at 33°17'S and 18°42'E. The climate is Mediterranean, 78% of the total long-term annual precipitation of 395 mm being recorded during winter (April to September). The experimental site is characterised by dry, hot and windy summers. Merino type ewes, belonging to five distinct lines, represented the female breeding animals under assessment. These ewes were born during 1997 and 1998, and were not selected as replacements for breeding purposes in their flocks of origin. They were thus considered to be ideal for diversification into slaughter lamb production in a terminal crossbreeding program. Evaluation took place over a four-year period, from 1999 to 2002. Approximately 20 ewes within birth year groups (i.e. 40 in total for each ewe genotype) represented each line. Dormer or Suffolk rams were used as terminal sire breeds on the ewe flock. Dormer rams were obtained from the Elsenburg stud (Van Wyk, 1992) while Suffolk rams were obtained from industry. The maternal lines were the following:

- SAMM ewes from the Elsenburg flock (Vosloo, 1967). The flock participated in the SA Mutton Merino breed analysis that was reported by Neser *et al.* (2000). From this analysis it was evident that the maternal breeding values for 100-day weaning weight in the Elsenburg flock were consistently above the breed average, while direct breeding values were comparable to breed means. This line could thus be considered as acceptable material for a dam line in a terminal crossbreeding enterprise.
- A cross between SAMM rams from the Elsenburg flock described above and commercial Merino ewes (SAMM cross line; Cloete & Durand, 2000).
- Dohne Merino ewes from the Kromme Rhee Dohne Merino flock (Cloete *et al.*, 1998b) for ewes born in 1997. This flock served as a nucleus flock for the Western Cape Dohne club. Since all the leading breeders in the area contributed breeding material, the flock could be considered as representative of the available breeding material. The flock was disbanded during 1997, owing to logistic problems, and the 1998-drop ewes could not be obtained from it. Twenty commercial two-tooth ewes were thus bought in from a nearby property to provide a 1998 ewe group.
- A specialist Merino line that has been selected since 1969 for clean fleece weight, with a check on fibre diameter on the male side (FW+; Cloete *et al.*, 1998a). This line is being maintained on the Tygerhoek experimental farm near Riviersonderend in the Southern Cape.
- A specialist Merino line that was selected since 1986 for the ability to rear multiple lambs per joining (Rep+ line; Cloete & Scholtz, 1998). This line was maintained on the Elsenburg experimental farm during the period that ewes were obtained from it.

Cognisance is taken of the fact that the flocks where the ewes were bred and the location and management where they grew up differed for the two-tooth ewes introduced to the experimental flock, except for the SAMM cross ewes. The latter were born and bred at Langgewens. The SAMM, SAMM cross and FW+ maiden ewes were approximately 22 months old at first joining in February 1999 and 2000. The Rep+ ewes were approximately 18 months and the Dohne Merino ewes approximately 16 months old. Prior to the 1999 joining, SAMM, Dohne Merino and Rep+ Merino ewes were transported to Langgewens only approximately one month prior to joining. In preliminary analyses, it was evident that carry-over effects from the location where they grew up were still present in live weight at joining. Seeing that approximately four months wool growth were grown on the locality of origin of the respective ewe lines, marked influences were also observed on wool traits. Prior to the 2000 joining, the 1998-born ewes were introduced to Langgewens at least five months prior to joining. No evidence of carry-over effects from the location where they grew up was observed in either joining weight or wool traits. The wool clip shorn during 2001 and 2002 was entirely produced on the Langgewens locality.

All available ewes were joined to lamb during June-July of each year. Individual live weights at joining were recorded. Two rams of each sire breed were used in single sire groups during 1999, when only the ewes born in 1997 were available. Three rams of each breed were used during 2000 to 2001. During 2002, when only 1998-drop ewes were available, two rams were once again used per sire breed. During the latter three years, one ram of each breed was retained for breeding, to provide sire links across years. All lambs were weaned during October at approximately 100 days of age. Parentage, contemporary group, survival to weaning and weaning weight were recorded for all lambs. It was possible to construct complete reproduction data for all ewes from this information. During each year, all available ewes were shorn during May-June, within four weeks of the commencement of lambing. Individual greasy fleeces were weighed at this stage and midrib samples were taken for further analysis. Clean yield, staple strength and fibre diameter were measured on these samples. Clean yield measurements were then used to calculate clean fleece weight.

The experimental flock grazed small grain cereal stubble during joining. The flock was retained on stubble lands until green feed became available after autumn and early winter rains. Medic pastures were mostly utilised during winter. Oat fodder crops were occasionally available. Limited supplementation was provided to lambs born during 2001 when uncharacteristically poor early summer conditions were experienced. No further supplementation was provided at any stage, but a fairly general health program for the area was followed. The ewes were maintained in a single flock for the duration of the experiment, except during joining in single sire groups and during peak lambing. Ewes were spread across 2-3 paddocks at this stage to reduce the density of lambing ewes per paddock.

A total of 562 reproduction records of ewes that were joined, was available for analysis. Joining weight and fleece data of 1999 were not considered, as motivated earlier. Only 464 joining weight records were thus used, while 462 records were considered in the analysis of wool traits. A total number of 777 lambs was recorded at birth, and 605 at weaning.

Least squares procedures were used to assess the data statistically, to account for uneven subclasses. The ASREML statistical package (Gilmour *et al.*, 1999) allows the estimation of a range of random effects in animal breeding, while also predicting estimates of appropriate least-squares means for selected fixed effects. Fixed effects that were considered in the analyses of lamb traits (birth weight, pre-weaning mortality and weaning weight) were birth year, sex, birth type, dam line and sire breed as well as relevant interactions. Binomially distributed lamb mortality data were linked to the normal distribution by the logit transformation (Gilmour *et al.*, 1999). Since interactions were not significant in the vast majority of cases, only main effect means were tabulated. Information is supplied in the text in those cases where significant interactions were found. Age of dam was confounded with production years and was thus not considered. A linear regression on weaning age was fitted for weaning weight. Random sire within ram breed and maternal permanent environmental effects were also computed. Back pedigrees were not included for sires and dams, since all sires and dams were derived from different flocks. It was thus not attempted to fit maternal genetic effects. It would also be of limited application in a terminal crossbreeding system where all female progeny are slaughtered. Genetic and ewe permanent environmental parameters generally corresponded with literature estimates (see Duguma *et al.*, 2002 for tabled literature estimates), and are thus not presented. The South African Journal of Animal Science is available online at www.sasas.co.za/Sajas.html

Production year, dam line and sire breed were typically fitted as fixed effects in the case of ewe reproduction and wool traits. Random animal effects stemming from repeated records on the same individuals were computed and used to derive repeatability estimates. It was not attempted to partition the animal effects into genetic and permanent environmental components, following the reasoning provided earlier. Repeatability estimates for reproduction and wool traits were not presented, since they accorded with literature estimates. Random service sire effects were also obtained in the case of lamb output, as reflected by number of lambs born, number of lambs weaned and total weight of lamb weaned. These effects only accounted for 2-3% of the overall phenotypic variance, and are not discussed in detail. It is conceded that the analysis of discrete data such as number of lambs born and weaned with parametric methods used in the present study is not optimal, as was outlined by Purvis & Hillard (1997). The availability of suitable software, and the close approximation of outcomes from linear models to those derived from non-linear methods have resulted in recommendations that the former methods could be employed until alternative software packages become readily available (Jorhensen, 1994; Brien *et al.*, 2002).

Results and Discussion

Birth weight was affected by a significant ($P < 0.05$) interaction between ewe line and birth type. The single progeny of SAMM cross ewes were 13% heavier than multiples (5.57±0.16 *vs*. 4.93±0.11 kg respectively). Corresponding differences for the other ewe lines were 20% for SAMM ewes (6.04±0.15 *vs*. 5.02±0.11 kg), 21% for FW+ Merino ewes (5.37±0.15 *vs*. 4.45±0.13 kg), 25% for Dohne Merino ewes (5.75±0.15 *vs*. 4.60±0.13 kg) and 30% for Rep+ Merino ewes (5.91±0.14 *vs*. 4.54±0.12 kg). Single lambs were heavier (P < 0.05) at birth than multiples (Table 1). No birth weight difference was obtained between lambs sired by Dormer or Suffolk rams. No significant differences were obtained as far as lamb mortality was concerned, although ewe lambs tended (P = 0.10) to have a lower mortality than ram lambs. There was also a tendency (P < 0.10) towards differences in lamb mortality between birth years. Although the absolute variation in lamb mortality between ewe lines was sufficiently large to be economically important, the derived F-value only indicated significance at P < 0.25.

Table 1 Least squares means (±s.e.) for lamb birth weight, weaning weight at 100 days of age and survival prior to weaning as affected by birth year, sex, birth type, ewe line and sire breed

Fixed effect	Birth weight kg	Weaning weight kg	Lamb mortality	
			Logit scale	Normal scale
Number of observations	777	605	777	
Overall mean	5.22±0.05	34.3±0.3	-1.316±0.132	0.221
Birth year	**	**	0.10	
1999	4.92±0.09	34.9±0.7	-1.001±0.252	0.269
2000	5.75±0.07	36.3±0.5	-1.538±0.199	0.179
2001	5.14±0.07	31.0±0.5	-1.041±0.184	0.261
2002	5.07±0.09	35.1±0.7	-1.687±0.294	0.156
Sex	**	**	0.10	
Ram	5.39±0.06	35.7±0.4	-1.160±0.156	0.239
Ewe	5.04±0.06	32.9±0.4	-1.473±0.167	0.186
Birth type	**	**	ns	
Single	5.73±0.07	36.8±0.4	-1.268±0.186	0.220
Multiple	4.71±0.06	31.7±0.3	-1.365±0.147	0.204
Dam line	**	**	ns	
SAMM	5.53±0.11	36.3±0.5	-1.012±0.226	0.266
SAMM cross	5.25±0.11	34.8±0.6	-1.141±0.232	0.242
Dohne Merino	5.18±0.11	35.7±0.5	-1.695±0.273	0.155
FW+	4.91±0.11	32.3±0.5	-1.187±0.246	0.234
Rep+	5.22±0.11	32.3±0.5	-1.548±0.259	0.175
Sire breed	ns	ns	ns	
Dormer	5.21±0.07	34.6±0.5	-1.353±0.158	0.205
Suffolk	5.23±0.07	34.0±0.5	-2.281±0.199	0.218
Regression on age (d)	—	0.290±0.016**	—	—

ns – Not significant (P > 0.10), ** – Significant (P < 0.01)

In general, the effects of sex and birth type on birth weight and lamb mortality were in correspondence with literature reports and will not be elucidated further. The only exception was with regard to lamb mortality. No difference was found between singles and multiples, while multiples are expected to sustain higher mortality levels. Yet a number of previous studies have shown that the survival of single and twin lambs was similar in relatively high performing flocks (Brand *et al.*, 1985; Cloete, 1992; Holst *et al.*, 1997; Cloete *et al.*, 1999a).

Lambs born in 2001 had lower (P < 0.05) weaning weights than those born in the other years. Ram lambs and singles were heavier (P < 0.05) than ewes and multiples at weaning. Crossbred lambs produced by dual-purpose ewes (SAMM, SAMM cross and Dohne Merino) were between 8 and 12% heavier (P < 0.05) at weaning than those produced by Merinos (Table 1). No corresponding results were found in the literature with regard to the breeds used in terminal crossbreeding. It was, however, found that weaning weights of purebred SAMM and Dohne Merino lambs were between 17 and 35% heavier than that of Merinos (see Table 4 for a summary of available literature). Keeping in mind that only the dam component was considered in the present study, these results are in adequate agreement with those obtained from the pure breeds regarding direction and magnitude.

The present results did not suggest a sire line difference (Table 1). In the only other local study that could be found where Dormer and Suffolk rams were compared as terminal crossbreeding sires, no differences were correspondingly reported for lamb growth, as reflected by lamb carcass weight when slaughtered at a fixed age (Erasmus *et al.*, 1983). The latter study also reported no significant differences in lamb mortality between the progeny of the two breeds. When averaged across ewe lines, the overall lamb mortality of lambs sired by Dormer rams was 12.1%, compared to 14.4% for Suffolk sires.

Table 2 Least squares means (±s.e.) for ewe reproduction, as affected by year, dam line and sire breed. All reproduction traits were expressed in relation to ewes joined

Effect	Ewe joining weight kg	Number of lamb born	Number of lambs weaned	Weight of lamb weaned kg
Number of observations	464	562	562	562
Overall mean	57.4±0.5	1.37±0.04	1.07±0.04	35.2±1.5
Year	**	ns	*	**
1999	–	1.22±0.08	0.87±0.09	28.7±3.1
2000	51.8±0.6	1.39±0.06	1.13±0.07	37.6±2.3
2001	58.2±0.5	1.42±0.06	1.05±0.07	31.8±2.3
2002	62.3±0.6	1.45±0.08	1.21±0.10	42.7±3.1
Dam line	**	**	ns	*
SAMM	60.3±1.0	1.47±0.07	1.07±0.08	37.3±2.8
SAMM cross	62.3±1.0	1.59±0.08	1.19±0.09	39.6±2.8
Dohne	60.9±1.0	1.23±0.08	1.01±0.09	35.5±2.8
FW+	54.9±1.0	1.21±0.08	0.95±0.09	28.9±2.8
Rep+	48.7±1.0	1.34±0.08	1.11±0.09	34.6±2.8
Sire breed	ns	ns	ns	ns
Dormer	57.8±0.6	1.37±0.06	1.09±0.06	36.2±2.2
Suffolk	57.0±0.7	1.37±0.06	1.05±0.06	34.2±2.2

ns – Not significant (P > 0.10)

* – Significant (P < 0.05)

** – Significant (P < 0.01)

Ewe joining weight increased from 2000 to 2002, as the breeding ewes approached mature live weight. Ewes from the dual-purpose breeds (SAMM, SAMM cross and Dohne ewes) were between 10 and 13% heavier ($P < 0.05$) than FW+ Merino ewes and between 24 and 28% heavier than Rep+ Merino ewes. Yearling or mature live weights of dual-purpose ewes were between 17 and 33% heavier than those of Merinos in the literature (Table 4), which is in adequate agreement with the outcome of the present study.

Ewes in the SAMM and SAMM cross lines produced more ($P < 0.05$) lambs born per ewe joined than FW+ Merino and Dohne ewes, with the Rep+ Merinos being intermediate (Table 2). Expressed relative to FW+ Merinos, the advantage amounted to 21% and 31% respectively in favour of SAMM and SAMM cross ewes. Number of lambs born per ewe joined was independent of year of lambing and the breed of the service sire. Differences between lambing years were significant ($P < 0.05$) for number of lambs weaned per joining, which was unaffected ($P > 0.10$) by dam line and breed of service sire. In the only other study where the respective ewe breeds were assessed under terminal crossbreeding conditions, SAMM ewes had a 25% advantage over Merino ewes for number of lambs born per ewe joined (Erasmus *et al.*, 1983 – Table 4).

No marked advantage of SAMM ewes was correspondingly found for number of lambs weaned per ewe joined. The mean for lambs marked per ewe joined was 28% higher in SAMM flocks than in Merino flocks (Table 4). All studies summarised from the literature reported only modest improvements in the reproduction of Dohne ewes compared to Merinos. Total weight of lamb weaned per joining differed ($P < 0.01$) between lambing years, but was independent of the breed of the service sire (Table 2). Total weight of lamb weaned per joining was 37% higher ($P < 0.05$) in SAMM cross ewes than in FW+ Merino ewes. Differences in weight of lamb weaned of dual-purpose ewes ranged from 18 to 43% compared to Merinos in studies on purebred ewes (Table 4).

No differences were found between the two terminal sire breeds as far as the reproduction of their ewe mates was considered. In this respect, it could be stated that Erasmus *et al.* (1983) reported average figures of respectively 1.20 lambs born and 1.06 lambs weaned per ewe joined for ewes joined to Dormer rams, compared to respective figures of 1.20 and 1.03 for Suffolk rams. Similar observations were made in studies where other sire breeds were considered (Wang *et al.*, 1989; Bunge *et al.*, 1993; Carson *et al.*, 1999).

The clean fleece weight produced by ewes generally decreased ($P < 0.05$) from 2000 to 2002 (Table 3), while fibre diameter generally increased. Clean yield was higher ($P < 0.05$) in 2001 than in 2000 and 2002, but staple strength was adversely affected ($P < 0.05$) during 2001 relative to 2000 and 2002. Clean fleece weight, clean yield and staple strength improved ($P < 0.05$) from SAMM ewes to FW+ ewes. The clean wool production of SAMM ewes amounted to 46% of that recorded in FW+ ewes. Corresponding percentages were 68% for SAMM cross ewes, 74% for Dohne Merino ewes and 90% for

Rep+ ewes. Wool production of SAMM ewes amounted from 52 to 57% of that produced by Merinos (Table 4). The quantity of wool produced by Dohne and SAMM cross ewes amounted to between 64 and 83% of that expected from Merinos.

Expressed relatively to FW+ Merino ewes, clean yield amounted to 86% for SAMM ewes, 91% for SAMM cross ewes and 96% for Dohne Merino ewes, all differences being significant ($P < 0.05$). The clean yield of SAMM wool amounted to between 87 and 88% of that yielded by Merino wool in the literature (Table 4). Corresponding percentages for Dohne Merino and SAMM cross wool ranged from 90 to 95% of the clean yield of Merino wool. The present results are in adequate agreement with these findings.

Table 3 Least squares means (±s.e.) for wool traits, as affected by year and dam line. Means for sire breed were not computed, since no theoretical basis existed for such a difference

Effect	Clean fleece weight kg	Clean yield %	Staple strength N/ktex	Fibre diameter µm
Number of observations	462	462	462	462
Overall mean	3.55±0.05	67.4±0.3	35.1±0.6	23.0±0.1
Year	**	**	**	**
2000	3.85±0.06	66.9±0.4	37.2±0.8	22.7±0.1
2001	3.50±0.06	68.5±0.4	32.0±0.8	23.0±0.1
2002	3.30±0.07	66.8±0.5	36.0±1.1	23.4±0.1
Dam line	**	**	**	**
SAMM	2.16±0.11	61.0±0.7	28.6±1.3	23.7±0.2
SAMM cross	3.19±0.12	64.9±0.8	32.9±1.4	23.3±0.2
Dohne	3.48±0.12	68.6±0.8	37.2±1.3	22.1±0.2
FW+	4.69±0.12	71.3±0.8	41.6±1.4	23.3±0.2
Rep+	4.23±0.12	71.3±0.8	35.7±1.4	22.8±0.2

** – Significant ($P < 0.01$)

Staple strength increased ($P < 0.05$) from SAMM ewes to FW+ ewes (Table 3). Relative to a value of 100% for FW+ Merino ewes, average performance levels amounted to 69% for SAMM ewes, 79% for SAMM cross ewes, 89% for Dohne Merino ewes and 86% for Rep+ Merino ewes. No corresponding results were found in the literature. In general, staple strength was within or above the range of 25 to 30 N/ktex, which is considered as sound (Read, 1996; Scrivener & Vizard, 1997).

The wool of SAMM ewes was approximately 2% coarser ($P < 0.05$) than that of FW+ Merino ewes. The fibre diameter of Dohne Merino and Rep+ ewes amounted to respectively 95% and 98% of FW+ ewes ($P < 0.05$). It is of interest to note that the fibre diameter of SAMM was only slightly coarser than those of SAMM cross and FW+ Merinos, with Dohne Merino ewes having slightly lower ($P < 0.05$) means for fibre diameter. The fibre diameter of SAMM sheep was found to be between 2 and 8% coarser than that of Merinos (Table 4). In the literature, fibre diameter of Dohne Merinos was comparable to that of Merinos where measured. The comparatively high fibre diameter of the FW+ line should also be seen from the context that this line was found to show a more pronounced increase in fibre diameter with age than the control line maintained alongside (Cloete *et al.*, 1999b). Ewes with an excessive fibre diameter would also not be considered as replacements in the FW+ and Rep+ lines. They would, however, still be considered for terminal crossbreeding, provided that they were of sound constitution. The chances that such ewes ended up as crossbred dams in the present study are thus good. Given the relatively high repeatability of fibre diameter (Cloete *et al.*, 1999b), this could also have contributed to the observed results.

Table 4 A summary of literature findings pertaining to the performance of the respective ewe lines evaluated during the study. Means were expressed relative to a value of 100 for Merinos, and provided in parentheses for the other lines

Trait and study	Line			
	SAMM	SAMM cross	Dohne Merino	Merino
Lamb weaning weight (kg):				
Basson *et al.* (1969)	–	–	23.5 (120)	19.6
Cloete *et al.* (1999a)	32.2 (124)	–	30.2 (117)	25.9
Brand & Franck (2000)	27.9 (135)	–	–	20.6
Lambs born per ewe joined:				
Basson *et al.* (1969)	–	–	1.21 (103)	1.18
Erasmus *et al.* (1983)	1.10 (125)	–	0.99 (113)	0.88
Lambs weaned per ewe joined:				
Basson *et al.* (1969)	–	–	1.08 (98)	1.10
Erasmus *et al.* (1983)	0.85 (104)	–	0.86 (105)	0.82
Lambs marked per ewe joined:				
Fourie & Cloete (1993)	1.13 (128)	–	0.93 (106)	0.88
Weight of lamb weaned (kg):				
Basson *et al.* (1969) – derived from means	–	–	25.4 (118)	21.6
Cloete *et al.* (1999a)	44.7 (143)	–	41.8 (134)	31.3
Yearling or adult live weight (kg):				
Basson *et al.* (1969)	–	–	60.0 (124)	48.2
Cloete et al. (1999a)	57.4 (133)	–	50.7 (117)	43.3
Cloete & Durand (2000)	–	53.0 (126)	–	42.0
Greasy fleece weight (kg):				
Basson *et al.* (1969)	–	–	4.1 (79)	5.2
Brand *et al.* (1999)	2.8 (54)	–	–	5.2
Brand & Franck (2000)	1.6 (57)	–	–	2.8
Cloete & Durand (2000)	–	3.9 (83)	–	4.7
Clean fleece weight (kg):				
Basson *et al.* (1969) – derived from means	–	–	2.1 (70)	3.0
Greeff (1990)	2.9 (52)	–	3.6 (64)	5.6
Cloete et al. (1999a)	1.5 (54)	–	2.0 (71)	2.8
Cloete & Durand (2000)	–	2.6 (79)	–	3.3
Clean yield (%):				
Basson *et al.* (1969)	–	–	52.4 (90)	58.5
Brand *et al.* (1999)	64.8 (88)	–	–	73.4
Cloete *et al.* (1999a)	64.0 (87)	–	68.9 (93)	73.9
Cloete & Durand (2000)	–	66.8 (95)	–	70.5
Fibre diameter (µm):				
Greeff (1990)	23.3 (102)	–	23.6 (103)	22.8
Brand et al. (1999)	23.1 (105)	–	–	22.0
Cloete et al. (1999a)	23.7 (108)	–	21.8 (99)	21.9
Cloete & Durand (2000)	–	21.8 (107)	–	20.3

Conclusions

It was evident that SAMM cross and Dohne ewes performed at least as well as purebred SAMM ewes with regard to lamb output in the terminal crossbreeding situation, while they had a clear advantage in terms of wool production. Advantages in wool weight and wool quality resulted in Dohne ewes being accordingly more efficient in economic terms than SAMM ewes (Schoeman, 1990). The same reasoning applies to Rep+ Merino ewes. It has to be conceded that the slower growth of progeny of the latter line may increase the risk involved in a crossbreeding program based on such ewes under conditions where a seasonal short supply of nutrients is expected. Part of the adaptability of a terminal crossbreeding system is the opportunity to maintain only the ewe breeding flock over a period of nutritional short supply, like the summer period in the Swartland. The slower growth by progeny of both Merino lines may make a system based on such ewes more risky. This element of risk will be compensated for by additional security in terms of a higher and more stable wool income from such dams during periods when the wool price is high.

No definite advantage for either of the ram lines could be demonstrated. Decision-making should thus be based on factors such as the availability of rams, and considerations like the probability of contamination with coloured fibres in the case of the Suffolk breed (Erasmus *et al*., 1983).

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References

Basson, W.D., Van Niekerk, B.D.H., Mulder, A.M. & Cloete, J.G., 1969. The productive and reproductive potential of three breeds mated at 8-monthly intervals under intensive feeding conditions. Proc. S. Afr. Soc. Anim. Prod. 8, 149-154.

Brand, A.A., Cloete S.W.P. & De Villiers, T.T., 1985. Faktore wat lamvrektes by die Elsenburg Dormer– en SA Vleismerinokuddes beïnvloed. S. Afr. Tydskr. Veek. 15, 155-161.

Brand, T.S. & Franck, F., 2000. Production responses of two genetic different types of Merino sheep to different nutritional levels. Small Rumin. Res. 37, 85-91.

Brand, T.S., Franck, F. & Coetzee, J., 1999. Kikuyu (*Pennisetum clandestinum*) pasture for sheep. 2. Production and nutritional status of ewes with or without lupin (*Lupinus albus*) supplementation. N. Z. J. Agric. Res. 42, 467-474.

Brien, F.D., Konstantinov, K.V. & Greeff, J.C., 2002. Comparison of linear and threshold models for predicting direct and maternal genetic effects on number of lambs weaned in Western Australian Merinos. Proc. 7th Wrld Cong. Genet. Appl. Livest. Prod. 18-23 August, Montpellier, France. 32, pp. 307-310.

Bunge, R., Thomas, D.L., Nash, T.G. & Fernando, R.L., 1993. Performance of hair breeds and prolific wool breeds of sheep in Southern Illinois: Effect of breed of service sire on lamb production of Suffolk and Targhee ewes. J. Anim. Sci. 71, 321-325.

Carson, A.F., McClinton, L.W. & Steen, R.W.J., 1999. Effects of Texel or Rouge de l'Quest genes in lowland ewes and rams on ewe prolificacy, lamb viability and weaned lamb output. Anim. Sci. 68, 69-78.

Cloete, S.W.P., 1992. Observations on litter size, parturition and maternal behaviour in relation to lamb mortality in fecund Dormer and SA Mutton Merino ewes. S. Afr. J. Anim. Sci. 22, 214-221.

Cloete, S.W.P., Coetzee, J., Schoeman, S.J., Morris, J. & Ten Hoope, J.M., 1999a. Production parameters for Merino, Dohne Merino and South African Mutton Merino sheep. Proc. Assoc. Advmnt Anim. Breed. Genet. 13, 189-193.

Cloete, S.W.P. & Durand, A., 2000. The crossing of commercial Merino ewes with South African (SA) Meat Merino rams for an increased lamb output. Aust. J. Exp. Agric. 40, 11-16.

Cloete, S.W.P, Olivier, J.J. & du Toit, E., 1999b. Age effects on wool traits in Merino lines differing in clean fleece weight. Proc. S. Afr. Soc. Anim. Sci. 37, 24-25.

Cloete, S.W.P., Olivier, J.J., Snyman, M.A. & du Toit, E., 1998a. Genetic parameters and trends in a selection experiment for increased clean fleece weight involving South African Merinos. Aust. J. Exp. Agric. 38, 427-432.

Cloete, S.W.P. & Scholtz, A.J., 1998. Lamb survival in relation to lambing and neonatal behaviour in medium wool Merino lines divergently selected for multiple rearing ability. Aust. J. Exp. Agric. 38, 801-811.

Cloete, S.W.P., Scholtz, A.J. & Aucamp, B.B., 1998b. Environmental effects, heritability estimates and genetic trends in a Western Cape Dohne Merino nucleus flock. S. Afr. J. Anim. Sci. 28, 185-195.

De Villers, T.T. & Cloete, S.W.P., 1984. The Dormer sheep breed. Proc. 2nd Wrld Cong. Sheep Beef Cattle Breed. 16 – 19 April 1984, Pretoria. South African Stud Book and Livestock Improvement Association, Bloemfontein (1984). pp. 695-698.

Duguma, G.J., Schoeman, S.J., Cloete, S.W.P. & Jordaan, G.F., 2002. Genetic parameter estimates of early growth traits in the Tygerhoek Merino flock. S. Afr. J. Anim. Sci. 32, 66-75.

Erasmus, L.S., 1965. Slaglamproduksie met die Merino as moederooi. M.Sc. Agric. thesis, University of Stellenbosch, South Africa.

Erasmus, L.S., De Kock, J.A. & Grobler, J.W., 1983. Slaglamproduksie in die Suid-Kaap. Els. J. 7, 13-32.

Fourie, A.J. & Cloete, S.W.P., 1993. Reproductive performance of commercial Merino, Dohne Merino and SA Mutton Merino flocks in the Southern Cape. S. Afr. J. Anim. Sci. 23, 104-110.

Gilmour, A.R., Cullis, B.R., Welham, S.J. & Thompson, R., 1999. ASREML – Reference manuel. NSW Agriculture Biometric Bulletin No. 3. NSW Agriculture, Orange Agricultural Institute, Forest Road, Orange 2800, NSW, Australia.

Greeff, J.C., 1990. The Merino and modern production systems. Proc. World. Merino Conf. Volume 1, 3.2,1-33. 2-4 May, 1990, Pretoria, South Africa. (Merino Studbreeders' Society of South Africa, P.O. Box 109, Graaff-Reinet 6280, South Africa.)

Holst, P.J., Fogarty, N.M., Hopkins, D.L. & Stanley, D.F., 1997. Lamb survival of Texel and Poll Dorset crossbred lambs. Proc. Assoc. Advmnt Anim. Breed. Genet. 12, 313-316.

Jorhensen, J.N., 1994. Estimation of genetic parameters for litter size in sheep using a non-linear method. Acta Agric. Scand. A. Anim. Sci. 44, 8-11.

Kleeman, D.O., South, M.H.L., Dolling, C.H.S. & Ponzoni, R.W., 1983. Survival, growth and wool production of South Australian strong-wool Merino and first-cross Merino lambs from birth to 16 months of age. Aust. J. Exp. Agric. Anim. Husb. 23, 271-279.

Kotzé, J.J.J., 1950. Fat-lamb production in the sour-grassveld area. Farm. S. Afr. November 1950, 357-369.

Kotzé, J.J.J., 1951. The development of a mutton-woolled sheep for the sour-grassveld area. Farm. S. Afr. April 1951, 110-113.

Mortimer, S.I. & Atkins, K.D., 1997. Improvement of Merino reproductive performance through bloodline substitution and crossing. Proc. Assoc. Advmnt Anim. Breed. Genet. 12, 404-407.

Nawaz, M., Meyer, H.H. & Thomas, D.R., 1992. Performance of Polypay, Coopworth and crossbred ewes: II. Survival and cumulative lamb and wool production over 4 years. J. Anim. Sci. 70, 70-77.

Neser, F.W.C., Erasmus, G.J. & van Wyk, J.B., 2000. Genetic studies on the South African Mutton Merino: growth traits. S. Afr. J. Anim. Sci. 30, 172-177.

Olivier, J.J., 1999. The South African Merino performance testing scheme. Proc. Assoc. Advmnt Anim. Breed. Genet. 13, 119-124.

Purvis, I.W. & Hillard, M., 1997. Biology and genetics of reproduction. In: The genetics of sheep. Eds Piper, L. & Ruvinsky, A., CAB International, Wallingford, Oxon, United Kingdom. pp. 375-394.

Read, S., 1996. Consumer demands of wool beyond 2000. Demands of wool and wool growers beyond 2000. SARDI Research report series, No 11. pp. 5-13.

Roux, C.Z., 1992. Maximum herd efficiency in meat production. III. Feeder-breeder dimorphism. S. Afr. J. Anim. Sci. 22, 11-15.

Schoeman, S.J., 1990. Productivity of purebred Dohne Merino, SA Mutton Merino and Dorper sheep under an intensive accelerated lambing system. Proc. 4th Wrld Cong. Genet. Appl. Livest. Prod., Edinburgh, UK. 15, pp. 373-376.

Scrivener, C.J. & Vizard, A.L., 1997. The relationship between reproductive performance, time of lambing and the staple strength of wool from Merino ewes. Wool Tech. Sheep Breed. 45, 120-128.

Van Wyk, J.B., 1992. A genetic evaluation of the Elsenburg Dormer stud. Ph.D. dissertation, University of the Orange Free State, Bloemfontein, South Africa.

Vosloo L.P., 1967. Faktore wat die produksie en reproduksie van die Elsenburg Duitse Merinokudde beïnvloed. D.Sc. dissertation, University of Stellenbosch, Stellenbosch, South Africa.

Wang, N., Vandepitte, W., Van Hofstraeten, W. & Van Isterdael, J., 1989. Crossbreeding between Suffolk, Flemisch Milksheep and Texel. 2. Estimation of crossbreeding effects for productive and reproductive performances. Rev. de l'Agric. 42, 673-680.

Chapter 6

Carcass characteristics and meat quality of progeny of five Merino type lines, crossed with Dormer and Suffolk sires

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Carcass characteristics and meat quality of progeny of five Merino type lines, crossed with Dormer and Suffolk sires

Abstract

This study details the slaughter traits of lambs born from a terminal crossbreeding experiment that involved five Merino type dam lines crossed with Dormer and Suffolk sires. Dam lines involved the SA Mutton Merino (SAMM), Dohne Merino, SAMM rams crossed to commercial Merino ewes (SAMM cross) and specialist Merino lines selected either for clean fleece weight (FW+) or an increased fertility (Rep+). Data include between 228 and 483 individual records, depending on the trait. FW+ and Rep+ Merino ewes produced lambs with heavier heads and skins than Dohne and SAMM ewes. Crossbred lambs from the Rep+ Merino ewes had heavier loins than lambs from FW+ Merino ewes. The fat depth 25 mm from the midline at the 13th rib of lambs from dual-purpose ewes was between 22 and 32 % greater than that of lambs from FW+ Merino ewes. Progeny from Rep+ Merino ewes showed a closer resemblance to the progeny of dual-purpose breeds than that of FW+ Merino ewes in this instance. The initial pH of meat from progeny of FW+ Merino ewes was lower than that from progeny of dual-purpose ewes, and Rep+ Merino ewes. No differences in Warner-Bratzler shear values of the meat were found between the different crosses. Crossbred progeny of the Merino lines performed satisfactorily for all the traits considered, and will not be discriminated in the market. No conclusive differences in favour of either sire breed were found.

Keywords: carcass characteristics, Dohne Merino, meat quality, SA Mutton Merino, terminal crossbreeding

Introduction

At the present wool:meat price ratio, most of the financial income acquired in a sheep enterprise is derived from meat, and particularly from the marketing of lambs. Therefore, many strategies for the improvement of lamb production and the growth performance of the lambs have been implemented. One such strategy is the production of commercial crossbred slaughter lambs where the crossbred lambs should have a higher birth weight, and better growth performance (relative to the mean of the parent breed) up to the age of weaning and should reach the mature slaughtering weight in an intensive fattening system faster (Teixeira *et al.*, 1996; Doloksaribu *et al.*, 2000; Freking *et al.*, 2000; Snowder & Duckett, 2003; Fogarty 2006).

Crossbreeding is a powerful tool for the animal breeder and is of critical importance to the meat sheep industry. Crossbred individuals are expected to exhibit heterosis. The percentage increase in performance relative to the mid-parent value of the pure breeds can range from 0 to 10% for growth traits. A good crossbreeding system aims to use breeding ewes that are small as well as prolific (Piper & Ruvinsky 1997).

However, within the South African scenario, very little research has been conducted on crossbreeding systems utilizing local South African breeds. The objective of this study is therefore to compare the carcass composition and meat quality of the progeny of Dormer and Suffolk sires crossed with five dam lines. The dam lines were South African Mutton Merino (SAMM), a first cross ewe line called SAMM cross (SAMM rams crossed to commercial Merino ewes), Dohne Merino, as well as two specialist Merino lines. The first of these were selected for clean fleece weight (FW+) and the second were selected for an increased reproduction (Rep+). Both lines originated from commercial Merino stock.

The Dormer breed was originally developed to provide a terminal crossbreeding sire breed for use on Merino ewes in the Western Cape (De Villiers & Cloete, 1984). The Suffolk sire is used widely in the world for slaughter lamb production. The Suffolk is one of the largest sheep breeds in the world and sires most of the lambs marketed as heavyweight lambs (Milton *et al*., 1994; Shrestha *et al.,* 2002). Ellis *et al*. (1997) found that Suffolk sired lambs were heavier, but with similar carcass weights and killing-out proportions compared to Charrollais and Texel rams. In this paper the carcass characteristics, carcass measurements and effect of ewe line on meat quality of the progeny sired by Dormer and Suffolk rams were compared.

Materials and Methods

The experiment was conducted at Langgewens experimental farm in the Swartland region of South Africa from 1999 to 2002. The climate is Mediterranean, with 78% of the total long-term annual precipitation of 395 mm being recorded during winter (April to September). Merino type ewes, belonging to five distinct lines, represented the female breeding animals. These ewes were born during 1997 and 1998, and were not selected as replacements for breeding purpose in their flocks of origin. Approximately 20 ewes within each birth year groups (40 in total) represented each line. The maternal lines were described in detail by Cloete *et al*. (2003). Dormer or Suffolk rams were used as terminal sire breeds on the ewe flock. Two rams of each sire breed were used in single sire groups during 1999, when only the ewes born in 1997 were available. Three rams of each breed were used in 2000 and 2001, while only two rams were used in 2002. In each year, one ram of each breed was retained for breeding, to provide sire links across years. In total, eight rams per sire breed were used.

The ewes lamb during June and July. All the lambs were slaughtered at approximately 40 kg live weight (Cloete *et al.,* 2004b*)*. Full body live weight was determined 24 hours prior to slaughtering (Hopkins *et al*., 1996). The sheep were slaughtered at a commercial abattoir using standard South African slaughter techniques, which included electrical stunning (4 seconds at 200 Volts) before being exsanguinated. The carcasses were subsequently hung to bleed out and were then skinned. The carcasses were kept in a cooler at 4 C^o for 24 hours, after which the dressed carcasses were transported (carcasses were transported in a refrigerated truck, and the duration of the trip was approximately 45 minutes) from the abattoir to a deboning facility, where they were kept for another 24 hours at 4 C^o, prior to deboning and sampling.

Carcass components that were weighed included the head, trotters and skin. Measurements on the carcass included the measurement of fat depth at two sites. The first site was for fat measurements at the 13th rib 25 mm from the midline and the second site between the 3rd and 4th lumbar vertebrae 25 mm from the midline on the left side of the carcass (Bruwer *et al*., 1987). The carcass length was measured on the hanging carcass from the *Pubis Ischium* to the cranial edge of the first rib. The hind leg circumference was measured at the maximum circumference of a line passing over the distal end of the iliac wings of the pelvis and the most caudal point on the median line between the legs (Stanford *et al.*, 1997). Hind leg length was measured from the inner edge of the proximal end of the tibia to the anterior tip of the pubis (Enright *et al.*, 1990). The carcass depth was measured at the first rib cranial of the sternum, and the carcass width was taken at the widest place of the carcass at the forequarter.

After 48 hours in cold storage (4 C^{o}) the carcasses were partitioned into South African retail cuts, which were weighed separately (Cloete *et al.*, 2004a). These cuts consisted of the neck, shoulder, chuck, flatrib, prime rib, loin and hindquarters. The neck was removed at the seventh cervical vertebrae (the point where the neck starts bending), the cut being made at right angles to the spine. Thereafter the hind legs were removed. This consisted of loosening the flanks on the inside of the legs (following the curve of the leg muscle) to an imaginary line perpendicular to the ilium (seen from the inside of the carcass). The leg was then removed by cutting along this line, just missing the ilium (through the last lumbar vertebrae). The rest of the carcass was then halved along the spinal column, prior to being separated into trade cuts (shoulder, chuck, flatrib, prime rib and loin). The shoulder was removed by sawing along an imaginary line from the elbow joint to a point below the spinal column, between the fifth and sixth ribs. The carcass was then swivelled so that the spinal column was sawn through at right angles. The flank was removed by sawing from the *obliquus abdominis internus* muscle parallel to the spine. The loin and rib were separated perpendicularly to the spinal column at the junction of the thoracic and lumbar vertebrae. All commercial cuts were weighed to the nearest gram without any trimming of fat.

Instrumental measurements of meat quality were made on the *M. longissimus lumborum.* A CRISON pH meter (507) fitted with a CRISON electrode (Cat. 52-32) was inserted directly into the meat, to measure pH 45 min, 24 h and 48 h post mortem. The pH meter was equipped with a thermometer that allowed automatic adjustment for temperature, and calibrated with standard buffers at pH 4.0 and pH 7.0. Recalibration was done after every 10 animals measured. The pH was measured on the right side of each animal in the *M. longissimus* between the 1^{st} and the 2^{nd} lumbar vertebrae.

After 48 h in the cooler the carcasses were weighed to determine cold carcass weight. The *M. longissimus dorsi* muscle from the left side was dissected from the 1^{st} to the 6^{th} lumbar vertebrae and used for meat quality analyses (Schönfeldt *et al.*, 1993). Two loin 1.5 cm sub-samples of approximately 35 g (the first taken at the first lumbar vertebrae and the second, caudally adjacent to it) were taken for the determination of cooking loss, drip loss, colour and meat tenderness (Honikel, 1998). For drip loss determination one of the loin sub-samples were weighed, placed in netting and suspended in an inflated plastic bag. After a storage period of 24 h at 4 °C, the samples were weighed again after removal from the bags, and the drip loss was calculated as weight loss expressed as a percentage of the original weight of the sample (Honikel, 1998).

The colour was evaluated by using a Color-guide $45^{o}/0^{o}$ colorimeter (BYK-Gardner, USA) to determine L*, a*, b*, chroma and hue angle (Commission International de l' Eclairage, 1976), with L* indicating brightness, a* the red-green range, and b* the blue-yellow range. The Color-guide $45^{0}/0^{0}$ colorimeter was calibrated using the green, black and white colour samples provided for this purpose. The meat samples were bloomed for 30 minutes at room temperature and three measurements per sample were taken.

For the cooking loss determination the other sub-sample was weighed and placed in a thin-walled plastic bag in a water-bath at 75 °C. After one hour the samples were removed from the water bath, cooled in cold water, removed from the plastic bag, blotted dry and weighed. The meat samples were cooked after retrieving it from the water bath. Cooking loss was calculated as the difference in sample weight before and after cooking, expressed as a percentage of the initial sample weight (Honikel, 1998).

Tenderness of the meat (same sample as used for cooking loss) was measured with the Warner-Bratzler shear force test using 1.27 cm diameter samples in triplicate (loin sub-samples were too small to measure more samples) (Honikel, 1998). Samples were randomly removed from the center of each cooled (4 °C) *M. longissimus dorsi lumborum* sample. Maximum shear force values (N) required to shear a cylindrical core, perpendicular to the grain (at a crosshead speed of 200.0 mm/min), were recorded for each sample and the mean was calculated for each muscle.

The ASREML statistical package (Gilmour *et al.*, 1999) is suitable for the estimation of various random effects in animal breeding, while also allowing for the prediction of least squares means for selected fixed effects. Fixed effects that were considered in the analyses of lamb slaughter traits (carcass measurements, retail cuts, pH measured 45 minutes, 24 hours and 48 hours post-slaughter, shearing values and colour measurements of the meat) were birth year, sex, birth type, dam line and sire breed as well as relevant interactions. Since interactions were not significant in the vast majority of cases, only main effect means were tabulated. Information is supplied in the text in those cases where significant interactions were found. Age of dam was confounded with production years and was thus not considered. Random sire within ram breed and maternal permanent environmental effects were also computed for the respective traits. Back pedigrees were not included for sires and dams, since all sires and dams were derived from different flocks. It was thus not attempted to fit maternal genetic effects. It would also be of limited application in a terminal crossbreeding system, where all female progeny are slaughtered. Carcass measurements and retail cut weights were adjusted for carcass weight as there were slight, but significant, differences in carcass weights between the different crossbred lambs (Cloete *et al.*, 2004b).

The random effects that were estimated could have been used for the calculation of genetic parameters, but since exhaustive parameter estimates on much more comprehensive data sets are available for most traits in sheep (Safari & Fogarty, 2003), estimates of these parameters from the current data are not reported. The random effects were, however, retained in the analysis, for the reduction in the mean squares for error it afforded.

Results

When carcass component weights adjusted for carcass weight were considered (Table 1), the head weight differed (P<0.01) between birth years, being lower during 2000 than 2002. Heads of male lambs were also 5% heavier (P<0.01) than those of female lambs. Birth type and ram line did not influence head weight. FW+ and Rep+ ewes bred lambs with heavier (P<0.05) heads than Dohne and SAMM ewes. Skin weight of lambs born in 2002 was heavier (P<0.05) than that from lambs born in 2000 and 2001. Singles and male lambs had heavier (P<0.01) skins than respectively multiples and female lambs. There were significant differences (P<0.01) in skin weight between lambs from the two Merino lines and lambs from the dual purpose ewes, with the progeny of the Merino lines having heavier skins.

Table 1 Least squares means (± s.e.) depicting the effects of gender, birth type, ewe line and ram breed on carcass components after adjustment for carcass weight at slaughter

Effect	Head (kg)	Skin (kg)	Trotters (kg)	Carcass length (cm)	Carcass depth (cm)	Carcass width (cm)	Leg length (cm)	Leg circumfe -rence (cm)
Overall mean	1.93±0.01	3.79±0.04	0.90±0.01	70.5±0.2	25.7±0.1	21.8±0.1	30.0±0.1	25.0±0.1
Year:	**	*	**	**	ns	**	**	**
2000	1.87^{a}±0.02	3.76^{a}±0.05	0.92^{b}±0.01	70.3^{a}±0.2	25.8±0.1	22.6^{b}±0.2	29.3^{a}±0.2	25.8^{b}±0.2
2001	1.93^{b}±0.01	3.77^{a}±0.05	0.89^{a}±0.01	69.9^{a}±0.2	25.7±0.1	21.1^{b}±0.2	31.0^{b}±0.2	24.5^{a}±0.2
2002	1.94^{b}±0.02	3.84^{b}±0.06	0.90^{a}±0.01	71.2^{b}±0.4	25.7±0.2	21.9^{ab}±0.3	29.8^{a}±0.2	24.6^{a}±0.2
Gender:	**	**	**	ns	ns	**	ns	ns
Male	1.97±0.02	3.66±0.05	0.94±0.01	70.3±0.2	25.8±0.1	21.5±0.2	30.1±0.2	24.9±0.2
Female	1.86±0.01	3.92±0.04	0.86±0.01	70.7±0.2	25.7±0.1	22.1±0.2	29.9±0.2	25.1±0.1
Birth type:	ns	**	**	ns	ns	ns	ns	ns
Single	1.91±0.01	3.83±0.05	0.92±0.01	70.7±0.3	25.6±0.1	21.7±0.2	30.0±0.2	25.1±0.2
Multiple	1.92±0.01	3.75±0.04	0.88±0.01	70.3±0.2	25.8±0.1	21.9±0.2	30.0±0.1	24.8±0.1
Ewe line:	**	**	ns	*	ns	**	ns	**
SAMM	1.88^{a}±0.02	3.48^{a}±0.07	0.92±0.01	70.3^{ab}±0.4	25.5±0.2	22.3^{b}±0.3	29.8±0.3	25.2^{b}±0.2
SAMM Cross	1.91^{a}±0.02	3.69^{a}±0.07	0.89±0.01	70.2^{ab}±0.4	25.5±0.2	22.1^{b}±0.3	29.7±0.3	25.0^{b}±0.2
Dohne	1.87^{a}±0.01	3.59^{a}±0.06	0.89±0.01	69.8^{a}±0.3	25.7±0.1	21.9^{ab}±0.2	29.9±0.2	25.3^{b}±0.2
FW+	1.95^{b}±0.02	4.18^{b}±0.07	0.91±0.01	70.9^{b}±0.3	25.9±0.2	21.4^{a}±0.2	30.2±0.2	24.4^{a}±0.2
Rep+	1.94^{b}±0.02	4.01^{b}±0.06	0.90±0.01	71.3^{b}±0.3	26.0±0.2	21.5^{a}±0.2	30.4±0.2	24.9^{b}±0.2
Ram breed:	ns	ns	**	ns	*	ns	ns	ns
Dormer	1.92±0.01	3.77±0.04	0.92±0.01	70.1±0.2	25.9±0.1	22.0±0.2	30.2±0.1	25.1±0.2
Suffolk	1.91±0.02	3.81±0.06	0.88±0.01	70.9±0.2	25.6±0.1	21.6±0.2	29.8±0.2	24.9±0.2

n.s. – Not significant (P>0.05); * – Significant (P<0.05); ** – Significant (P<0.01)
[abc] Column means with different superscripts differ significantly (P<0.05)

Lambs born in 2000 had heavier (P<0.01) trotters than lambs born in 2001 and 2002. Male and single lambs also had heavier (P<0.01) trotters than female and multiples. No differences in trotter weight were found between lambs from the different ewe lines, but Dormer-sired lambs had heavier trotters than Suffolk sired lambs.

Results of carcass measurements are also shown in Table 1. Lambs born in 2002 had longer ($P<0.01$) carcasses than lambs born in 2001. In general, carcass measurements were independent of gender, birth type and sire line. The only difference in carcass depth was between the two sire breeds, where the Dormer-sired lambs had a greater carcass depth. The leg circumferences of crossbred lambs from the dual purpose ewes were greater than lambs from the FW+ Merino ewes.

When retail cut weights were considered after adjustment for carcass weight, it was clear that the neck weights of lambs born in 2000 and 2001 were heavier ($P<0.01$) than those from lambs born in 2002 (Table 2). Male lambs had also heavier necks than female lambs ($P<0.01$). No differences were found for the other fixed effects. The shoulder retail cut weights of Dohne Merino crossbred lambs was lighter ($P<0.05$) than those of the other crossbred lambs. Singles and lambs born in 2002 had higher ($P<0.01$) chuck retail cuts weights than respectively multiples and lambs born in 2000 and 2001. No differences were found for other fixed effects. Lambs born in 2000 had higher flatrib weights than lambs born in 2001 and 2002. The flatrib weights of lambs from Dohne Merino and FW+ Merino ewes were lighter than those from the other crossbred types. Loin weights of lambs born in 2001 were lower than from lambs born in 2000 and 2002. Crossbred lambs bred from Rep+ Merino ewes had higher loin weights than lambs from FW+ Merino ewes ($P<0.05$). Primerib weight of lambs born in 2001 was also lighter than those born in the other two years, but their hindquarter weights were higher. Primerib and hindquarter weights of singles were higher than those of multiples. Primerib and the hindquarter weights were independent of ewe line and ram breed.

Fat depth measurements of progeny born during 2001 were lower ($P<0.01$) than that of progeny born in 2000 and 2002 (Table 3). Ewe lambs had a greater ($P<0.05$) fat cover than rams at the 13th rib, with a corresponding tendency between the 3rd and 4th lumbar vertebra. Multiple lambs were generally leaner ($P<0.01$) than singles. At the 13th rib, the fat depth of progeny from the dual-purpose breeds (SAMM, SAMM Cross and Dohne Merino) was between 22 and 32 % thicker ($P<0.05$) than that of lambs of the same weight reared by FW+ Merino ewes. The progeny of Rep+ Merino ewes resembled those of the dual-purpose ewe lines more closely than lambs reared by FW+ ewes. Fat depth between the 3rd and 4th lumbar vertebra was affected by a significant interaction between ewe line and birth type. In the case of progeny from purebred SAMM ewes and Dohne ewes, averages for fat depth of singles were respectively 78 and 69 % thicker ($P<0.05$) than that of multiples (3.35 ± 0.24 vs. 1.88 ± 0.14 mm and 2.92 ± 0.20 vs. 1.73 ± 0.17 mm respectively). The corresponding difference ($P<0.05$) for single and multiple progeny of FW+ Merino ewes amounted to 38 % (2.07 ± 0.21 vs. 1.50 ± 0.18 mm respectively). No conclusive birth type differences could be demonstrated for the progeny of SAMM cross ewes (2.32 ± 0.27 vs. 1.82 ± 0.14 mm for singles and multiples respectively) and the progeny of Rep + Merino ewes (2.35 ± 0.22 vs. 2.01 ± 0.15 mm respectively). Fat depth between the 3rd and 4th lumbar vertebra was also affected by an interaction ($P<0.05$) between ram breed and birth year. During 2000, Dormer-sired progeny had a thicker ($P<0.05$) average fat depth at this site than contemporaries sired by Suffolk rams (2.68 ± 0.17 vs. 2.26 ± 0.13 mm, respectively). No sire breed differences were obtained during 2001 (1.28±0.17 vs. 1.56±0.14 mm, respectively) and 2002 (2.64±0.24 vs. 2.75±0.18 mm, respectively).

Table 2 Least squares means (± s.e.) depicting the effects of gender, birth type, ewe line and ram breed on the weights of retail cuts after adjustment for carcass weight

Effect	Neck (kg)	Shoulder (kg)	Chuck (kg)	Flatrib (kg)	Loin (kg)	Primerib (kg)	Hindquarters (kg)
Overall mean	0.72±0.02	0.83±0.02	4.30±0.05	1.64±0.03	1.62±0.02	1.24±0.01	4.91±0.05
Year:	**	**	**	**	**	**	**
2000	0.76^b±0.02	0.99^b±0.02	4.06^a±0.06	1.96^b±0.04	1.73^b±0.02	1.33^b±0.02	4.93^b±0.07
2001	0.75^b±0.02	0.72^a±0.03	4.19^a±0.07	1.51^a±0.05	1.29^a±0.03	1.11^a±0.02	5.08^b±0.08
2002	0.65^a±0.03	0.79^a±0.03	4.66^b±0.08	1.44^a±0.06	1.82^b±0.04	1.27^b±0.03	4.71^a±0.10
Gender:	**	ns	ns	ns	ns	ns	ns
Male	0.73±0.02	0.86±0.02	4.27±0.06	1.61±0.04	1.61±0.03	1.24±0.02	4.86±0.06
Female	0.70±0.02	0.81±0.02	4.33±0.05	1.67±0.04	1.63±0.02	1.24±0.02	4.95±0.06
Birth type:	ns	ns	**	ns	ns	**	**
Single	0.73±0.02	0.83±0.02	4.44±0.07	1.66±0.05	1.65±0.03	1.30±0.02	5.03±0.07
Multiple	0.71±0.02	0.84±0.02	4.16±0.05	1.62±0.03	1.59±0.02	1.18±0.01	4.79±0.06
Ewe line:	ns	*	ns	*	**	ns	ns
SAMM	0.73±0.02	0.85^b±0.03	4.26±0.08	1.70^b±0.06	1.62^{ab}±0.04	1.28±0.03	5.02±0.09
SAMM Cross	0.74±0.02	0.85^b±0.03	4.30±0.09	1.73^b±0.07	1.60^{ab}±0.04	1.25±0.03	4.94±0.09
Dohne	0.71±0.02	0.77^a±0.03	4.39±0.08	1.53^a±0.06	1.61^{ab}±0.04	1.23±0.03	4.97±0.08
FW+	0.70±0.02	0.84^b±0.03	4.23±0.08	1.57^a±0.06	1.56^a±0.04	1.20±0.03	4.71±0.08
Rep+	0.72±0.02	0.87^b±0.03	4.34±0.08	1.66^{ab}±0.06	1.68^b±0.04	1.24±0.03	4.89±0.08
Ram breed:	ns	ns	ns	ns	ns	ns	ns
Dormer	0.72±0.03	0.84±0.02	4.26±0.04	1.64±0.04	1.58±0.02	1.23±0.02	4.96±0.06
Suffolk	0.72±0.01	0.83±0.02	4.38±0.08	1.64±0.05	1.65±0.03	1.25±0.02	4.86±0.08

n.s. – Not significant (P>0.05); * – Significant (P<0.05); ** – Significant (P<0.01)

^{abc} Column means with different superscripts differ significantly (P<0.05)

The initial pH measured 45 minutes after slaughter of *M. longissimus dorsi lumborum* from carcasses slaughtered during 2002 were lower (P<0.05) compared to those slaughtered during 2000 and 2001 (Table 4). Ram lambs and singles had higher (P<0.05) initial pH values than ewes and multiples. The initial pH values of lambs from the dual-purpose ewe lines were between 0.19 and 0.20 units higher than those of progeny of FW+ Merino ewes. Progeny from the Rep+ Merino ewes resembled the dual-purpose ewe lines in this regard, with a 0.14 units higher initial pH than FW+ progeny (P<0.05). Year differences in pH measured 24 and 48 hours post-slaughter were also significant (P<0.05), although the birth years were not ranked similarly throughout. Overall, measurements of pH 24 hours post-slaughter were independent (P>0.25) of gender, birth type, ewe line and sire breed. Measurements of pH obtained 48 hours post-slaughter were affected by sire breed where progeny from the Dormer rams had a higher pH value than progeny from the Suffolk rams (Table 4). There were also a sire breed x birth year interaction (P<0.05). During 2000, there was no breed difference between Dormer and Suffolk sires (5.97±0.05 vs. 5.95±0.05 respectively). During 2001, pH measurements made on progeny from Dormer sires were higher than that of Suffolk sires (5.78±0.04 vs. 5.52±0.05). No breed differences were again obtained during 2002 (5.98±0.05 vs. 5.87±0.06), but the tendency was in the same direction as for 2001.

Table 3 Least squares means (± s.e.) depicting the effects of gender, birth type, ewe line and ram breed on fat depth at two sites

Effect	13th rib	3rd / 4th lumbar vertebrae
Number of observations	483	483
Overall mean	1.61±0.06	2.20±0.08
Year:	**	**
2000	1.74^{b}±0.08	2.47^{b}±0.11
2001	1.08^{a}±0.08	1.42^{a}±0.11
2002	2.00^{b}±0.11	2.69^{b}±0.15
Gender:	**	n.s.
Male	1.47±0.07	2.11±0.10
Female	1.74±0.07	2.29±0.09
Birth type:	**	**
Single	1.87±0.08	2.60±0.11
Multiple	1.35±0.06	1.79±0.08
Ewe line:	*	**
SAMM	1.68^{b}±0.10	2.62^{c}±0.14
SAMM cross	1.65^{b}±0.11	2.07^{ab}±0.15
Dohne	1.79^{b}±0.10	2.33^{bc}±0.14
FW+ Merino	1.35^{a}±0.10	1.78^{a}±0.14
Rep+ Merino	1.56^{ab}±0.10	2.18^{b}±0.14
Ram breed:	n.s.	n.s.
Dormer	1.59±0.09	2.20±0.12
Suffolk	1.62±0.08	2.19±0.09

n.s. – Not significant (P>0.05); * – Significant (P<0.05); ** – Significant (P<0.01)
^{abc} Column means with different superscripts differ significantly (P<0.05)

Cooking loss differed (P<0.01) markedly between birth years, being markedly lower during 2000 than in 2001 and 2002 (Table 4). Gender did not influence cooking loss, but multiples had a higher (P<0.01) cooking loss than singles. Birth type was also involved in an interaction (P<0.05) with ewe line. Single and multiple born progeny of purebred SAMM ewes and Dohne ewes did not differ with regard to cooking loss (28.2±0.9 vs. 29.1±0.5 % and 28.8±0.7 vs. 27.7±0.6 % respectively). In the two Merino lines cooking loss differences were generally in favour of singles, 27.4±0.7 vs. 30.4±0.7 % for the progeny of FW+ Merino ewes, and 27.8±0.5 vs. 29.6±0.6 % for the progeny of Rep+ Merino ewes. Results obtained from the progeny of SAMM cross ewes followed an opposite direction, singles having higher cooking loss values than multiples (32.4±1.0 vs. 30.2±0.5 % respectively). Ram breed and year were also involved in a significant (P<0.05) interaction. During 2000, Dormer-sired lambs had higher cooking loss values than Suffolk-sired lambs (23.2±0.5 vs. 21.7±0.5 % respectively). An opposite result was obtained during 2001, Dormer-sired progeny having a lower average cooking loss than contemporaries sired by Suffolk rams (31.4±0.5 vs. 33.4±0.5 % respectively). No ram breed difference was found during 2002 (32.9±0.5 vs. 32.5±0.5 % for progeny of Dormer and Suffolk rams respectively). Drip loss were not affected by any of the fixed effects apart from birth year, where lambs born during 2001 had a higher (P<0.05) drip loss than those born during 2000 and 2002. A significant (P<0.05) interaction was obtained between ram breed and birth year. During 2000 and 2002, Dormer-sired lambs tended to have higher drip loss values than Suffolk-sired lambs (1.09±0.06 vs. 1.03±0.07 % and 1.06±0.06 vs. 0.93±0.08 % respectively). An opposite result was obtained during 2001, Dormer-sired progeny having a lower (P<0.05) average drip loss than contemporaries sired by Suffolk rams (1.20±0.06 vs. 1.42±0.08 % respectively). Warner-Bratzler shear values were higher during 2000 and 2001 when compared to 2002 (Table 4). Shear strength was unaffected by the other fixed effects, although there was a suggestion (P<0.25) for Dormer-sired lambs to have higher shear values than the progeny of Suffolk rams.

Table 4 Least squares means (± s.e.) depicting the effects of gender, birth type, ewe line and ram breed on pH values 45 minutes, 24 hours and 48 hours post slaughter, as well as shear value, cooking loss and drip loss

Effect	pH certain periods post slaughter			Shear value (N)	Cooking loss (%)	Drip loss (%)
	45 min	24 hours	48 hours			
Number of observations	393	236	393	232	254	254
Overall mean	6.86±0.02	5.64±0.01	5.62±0.01	97.8±2.4	29.2±0.2	1.12±0.03
Year:	**	**	**	**	**	**
2000	6.91^a±0.04	5.72^b±0.02	5.67^a±0.01	103^b±4.0	22.4^a±0.4	1.06^a±0.05
2001	6.91^a±0.03	5.60^a±0.02	5.54^b±0.01	112^b±3.6	32.4^b±0.4	1.31^b±0.05
2002	6.75^b±0.05	5.62^a±0.03	5.67^a±0.01	77.8^a±4.0	32.7^b±0.4	1.00^a±0.05
Gender:	**	n.s.	*	n.s.	0.25	n.s.
Male	6.92±0.03	5.65±0.02	5.64±0.01	100.1±3.0	29.5±0.3	1.11±0.04
Female	6.80±0.03	5.64±0.02	5.61±0.01	95.5±3.0	28.8±0.3	1.14±0.04
Birth type:	*	n.s.	n.s.	n.s.	**	n.s.
Single	6.90±0.03	5.65±0.02	5.64±0.01	96.7±3.5	28.7±0.4	1.11±0.05
Multiple	6.82±0.03	5.64±0.01	5.62±0.01	99.0±2.6	29.7±0.3	1.14±0.04
Ewe line:	**	n.s.	n.s.	n.s.	*	n.s.
SAMM	6.91^b±0.04	5.65±0.03	5.63±0.02	95.8±4.8	28.6^a±0.5	1.09±0.07
SAMM cross	6.89^b±0.04	5.68±0.03	5.62±0.02	102.9±5.0	31.4^b±0.6	1.20±0.07
Dohne	6.92^b±0.04	5.66±0.03	5.60±0.01	92.0±4.3	28.3^a±0.5	1.21±0.06
FW+ Merino	6.72^a±0.04	5.62±0.02	5.63±0.02	98.1±4.2	28.9^a±0.5	1.04±0.06
Rep+ Merino	6.86^b±0.04	5.62±0.03	5.64±0.02	100.3±4.4	28.7^a±0.5	1.08±0.06
Ram breed:	n.s.	n.s.	*	n.s.	n.s.	n.s.
Dormer	6.86±0.04	5.66±0.02	5.64±0.01	101.4±3.7	29.2±0.3	1.12±0.04
Suffolk	6.85±0.03	5.63±0.02	5.61±0.01	94.3±2.7	29.2±0.3	1.13±0.05

n.s. – Not significant (P>0.05); * – Significant (P<0.05); ** – Significant (P<0.01)
^{abc} Column means with different superscripts differ significantly (P<0.05)

When meat colour was considered, it was clear that the L* value of progeny born during 2001 was somewhat higher than in the other two years (Table 5). Male lambs and Suffolk-sired progeny also had generally higher (P<0.05) L* values than respectively ewe lambs and Dormer-sired progeny. Birth type and ewe line did not affect L* values. Values of a* were higher in 2001 than in 2000 and 2002. Progeny of FW+ Merino ewes also had meat that was situated more towards saturated red on the green-red scale than progeny of purebred SAMM ewes and SAMM cross ewes. Position on the blue-yellow axis b* value was affected by birth year, gender and birth type. Higher (P<0.05) values were obtained during 2000 and 2001, by rams and by singles. There was also a suggestion of values closer to saturated yellow in the case of Suffolk-sired progeny (P<0.25), but it did not reach significance. Hue angle were affected (P<0.05) by birth year, gender and birth type, but not by ewe line. Suffolk-sired lambs tended to have a higher (P<0.10) hue angle than Dormer-sired lambs. Chroma was affected by birth year and birth type, but not by gender, ewe line and sire breed. No significant interactions were found in these analyses.

Table 5 Least squares means (± s.e.) depicting the effects of gender, birth type, ewe line and ram breed on meat colour parameters measured on the *M. longissimus lumborum*

Effect	L*	a*	b*	Hue	Chroma
Number of observations	228	228	228	228	228
Overall mean	37.1±0.2	12.1±0.1	9.0±0.1	36.6±0.4	15.2±0.1
Year:	**	**	**	**	**
2000	36.9^{b}±0.3	12.0^{ab}±0.1	9.2^{b}±0.2	37.4^{b}±0.6	15.2^{ab}±0.2
2001	38.4^{b}±0.3	12.4^{b}±0.1	9.3^{b}±0.2	36.8^{b}±0.6	15.7^{b}±0.2
2002	36.0^{a}±0.4	11.8^{a}±0.1	8.6^{a}±0.2	35.8^{a}±0.6	14.7^{a}±0.2
Gender:	**	n.s.	*	*	n.s.
Male	37.7±0.2	12.0±0.1	9.3±0.2	37.5±0.5	15.3±0.1
Female	36.6±0.2	12.2±0.1	8.8±0.1	35.8±0.5	15.0±0.1
Birth type:	n.s.	n.s.	**	**	**
Single	37.2±0.3	12.1±0.1	9.5±0.2	37.9±0.6	15.4±0.1
Multiple	37.0±0.2	12.1±0.1	8.6±0.1	35.4±0.4	14.9±0.1
Ewe line:	n.s.	*	n.s.	n.s.	n.s.
SAMM	37.0±0.3	11.9^{a}±0.2	9.3±0.2	37.6±0.8	15.2±0.2
SAMM cross	37.4±0.4	11.9^{a}±0.2	9.2±0.2	37.6±0.8	15.1±0.2
Dohne	37.2±0.3	12.1^{ab}±0.2	8.8±0.2	36.1±0.8	15.0±0.2
FW+ Merino	37.0±0.3	12.5^{b}±0.2	9.0±0.2	35.6±0.7	15.5±0.2
Rep+ Merino	37.0±0.3	12.0^{ab}±0.2	8.9±0.2	36.3±0.7	15.0±0.2
Ram breed:	**	n.s.	n.s.	n.s.	n.s.
Dormer	36.5±0.2	12.1±0.1	8.9±0.1	36.1±0.5	15.1±0.1
Suffolk	37.7±0.3	12.1±0.1	9.2±0.2	37.2±0.5	15.3±0.1

n.s. – Not significant (P>0.05); * – Significant (P<0.05); ** – Significant (P<0.01)
[abc] Column means with different superscripts differ significantly (P<0.05)

Discussion

All the animals were slaughtered at the same abattoir using mostly the same staff throughout the experiment. Although the lambs were not all slaughtered on the same day under the same environmental conditions because they were slaughtered as they reached a target weight, it was assumed that potential environmental effects would have been evened out. No abnormal environmental conditions (e.g. excessive heat, humidity, long transport etc.) were noted on the days that the lambs were slaughtered.

Rams had heavier head and neck weights than ewes in the present study, as was also found by Jeremiah *et al.* (1997). The phenomenon of heavier forequarters in male sheep is typical of sexual dimorphism. Lambs from the two Merino lines also had heavier head weights than those of the dual purpose ewes. This could be related to the fact that Merinos have horns, which are transferred to some of their crossbred progeny (Campher *et al.*, 1998). As Merinos are specialist wool-producing sheep, it could be expected that crossbred lambs from the two Merino lines were likely to have heavier skin weights than the crossbred progeny of the dual-purpose ewes. Female lambs took longer to reach slaughter weight (Cloete *et al.*, 2004b), resulting in a longer wool growth period and consequently heavier skin weights.

Year differences in shoulder and chuck retail cut weights is most probably due to the cutting technique as different block men were employed. Although it was attempted to minimize this effect, this is a problem that is frequently encountered when research is conducted in a commercial breaking plant over an extended (three year investigation) period. Lambs born during 2000 had the heaviest shoulders but their chuck weights were the lowest. The same occurred with the loin and hindquarter weights, the lambs born in 2002 having the heaviest loin weights but the lowest hindquarter weights. These results indicate that the block men did not always follow exactly the same procedure. It is noteworthy that progeny from the Rep+ ewes produced heavier loins than lambs from FW+ Merino ewes, when adjusted for lamb carcass weight. An earlier study also found that purebred Rep+ Merino hoggets had heavier loin retail cut weights after adjustment for carcass weight, as compared to a purebred line selected against reproduction (Cloete *et al.*, 2004a).

A gender influence on subcutaneous fat depth is consistent with trends generally found in the literature, with ewe carcasses being fatter and with a higher dressing percentage (Kirton *et al.*, 1982; Cloete *et al.*, 2005). The significant effect of birth type on fat depth was consistent with the study of Greeff *et al.* (2003) where singles were fatter than multiples at slaughter, based on data for 829 Merino ram hoggets.

Lambs produced by the dual purpose and Rep+ Merino ewes had higher meat pH 45 minutes post slaughter than the progeny of the FW+ Merino ewes. This finding may be related to a greater susceptibility to pre slaughter stress, since a low pH 45 min post slaughter are regarded as an indicator of acute, short-term stress as been indicated by Cloete *et al.* (2005). These results could be related to a previous study where purebred Rep+ line progeny had higher pH values within 45 minutes after slaughter than contemporaries from a line that was selected against reproduction (Cloete *et al.*, 2005). The contention that selection resulted in reduced levels of fear from humans was supported by behavioural observations that Rep+ line progeny allowed shorter distances between them and a human operator when unaccustomed to handling, while they were also less likely to defecate during the test (Cloete *et al.*, 2005). Although there were differences in pH mesured 45 minutes after slaughter there were no differences in final pH values (48 hours after slaughter) between the lambs from the different ewe lines. Fogarty *et al.* (2000), Hopkins & Fogarty (1998) and Purchas *et al.* (2001) also found no differences in the ultimate pH between lambs sired by different sires used on Romney ewes. The fact that there were no differences in final pH could indicate that the lambs were not really put under severe stress (Lawrie, 1998). Limited genetic variation was found in pH measured 24 hours after slaughter in the study of Greeff *et al.* (2003), supporting the lack of genetic differences between ewe lines and sire breeds in the present study. In contrary to this Fogarty *et al.* (2003) found a heritability estimate for muscle pH of 0.27 ±0.09.

Juiciness of meat is directly related to the intramuscular lipids and moisture content of meat. In combination with water, the melted lipids constitute a "broth" that is retained in meat (Schönfeldt *et al.*, 1993). Overall, cooking loss from fatter meat tends to be less than from lean meat. Although fatter meat loses more fat (which is expected in view of a higher fat content), it loses less moisture, possibly because the structural changes caused by the presence of the fat enhance the water-holding capacity (Lawrie, 1998). This reasoning could explain why the cooking loss of the meat from multiples was generally higher than that for meat from the singles. The thicker average fat cover of singles compared to multiples provides further support to this line of reasoning.

The higher drip loss of meat from lambs born in 2001 could be related to a lower final pH, since a lower final pH leads to higher drip loss (Lawrie 1998). In accordance with the results from the present study, Hoffman *et al.* (2003) found no line or breed differences in cooking loss and drip loss between lambs sampled from the same experiment, although it needs to be stated that only a small number of lambs born in 2000 were used.

No significant differences in shear values were found between the ewe lines or sire breeds. Young & Dobbie (1994) compared the inter-muscular collagen content of purebred Romney lambs and lambs sired by a terminal sire breed (Texel). They found that there was no effect of breed on collagen content between slaughter ages of 100 – 215 days. The mean slaughter age of progeny from the respective ewe lines in the present experiment ranged from 134 to 165 days (Cloete *et al.*, 2004b). These results suggest that the use of terminal sires is unlikely to affect the tenderness of lamb slaughtered in this range. In support of this argument, Hoffman *et al.* (2003) found no differences in tenderness between lambs from different genotypes originating from the same experiment in a taste panel. It has to be conceded that only a small number of lambs born in 2000 were used for the latter investigation. Although there were no differences in toughness between the ewe lines, it has to be pointed out that the absolute levels indicate the meat in this study was very tough.

The higher L* and a* value of the lambs born in 2001 indicated that the meat was more pink than that of the lambs born in 2000 and 2002 (Table 3). This could also be related to the fact that the initial pH (Table 2) of the lambs born in 2001 was higher ($P<0.05$) than that of the lambs born in the other years. Priolo *et al.* (2000) and Sañudo *et al.* (1998) found that muscle with a higher initial pH tended more towards the saturated red end of the colour scale. Previous observations on the pH and a* value of meat produced by the progeny of Merino ewes divergently selected for reproduction also supports this line of reasoning (Cloete *et al.*, 2005). Although there were some differences in colour between years and sexes, there were no substantial differences between lambs from the different dam lines. In a recent study, Greeff *et al.* (2003) accordingly reported limited genetic variation for meat colour measurements. Values for pH and colour measurements after 24 hours of cooling were also unaffected by birth type in the study of Greeff *et al.* (2003), which is in agreement with the general trend found in the present study.

Conclusion

Terminal crossbreeding of five Merino-type ewe lines with Dormer and Suffolk sires did not have serious adverse effects on the meat quality and retail cut weights of the lamb produced. The utilization of heterosis in terminal crossbreeding systems with specialist meat breeds thus seems to be a viable proposition in South Africa. Differences that were found were mostly between the progeny of dual-purpose ewes and Merino ewes selected for clean fleece weight (FW+), i.e. lower initial pH values and a reduced fat depth. Relatively inexpensive components of the carcass, viz. the skins and heads of progeny of both Merino dam lines were heavier than those of dual-purpose lines. Crossbred progeny of the Merino lines, however, still performed satisfactorily for all the traits considered. Decisions pertaining to the choice of ewe line could thus be based on other concerns, such as the relative economic return of the genotype (see Cloete *et al.*, 2004b for further details in this respect). It was interesting to note that the crossbred progeny of Rep+ Merino ewes resembled the progeny of dual-purpose ewes rather than that of FW+ Merino ewes for traits like initial pH, fat depth and loin weight. Previous work has also suggested that selection for reproduction in this line has not deleteriously affected slaughter traits (Cloete *et al.*, 2004a; 2005).

No clear advantage in favour of either one of the ram breeds was found. The choice of rams between the two breeds could thus be based on other factors like the availability of rams, and considerations like the probability of contamination with coloured fibres in the case of the Suffolk breed (Erasmus *et al.*, 1983; Cloete *et al.* 2004b).

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References

Bruwer, G.G., Naude, R.T. & Vosloo, W.A., 1987. An evaluation of the lamb and mutton carcass grading system in the Republic of South Africa. 1. A survey of carcass characteristics of the different grades. S. Afr. J. Anim. Sci. 17, 79-84.

Cloete, J.J.E., Cloete, S.W.P. & Hoffman, L.C., 2005. Behaviour of Merinos divergently selected for multiple rearing ability in response to external stimuli. Small Rumin. Res. 60, 227-236.

Cloete, J.J.E., Cloete, S.W.P., Hoffman, L.C. & Fourie, J.E., 2004a. Slaughter traits of Merino sheep divergently selected for multiple rearing ability. S. Afr. J. Anim. Sci. 34, 189-196.

Cloete, S.W.P., Cloete, J.J.E., Durand, A & Hoffman, L.C., 2003. Production of five Merino type lines in a terminal crossbreeding system with Dormer or Suffolk sires. S. Afr. J. Anim. Sci. 33, 223-232

Cloete, S.W.P., Cloete, J.J.E., Herselman, M.J. & Hoffman, L.C., 2004b. Relative performance and efficiency of five Merino dam lines in a terminal crossbreeding system with Dormer or Suffolk sires. S. Afr. J. Anim. Sci. 34, 135-143.

Campher, J.P., Hunlun, C. & Van Zyl, G.J., 1998. South African Livestock Breeding. South African Stud Book and Livestock Improvement Association. PO Box 270. Bloemfontein 9300, South Africa.

Commision International De L' Eclairage, 2nd, 1976. Commision Internationale De L' Eclairage, 18th session, London, England. September 1975. CIE publication no. 36.

De Villers, T.T. & Cloete, S.W.P., 1984. The Dormer sheep breed. Proc. 2nd World Cong. Sheep Beef Cattle Breed. 16 – 19 April 1984, Pretoria. South African Stud Book and Livestock Improvement Association, Bloemfontein (1984), 695-698.

Doloksaribu, M., Gatenby, R.M., Subandriyo, S.T. & Bradford, G.E., 2000. Comparison of Sumatra sheep crossbreds. III. Reproductive performance of F_2 ewes and weights of lambs. Small Rum. Res. 38, 115-121.

Ellis, M., Webster, G.M., Merrell, B.G. & Brown, I., 1997. The influence of terminal sire breed on carcass composition and eating quality of crossbred lambs. Anim. Sci. 64, 77-86.

Enright, W.J., Quirke, J.F., Gluckman, P.D., Breier, B.H., Kennedy, L.G., Hart, I.C., Roche, J.F., Coert, A. & Allen, P., 1990. Effects of long-term administration of pituitary-derived bovine growth hormone and estradiol on growth in steers. J. Anim. Sci. 68, 2345-2356.

Erasmus, L.S., De Kock, J.A. & Grobler, J.W., 1983. Slaglamproduksie in die Suid-Kaap. Els. J. 7, 13-32.

Fogarty, N.M., 2006. Utilization of breed resources for sheep production. 8th World Congress on Genetics Applied to Livestock Production, Belo Horizonte, MG, Brasil.

Fogarty, N.M., Hopkins, D.L. & van der Ven, R., 2000. Lamb production from diverse genotypes. 2. Carcass characteristics. Anim. Sci. 70, 147-156.

Fogarty, N.M., Safari, E., Taylor, P. J. & Murray W., 2003. Genetic parameters for meat quality and carcass traits and their correlation with wool traits in Australian Merino sheep. Aust. J. Agric. Res. 54, 715-722.

Freking, B.A., Leymaster, K.A. & Young L.D., 2000. Evaluation of Dorset, Finnsheep, Romanov, Texel, and Montadale breeds of sheep: I. Effects of ram breed on productivity of ewes of two crossbred populations. J. Anim. Sci. 78, 1422-1429.

Gilmour, A.R., Cullis, B.R., Welham, S.J. & Thompson, R., 1999. ASREML – Reference manual. NSW Agricultural Biometric Bulletin No. 3. NSW Agriculture, Orange Agricultural Institute, Forest Road, Orange 2800, NSW, Australia.

Greeff, J.C., Davidson, R. & Skerritt, J.W., 2003. Genetic relationship between carcass quality and wool production traits in Australian Merino rams. Proc. Assoc. Advmt. Anim. Breed. Gen. 15, 330-333.

Hoffman, L.C., Muller, M.M., Cloete S.W.P. & Schmidt, D. 2003. Comparison of six crossbred lamb types: sensory, physical and nutritional meat quality characteristics. Meat Sci. 65, 1265-1274.

Honikel, K.O., 1998. Reference methods for the assessment of physical characteristics of meat. Meat Sci. 49, 447-457.

Hopkins, D.L. & Fogarty, N.M., 1998. Diverse lamb genotypes 2. Meat pH, colour and tenderness. Meat Sci. 49, 477-488.

Hopkins, D.L., Gilbert, K.D., Pirlot, K.L. & Roberts, A.H.K., 1996. Elliottdale and crossbred lambs: growth rate, wool production, fat depth, saleable meat yield, carcass composition and muscle content of selected cuts. Aust. J. Exp. Agric. 32, 429-434.

Jeremiah, L.E., Jones, S.D.M., Tong, A.K.W., Robertson, W.M. & Gibson, L.L., 1997. The influence of lamb chronological age, slaughter weight and gender on yield and cutability. Int Sheep Goat Res. J. 13, 39-46.

Kirton, A.H., Clarke, J.N. & Hickey, S.M., 1982. A comparison of the composition and carcass quality of Kelly and Russian castrate, ram, wether and ewe lambs. Proc. N. Z. Soc. Anim. Prod. 42, 117-118.

Milton, J.T.B., Banks, R.B., Hepworth, G.W. & Dorman, S.A., 1994. Genetic evaluation of American Suffolks through progeny testing. Proc. Aust. Soc. Anim. Prod. 20, 167-177.

Lawrie, R.A., 1998. Lawrie's Meat Science. 6th ed. Woodhead Publ. Ltd. Cambridge, England.

Piper, L. & Ruvinsky, A. 1997. The genetics of sheep. CAB international 198 Madison Avenue New York, NY 10016-4314 USA.

Priolo, A., Waghorn, G.C., Lanza, M., Biondi, L. & Pennisi, P., 2000. Poleythylene glycol as a means for reducing the impact of condensed tannins in carob pulp: Effects on lamb growth performance and meat quality. J. Anim. Sci. 78, 810-816.

Purchas, R.W., Silva Sobrinho, A.G., Garrick, D.J., Lowe, K.I., 2001. Effects of age at slaughter and sire genotype on fatness, muscularity, and the quality of meat from ram lambs born to Romney ewes. N. Z. J. Agric. Res. 45, 77-86.

Safari, E. & Fogarty, N.M., 2003. Genetic parameters for sheep production traits: Estimates from the literature. Tech. Bull. 49. NSW Agriculture, Orange, Australia. http://www.sheep.crc.org.au/articles.php?rc=145.

Sañudo, C., Sierra, I., Olleta, J.L., Martin, L., Campo, M.M., Santolaria, P., Wood, J.D. & Nute, G.R., 1998. Influence of weaning on carcass quality, fatty acid composition and meat quality in intensive lamb production systems. Anim. Sci. 66, 175-187.

Schönfeldt, H.C., Naudè, R.T., Bok, W., Van Heerden, S.M. & Smit, R., 1993. Flavour- and tenderness-related quality characteristics of goat and sheep meat. Meat Sci. 34, 363-379.

Shrestha, J.N.B., Boylan, W. J. & Rempe, W. E., 2002. Evaluation of breeds of sheep and their crosses based on ewe productivity indices. Small Rumin. Res. 46, 89-96.

Snowder, G.D. & Duckett S.K., 2003. Evaluation of the South African Dorper as a terminal sire breed for growth, carcass, and palatability characteristics. J. Anim. Sci. 81, 368-375

Stanford, K., Woloschuk, C.M., McClelland, L.A., Jones, S.D.M. & Price, M.A., 1997. Comparison of objective external carcass scores for prediction of lamb carcass quality. Can. J. Anim. Sci. 77, 217-223.

Teixeira, A., Delfa, R. & Treacher, T., 1996. Carcass composition and body fat depots of Galego Bragançano and crossbred lambs by Suffolk and Merino Precoce sire breeds. Anim. Sci. 63, 389-394.

Young, O.A. & Dobbie, J.L., 1994. Characteristics of intermuscular collagen. N. Z. J. Agric. Res. 37, 97-105.

Chapter 7

Relative performance and efficiency of five Merino-type dam lines in a terminal crossbreeding system with Dormer or Suffolk sires

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Relative performance and efficiency of 5 Merino dam lines in a terminal crossbreeding system with Dormer or Suffolk sires

Abstract

The production performance of ewes was assessed in a terminal crossbreeding experiment involving five Merino dam lines and two terminal crossbreeding sire lines. Ewe lines were SA Mutton Merino (SAMM), SAMM rams crossed to Merino ewes (SAMM cross), Dohne Merino, as well as specialist Merino lines selected for clean fleece weight (FW+) and for an increased reproduction (Rep+). Dormer and Suffolk rams were used as sires. Dual-purpose ewes were heavier than Merinos on average and at the ultimate joining on 3.5 years. Average clean fleece weight for SAMM ewes were approximately half that of Merino ewes. Dohne and SAMM cross ewes clean fleece weights were intermediate. Differences between progeny in slaughter age, marketing weight, dressing percentage and carcass weight could largely be attributed to the comparison of purebred Merino lines with dual-purpose lines. The slaughter age of lambs from the two Merino lines was between 14 and 21% higher than that of the dual-purpose lines. Lambs from purebred SA Mutton Merino (SAMM) dams also outperformed lambs from SAMM cross ewes for slaughter age, slaughter weight and carcass weight. Considerable variation was found between ewe lines for reproduction parameters, but few significant differences were found. Total weight of lamb slaughtered per joining averaged 42.7 kg for SAMM ewes, 44.2 kg for SAMM cross ewes, 39.3 kg for Dohne ewes, 32.9 kg for FW+ Merino ewes and 42.0 kg for Rep+ Merino ewes, but differences between lines was not significant. Sire line did not affect lamb performance or ewe productivity markedly. An economic simulation indicated large differences in gross income per small stock unit between ewe lines, warranting further research on the efficiency of terminal Merino-type dam lines.

Keywords: Efficiency, fibre diameter, lamb output, reproduction, wool yield

Introduction

Fluctuations in the ratio between wool and meat prices have resulted in the emphasis on the two products changing markedly over the past decade. Commercial producers often seek other ways to exploit short-term benefits resulting from an increase in the price of meat than within flock selection, without compromising the wool-producing capacity of their ewe flocks (Erasmus, 1965). Crossbreeding of Merino type ewes with mutton type rams in a terminal crossbreeding system may be considered to realize this goal (Kleeman *et al.*, 1983). Such a system allows spreading of risk over the meat and wool commodities. It is also suitable for the exploitation of sexual dimorphism between dam and sire lines (Roux, 1992). This practice has often been implemented injudiciously in the past, resulting in wool contamination and the loss of genetic material needed for pure breeding (Erasmus, 1965).

This study evaluated a range of Merino-type bloodlines as dam lines in a terminal crossbreeding system. Lines were SA Mutton Merino (SAMM), SAMM rams crossed to Merino ewes, Dohne Merino, as well as specialist Merino lines selected for clean fleece weight or selected for an increased reproduction (Cloete *et al.*, 2003). The SAMM and Dohne Merino breeds are important dual-purpose genotypes, producing apparel wool, free from undesirable fibres (Terblanche, 1979). These lines were found to outperform purebred Merino lines for live weight traits of the ewes and their crossbred progeny, but were inferior with regard to wool production (Cloete *et al.*, 2003). SAMM rams are also used on Merino ewes to produce first-cross ewes for commercial lambs and wool production. The reproductive performance of such ewes compared to the parent breeds (SAMM and Merino) and the Dohne Merino has not been studied adequately (Erasmus *et al.*, 1983; Cloete *et al.*, 2003). All these genotypes may be considered as dam lines in a terminal crossbreeding system, without seriously compromising wool quality. When the economic implications of changes involving production systems is considered, it is necessary to include the impact of such changes upon the requirements of the breeding flock (White, 1984).

The lifetime (defined as three reproduction opportunities) performance, in terms of lamb and wool output, of the respective dam lines in a commercial, terminal crossbreeding system was studied, using Dormer and Suffolk rams as sires. The performance of these lines was entered in an economic simulation, to get an indication of the relative economic yield expected from a terminal crossbreeding based on the respective ewe lines.

Material and Methods

The experiment was carried out on the Langgewens experimental farm in the Swartland. The location and the general husbandry of the animals used were described by Cloete *et al.* (2003). Merino type ewes, belonging to five distinct lines, represented the female breeding animals under assessment. These ewes were not selected as replacements in their flocks of origin, and were considered as ideal for slaughter lamb production in terminal crossbreeding. Evaluation took place over a four-year period, from 1999 to 2002. Between 39 and 41 ewes initially represented each line. The maternal lines were the following (for more details, see Cloete *et al.*, 2003):

- SAMM ewes from the Elsenburg flock (Vosloo, 1967).
- A cross between SAMM rams and Merino ewes (SAMM cross line; Cloete & Durand, 2000).
- Dohne Merino ewes from the Kromme Rhee Dohne Merino flock (Cloete *et al.*, 1998b) for ewes born in 1997. Twenty two-tooth ewes bought in from a nearby property provided a 1998 ewe group.
- A Merino line selected for fleece weight, with a check on fibre diameter (FW+; Cloete *et al.*, 1998a).
- A Merino line selected for the ability to rear multiples per joining (Rep+; Cloete & Scholtz, 1998).

Dormer or Suffolk rams were used as terminal sires on the ewe flock. Dormer rams were obtained from the Elsenburg stud (Van Wyk *et al.*, 2003), and Suffolk rams from industry (Cloete *et al.*, 2003). Ewes were annually joined to 2 – 3 rams of each breed in single sire groups to lamb during June-July. Live weights were recorded at joining. The final live weight that was recorded was considered as an indication of the mature live weight of the ewes. Lambs were weaned at an average (± SD) age of 98 ± 12 days, and weaning weight was recorded, as described by Cloete *et al.* (2003). It was attempted to slaughter all lambs at a live weight of approximately 38 – 40 kg. All remaining lambs were, however, slaughtered towards the end of February each year. The seasonal period of nutritional short supply in the Swartland is expected to commence at this stage, and the lambs were slaughtered to ensure that they were not carried over into the next production season. Slaughter age and slaughter weight were known individually for 580 lambs. Cold carcass weight and dressing percentage of these lambs were measured after 24 hours in the cooler. Weight of lamb slaughtered per ewe per year was calculated from survival to slaughter age and lamb slaughter weight. Weight of carcass produced per ewe per year was determined correspondingly. Grading was also acquired for 508 lamb carcasses, according to standard South African regulations. No lambs were downgraded for excessive fat depth (> A4). Lamb meat prices in the A0 – A3 range were fairly stable, except for somewhat lower prices for carcasses graded as A0. The proportion of carcasses of crossbred progeny with a better grading than A0 was thus compared between ewe lines. Ewes were shorn during May-June, and clean fleece weight, staple strength and fibre diameter were determined individually. The data obtained in this way was used to obtain average annual production figures for each ewe. The ewes were maintained in a single flock, except during joining and lambing (Cloete *et al.*, 2003). During mating, they were split up in single sire mating groups, and at lambing they were randomly allocated to smaller flocks to facilitate data recording.

The proportions of ewe lines surviving to their third lambing opportunity and for the grading of lamb and ewe carcasses were compared between lines by using Chi² procedures (Siegel, 1956). Averaged lamb production and wool data were analysed according to a 5 (dam lines) X 2 (sire breeds) factorial analysis. Least squares procedures were used, to account for uneven subclasses (Harvey, 1990). Although sire breed was fitted for ewe weight and wool traits, it was not significant. These results are not presented, since no theoretical basis exists for differences in these traits between sire breeds.

Data obtained from the present study were combined with those obtained earlier by Cloete *et al.* (2003), and entered in an economic simulation study using SM2000 (Herselman, 2002). Information on the details required by SM2000 for an economic simulation, is provided in the latter literature source. Since a terminal crossbreeding system involves the buying in of females, it was assumed that ewes were bought in at yearling age. It was assumed that they weighed 75% of their mature weight at this stage, and that they were bought in for slaughter value plus 20%. Feeding costs are considered as a major cost item for commercial sheep production systems (Greeff *et al.*, 1990; Schoeman *et al.*, 1995). In the simulation, live weight was used as an indication of the feed requirements of ewes and lambs in a specific crossbreeding system, as defined by Herselman (2002). Expenses were not broken down further, but is was assumed that all ewe lines were subjected to the same level of husbandry and health care, since they were maintained in a single flock. Results were thus expressed on a gross income per small stock unit (SSU) basis. Wool prices and meat prices were obtained from the industry. In order to provide an outcome with a measure of robustness, a range of wool prices was simulated against the current meat price, to result in a wool:meat price ratio range of 0.78 – 2.35. Gross income was depicted against this ratio in a graph, to reflect the impact of varying wool prices upon the relative economic returns from the respective.

Results and Discussion

Ewe survival was independent of dam line up to the termination of the experiment ($Chi^2 = 3.39$; degrees of freedom = 4; $P > 0.50$), and proportions ranging between 0.90 and 0.78 was available for the respective ewe lines. Cumulative death rates for ewes up to their third production year were 15% for Merinos (Heydenrych, 1975) and 19% for Dohne Merinos (Fourie, 1981). In a study involving pure-bred Merinos and 6 crossbred genotypes, survival to the fourth joining ranged from 89 – 98% (Greeff *et al.*, 1990). Expressed as an average per year, ewe deaths ranged between 3.3% and 7.3% in the present study. Annual ewe deaths ranged from 0 – 5.9% for Merino flocks and from 0.5 – 7.1% for Dohne Merino flocks in the Bredasdorp area of the southern Cape (Fourie & Cloete, 1993). Lamb losses owing to ewe deaths amounted to 2 – 6% for Western Australian and New Zealand sheep flocks (Knight, 1990). The death rates incurred in the present study were well within these ranges these ranges.

Table 1 Numbers of breeding ewes of the respective dam lines available initially and at the termination of the experiment, as well as the proportion ewes surviving

Ewes available (n)	Dam Line				
	SAMM	SAMM cross	Dohne	FW+ Merino	Rep+ Merino
Initially	41	40	39	39	39
At termination of experiment	37	31	33	33	35
Proportion ewes survived	0.90	0.78	0.85	0.85	0.90

* Critical Chi^2 for 4 degrees of freedom = 9.49; SAMM – South African Mutton Merino

Average ewe weight at joining of dual-purpose ewes was 13 – 14% higher than in FW+ Merinos, and 24 – 25% higher than in Rep+ Merino ewes ($P < 0.01$; Table 2). Corresponding ranges of differences in ultimate live weight at the termination of the trial ranged from 15 – 19% and from 19 – 23% respectively ($P < 0.01$). These differences accorded well with earlier estimates based on annual ewe joining weights (Cloete *et al.* 2003), as could have been expected. Yearling live weight of SAMM and Dohne Merino progeny were correspondingly 33% and 17% higher than that of purebred Merinos (Cloete *et al.*, 1999). Basson et al. (1969) also reported that mature Dohne Merino ewes were 24% heavier than Merinos.

Table 2 Least squares means (±SE) depicting the influence of ewe line upon live weight (LW), clean fleece weight (CFW) and average wool traits (Staple strength – SS and Fibre diameter – FD) of breeding ewes available at third joining

Ewe line	LW (kg)		CFW		Average wool traits	
	Average LW	Ultimate LW	Average CFW	CFW as % of LW	SS (N/ktex)	FD (µm)
SAMM	$63.5^{c} \pm 0.8$	$67.4^{b} \pm 1.1$	$2.20^{e} \pm 0.11$	$3.3^{e} \pm 0.2$	$28.4^{a} \pm 1.3$	$23.5^{c} \pm 0.2$
SAMM Cross	$63.8^{c} \pm 0.9$	$65.5^{b} \pm 1.2$	$3.24^{d} \pm 0.11$	$5.0^{d} \pm 0.2$	$31.9^{b} \pm 1.3$	$23.0^{b} \pm 0.2$
Dohne	$62.9^{c} \pm 0.9$	$65.1^{b} \pm 1.2$	$3.53^{c} \pm 0.11$	$5.5^{c} \pm 0.2$	$37.3^{c} \pm 1.3$	$22.0^{a} \pm 0.2$
FW+ Merino	$55.9^{b} \pm 0.9$	$56.7^{a} \pm 1.1$	$4.81^{a} \pm 0.11$	$8.5^{a} \pm 0.2$	$40.7^{d} \pm 1.3$	$22.9^{b} \pm 0.2$
Rep+ Merino	$50.9^{a} \pm 0.9$	$54.7^{a} \pm 1.2$	$4.19^{b} \pm 0.11$	$7.7^{b} \pm 0.2$	$35.9^{c} \pm 1.3$	$22.4^{a} \pm 0.2$

[a,b,c,d,e] Means in the same column with different superscripts differ (P < 0.05) SAMM – South African Mutton Merino

Expressed relative to FW+ Merinos, average clean fleece weight of SAMM ewes amounted to 46 % of that recorded in the former line (Table 2). Merinos were previously reported to produce approximately twice the quantity of clean wool produced by SAMM sheep (Greeff, 1990; Cloete *et al.*, 1999; Cloete *et al.*, 2003). Corresponding percentages were 67 % for SAMM cross ewes, 73 % for Dohnes and 87 % for Rep+ Merinos, all differences being significant (P < 0.05). The wool yield of SAMM cross and Dohne Merino sheep were also reported to be roughly on the midparent value between the parent breeds (Basson *et al.*, 1969; Greeff, 1990; Cloete *et al.*, 1999; Cloete & Durand, 2000). Clean fleece weight of SAMM Merino ewes amounted to roughly 3 % of ultimate live weight, compared to about 8 % in FW+ and Rep+ Merinos (P < 0.05; Table 2). Dohne and SAMM cross ewes were intermediate.

Average staple strength increased (P < 0.05) from SAMM ewes to FW+ ewes. Expressed as a percentage of the average staple strength of FW+ Merino ewes, performance levels amounted to 70% for SAMM ewes, 78% for SAMM cross ewes, 92% for Dohne Merino ewes and 88% for Rep+ Merino ewes. We did not find any previous results on staple strength of the breeds under consideration, except for a previous study on the annual performance of the same resource flock (Cloete *et al.*, 2003). Naturally, results from the latter study were in close correspondence with the present results. Between line variation in fibre diameter was lower. SAMM ewes produced 3 % coarser wool than FW+ Merinos. Previous studies suggested that the fibre diameter of SAMM sheep was 2 – 8% higher than that of Merinos (Greeff, 1990; Brand *et al.*, 1999; Cloete *et al.*, 1999). Average fibre diameter of Dohne ewes was 4 % finer than that of FW+ Merinos. Previous studies on the relative performance of Dohne Merinos and Merinos pertaining to fibre diameter suggested small differences between the breeds (Greeff, 1990; Cloete *et al.*, 1999). The generally higher fibre diameter of Merinos in the present study may be related to discrimination against ewes with an excessive fibre diameter in the flocks of origin (Cloete *et al.*, 2003). Such ewes were however still regarded as suitable for terminal crossbreeding.

Approximately three-quarters of those lambs born were slaughtered in the terminal crossbreeding system (Table 3). The same percentage of lambs was slaughtered per lambs born in another crossbreeding trial (Malik *et al.*, 2000). When dam line was considered absolute means ranged from 0.71 for SAMM dams to 0.81 for Rep+ Merino dams (Chi² = 6.93; degrees of freedom = 4; P < 0.25).

Table 3 Proportions of lambs slaughtered as well as least squares means (±SE) depicting the influence of ewe line and ram line upon lamb slaughter and carcass traits

Line	Lambs slaughtered		Slaughter age	Slaughter	Dressing %	Carcass
	Number	Proportion	(days)	weight (kg)		weight (kg)
Ewe line						
SAMM	125	0.71	$134^{a} \pm 2$	$40.3^{c} \pm 0.3$	$41.0^{c} \pm 0.3$	$16.6^{d} \pm 0.2$
SAMM Cross	126	0.72	$143^{b} \pm 2$	$39.2^{b} \pm 0.3$	$40.6^{c} \pm 0.3$	$16.0^{c} \pm 0.2$
Dohne	109	0.80	$142^{a,b} \pm 3$	$39.7^{b,c} \pm 0.3$	$40.0^{b,c} \pm 0.3$	$15.9^{c} \pm 0.2$
FW+ Merino	101	0.72	$164^{c} \pm 3$	$37.0^{a} \pm 0.3$	$38.5^{a} \pm 0.4$	$14.3^{a} \pm 0.2$
Rep+ Merino	120	0.81	$165^{c} \pm 2$	$37.8^{a} \pm 0.3$	$39.3^{a,b} \pm 0.3$	$14.9^{b} \pm 0.2$
Ram line						
Dormer	303	0.75	148 ± 2	38.9 ± 0.2	39.9 ± 0.2	15.6 ± 0.1
Suffolk	279	0.75	151 ± 2	38.7 ± 0.2	39.9 ± 0.2	15.5 ± 0.1

* Critical Chi² for 4 degrees of freedom = 9.49

[a,b,c,d,e] Means in the same column with different superscripts differ (P < 0.05)

Slaughter age, slaughter weight, carcass weight and dressing percentage were affected (P < 0.05) by dam line, but not by sire breed (P > 0.10). Differences between dam lines could mostly be attributed to the comparison of purebred Merino lines with the dual-purpose lines (Table 1). Rathie & Teasdale (1994) also found that purebred Merinos were outperformed by dual-purpose ewes. The lower dressing percentage of lambs from purebred Merino lines could be due to their generally thinner fat cover and more wool on the skins (Kirton *et al.*, 1995). In relation to the dual-purpose lines, the slaughter age of lambs produced by dams from the two Merino ewe lines were between 14 and 21 % higher (P<0.05). Although it was attempted to slaughter all lambs at a live weight of approximately 40 kg, this objective was not reached. In the quest to slaughter all progeny born before the expected nutritional short supply of nutrients in late summer, individuals were slaughtered when they started losing weight, and all remaining lambs were slaughtered by the middle of February each year. Especially the slower growing progeny of the two Merino lines had lower (P < 0.05) slaughter weights than those of the dual-purpose lines. Carcass weights and dressing percentage followed the same pattern. Slaughter lambs produced by purebred SAMM dams also outperformed those reared by SAMM cross ewes for slaughter age, slaughter weight, dressing percentage and carcass weight. These differences, however, failed to exceed 10 % of the mean performance of purebred SAMM progeny. No corresponding results on the comparison of these lines were found in the literature.

Absolute means for number of lambs slaughtered per ewe joined ranged from 0.90 for FW+ Merinos to 1.16 for SAMM cross ewes (Table 4; P = 0.12). The lines were previously also found not to differ for number of lambs weaned per ewe joined (Cloete *et al.*, 2003). Average weight of lamb slaughtered per ewe joined ranged between approximately 33 kg for FW+ Merino ewes to ≥ 42 kg for Rep+, SAMM and SAMM cross ewes, but the observed differences only approached significance (P = 0.07). Ewes in the SAMM cross line were previously found to outperform those in the FW+ line for weight of lamb weaned per ewe joined (Cloete *et al.*, 2003). The superior growth performance of progeny of ewes in this line is also reflected in the lower age at slaughter in the present study. Average weight of carcass produced per ewe joined ranged from 12.7 kg per ewe for FW+ Merinos to nearly 18 kg of carcass produced per ewe joined for SAMM and SAMM cross ewes (P<0.05). No difference was found between sire breeds as far as number of lambs or weight of lamb slaughtered per ewe joined were concerned (P > 0.50). No sire breed differences were correspondingly found in a previous study on the two sire breeds (Erasmus *et al.*, 1983). When lamb output was expressed as percentage of average ewe live weight, means ranged between approximately 60% for FW+ Merinos to >80% for Rep+ Merinos (P < 0.05). Corresponding differences for weight of carcass produced per ewe joined ranged between 23% for FW+ Merino ewes to > 32 % for Rep+ Merinos (P < 0.05). The dual-purpose breeds were intermediate in both instances.

Table 4 Least squares means (±SE) depicting the influence of ewe line and ram line upon average lamb output, expressed as number of lambs and weight of lamb or carcass produced

Line	Slaughter lamb production per ewe joined			Lamb produced as % of LW	
	Number	Weight (kg)	Carcass (kg)	Weight (%)	Carcass (%)
Ewe line					
SAMM	1.07 ± 0.08	42.7 ± 2.9	17.8^{b} ± 1.1	67.7^{ab} ± 5.1	28.2^{bc} ± 2.0
SAMM Cross	1.16 ± 0.08	44.2 ± 3.1	17.6^{b} ± 1.2	70.2^{ab} ± 5.4	27.9^{abc} ± 2.2
Dohne	0.99 ± 0.08	39.3 ± 3.1	15.7^{b} ± 1 2	63.3^{a} ± 5.4	25.4^{ab} ± 2.2
FW+ Merino	0.90 ± 0.08	32.9 ± 3.0	12.7^{a} ± 1.2	59.7^{a} ± 5.2	23.0^{a} ± 2.1
Rep+ Merino	1.12 ± 0.08	42.0 ± 3.0	16.4^{b} ± 1.2	83.4^{b} ± 5.3	32.6^{c} ± 2.1
Ram line					
Dormer	1.05 ± 0.05	40.5 ± 1.9	16.3 ± 0.8	69.1 ± 3.3	27.7 ± 1.3
Suffolk	1.04 ± 0.05	39.9 ± 1.9	15.8 ± 0.8	68.7 ± 3.4	27.1 ± 1.3

^{a,b,c,d,e} Means in the same column with different superscripts differ (P < 0.05)

Mean slaughter weights and dressing percentages of the dual-purpose dam lines were respectively 11-16% and 10-14% higher than those of FW+ Merino ewes (P < 0.05; Table 5). Carcass weight was thus 22-33% higher in dual-purpose ewes than in FW+ Merino ewes. No significant differences were found between FW+ and Rep+ Merino ewes. Results pertaining to the slaughter weight of the respective dam lines were consistent with the ultimate live weight means reported in Table 2.

Table 5 Least squares means (±SE) depicting slaughter traits of ewes at the termination of the experiment

Dam line	Ewes slaughtered (n)	Live weight (kg)	Dressing %	Carcass weight (kg)
SAMM	16	66.5^{b} ± 1.9	39.9^{b} ± 1.1	26.5^{b} ± 1.1
SAMM Cross	15	67.4^{b} ± 1.9	41.4^{b} ± 1.4	28.1^{b} ± 1.1
Dohne	14	64.6^{b} ± 1.9	40.1^{b} ± 1.1	25.9^{b} ± 1.2
FW+ Merino	15	58.1^{a} ± 1.9	36.4^{a} ± 1.1	21.2^{a} ± 1.1
Rep+ Merino	17	57.8^{a} ± 1.8	37.2^{a} ± 1.0	21.6^{a} ± 1.0

^{a,b} Means in the same column with different superscripts differ (P < 0.05)

Proportions of lamb carcasses grading better than A0 did not differ between ewe lines ($Chi^2 = 1.84$; degrees of freedom = 4; $P > 0.50$; Table 6). No lambs were graded as A4 or higher, when carcasses are downgraded because of excessive fatness. The average lamb price realised by progeny produced by the respective lines was thus very stable at between R 20.38 and R 20.47.

Table 6 Grading of lamb (grade A) and ewe (grade C) carcasses as well as meat and wool prices (expressed per kg) used in the economic analysis

Ewe Line	Lamb carcasses			Ewe carcasses			Wool price (R)
	Number	≥ A1*	Price (R)	Number	> C3*	Price (R)	
SAMM	93	0.85	20.38	16	0.37	14.53	29.3
SAMM Cross	82	0.87	20.39	15	0.53	14.27	33.1
Dohne	86	0.88	20.45	14	0.36	14.56	37.0
FW+ Merino	77	0.88	20.47	15	0.07	15.04	39.5
Rep+ Merino	80	0.87	20.39	17	0.18	14.86	37.5

* Critical Chi^2 for 4 degrees of freedom = 9.49

South African carcass fatness classification on a scale of 1 to 5, with 1 – very lean, 5 – overfat;

R – South African Rand;

There was a tendency ($P < 0.10$) for SAMM cross ewes to have a higher proportion of carcasses graded A4 or worse when compared to FW+ Merinos ($Chi^2 = 9.33$; degrees of freedom = 4; $P < 0.10$; Table 6). This tendency resulted in fairly large differences in the average price of C-grades between ewe lines, with the leaner Merino carcasses achieving slightly higher prices than those of the dual-purpose breeds. Clean wool prices for ewe lines increased from R 29.3 for SAMM ewes to R 39.5 for FW+ Merino ewes. Since the average fibre diameter of the ewes in the present study were mostly in the range where the micron premium is low, staple strength was one of the most important contributors to the realised wool prices.

The outcome from the economic simulation suggested gross returns per small stock unit (SSU) of R285 for SAMM ewes, R306 for SAMM cross ewes, R322 for Dohne Merino ewes, R354 for FW+ Merino ewes and R365 for Rep+ Merino ewes when the current product prices were used. The simulated income derived from the highest yielding Rep+ line was R 80 per SSU higher than that obtained from the lowest yielding SAMM ewes. Expressed relative to SAMM ewes, this difference amounted to 28% per SSU. When the ratio of the wool price to the meat price are very low (<1:1), the simulation study suggested that the gross income from dual purpose ewes and FW+ ewes were quite similar (Figure 1). A slightly higher income could be generated from the Rep+ line at this stage. As the ratio of the wool price to the meat price increased, trend-lines for the respective ewe lines diverged, according to their wool production capacity. This was particularly true in the FW+ Merinos, where a similar income per SSU compared to the Rep+ line was found at the widest wool:meat price ratio included in the simulation. At this stage, the simulated income from the two Merino lines exceeded that of the SAMM line by approximately 37%.

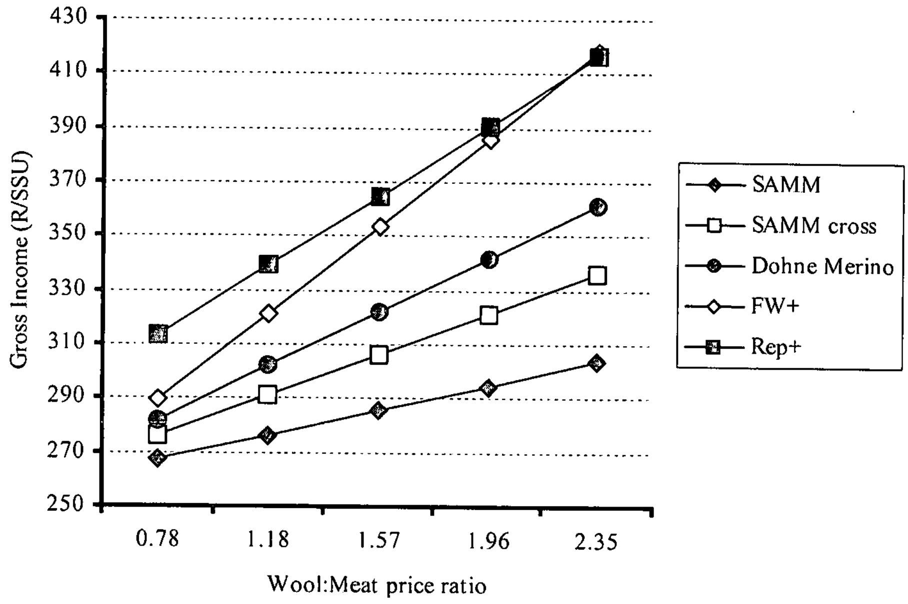

Figure 1 Gross income per small stock unit (SSU) for the respective ewe lines when assessed at different wool:meat price ratios

The relative success of the Merino lines seems to stem from two factors, namely their improved wool production capacity relative to the dual-purpose lines and their smaller body size. They were also capable of attaining reproduction rates that were comparable with the larger dual-purpose ewes. A number of references has indicated the contribution of a small maternal size to efficiency in a terminal crossbreeding system (Large, 1970; Dickerson, 1978, Greeff *et al.*, 1990; Schoeman *et al.*, 1995). Dimorphism between the size of male and female breeding animals were pointed out as one factor contributing most to flock cost efficiency (Roux, 1992). Moreover, it was also listed as one of the adaptations that were easy to achieve. Other factors contributing markedly to the gain in economic efficiency in cattle and sheep, were an improved reproduction rate and the improvement of the feed efficiency of female animals. The difficulty in achieving an improved reproduction rate was rated as medium, while an improved feed efficiency of lactating animals were rated as difficult to attain. If it is considered that mature rams of the Dormer and Suffolk breeds are considered to weigh at least 100 kg (Terblanche, 1979), it is clear that the ratio of ewe weight to sire weight was ≥ 1:1.76 in Merinos, compared to 1:1.48 – 1:1.54 in ewes from the dual-purpose breeds.

This study demonstrated substantial differences in the economic output of the Merino-type lines considered. In the study of Fogarty *et al.* (2001), progeny test results of maternal sires in the lamb industry indicated that there were also marked differences between sires in maternal attributes of first cross ewes. Monetary output generated by progeny of these sires ranged from $A 158 to $A 263 over a three year period. When expressed relative to the progeny of the lowest ranking sire, the yield of the best sire was 66% higher.

It thus seems as if ample genetic variation could be exploited within the confines of a terminal crossbreeding system.

In view of a lack of significant differences in any of the traits involving ewes joined to either Dormer or Suffolk sires, it was not attempted to extend the economic simulation to cover the importance of sire breed. The choice of rams between the two breeds could thus be based on other properties, like the availability and affordability of rams, as well as the higher probability of wool contamination with dark fibres in the case of Suffolk sires. Another factor that could be considered is access to national direct breeding values for early growth for all individuals in the terminal sire breed.

Conclusions

Considerable variation was found between ewe lines for live weight, wool yield and reproduction, although few reproduction differences were significant. The combination of relatively small size with acceptable reproduction and high levels of fibre production resulted in the Merino types being extremely competitive in terms of economic yield. Further research on the establishment of specialist terminal dam lines is indicated, since it appear to be one of the avenues available for commercial sheep producers to enhance flock efficiency at a limited cost.

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References

Basson, W.D., Van Niekerk, B.D.H., Mulder, A.M. & Cloete, J.G., 1969. The productive and reproductive potential of three breeds mated at 8-monthly intervals under intensive feeding conditions. Proc. S. Afr. Soc. Anim. Prod. 8, 149-154.

Brand, T.S., Franck, F. & Coetzee, J., 1999. Kikuyu (*Pennisetum clandestinum*) pasture for sheep. 2. Production and nutritional status of ewes with or without lupin (*Lupinus albus*) supplementation. N. Z. J. Agric. Res. 42, 467-474.

Cloete, S.W.P., Cloete, J.J.E., Durand, A. & Hoffman, L.C., 2003. Production of five Merino type lines in a terminal crossbreeding system with Dormer or Suffolk sires. S. Afr. J. Anim. Sci. 33, 223-232.

Cloete, S.W.P., Coetzee, J., Schoeman, S.J., Morris, J. & Ten Hoope, J.M., 1999. Production parameters for Merino, Dohne Merino and South African Mutton Merino sheep. Proc. Assoc. Advmnt. Anim. Breed. Genet. 13,189-193.

Cloete, S.W.P. & Durand, A., 2000. The crossing of commercial Merino ewes with South African (SA) Meat Merino rams for an increased lamb output. Aust. J. Exp. Agric. 40, 11-16.

Cloete, S.W.P., Olivier, J.J., Snyman, M.A. & du Toit, E., 1998a. Genetic parameters and trends in a selection experiment for increased clean fleece weight involving South African Merinos. Aust. J. Exp. Agric. 38, 427-432.

Cloete, S.W.P. & Scholtz, A.J., 1998. Lamb survival in relation to lambing and neonatal behaviour in medium wool Merino lines divergently selected for multiple rearing ability. Aust. J. Exp. Agric. 38, 801-811.

Cloete, S.W.P., Scholtz, A.J. & Aucamp, B.B., 1998b. Environmental effects, heritability estimates and genetic trends in a Western Cape Dohne Merino nucleus flock. S. Afr. J. Anim. Sci. 28, 185-195.

Dickerson, G.E., 1978. Animal size and efficiency: basic concepts. Anim. Prod. 27, 367-379.

Erasmus, L.S., 1965. Slaglamproduksie met die Merino as moederooi. M.Sc. Agric. thesis, University of Stellenbosch, South Africa.

Erasmus, L.S., De Kock, J.A. & Grobler, J.W., 1983. Slaglamproduksie in die Suid-Kaap. Els. J. 7:13-32.

Fogarty, N.M., Cummings, L., Gaunt, G., Hocking-Edwards, J., Edwards, N., Lees, K. & Morgan, J., 2001. Opportunities to exploit genetic variation among maternal sires in the lamb industry. Proc. Assoc. Advmt. Anim. Breed. Gen. 14, 123-126.

Fourie, A.J., 1981. 'n Studie van fenotipiese en genetiese aspekte van produksie-eienskappe van die Dohne-merinokudde op die Dohne navorsingsinstituut. M.Sc.(Agric.)-verhandeling, Universiteit van Stellenbosch, Stellenbosch, Suid-Afrika.

Fourie, A.J. & Cloete, S.W.P., 1993. Reproductive performance of commercial Merino, Dohne Merino and SA Mutton Merino flocks in the Southern Cape. S. Afr. J. Anim. Sci. 23, 104-110.

Greeff, J. C., 1990. The Merino and modern production systems. Proc. World. Merino Conf. Volume 1, 3.2,1-33. 2-4 May, 1990, Pretoria, South Africa. (Merino Studbreeders' Society of South Africa, P.O. Box 109, Graaff-Reinet 6280, South Africa.)

Greeff, J.C., Roux, C.Z. & Wyma, G.A., 1990. Lifetime meat production from six different F1 crossbred ewes. S. Afr. J. Anim. Sci. 20, 71-77.

Harvey, W.R. 1990. User's guide for LSMLMW and MIXMDL. PC-2 version, Mimeograph.

Herselman, M.J., 2002. The role of simulation models in agricultural extension. Proc. 1st Joint Cong. Grassl. Soc. of Southn Afr. & S. Afr. Soc. Anim. Sci., 13-16 May 2002, Cristiana Aventura, pp 46a-46c.

Heydenrych, H.J., 1975. 'n Studie van kuddestatistieke, nie-genetiese faktore genetiese parameters, en seleksievordering met betrekking tot die Tygerhoek Merinokudde. Ph.D. Proefskrif, Universiteit van Stellenbosch, Stellenbosch, Suid-Afrika.

Kirton, A.H., Carter, A.H., Clarke, J.N., Sinclair, D.P., Mercer, G.J.K. & Duganzich, D.M., 1995. A comparison between 15 ram breeds for export lamb production 1. Liveweights, body composition, carcass measurements and composition. N. Z. Agric. Res. 38, 347-360.

Kleeman, D.O., South, M.H.L., Dolling, C.H.S. & Ponzoni, R.W., 1983. Survival, growth and wool production of South Australian strong-wool Merino and first-cross Merino lambs from birth to 16 months of age. Aust. J. Exp. Agric. Anim. Husb. 23, 271-279.

Knight, T.W., 1990. Reproductive wastage, a guide for fundemental research: a New Zealand perspective. In: Reproductive physiology of Merino sheep – concepts and consequences. Eds: C.M. Oldham, G.B. Martin & I.W. Purvis. School of Agriculture (Animal Science), The University of Western Australia, Nedlands 6009, WA, Australia. pp 11-21.

Large, R.V., 1970. The biological efficiency of meat production in sheep. Anim. Prod. 12, 393-401.

Malik, R.C., Al-Khozam, N.M. & Abbas S.A., 2000. Crossbreeding for intensive lamb production: reproduction, lamb survival and growth. Proc. Aust. Soc. Anim. Prod V, 173-176.

Rathie, K.A. & Teasdale, C.K., 1994. Assessing Wiltshire Horn-Merino crosses. 3. The 50% Wiltshire Horn as a prime lamb producer. Aust. J. Exp. Agric. 34, 733- 739.

Roux, C.Z., 1992. Maximum herd efficiency in meat production III. Feeder-breeder dimorphism. S. Afr. J. Anim. Sci. 22, 11-15.

Schoeman, S.J., De Wet, R., Botha, M.A. & Van der Merwe, C.A., 1995. Comparative assessment of biological efficiency of crossbred lambs from two composite lines and Dorper sheep. Small Rumin. Res. 16, 61-67.

Siegel, S., 1956. Non parametric statistics for the behavioral sciences. McGraw-Hill Inc., New York.

Terblanché, E. le F. (1979). Ken ons kleinveerasse. Human en Rousseau Uitgewers, Kaapstad, Suid-Afrika.

Van Wyk, J.B., Fair, M.D. & Cloete, S.W.P., 2003. Revised models and genetic parameters for production and reproduction traits in the Elsenburg Dormer stud. S. Afr. J. Anim. Sci. 33, 213-222.

Vosloo L.P., 1967. Faktore wat die produksie en reproduksie van die Elsenburg Duitse Merinokudde beïnvloed. D.Sc. dissertation, University of Stellenbosch, Stellenbosch, South Africa.

White, D.H., 1984. Economic values of changing reproductive rate. In: Lindsay, D.R., Pearce, D.T. (Eds.), Reproduction in Sheep. Australian Academy of Science in Conjunction with Australian Wool Corporation, Canberra, Australia, pp. 371 - 377.

Chapter 8

Relative production performance of Merino ewes crossed with six sire breeds and carcass characteristics and meat quality of the progeny

Relative production performance of Merino ewes crossed with six sire breeds and carcass characteristics and meat quality of the progeny

Abstract

This study details the slaughter traits of lambs born from a terminal crossbreeding experiment that involved commercial Merino ewes crossed with Dormer, Ile de France (IdF), Merino Landsheep (ML), Suffolk and Dorper rams, while purebred Merino rams were used as control. Purebred Merino lambs were slaughtered at 340±7 days of age, which was on average 40 to 50 days later than the crossbred lambs. The crossbred lambs were also 9 - 11% heavier at slaughter than purebred Merinos. The average fat cover of purebred Merino and ML cross lambs was lower than that of the other crossbred lambs. Dorper and Dormer crossbred lambs had the highest fat cover at the 13th rib and between the 3rd and 4th lumbar vertebrae. These two breeds are regarded as early maturing breeds, which tend to put on more fat at the same live weight than late maturing breeds. Initial pH measurements (measured 45 min after slaughter) did not differ between the different breed combinations. However, final pH values (measured 48 hours after slaughter) of purebred Merino, IdF cross and ML cross lambs were higher than those of Dormer and Dorper sired lambs. Cooking losses of meat from Merino lambs were higher than those of the crossbred lambs, but no differences were found for drip losses between the different breed combinations. No differences were found in the L* colour reading, but the average a* value of meat from purebred Merino lambs was higher than those of all the other breed combinations. This higher a* value could be linked to the higher ultimate pH of meat from the purebred Merino lambs. Meat from the *M. longissimus dorsi* did not differ between the different crossbred combinations for shearing value. This study shows that crossbred lambs reached slaughter weight at an earlier age than purebred Merino lambs. No conclusive advantages in favour of any of the terminal sire breeds on Merino ewes were obtained.

Keywords: Colour, cooking loss, Dormer, Dorper, Ile de France, meat quality, Merino Landsheep, pH, Suffolk

Introduction

Fluctuations in the ratio between wool and meat prices and low wool prices have resulted in the emphasis on the two products changing. Presently, South African farmers tend to rely more on the meat income from Merino sheep than on the wool income. Commercial producers often seek other ways to exploit short-term benefits resulting from an increase in the price of meat than within flock selection, without compromising the wool-producing capacity of their ewe flocks (Erasmus, 1965; Cloete *et al.,* 2004b;).

Crossbreeding of Merino ewes with mutton type rams in a terminal crossbreeding system may be considered to realize this goal (Kleeman *et al.*, 1983). Such a system allows spreading of risk over the meat and wool commodities, while it is also possible to exploit the advantage of sexual dimorphism for live weight between ewe lines and ram lines (Roux, 1992). It is also a rapid and frugal genetic method to manipulate the efficiency of sheep production. In the past, this practice has often been implemented injudiciously, resulting in wool contamination and the loss of genetic material needed for pure breeding (Erasmus, 1965). Because of this, it has often been discouraged in the South African wool industry.

Crossbreeding is often practiced to utilize breed and land resources more efficiently, exploit heterosis and to produce specialized products (Fogarty, 2006). Favourable effects of heterosis on individual production traits have been described (Notter, 1987). The production of commercial crossbred slaughter lambs results in lambs with a higher birth weight, better survival and better growth performance up to the age of weaning that should also reach mature slaughter weight in an intensive fattening system more rapidly (Doloksaribu *et al.*, 2000; Snowder & Duckett, 2003).

In the South African scenario little research has been done using Merino ewes as dam line in crossbreeding systems. Therefore the purpose of this study was to evaluate Merino crossbred lambs. Sire breeds that were used were Dormer, Ile de France (IdF), Merino Landsheep (ML), Suffolk and Dorper rams, while purebred Merino rams were used as control. During the evaluation of slaughter lamb output, the quality of the product should also be measured. To achieve this, the carcass characteristics and meat quality of the different crosses were also compared.

Materials and methods

The experiment was carried out on the Tygerhoek experimental farm in the Southern Cape of South Africa. The climate is Mediterranean, with a total annual precipitation of 425 mm. Most of the rain is recorded in winter, with 58-65% of the total rainfall being recorded from April to September. Occasionally, good summer rains also occur. Sire breeds that were used included Dormer, Ile de France (IdF), Merino Landsheep (ML), Suffolk, Dorper rams, while purebred Merinos were used as control.

Approximately 240 Merino ewes were used each year. The ewes were randomly allocated to six groups of forty ewes each. These groups were randomly assigned to be flock-mated to two rams of the respective sire breeds. Mating took place over a 6-week period. Approximately 20 ewes were thus designated to be mated to each ram. The same flock of ewes were used in the second year. During both years the ewes were mated during April – May and the lambs were born in September – October. Contemporary group, birth weight (obtained within 24 hours of birth), survival to slaughter and weaning weight (at an average ± SD age of 100 ± 9 days) were recorded for all lambs.

All the lambs were slaughtered at a live weight of approximately 42 kg. Full body weight was determined 24 hours prior to slaughtering. The sheep were slaughtered at a commercial abattoir using standard South African slaughter techniques for this species (Cloete *et al.*, 2004a,b). One day after slaughter, the dressed carcasses were transported from the abattoir to a deboning facility, where they were kept (< 6 °C) for another 24 hours prior to deboning and sampling.

The following carcass measurements were taken (according to the procedures described in Cloete *et al.*, 2004b): Cold carcass weight, fat depth at the 13th rib 25 mm from the midline and between the 3rd and 4th lumbar vertebrae 25 mm from the midline, carcass length, leg circumferences, hind leg length, eye-muscle area. After 48 hours in the cooler the carcasses were partitioned into South African retail cuts, which were weighed separately. These cuts consisted of the neck, shoulder, chuck, flatrib, prime rib, loin and hindquarters (Cloete *et al.*, 2004b; Hoffman, 2000).

The pH of the *M. longissimus dorsi* from the right side of the carcass was measured between the 11th and 13th rib at two different times, namely 45 minutes and 48 hours after slaughter (Cloete *et al.*, 2004a). The pH meter was equipped with a thermometer that allowed automatic adjustment for the temperature, and was calibrated with standard buffers at pH 4.0 and pH 7.0. Recalibration was done after every 10 animals measured.

The left loin retail cut was removed and taken to the laboratory for the measurement of various physical meat-quality attributes. The *M. longissimus dorsi lumborum* was dissected from the 1st to the 6th lumbar vertebrae and used for the following analyses as described in Cloete *et al.* (2005b): cooking loss, drip loss, colour and meat tenderness.

The data were analysed according to least squares procedures to account for uneven subclasses (Harvey, 1990). Fixed effects that were considered in the analyses of carcass traits, retail cut weights and meat quality attributes were birth year, sex, birth type, and sire breed as well as two-factor interactions between main effects. Since interactions were not significant in the vast majority of cases, only relevant means for the main effects are tabulated. Interaction effects are also provided in the text in cases where they were significant. The differences between the various parameters determined for the different age groups and between ewes with different lambing ability were then tested separately by means of the null hypothesis (H_o) with H_o : $\mu=\mu_o$ and the alternative hypothesis (H_μ) being H_μ : $\mu\neq\mu_o$. This was done by means of contrast analysis and estimated least square means (± SE) as reported in the tables. Differences between the variables were accepted as being significant if the possibility of rejection of H_o was equal to or less than 5% ($P \leq 0.05$), and highly significant if equal to or less than 1% ($P \leq 0.01$) for the different classes of a specific fixed effect.

Results and Discussion

For slaughter traits and carcass characteristics, all the traits were statistically analyzed with and without carcass weight as a covariant, in the cases where carcass weight had no significant effect the data were presented without correction for difference in carcass weight. It was intended to slaughter all lambs at an approximate live weight of 45 kg but this objective was not reached and the lambs were slaughtered at a live weight of approximately 42 kg. All the animals were slaughtered at the same abattoir using mostly the same personnel throughout the experiment. The lambs were not all slaughtered on the same day under the same environmental conditions due to the fact that they were slaughtered as they reached a target weight. However, it was assumed that potential environmental effects would have been evened out, not leading to substantial bias. No abnormal environmental conditions (e.g. excessive heat, humidity, long transport or lairage, etc.), were noted on the days that the lambs were slaughtered.

Mean birth weights of the lambs from Idf, ML and Suffolk sires were significantly higher ($P < 0.05$) than those of progeny from Merino, Dormer and Dorper rams (Table 1). In a study by Cloete *et al.* (2004c) no differences were found for birth weight between crossbred lambs from Dormer and Suffolk rams. Erasmus (1965) also found no differences in birth weight between crossbred lambs from Dormer and purebred Merino lambs. However in a study using Dorper ewes for crossbreeding Idf and ML crossbred lambs were heavier at birth than purebred Dorper lambs (Cloete *et al.* 2005b). The present results support these findings that Idf and ML crossbred lambs are heavier at birth.

Table 1 Least square means (±se) depicting growth traits of Merino and Merino crossbred lambs

Trait	Sire breed					
	Merino	Dormer	Idf	ML	Suffolk	Dorper
Birth weight (kg)	4.07^{b}±0.11	4.19^{b} ±0.10	4.54^{a}±0.12	4.47^{a}±0.12	4.62^{a}±0.12	4.21^{b} ±0.10
Weaning weight (kg)	25.9^{b}±1.0	31.5^{a} ±0.8	32.8^{a}±1.5	30.4^{a}±1.3	27.4^{b} ±1.3	31.4^{a}±0.8
Slaughter age (days)	340^{a} ±7	289^{cd}±5	278^{d}±7	282^{cd}±7	300^{b} ±7	296^{bc}±6
Slaughter weight (kg)	38.7^{b}±0.8	43.0^{a} ±0.6	43.2^{a}±0.8	43.5^{a}±0.8	42.7^{a}±0.8	43.2^{a}±0.6

^{abcd} Row means with different superscripts differ significantly ($P < 0.05$)

Dormer, Idf, ML and Dorper crossbred lambs were heavier ($P < 0.05$) at weaning than purebred Merino and Suffolk crossbred lambs (Table 1). The higher weaning weight can be linked to a higher pre-weaning growth rate of these crossbred lambs. In a study by Erasmus (1965) he found that purebred Merino lambs were lighter at weaning than crossbred lambs. It was intended to slaughter all lambs at an average live weight of 40 kg. However, the purebred Merino lambs did not reach the designated slaughter weight, even after an additional forty days. Erasmus (1965) reported that purebred Merino lambs were slaughtered at 350 days of age and Dormer crossbred lambs at 276 days of age at a slaughter weight of 31.5 kg and 32.9 kg respectively. After this additional time the Merino lambs were slaughtered at a lower ($P < 0.05$) slaughter weight of 38.7 kg (Table 1). The Idf crossbred lambs reached the target slaughter weight twenty days earlier than the Suffolk and Dorper crossbred lambs (Table 1).

Differences in birth weight between rams and ewes, singles and multiples were as expected with rams and single born lambs being heavier than ewes and multiples. Lambs born from mature ewes were heavier (P < 0.05) than lambs from young ewes. This result of fixed effects on birth weight accorded with results in the literature (Hight & Jury, 1970; Dalton *et al.,* 1980; Cloete, 1993; Cloete *et al.,* 2005b). Rams and single born lambs were heavier at weaning and were slaughtered at an earlier age than ewes and multiple born lambs (Table 2). The effects of gender and birth type on lamb performance were in correspondence with the available literature and will thus not be discussed in detail.

Table 2 Least square means (±se) depicting growth traits of Merino and Merino crossbred lambs comparing different sexes, birth type, ewe age and lambing year

	Birth weight (kg)	Weaning weight (kg)	Slaughter age (days)	Slaughter weight (kg)
Sex	*	**	**	*
Ram	4.45±0.06	30.7±0.6	283±4	43.54±0.4
Ewe	4.25±0.06	29.1±0.6	313±4	41.2±0.4
Birth type	*	**	**	n.s.
Single	4.45±0.06	31.7±0.8	285±4	42.7±0.04
Multiple	4.25±0.06	28.1±0.5	311±4	42.1±0.05
Ewe age	*	**	**	n.s.
Young	4.15±0.10	28.6±0.6	305±4	42.0±004
Mature	4.43±0.09	31.2±0.6	291±3	42.8±0.04
Year	*		**	**
2000	4.25±0.07		244±3	41.2±0.4
2001	4.45±0.07		352±5	43.7±0.5

n.s. – Not significant; * – Significant (P < 0.05); ** – Significant (P < 0.01)

Lambs from mature ewes were also heavier at weaning and reached slaughter age at an earlier (P < 0.05) age than lambs from young ewes (Table 2). Other research also shows that the offspring of young ewes are lighter at weaning (Cloete *et al.*, 2003). Birth weight of the lambs from the two production years differed significantly (P < 0.05) with a heavier birth weight in the second year. Also, the lambs born in the second year were slaughtered at a later stage which also contributed to the heavier slaughter weight than lambs born in the first year (Table 2).

Evaluation of the so-called fifth quarter, indicated that the trotters of purebred Merino and Dorper crossbred lambs were lighter than that of the other crossbred combinations. The Idf crossbred lambs had the heaviest trotters (Table 3). On the other hand, the skin weight of purebred Merino lambs was the heaviest (P < 0.05), with the Dorper crossbred lambs delivering the lightest skins. This higher skin weight of the purebred Merino lambs could be linked to their wool cover even though the lambs were shorn before they were intended to be slaughtered, however there could have been a time laps between shearing and when the last Merino lamb was slaughtered, which could resulted in higher skin weights because of the wool growth. The lower skin weight of the Dorper crossbred lambs could be linked to the hair cover of the Dorper rams.

After adjustment for carcass weight, the Merino lambs had a shorter average carcass length than those of the other breed combinations (Table 3). According to Campher *et al.* (1998) the breeds used for crossbreeding in this investigation with the exception of the Dorper, are large frame sheep and this could explain why carcasses of the crossbred lambs were longer than those from purebred Merino lambs. After adjustment for differences in carcass weights the carcass depth of Idf lambs was lower than those from the other crosses and purebred Merino lambs. The carcasses of Merino lambs were also narrower than those of crossbred lambs (Table 3). Dorper crossbred lambs had larger leg circumferences compared to purebred Merino and Suffolk crossbred lambs, this larger leg circumference could be linked to the way the Dorper has been selected, with more emphasis been put on body conformation especially the hindquarter (Olivier & Cloete, 2006).

Table 3 Least square means (±se) depicting carcass traits and fat depths of Merino and Merino crossbred lambs (with slaughter weight as co-variant)

Trait	Sire breed					
	Merino	Dormer	Idf	ML	Suffolk	Dorper
Head weight (kg)	2.17±0.07	2.20±0.05	2.29±0.07	2.24±0.07	2.16±0.06	2.15±0.05
Trotters weigth (kg)	0.92^{c}±0.12	0.97^{b}±0.01	1.02^{a}±0.01	0.99^{ab}±0.01	0.97^{b}±0.01	0.93^{c}±0.01
Skin weight (kg)	5.03^{a}±0.11	4.00^{b}±0.08	4.12^{b}±0.11	4.12^{b}±0.11	4.36^{b}±0.11	3.41^{c}±0.09
Carcass length (cm)	73.7^{b}±1.0	75.9^{a}±0.7	76.6^{a}±0.9	76.8^{a}±0.9	77.3^{a}±0.9	77.3^{a}±0.7
Carcass depth (cm)	27.7^{a}±0.3	27.8^{a}±0.2	26.8^{b}±0.3	28.2^{a}±0.3	27.9^{a}±0.3	28.1^{a}±0.2
Carcass width (cm)	20.9^{c}±0.2	23.3^{a}±0.2	23.3^{a}±0.2	22.3^{b}±0.2	22.2^{b}±0.2	23.3^{a}±0.2
Leg length (cm)	31.4^{a}±0.3	29.5^{b}±0.2	29.9^{b}±0.3	31.7^{b}±0.3	30.4^{a}±0.3	29.1^{b}±0.2
Leg circumference (1) (cm)	37.9^{c}±0.3	39.2^{ab}±0.2	39.3^{ab}±0.3	38.9^{ab}±0.3	38.8^{b}±0.3	39.6^{a}±0.2
Leg circumference (2) (cm)	24.3±0.3	25.4±0.2	25.2±0.3	24.9±0.2	25.1±0.2	25.1±0.2
Backfat depth (13th rib) (mm)	1.73^{c}±0.20	2.76^{a}±0.14	2.15^{b}±0.19	1.78^{c}±0.18	2.14^{b}±0.18	2.67^{a}±0.14
Backfat depth (3rd an 4th lumbar) (mm)	2.13^{c}±0.21	3.29^{a}±0.15	3.01^{a}±2.05	1.88^{c}±0.20	2.64^{b}±0.19	3.40^{a}±0.16
Kidney fat (kg)	2.23^{c}±0.27	3.26^{a}±0.20	2.53^{c}±0.28	2.60^{c}±0.27	2.77^{bc}±0.27	3.17^{ab}±0.21
Internal fat (kg)	0.30^{d}±0.03	0.42^{b}±0.02	0.33^{cd}±0.03	0.34^{c}±0.03	0.37^{c}±0.03	0.56^{a}±0.02
Liver (kg)	0.64^{b}±0.02	0.70^{a}±0.01	0.69^{a}±0.02	0.70^{a}±0.02	0.70^{a}±0.02	0.69^{a}±0.01

^{abcd} Column means with different superscripts differ significantly (P < 0.05)

Purebred Merino and ML crossbred lambs had less (P < 0.05) fat at both backfat depth sites than the other crosses. Suffolk sired lambs were intermediate with Dormer, Idf and Dorper sired lambs having the thickest (P < 0.05) fat cover (Table 3). After adjustment for differences in slaughter weight Dormer and Dorper crossbred lambs had the most kidney fat, with purebred Merino, Idf and ML crossbred lambs the lowest. Dorper crossbred lambs had significantly (P < 0.05) more internal fat, with ML sired lambs having the lowest average kidney fat weight (Table 3). The ML is a late maturing breed (Campher *et al.*, 1998), and its offspring would tend to put on fat at a later age than those of the early maturing breeds such as the Dorper, Idf and Dormer. The purebred Dorper is considered an early-maturing breed (Cloete *et al.*, 2000) and therefore tends to deposit fat at an earlier age. This is probably the reason why the Dorper crossbred lambs were fatter. After adjustment for slaughter weight, the purebred Merino lambs had a smaller liver than the crossbred combinations.

For the main effects of gender and birth type, the so-called fifth quarter, indicated that the head and trotter weights of the rams were heavier ($P < 0.01$) than those from the ewes. Singles were similarly heavier than multiples (Table 4). After adjustment for slaughter weight (Table 4), the average skin weight of the ewes was heavier ($P < 0.05$) that that from the rams. No dam age differences were found for head, feet and skin weight between lambs from young and mature ewes after adjustment for slaughter weight. Only the skin weight differed between the two lambing years, with lambs born in 2000 having heavier ($P < 0.05$) skins (Table 4).

Table 4 Least square means (±se) depicting carcass measurements of Merino and Merino crossbred lambs comparing different sexes, birth type, ewe age and lambing year (with slaughter weight as co-variant)

	Head (kg)	Feet (kg)	Skin weight (kg)
Sex	**	**	*
Ram	2.39±0.04	1.02±0.01	4.08±0.06
Ewe	2.01±0.03	0.92±0.01	4.27±0.06
Birth type	*	*	n.s.
Single	2.26±0.04	0.99±0.01	4.20±0.06
Multiple	2.14±0.04	0.95±0.01	4.15±0.07
Ewe age	n.s.	n.s.	n.s.
Young	2.23±0.04	0.97±0.01	4.18±0.07
Mature	2.18±0.03	0.97±0.01	4.17±0.05
Year	n.s.	n.s.	*
2000	2.15±0.04	0.98±0.01	4.93±0.06
2001	2.26±0.04	0.96±0.01	3.42±0.07

n.s. – Not significant; * – Significant ($P < 0.05$); ** – Significant ($P < 0.01$)

Carcass length, leg length and the two leg circumferences did not differ between the sexes after adjustment for slaughter weight (Table 5). Carcass depth from ram carcasses was greater ($P < 0.05$) than that of ewes, whilst ewes had wider carcasses than rams (Table 5). No differences were found for carcass measurements between singles and multiples, nor for lambs from young and mature ewes (Table 5). Lambs born in 2000 had significantly ($P < 0.05$) shorter carcass lengths, leg lengths and leg circumferences than lambs born in 2001 (Table 5).

As pertaining to the effect of gender, the fat depths and fat depots that were measured and weighed were as expected with the ewes having thicker ($P < 0.05$) fat depths at both sites and higher amounts of fat in the various fat depots than the ram carcasses (Table 6). Cloete *et al.* (2004a) and Teixeira *et al.* (1996) noted that ewes were fatter than rams of the same age. In this investigation, no differences were found for birth type and ewe age when the different fat depths and fat depots was considered (Table 6). From Table 6 it can also be seen that after adjustment for carcass weight, the lambs born in 2000 were fatter (P < 0.05) than those born in 2001.

Table 5 Least square means (±se) depicting carcass measurements of Merino and Merino crossbred lambs comparing different sexes, birth type, ewe age and lambing year (with slaughter weight as co-variant)

	Carcass length (cm)	Carcass depth (cm)	Carcass width (cm)	Leg length (cm)	Leg circumference (1) (cm)	Leg circumference (2) (cm)
Sex	n.s.	*	*	n.s.	n.s.	n.s.
Ram	76.5±0.5	28.0±0.2	22.2±0.1	30.5±0.2	38.9±0.2	24.9±0.1
Ewe	76.0±0.5	27.5±0.2	22.9±0.1	30.2±0.2	39.0±0.2	25.1±0.1
Birth type	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Single	75.8±0.5	28.0±0.2	22.7±0.1	30.3±0.2	38.9±0.2	25.1±0.1
Multiple	76.7±0.5	27.5±0.2	22.4±0.1	30.4±0.2	39.1±0.2	24.9±0.1
Ewe age	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Young	76.4±0.5	27.5±0.2	22.6±0.1	30.2±0.2	39.1±0.2	24.8±0.1
Mature	76.1±0.4	28.0±0.1	22.5±0.1	30.4±0.1	38.8±0.1	25.1±0.1
Year	**	n.s.	n.s.	**	**	n.s.
2000	74.8±0.5	27.8±0.2	22.5±0.1	29.5±0.2	38.3±0.2	25.1±0.1
2001	77.7±0.6	27.7±0.2	22.5±0.1	31.1±0.2	39.6±0.2	24.9±0.2

n.s. – Not significant; * – Significant (P<0.05); ** – Significant (P<0.01)

Table 6 Least square means (±se) depicting fat depths and amount of fat in various fat depots of Merino and Merino crossbred lambs comparing different sexes, birth type, ewe age and lambing year (with slaughter weight as co-variant)

	Backfat depth (13^{th} rib) (mm)	Backfat depth (3^{rd} and 4^{th} lumbar) (mm)	Kidney fat (kg)	Internal fat (kg)	Liver (kg)
Sex	**	**	*	**	*
Ram	1.75±0.10	2.36±0.11	2.18±0.15	0.29±0.02	0.71±0.01
Ewe	2.66±0.97	3.09±1.11	3.34±0.14	0.49±0.02	0.66±0.01
Birth type	n.s.	n.s.	n.s.	n.s.	n.s.
Single	2.18±0.10	2.66±0.11	2.79±0.15	0.38±0.02	0.69±0.01
Multiple	2.23±0.11	2.79±0.11	2.73±0.16	0.40±0.02	0.69±0.01
Ewe age	n.s.	n.s.	n.s.	n.s.	n.s.
Young	2.8±0.11	2.72±0.12	2.82±0.16	0.40±0.02	0.69±0.01
Mature	2.13±0.08	2.73±0.09	2.70±0.12	0.37±0.01	0.68±0.01
Year	**	**	*	**	*
2000	2.42±0.10	3.20±0.11	3.00±0.15	0.45±0.02	0.67±0.01
2001	1.99±0.11	2.25±0.13	2.52±0.17	0.32±0.02	0.70±0.01

n.s. – Not significant; * – Significant (P<0.05); ** – Significant (P<0.01)

For the comparison of the retail cuts, the data depicted in Table 7 was recalculated with carcass weight as co-variant. The neck retail cut weight of the Dorper crossbred lambs was heavier (P < 0.05) than that from the other crossbred combinations and purebred Merino lambs (Table 7). No differences were found for the shoulder retail cut weight among the different breed combinations. Purebred Merino and ML crossbred lambs had lighter ($P < 0.05$) chuck retail cut weights than the other crossbred combinations. Dorper crossbred lambs had heavier flatrib retail cut weights than the other breeds, with the purebred Merino lambs having the lightest retail cut weights (Table 7). When comparing the prime rib cut, that from the Idf crossbred lambs were the heaviest ($P < 0.05$), whilst those from the Dorper, Dormer and Suffolk crossbred lambs were also significantly ($P < 0.05$) heavier than that of the purebred Merino lambs. Dorper crossbred lambs had the heaviest ($P < 0.05$) loin retail cut weight, whilst those from Dormer and ML crossbred lambs were heavier than those of Idf and Suffolk crosses, as well as purebred Merino lambs (Table 7). Hindquarter weights of Dorper crossbred lambs were heavier ($P < 0.05$) than those of the other crossbred combinations and purebred Merino lambs, while that of the purebred Merino lambs were the lightest. The higher loin and hindquarter weights of Dorper crossbred lambs could be linked to the fact that the Dorper is an early maturing breed (Cloete *et al.*, 2005b). Early maturing breeds tend to be more developed in loin and hindquarter areas at the same age than later maturing breeds (Cloete *et al.*, 2004b)

Table 7 Least square means (±se) depicting retail cuts of Merino and Merino crossbred lambs (with carcass weight as co-variant)

Trait	Sire breed					
	Merino	Dormer	Idf	ML	Suffolk	Dorper
Neck (kg)	$0.80^{c}\pm0.02$	$0.82^{c}\pm0.01$	$0.86^{b}\pm0.02$	$0.85^{b}\pm0.02$	$0.87^{b}\pm0.02$	$0.91^{a}\pm0.01$
Shoulder (kg)	1.67±0.07	1.84±0.05	1.78±0.06	1.72±0.06	1.82±0.06	1.73±0.05
Chuck (kg)	$2.85^{b}\pm0.06$	$3.03^{a}\pm004$	$3.02^{a}\pm0.05$	$2.89^{b}\pm0.05$	$3.08^{a}\pm0.05$	$3.11^{a}\pm0.04$
Flat rib (kg)	$2.21^{e}\pm0.07$	$2.76^{b}\pm0.05$	$2.71^{bc}\pm0.07$	$2.51^{d}\pm0.06$	$2.65^{c}\pm0.06$	$2.89^{a}\pm0.05$
Prime rib (kg)	$1.35^{c}\pm0.15$	$1.60^{b}\pm0.10$	$2.11^{a}\pm0.14$	$1.49^{bc}\pm0.14$	$1.62^{b}\pm0.13$	$1.71^{b}\pm0.11$
Loin (kg)	$1.77^{e}\pm0.05$	$2.07^{b}\pm0.03$	$2.01^{c}\pm0.05$	$1.92^{d}\pm0.05$	$1.99^{c}\pm0.04$	$2.15^{a}\pm0.04$
Hindquarter (kg)	$5.18^{c}\pm0.09$	$5.65^{b}\pm0.06$	$5.68^{b}\pm0.09$	$5.56^{b}\pm0.09$	$5.69^{b}\pm0.08$	$5.81^{a}\pm0.68$

^{abcde} Column means with different superscripts differ significantly ($P < 0.05$)

The pH readings taken 45 minutes after slaughter in the *M. longissimus dorsi* did not differ between the different crossbred combinations and purebred Merino lambs. The forty eight hours post mortem pH of purebred Merino, Idf and ML crossbred lambs were higher ($P < 0.05$) than recordings from Dorper and Dormer crossbred lambs (Table 8). The cooking loss of the meat from purebred Merino lambs was higher ($P < 0.05$) than those of Dormer, Idf, Suffolk and Dorper crossbred lambs (Table 8). The higher cooking loss of the meat from the purebred Merino lambs could be linked to their lower fat cover (Table 3). According to Dryden & Marchello (1970), juiciness is related to both the capacity of the muscle to release its constitutive water and the infiltrated fat content. In combination with water, the melted lipid constitutes a broth which is maintained in the meat after cooling down of the meat sample, which results in a lower cooking loss percentage.

As pertaining to the muscle colour, the meat from the purebred Merino lambs was more towards the saturated red spectra than the crossbred combinations. These higher a* colour reading could be linked to the higher ultimate pH value of meat from the purebred Merino lambs (Cloete *et al.*, 2004a). The b* colour reading of the meat from the crossbred Dorper lambs were higher ($P < 0.05$) than that from Suffolk crossbred lambs (Table 8). Although there were statistically significant colour differences in the meat yielded by the respective breed combinations, it is debatable whether the industry would have discriminated between breeds based on these differences. No differences were found for shear force values of the meat from the different crossbred combinations and purebred Merino lambs.

Table 8 Least square means (±se) depicting pH and meat quality parameters of Merino and Merino crossbred lambs

Trait	Sire breed					
	Merino	Dormer	Idf	ML	Suffolk	Dorper
pH45	6.47±0.07	6.49±0.05	6.47±0.07	6.41±0.07	6.59±0.07	6.47±0.05
pH48	5.61^{a}±0.02	5.54^{b}±0.01	5.58^{a}±0.02	5.59^{a}±0.02	5.56^{ab}±0.02	5.56^{b}±0.01
Cooking loss %	30.5^{a}±0.7	27.2^{b}±0.7	27.9^{b}±0.7	29.9^{ab}±0.7	27.9^{b}±0.7	28.2^{b}±0.7
Drip loss %	0.95±0.08	0.98±0.07	1.00±0.07	1.08±0.07	1.02±0.07	1.13±0.08
Colour L*	35.2±0.4	34.9±0.3	35.8±0.4	36.0±0.3	35.4±0.3	34.8±0.4
a*	15.1^{a}±0.5	12.8^{c}±0.4	12.9^{c}±0.4	13.7^{b}±0.4	13.8^{b}±0.4	14.2^{b}±0.5
b*	8.33^{ab}±0.33	8.31^{ab}±0.3	8.29^{ab}±0.31	8.49^{ab}±0.30	7.94^{b}±0.29	9.33^{a}±0.33
Shearing value (N)	80.7±4.9	69.3±4.5	77.2±4.6	83.8±4.5	85.2±4.4	74.4±5.0

abc Column means with different superscripts differ significantly ($P < 0.05$)

After adjustment for carcass weight, the average neck retail cut weight of the rams was higher ($P < 0.05$) than that of the ewes. Jeremiah *et al.* (1997) and Cloete *et al.* (2004b) reported similar results. In the case of the prime rib and loin retail cut weights, these cuts from the ewes were heavier ($P < 0.05$) than from the rams (Table 9). Cloete *et al.* (2004b) and Fahmy *et al.* (1999) also found ewes to have heavier loin retail cuts than rams, which is typical sexual dimorphism between ewes and rams.

When adjusted for carcass weight (Table 9), only the flat rib retail weight differed between single and multiple born lambs, with the former being higher ($P < 0.05$). The shoulder, prime rib and hindquarter weights of lambs bred from young ewes were higher ($P < 0.05$) than those of lambs bred from mature ewes. Lambs born in 2000 were better developed in the neck, flat rib and loin area whilst the lambs born in 2001 were more developed in the shoulder and hindquarter area.

Table 9 Least square means (±se) depicting retail cuts of Merino and Merino crossbred lambs comparing different sexes, birth type, ewe age and lambing year (with slaughter weight as co-variant)

	Neck (kg)	Shoulder (kg)	Chuck (kg)	Flat rib (kg)	Prime rib (kg)	Loin (kg)	Hindquarter (kg)
Sex	*	n.s.	n.s.	n.s.	*	**	n.s.
Ram	0.89±0.01	1.76±0.03	3.00±0.03	2.61±0.04	1.54±0.08	1.92±0.03	5.55±0.05
Ewe	0.82±0.01	1.77±0.03	3.00±0.02	2.63±0.03	1.75±0.07	2.05±0.04	5.64±0.05
Birth type	n.s.	n.s.	n.s.	**	n.s.	n.s.	n.s.
Single	0.86±0.01	1.74±0.04	3.00±0.3	2.68±0.04	1.68±0.08	2.01±0.03	5.54±0.05
Multiple	0.85±0.01	1.78±0.03	3.99±0.3	2.56±0.04	1.61±0.08	1.95±0.03	5.65±0.05
Ewe age	n.s.	**	n.s.	n.s.	**	n.s.	**
Young	0.85±0.01	1.80±0.03	3.02±0.03	2.61±0.04	1.75±0.08	1.99±0.03	5.65±0.05
Mature	0.86±0.01	1.72±0.03	2.97±0.02	2.63±0.03	1.54±0.06	1.97±0.02	5.54±0.04
Year	**	**	n.s.	**	n.s.	**	**
2000	0.88±0.01	1.63±0.03	2.98±0.03	2.76±0.04	1.60±0.07	2.13±0.03	5.26±0.05
2001	0.82±0.01	1.89±0.04	3.02±0.03	2.48±0.04	1.69±0.09	1.92±0.03	5.92±0.05

n.s. – Not significant; * – Significant (P < 0.05); ** – Significant (P < 0.01)

The only meat quality parameters that differed between the different sexes were the L* and a* meat colour readings, with meat from rams showing a higher L* (P < 0.05) reading than that of ewes. Meat from the ewes was situated more towards the saturated red spectra than that of rams (Table 10). The pH measured 45 minutes post mortem of the single lambs was higher (P < 0.05) than that from multiple born lambs. This could be an indication that multiples are less susceptible to stress than single born lambs (Cloete *et al.*, 2005b).

Table 10 Least square means (±se) depicting pH and meat quality parameters of Merino and Merino crossbred lambs comparing different sexes, birth type, ewe age and lambing year (with slaughter weight as co-variant)

	pH45	pH48	Cooking loss %	Drip loss %	Colour L*	a*	b*	Shearing value (N)
Sex	n.s.	n.s.	n.s.	n.s.	*	*	n.s.	n.s.
Ram	6.52±0.04	5.58±0.01	29.1±0.4	1.06±0.04	35.9±0.2	13.0±0.3	8.22±0.18	76.6±2.7
Ewe	6.44±0.04	5.56±0.01	28.2±0.4	1.00±0.04	34.8±0.2	14.5±03	8.67±0.18	80.3±2.6
Birth type	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Single	6.55±0.04	5.57±0.01	29.0±0.4	1.07±0.04	35.6±0.2	13.6±0.2	8.39±0.18	76.6±2.6
Multiple	6.41±0.04	5.59±0.01	28.2±0.5	0.99±0.05	35.1±0.2	13.9±0.3	8.51±0.22	80.3±3.2
Ewe age	**	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.
Young	6.35±0.04	5.57±0.01	28.6±0.5	0.98±0.05	35.1±0.3	14.1±0.3	8.46±0.21	80.0±3.2
Mature	6.61±0.03	5.58±0.01	28.7±0.3	1.07±0.04	35.6±0.2	13.4±0.2	8.43±0.15	76.9±3.2
Year	n.s.	n.s.	**	**	**	**	**	**
2000	6.52±0.04	5.59±0.01	27.7±0.4	0.91±0.04	35.9±0.2	14.8±0.3	9.01±0.19	103.6±2.8
2001	6.44±0.04	5.56±0.01	29.6±0.4	1.15±0.05	34.9±0.2	12.7±0.3	7.89±0.19	53.2±2.9

n.s. – Not significant; * – Significant (P < 0.05); ** – Significant (P < 0.01)

No other meat quality differences were found between the meat from single and multiple born lambs. Meat from lambs bred from mature ewes had a higher (P < 0.05) pH reading 45 minutes post mortem (Table

10). The a* colour reading of the lambs born from young ewes were more towards the saturated red spectra than meat from lambs born from mature ewes (Table 10). These higher a* colour readings could possible relate to the differences in pH measured 45 minutes post mortem. The same was found by Cloete *et al.* (2005a). Lambs born in 2000 had meat with a significantly lower ($P < 0.05$) drip and cooking loss percentage than meat from lambs born in 2001. The L*, a* and b* colour readings of the meat from the lambs born in 2000 were also higher than the meat of the lambs born in 2001. Meat of lambs born in 2000 were also significantly ($P < 0.05$) tougher than meat from lambs born in 2001.

Conclusion

It has to be conceded that the number of rams used per breed in this investigation was low. These results should thus be interpreted with due caution. However, this study showed that crossbred lambs reached slaughter weight at an earlier age than purebred Merino lambs. Part of the adaptability of a terminal crossbreeding system is the opportunity to maintain only the ewe flock over a period of nutritional short supply. The slower growth rate of purebred Merino lambs could be compensated for by additional security in terms of the wool income of the lambs. No conclusive advantages in favour of any of the terminal sire breeds on Merino ewes were obtained as far as growth and objectively measured meat quality traits are concerned. Decision-making should thus be based on factors such as the availability of rams, and considerations like the probability of contamination with coloured fibers.

References

Campher, J.P., Hunlun, C., Van Zyl, G.J., 1998. South African Livestock Breeding. South African Stud Book and Livestock Improvement Association. PO Box 270. Bloemfontein 9300, South Africa.

Cloete S.W.P., 1993. Observations on neonatal progress of Dormer and South African Mutton Merino lambs. S. Afr. J. Anim. Sci. 23, 38-42.

Cloete, S.W.P., Cloete, J.J.E., Herselman M.J. & Hoffman, L.C., 2004c. Relative performance and efficiency of five Merino-type dam lines in a terminal crossbreeding system with Dormer or Suffolk sires. S. Afr. J. Anim. Sci. 34, 135-143.

Cloete, J.J.E., Cloete, S.W.P. & Hoffman, L.C., 2005a. Behaviour of Merinos divergently selected for multiple rearing ability in response to external stimuli. Small Rum Res. 60, 227-236.

Cloete, J.J.E., Cloete, S.W.P., Hoffman, L.C. & Fourie, J.E., 2004a. Slaughter traits of Merino sheep divergently selected for multiple rearing ability. S. Afr. J. Anim. Sci. 34,189-196.

Cloete, J.J.E., Cloete, S.W.P, Olivier, J.J. & Hoffman, L.C., 2005b. Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Ewe production and lamb performance. Small Rumin. Res. doi:10.1016/j.smallrumres.2005.12.005.

Cloete, J.J.E., Hoffman, L.C., Cloete, S.W.P. & Fourie, J.E., 2004b. A comparison between the body composition, carcass characteristics and retail cuts of South African Mutton Merino and Dormer sheep. S. Afr. J. Anim. Sci. 34, 44-51.

Cloete, S.W.P., Olivier, J.J., van Wyk, J.B., Erasmus G.J. & Schoeman S.J., 2003. Genetic parameters and trends for birth weight, birth coat score and weaning weight in Merino lines divergently selected for ewe multiple rearing ability. S. Afr. J. Anim. Sci. 23, 248-256.

Cloete, S.W.P., Snyman, M.A., Herselman, M.J, 2000. Productive performance of Dorper sheep. Small Rumin. Res. 36, 119-135.

Dalton, D,C., Knight, K.E. & Johnson, D.L., 1980. Lamb survival in sheep breeds on New Zealand hill country. N.Z.J. Agric. Res. 23, 167-173.

Doloksaribu, M., Gatenby, R.M., Subandriyo, S.T. & Bradford, G.E., 2000. Comparison of Sumatra sheep crossbreds. III. Reproductive performance of F_2 ewes and weights of lambs. Small Rum. Res. 38, 115-121.

Dryden, F.D. & Marchello, J.A., 1970. Influence of total lipid and fatty acid composition upon the palatability of three bovine muscles. J. Anim. Sci. 31, 36-41.

Erasmus, L. S., 1965. Slaglamproduksie met die Merino as moederooi. M.Sc. Agric. thesis, University of Stellenbosch, South Africa.

Fahmy, M.H., Gariepy, C. & Fortin, J., 1999. Carcass quality of crossbred lambs expressing the callipyge phenotype born to Romanov purebred and crossbred ewes. Anim. Sci. 69, 525- 533.

Fogarty, N.M., 2006. Utilization of breed recourses for sheep production. 8th World Congress on Genetics Applied to Livestock Production, Belo Horizonte, MG, Brasil.

Harvey, W.R. 1990. User's guide for LSMLMW and MIXMDL. PC-2 version, Mimeograph.

Hight, G.K. & Jury, K.E., 1970. Hill country sheep production. II. Lamb mortality and birth weights in Romney and Border Leicester X Romney flocks. N. Z. J. Agric. Res. 13, 735-746

Hoffman, L.C., 2000. The yield and carcass chemical composition of impala (Aepyceros melampus), a southern African antelope species. J. Sci. Food Agric. 80, 752-756.

Jeremiah, L.E., Jones, S.D.M., Tong, A.K.W., Robertson, W.M. & Gibson, L.L., 1997. The influence of lamb chronological age, slaughter weight and gender on yield and cutability. Int Sheep Goat Res. J. 13, 39-46.

Kleeman, D.O., South, M.H.L., Dolling, C.H.S. & Ponzoni, R.W., 1983. Survival, growth and wool production of South Australian strong-wool Merino and first-cross Merino lambs from birth to 16 months of age. Aust. J. Exp. Agric. Anim. Husb. 23, 271-279.

Notter, D. R., 1987. The crossbred sire: Theory. J. Anim. Sci. 65, 99-109.

Olivier, J.J. & Cloete, S.W.P., 2006. Genetic analysis of the South African Dorper sheep. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 04-10.

Snowder, G.D. & Duckett, S.K., 2003. Evaluation of the South African Dorper as a terminal sire breed for growth, carcass, and palatability characteristics. J. Anim. Sci. 81, 368-375.

Teixeira, A., Delfa, R. & Treacher, T., 1996. Carcass composition and body fat depots of Galego Bragnançano and crossbred lambs by Suffolk and Merino Precoce sire breeds. Anim. Sci. 63, 389-394.

Roux, C.Z., 1992. Maximum herd efficiency in meat production III. Feeder-breeder dimorphism. S. Afr. J. Anim. Sci. 22, 11-15.

Part 3

Importance of carcass quality using leaner sire breeds on early maturing Dorpers

Chapter 9

Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Ewe production and lamb performance

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Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Ewe production and lamb performance

Abstract

The effect of crossing Dorper ewes with Ile de France (IdF), Merino Landsheep (ML) and SA Mutton Merino (SAMM) rams in a terminal crossbreeding program was investigated during 2000 and 2001. Expressed as percentage of purebred Dorper lambs, the average birth weights of IdF cross and ML cross lambs were increased by 12 and 7 % respectively. Crossbred progeny of IdF sires were 10 % heavier than purebred Dorpers at weaning. A corresponding difference in favour of ML sires amounted to 5 %. IdF crossbred lambs reached slaughter weight earlier than the other cross lambs and purebred Dorper lambs. Lamb mortality prior to weaning was unaffected by the breed of the service sire, and ranged between 0.13 for lambs sired by IdF rams to 0.22 for purebred Dorper lambs. Ewe joining weight, as well as number of lambs born and weaned per ewe lambed was independent of the breed of the service sire. When weight of lamb weaned per ewe lambed was considered, there was a tendency towards higher lamb outputs in ewes that were joined to IdF and SAMM sires. Estimated repeatability derived for joining weight and the various measures of reproduction generally accorded with literature estimates. Backfat depth (taken at the 13th rib, 25 mm from the midline) indicated that purebred Dorper lambs had a thicker fat cover compared to all combinations of crossbred lambs. Corresponding sire breed differences were found between the 3rd and 4th lumbar vertebra, 25 mm from the midline. Terminal crossbreeding of Dorper ewes with IdF, ML and SAMM sires did not deleteriously affect lamb growth and survival or ewe reproduction. Terminal crossbreeding could thus be implemented in commercial Dorper flocks, without compromising productivity and/or product quality.

Keywords: Dressing percentage, fat depth, lamb growth, lamb output, reproduction, weaning weight

Introduction

The Dorper is a composite breed derived in South Africa from a cross between the Dorset Horn and the Blackheaded Persian. The breed is well adapted to thrive under arid and hot conditions. Dorpers that were maintained in divergent environments and under a variety of managerial regimes were capable of fairly high levels of reproduction i.e. 0.9 – 1.5 lambs weaned per ewe, as reviewed by Cloete *et al.* (2000). In terms of meat production, Dorpers outperformed woolled breeds and other breeds indigenous to South Africa, while comparing favourably with specialist meat sheep breeds (Schoeman, 2000). The exception is for parasite resistance, where purebred Dorpers were outperformed by resistant Red Maaisai sheep in the humid tropics (Baker *et al.,* 1998). According to the review by Schoeman (2000), there is a lack of structured crossbreeding studies on the Dorper breed.

Growth of Dorper lambs under arid conditions are generally acceptable i.e. 170 – 300 g/day (Cloete *et al.*, 2000) and compared favourably with that of other breeds (Schoeman, 2000). Dorper lambs, however, are early maturing and tend to deposit excessive fat at a relatively early chronological age. Webb & Casey (1995) reported that the subcutaneous fat cover of Dorper wethers were about double that of South African Mutton Merino (SAMM) wethers at the same age. With the Blackheaded Persian contributing genes to the Dorper, it is also sometimes alleged that the fat distribution of the breed is not optimal, with fat localised at the tail area (Greeff *et al.,* 1988). According to a literature review, fat measurements on Dorper carcasses ranged from 3.5 to 12.8 mm between the 3rd and 4th sacral vertebrae, 25 mm from the midline, and from 3.3 to 5.9 mm between the 3rd and 4th lumbar vertebrae, 25 mm from the midline and from 1.0 to 5.8 mm between the 9th and 10th rib, 25 mm from the midline (Cloete *et al.,* 2000). With the present emphasis on lean growth, consumers prefer leaner cuts of meat. Excessive fat thus impacts negatively on meat price. Under these conditions, the terminal crossbreeding of Dorper ewes with rams of relatively lean breeds could be considered, with the aim of improving the carcass value of the crossbred offspring.

Against this background, the relative performance of the Dorper ewes and their crossbred progeny were studied in a commercial, terminal crossbreeding system, using Ile de France (IdF), Merino Landsheep (ML) and South African Mutton Merino (SAMM) rams as sires. A control group involving Dorper rams joined to the Dorper ewes was also included.

Materials and Methods

The experiment was carried out on the Nortier experimental farm in the West Coast Strandveld area of the Western Cape. Cloete & De Villiers (1987) gave an in depth description of the location and vegetation of the experimental farm. The site is situated at 32°02'S and 18°20'E. The climate is Mediterranean, with 76 % of the total long-term annual precipitation of 221 mm being recorded during winter (April to September). The experimental site is characterised by dry, hot summers and cooler winters with an unpredictable and variable rainfall.

The experimental animals were a flock of Dorper ewes available on the experimental farm. Pedigrees and age at lambing were unknown for individual ewes. All available ewes were joined to lamb during June-July of each year. Ewes in the experiment numbered 251 during 2000 and 250 during 2001. The number of ewes allocated to each ram breed is reported in Table 2. The experimental flock grazed on natural pasture throughout the production cycle. Mating took place in 15 adjacent paddocks of approximately 20 ha each. Three rams of each sire breed were used in single sire groups during 2000, with the exception of the IdF and SAMM groups, where only 2 rams were available. The same flock of ewes were used in 2001 and two rams of each breed were used, except for the purebred Dorper genotype, which was represented by three sires, one ram from the previous year and two new rams. One to two rams of each breed were retained from 2000 for breeding in 2001, to provide linkage across years. In both years, all ewes were maintained in a single flock immediately after joining. Each year the ewes were randomly divided between the sire groups, and ewes could be allocated to different sire breeds in the respective years. At joining in 2001, the apparently old ewes were culled on teeth and general constitution, while available two-tooth ewes were brought into the breeding flock.

Parentage, contemporary group, birth weight (obtained within 24 hours of birth), survival to weaning and weaning weight (obtained during October at an average ± SD age of 100 ± 9 days) were recorded for all lambs. From this information it was possible to construct complete reproduction data for all ewes. The traits that were assessed included: number of lambs born and weaned per ewe per parity, total weight of lamb weaned per ewe per parity and ewe live weight at joining. Individual weaning weights of lambs were used to derive total weight of lamb weaned per parity, without previous correction for sex. The correction was considered as unnecessary, since a previous study indicated that the phenotypic correlation between total weight of lamb weaned per parity with and without correction did not differ from unity, at 0.99 ± 0.01 (Cloete, 2002b). Owing to the differences in the lambing rate of the ewes joined to the respective ram groups (see Table 2), all reproduction traits were expressed on a per ewe lambed basis. All the lambs were slaughtered at an average live weight of approximately 43 kg. During 2000 a number (n = 160) of lambs were finished on concentrates, as there were insufficient food available for the lambs to reach the designated slaughter weight. Cold carcass weight, dressing percentage and fat depth at two sites were measured after slaughter. The first site was at the 13th rib 25 mm from the midline and the second site was between the 3rd and 4th lumbar vertebrae 25 mm from the midline (Bruwer *et al.*, 1987).

Least squares procedures were used to assess the data statistically, to account for uneven subclasses. The ASREML statistical package (Gilmour *et al.,* 1999) was used for this purpose. The software allows the estimation of various random effects in animal breeding, while it is also possible to predict least squares means for selected fixed effects. Fixed effects that were considered in the analyses of lamb traits (birth weight, weaning weight and slaughter traits) were birth year (2000 or 2001), sex (male or female), birth type (singles or pooled multiples) and sire breed (IdF, ML, SAMM or Dorper) as well as relevant two-factor interactions between the different effects. Since interactions were generally not significant, only main effect means were tabulated. Interaction effects are provided in the text in cases where it was significant. Although it is generally known that ewe age affects reproduction and lamb performance, it was impossible to compute this effect due to a lack of information on individuals. A linear regression on weaning age was also fitted for weaning weight. Means for weaning weight were calculated at the mean weaning age. Random sire within ram breed and dam permanent environmental effects were also computed. Variance components stemming from the analyses could potentially be used for the estimation of genetic parameters. This was not attempted owing to a general lack of significance, the small size of the data sets, and a lack of pedigree information. Binomially distributed ewe conception and lamb mortality data were assessed by standard Chi-squared procedures (Siegel, 1956).

Production year (2000 or 2001) and sire breed (IdF, ML, SAMM or Dorper) was fitted as fixed effects in the case of ewe reproduction traits. Random animal effects stemming from repeated records on the same individuals were computed, and used to derive repeatability estimates. Repeatability estimates for reproduction traits of Dorper ewes are scarce in the literature, and these estimates were presented and discussed. Random service sire within ram breed effects were also obtained in the case of reproduction, as defined previously. Service sire effects were, however, not significant and were excluded from the final analyses. It is conceded that the analysis of discrete data such as number of lambs born and weaned with parametric methods used in the present study is not optimal, as was outlined by Purvis & Hillard (1997). The availability of suitable software, and the close approximation of outcomes from linear models to that derived from non-linear methods has resulted in recommendations that the former methods could be employed until alternative software packages become readily available (Jorhensen, 1994; Brien *et al.*, 2002).

Results

Birth weights of ram lambs and singles were heavier ($P < 0.05$) than that of respectively ewe lambs and multiples (Table 1). Lambs born in 2001 were also heavier ($P < 0.05$) than those born in 2000. Expressed relative to purebred Dorper lambs, the birth weights of IdF cross and ML cross lambs were increased ($P < 0.05$) by 12 and 7 % respectively. At weaning, ram lambs and singles were heavier ($P<0.01$) than respectively ewes and multiples. Lambs born in 2001 were heavier ($P < 0.05$) than those born in 2000 at weaning. Weaning weight was affected by age at weaning, and increased by 0.17 kg per day of age. Progeny sired by IdF rams were 10 % heavier ($P < 0.01$) than purebred Dorper lambs at weaning. A corresponding difference ($P < 0.05$) in favour of the progeny of ML sires amounted to 5 %. The mortality of lambs born during 2000 was higher ($P < 0.01$) than that of lambs born in 2001. The only other significant difference as far as lamb mortality was concerned, was for birth type. Singles sustained ($P < 0.05$) a lower mortality rate than multiples.

The proportion of ewes that lambed per ewe mated is given in Table 2. It is evident that performance in the group of ewes joined to ML sires was inferior to that of those ewes joined to IdF and Dorper sires ($P < 0.05$). The difference between the ewes joined to ML rams and those joined to SAMM rams also approached significance ($P < 0.10$). Further scrutiny of the data indicated that this result was mainly caused by an inferior lambing rate in ewes joined to a specific ML ram during 2000. Only 10 % of 20 ewes allocated to this specific ram lambed. On this basis, it was decided to conduct further analyses of reproduction traits on a per ewe lambed basis. Number of lambs born and number of lambs weaned per ewe lambed were not influenced by the breed of the service sire (Table 3). When weight of lamb weaned per ewe lambed was considered, there was a suggestion ($P < 0.10$) of higher lamb outputs in ewes joined to IdF and SAMM sires. The average weight of ewes joined during 2000 were lighter ($P < 0.01$) than those joined during 2001. The difference in lamb output (defined as weight of lamb weaned per ewe lambed) correspondingly tended ($P = 0.10$) to be lower in 2000 than in 2001.

Table 1 Least squares means (±SE) for lamb birth weight, weaning weight at an average weaning age and survival prior to weaning as affected by birth year, sex, birth type and sire breed

Fixed effect	Birth weight (kg)	Weaning weight (kg)	Lamb mortality
Number of observations	507	399	511
Overall mean	4.3±0.1	32.4±0.3	0.22
Birth year	**	**	*
2000	4.1±0.1	30.1±0.4	0.27
2001	4.6±0.1	34.7±0.4	0.17
Sex	**	**	ns
Ram	4.5±0.1	34.3±0.4	0.20
Ewe	4.2±0.1	30.6±0.4	0.24
Birth type	**	**	*
Single	4.7±0.1	35.5±0.4	0.16
Multiple	4.0±0.1	29.4±0.4	0.25
Sire breed	**	**	ns
Ile de France	4.6^{c}±0.1	34.5^{b}±0.5	0.18
Merino Landsheep	$4.4^{b,c}$±0.1	32.9^{b}±0.7	0.22
SA Mutton Merino	$4.2^{a,b}$±0.1	31.1^{a}±0.6	0.22
Dorper	4.1^{a}±0.1	31.3^{a}±0.5	0.24
Regression on weaning age	–	0.17±0.03**	–

ns Not significant (P > 0.10), * Significant (P < 0.05), ** Significant (P < 0.01)

a,b,c Denote significant differences in columns (P < 0.05)

Ewe live weight at joining was highly repeatable (0.76; Table 4). The repeatability estimates for the various measures of reproduction were markedly lower, ranging from 0.14 to 0.25. Estimates derived for number of lambs and weight of lamb weaned per ewe lambed were not statistically significant (P < 0.05), as they did not exceed a level of twice the corresponding standard error.

It was intended to slaughter all lambs at an approximate live weight of 43 kg but this objective was not reached. Lambs sired by IdF and ML rams were respectively 3.1 and 2.6 % heavier than purebred Dorpers at slaughter (43.4 ± 0.3 and 43.2 ± 0.4 vs. 42.1 ± 0.3 kg respectively; P < 0.05). Lambs sired by SAMM rams were of intermediate slaughter weight, and not different from either group at 42.7 ± 0.4 kg (P > 0.05).

Lambs sired by IdF rams reached slaughter weight respectively 17 and 29 days earlier than SAMM crosses and purebred Dorpers (P < 0.05; Table 5). Purebred Dorper lambs had a thicker (P < 0.05) fat cover than all crossbred combinations at the 13th rib, 25 mm from the midline (Table 5). Similar results were found at the site between the 3rd and 4th lumbar vertebra, 25 mm from the midline. Adjustment for slaughter weight differences by analysis of covariance resulted in somewhat smaller sire line differences in slaughter age, while the contrast in fat depth between purebred Dorpers and crossbred lambs was accentuated. The general outcomes of the analysis were thus independent of this adjustment, and the same deductions would have been made.

Table 2 Lambing rate of ewes in the terminal crossbreeding study, as affected by the breed of the service sire

Breed of sire	Number of ewes mated	Ewes lambed per ewe mated
Ile de France	111	0.72[a]
Merino Landsheep	110	0.50[b]
SA Mutton Merino	101	0.68[a,b]
Dorper	170	0.75[a]
Chi^2		21.1*

* Critical Chi^2 for 3 degrees of freedom = 7.82

[a,b] Denote significant differences in columns ($P < 0.05$)

Table 3 Least squares means (±SE) for ewe reproduction as affected by year and sire breed. All reproduction traits were expressed in relation to ewes that lambed

Effect	Ewe joining weight (kg)	Number of lambs born	Number of lambs weaned	Weight of lamb weaned (kg)
Number of observations	562	562	562	652
Overall mean	63.5±0.5	1.50±0.03	1.18±0.04	41.9±1.2
Year	**	ns	ns	P=0.10
2000	62.5±0.6	1.54±0.04	1.13±0.05	39.9±1.6
2001	64.5±0.6	1.46±0.04	1.24±0.05	44.0±1.7
Sire breed	ns	ns	ns	P<0.10
Ile de France	63.5±0.8	1.50±0.06	1.22±0.07	45.9±2.3
Merino Landsheep	64.0±0.9	1.42±0.07	1.11±0.08	40.4±2.7
SA Mutton Merino	63.7±0.8	1.59±0.06	1.29±0.07	43.0±2.3
Dorper	62.9±0.8	1.49±0.06	1.12±0.05	38.4±1.8

ns Not significant ($P > 0.10$), ** Significant ($P < 0.01$)

[a,b] Denote significant differences in columns ($P < 0.05$)

Restrictions imposed by the available animal and financial resources allowed the usage of relatively few sires to represent each genotype in the experiment. Nevertheless, it is important to note that differences in some lamb traits were obtained between sire breeds (Tables 1 and 5), whereas the variation between sires within breeds was relatively low for all traits.

Table 4 Repeatability estimates for ewe live weight and lamb output

Trait	Repeatability ± SE
Ewe joining weight (kg)	0.76±0.04
Number of lambs born	0.25±0.09
Number of lambs weaned	0.17±0.10
Weight of lamb weaned (kg)	0.14±0.10

Significant differences were also found for dressing percentage and the two measures of fat depth, where means for ewes were higher than that of rams (Table 5; $P < 0.05$). Fat depth of carcasses from multiple lambs was on average leaner ($P < 0.05$) than that from singles. Progeny born during 2000 were slaughtered at an older age ($P < 0.01$) than those born during 2001. Year of birth interacted with sire breed as far as dressing percentage were concerned ($P < 0.05$). During 2000, purebred Dorper lambs had a higher dressing percentage ($P < 0.05$) than IdF and ML crossbred lambs. During 2001, when lambs were marketed earlier, no distinct differences in dressing percentage were obtained between the different crosses and purebred Dorper lambs. The lambs were marketed earlier in 2001 because of a restriction in food in 2000, leading to the finishing of some lambs on concentrates.

Table 5 Least squares means (± SE) for slaughter age, dressing percentage and fat depth of Dorper and Dorper crossbred lambs

Effect	Slaughter age (days)	Dressing %	Backfat depth at the 13th rib (mm)	Backfat depth between the 3rd and 4th lumbar vertebra (mm)
Year	**	**	**	*
2000	251^b±4	42.2^b±0.4	2.10^b±0.12	2.58^b±0.14
2001	169^a±4	39.4^a±0.4	1.51^a±0.11	1.87^a±0.12
Birth type	**	**	**	*
Singles	188^a±4	42.0^b±0.4	1.94^b±0.13	2.38^b±0.14
Multiples	231^b±4	39.7^a±0.4	1.67^a±0.10	2.07^a±0.12
Sex	**	*	**	*
Ram	192^a±4	40.4^a±0.4	1.45^a±0.11	1.45^a±0.11
Ewe	228^b±4	41.5^b±0.4	2.16^a±0.11	2.16^b±0.11
Sire breed	*	ns	*	*
Ile de France	195^a±5	40.5±0.5	1.68^a±0.16	2.22^a±0.19
Merino Landsheep	$209^{a,b}$±6	40.7±0.6	1.62^a±0.18	1.91^a±0.20
SA Mutton Merino	$212^{b,c}$±6	40.9±0.6	1.76^a±0.18	2.11^a±0.20
Dorper	224^c±4	41.6±0.4	2.16^b±0.13	2.65^b±0.14

ns Not significant ($P > 0.10$), * Significant ($P < 0.05$), ** Significant ($P < 0.01$)

a,b,c Denote significant differences in columns ($P < 0.05$)

Discussion

The variation between sires within sire breeds was low in the analysis of lamb traits in the present study. It is important to take note of the fact that significant variation in some production traits was attributed to breeds, rather than to variation between sires within breeds. However, it has to be conceded that the number of rams used to represent a genotype were low, since the experiment had to be conducted within constraints imposed by the available animal and financial resources. Further work is therefore required to confirm or refute these results.

The effects of gender and birth type on lamb performance were in correspondence with the available literature. These results will thus not be discussed in detail. The performance of ewes and lambs generally improved in 2001 relative to 2000, although a conclusive difference could not be demonstrated for weight of lamb weaned per ewe lambed. The reason for these observations is probably the effect of rainfall on the availability of suitable herbage. The overall precipitation recorded during 2000 amounted to only 67 % of the long term average, while conditions were nearer to normal during 2001.

Overall performance of purebred ewes and lambs were generally consistent with figures reviewed for purebred Dorpers from the literature (Cloete *et al.*, 2000). Corresponding figures ranged between 16.1 and 41.3 kg for lamb weaning weight, between 0.09 and 0.22 for lamb mortality and between 1.00 and 1.73 for multiple birth rate in ewes. Mature Dorper ewes correspondingly weighed between 51.6 and 76.9 kg (Cloete *et al.*, 2000). When Dorpers were maintained under an accelerated lambing system, mean performance levels amounted to 4.2 kg for birth weight, 27.9 kg for lamb 100-day weight, 61.3 kg for ewe pre-joining live weight and 1.41 for average litter size (Schoeman & Burger, 1992). Means for hair and wool type Dorpers ranged from 4.06 to 4.12 for birth weight, 30.0 to 30.1 for 100-day weaning weight, 56.4 to 57.4 for ewe pre-joining weight, and 1.497 to 1.504 for number of lambs born per ewe lambed (Snyman & Olivier, 2002). All the corresponding traits in the present study are well within these ranges.

Crossbreeding studies involving Dorper sheep were reviewed by Schoeman (2000). Local studies included those of Olivier *et al.* (1984) and Greeff *et al.* (1988). In the former study, purebred white Dorpers were compared to purebred Merinos and the cross between these breeds. The Dorper breed was not used as a dam line in that study. Those crosses were made during the formation of the Afrino breed, thus making it difficult to draw comparisons with the present investigation. Greeff *et al.* (1988) studied crosses between the Dorper and the Romanov, with the objective of establishing a prolific ewe line of intermediate size. No instances were found where Dorper ewes were used as the dam line in a terminal crossbreeding experiment, as in the present study. Purebred Dorper lambs did not outperform crossbred progeny for any of the traits that were considered. Progeny sired by IdF and ML rams were, in fact, heavier than purebred Dorpers at birth. Similarly, the crossbred progeny sired by IdF and ML rams were also heavier than purebred Dorpers at weaning. Although lamb mortality was unaffected by sire breed, it is important to note that purebred Dorper lambs sustained the highest level of mortality in absolute terms. These differences and trends could possibly be related to direct heterosis, since it involved traits often benefiting from heterosis (Rae, 1982). Since the present study was not designed to study hybrid vigour, it is not possible to make any deductions in this regard. The same reasoning applied to ewe reproduction. The only suggestion of a difference ($P < 0.10$) involved the lamb output of ewes joined to IdF and SAMM rams, which tended to perform better than control ewes for weight of lamb weaned per ewe lambed. When contrasting hair (St. Croix and Barbados) and wool (Finsheep, Combo-6, Booroola Merino) breed rams as sires used on either Suffolk or Targhee ewes, Bunge *et al.* (1993) demonstrated that neither type had a conclusive advantage as far as ewe prolificacy were concerned. Wool breeds had a slight advantage for weaning weight. These results are in broad agreement with the outcome of the present study.

The only other studies in the literature that derived repeatability estimates for ewe traits in Dorpers were those of Cloete & De Villiers (1987) and Schoeman & Burger (1992). Estimates of repeatability from the former study amounted to 0.45 for ewe joining weight, 0.08 for lambs born per ewe mated and 0.07 for lambs weaned per ewe mated. These parameters were generally somewhat lower than those estimated in the present study. The facts that data were recorded over only two years in the present study and that reproduction data were expressed on a per ewe lambed basis may have contributed to this result. Schoeman & Burger (1992) estimated the repeatability of average litter size at 0.32. This figure is in close correspondence with the estimate of 0.25 found for number of lambs born per ewe lambed in the present study.

The younger slaughter age of IdF crossbred lambs could be attributed to the differences in growth rate between the different crosses, resulting in a corresponding difference in weaning weight (Dass & Acharva, 1970). The Dorper is considered an early-maturing breed (Cloete *et al.*, 2000) and therefore tend to put on fat earlier. It is thus understandable that the purebred Dorpers had a thicker average fat depth on the same live weight as compared to the crossbred lambs. Although the purebred Dorper lambs were generally fatter, a fat cover of between two and three millimetre is still acceptable for the best grades in the South African meat industry. No penalty for excessive fat deposition was thus incurred under the conditions of the present study. This is in contrast with most literature sources, since purebred Dorper lambs slaughtered by Webb & Casey (1995) at a target slaughter weight of 43 kg had an average fat depth of 4.63 mm at the 13th rib, which is more than double that recorded in the present study. In the study of Snyman & Olivier (2002), purebred Dorper lambs were slaughtered at eight to nine months, at a live weight of approximately 40 kg. The average fat depth between the 3rd and 4th lumbar vertebrae in their study was also substantially thicker, and averaged between 5.6 and 5.8 mm. The general thinner fat cover of purebred Dorpers in the present study could be attributed to the relatively dry conditions and the reduced food supply during the experimental period.

A gender influence in the present study is consistent with trends generally found in the literature, with ewe carcasses being fatter with a higher dressing percentage (Cloete, 2002a). The significant effect of birth type on fat depth was consistent with the study of Greeff *et al.* (2003), involving data of 829 Merino ram progeny. During 2000, lambs were slaughtered at an average age of 251 days compared to 169 days in 2001, as dictated by the poorer growth conditions in the former year. The difference in slaughter age could account for differences in fat depths between the two years. According to Lawrie (1998), subcutaneous fat depth increases with an increase in age. Due to the difference in fat cover between the two years, there was a difference in dressing percentage between years. Dressing percentage is known to increase with animal weight and degree of fatness (Kirton *et al.,* 1995). The thicker fat cover in 2000 thus resulted in a generally higher dressing percentage.

Conclusions

Ewe reproduction and lamb performance were not compromised by the crossing of Dorper ewes with IdF, ML or SAMM rams. Where differences did occur, crossbred progeny generally outperformed purebred Dorper lambs. The same general trend applied to the lamb output of Dorper ewes that were joined to IdF or SAMM sires. It is unfortunate that it was not possible to assess the reproductive output of the ewes mated to the respective sire breeds on a per ewe mated basis. However, the lack of differences between IdF, SAMM or Dorper rams with regard to ewe lambing rate indicate that acceptable conception rates are possible when Dorper ewes are joined to other breeds.

Differences in fat depth were in favour of the crossbred genotypes, i.e. a reduced fat depth in all crossbred genotypes. It has to be conceded that environmental conditions during the trial did not sustain the early deposition of adipose tissue. The full potential of crossbreeding Dorper ewes with late-maturing leaner breeds was thus probably not fully realised. The benefits will possibly be more pronounced under favourable environmental conditions, but further work is required for the confirmation of this deduction. The outcome from this study, however, indicate that terminal crossbreeding of Dorper ewes with leaner specialist mutton breeds may become a viable proposition for commercial Dorper producers.

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References

Baker, R.L., Rege, J.E.O., Tembely, S., Mukasa-Mugerwa, E., Anindo, D., Mwamachi, D.M., Thorpe, W. & Lahlou-Kassi, A., 1998. Genetic resistance to gastrointestinal nematode parasites in some indigenous breeds of sheep and goats in East Africa. Proc. 5th World Cong. Gen. Appl. Livest. Prod. Armidale, Australia. 25, 269-272.

Brien, F.D., Konstantinov, K.V. & Greeff, J.C., 2002. Comparison of linear and threshold models for predicting direct and maternal genetic effects on number of lambs weaned in Western Australian Merinos. Proc. 7th World Cong. Gen. Appl. Livest. Prod. 18-23 August, Montpellier, France. 32, 307-310.

Bruwer, G.G., Naude, R.T. & Vosloo, W.A., 1987. An evaluation of the lamb and mutton carcass grading system in the Republic of South Africa. 1. A survey of carcass characteristics of the different grades. S. Afr. J. Anim. Sci. 17, 79-84.

Bunge, R., Thomas, D.L., Nash, T.G. & Fernando, R.L., 1993. Performance of hair breeds and prolific wool breeds of sheep in Southern Illinois: Effect of breed of service sire on lamb production of Suffolk and Targhee ewes. J. Anim. Sci. 71, 321-325.

Cloete, J.J.E., 2002a. Carcass traits in relation to genotype in sheep. M.Sc. (Agric.) thesis, University of Stellenbosch, Stellenbosch, South Africa.

Cloete, S.W.P., 2002b. Studies on the behavioural and genetic aspects of ewe rearing ability and lamb survival in South African sheep flocks. Ph.D. dissertation, University of the Free State, Bloemfontein, South Africa.

Cloete, S.W.P. & De Villiers, T.T., 1987. Production parameters for a commercial Dorper flock on extensive pasture. S. Afr. J. Anim. Sci. 27, 121-127.

Cloete, S. W. P., Snyman, M.A. & Herselman, M.J., 2000. Productive performance of Dorper sheep. Small Rumin. Res. 36, 119-135.

Dass, G.S. & Acharva, R.M., 1970. Growth of Bikaneri sheep. J. Anim. Sci. 31, 14 -17.

Gilmour, A.R., Cullis, B.R. & Welham, S.J., Thompson, R., 1999. ASREML – Reference manual. NSW Agriculture Biometric Bulletin No. 3. NSW Agriculture, Orange Agricultural Institute, Forest Road, Orange 2800, NSW, Australia.

Greeff, J.C., Davidson, R. & Skerritt, J.W., 2003. Genetic relationship between carcass quality and wool production traits in Australian Merino rams. Proc. Assoc. Advmt. Breed. Gen. 15, 330-333.

Greeff, J.C., Hofmyer, J.H., Wyma, G.W. & Van Deventer, J.F.P.J., 1988. Preliminary results on heterosis and breed transmitted effects of fertility and survival rate of Romanov and Dorper crossbreds. 19-23 June 1988, Institut National de la Recherche Agronomique, Paris, France. Proc. 3rd World Cong. Sheep Beef Cattle Breed 673-675.

Jorhensen, J.N., 1994. Estimation of genetic parameters for litter size in sheep using a non-linear method. Acta Agric. Scand. A. Anim. Sci. 44, 8-11.

Kirton, A.H., Carter, A.H., Clarke, J.N., Sinclair, D.P., Mercer, G.J.K. & Dunganzich, D.M., 1995. A comparison between 15 ram breeds for export lamb production 1. Liveweights, body composition, carcass measurements and composition. N. Z. J. Agric. Res. 38, 347-360.

Lawrie, R.A., 1998. Lawrie's Meat Science. 6th ed. Woodhead Publ. Ltd. Cambridge, England.

Olivier, J.J., Marais, P.G. & Cloete, J.A.N., 1984. Evaluation of different breed crosses in the development of a white-wooled mutton sheep breed: the Afrino. S. Afr. J. Anim. Sci 14, 105-109.

Purvis, I.W. & Hillard, M., 1997. Biology and genetics of reproduction. In: The genetics of sheep. (Eds L. Piper and A. Ruvinsky) 375-394. CAB International, Wallingford, Oxon, United Kingdom.

Rae, A.L., 1982. Breeding. In: Sheep and goat production – World Animal Science. Ed: I.E. Coop. 15-55. Elsevier Scientific Publishing company, Amsterdam.

Schoeman, S.J., 2000. A comparative assessment of Dorper sheep in different production environments and systems. Small Rumin. Res. 36, 137-146.

Schoeman, S.J. & Burger, R., 1992. Performance of Dorper sheep under an accelerated lambing system. Small Rumin. Res. 9, 265-281.

Siegel, S., 1956. Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill.

Snyman, M.A. & Olivier, W.J., 2002. Productive performance of hair and wool type Dorper sheep under extensive conditions. Small Rumin. Res. 45, 17-23.

Webb, E.C. & Casey, N.H., 1995. Genetic differences in fatty acid composition of subcutaneous adipose tissue in Dorper and SA Mutton Merino wethers at different live weights. Small Rumin. Res. 18, 81-88.

Chapter 10

Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Carcass traits of lambs

Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Carcass traits of lambs

Abstract

A terminal crossbreeding trial with Dorper ewes as dam line was conducted during 2000 and 2001. Sire breeds included the Ile de France (IdF), SA Mutton Merino (SAMM), Merino Landsheep (ML) and purebred Dorpers. The objective of the study was the comparison of carcass characteristics of heavy crossbred lambs, with less fat, to purebred Dorpers. All lambs were slaughtered at an average live weight of approximately 43 kg. Backfat depth was taken at the 13th rib and between 3rd and 4th lumbar vertebra 25 mm from the midline. Purebred Dorper lambs had a thicker fat cover at the 13th rib compared to crossbred lambs. At the 3rd and 4th lumbar vertebra the purebred Dorper lambs also had a thicker fat cover than lambs from ML and SAMM crosses. The pH, cooking loss, drip loss and colour of meat from the *M. longissimus dorsi lumborum* did not differ between the terminal sire crosses. Purebred Dorper lambs had meat with a higher shear force value than SAMM cross lambs in the *M. longissimus dorsi lumborum*. A sensory evaluation of the *M. semimembrinosus* showed no differences between the different crosses and purebred Dorper lambs. It was shown that terminal crossbred lambs were equal to or superior to purebred Dorpers with regard to quantitative and qualitative carcass parameters evaluated.

Keywords: Cooking loss, crossbreeding, lamb meat quality, meat colour, pH, sensory attributes

Introduction

In numbers, the Dorper has grown to be the second largest sheep breed in South Africa. The breed was established in 1950, and breeding stock has also been exported to other countries (Cloete *et al.,* 2000). Dorper sheep are regarded as early-maturing and therefore tend to put on fat at a relatively early age. The propensity of Dorper lambs to put on more localised fat at lower live weights than late maturing breeds is seen as a disadvantage. It is generally accepted that modern consumers demand leaner cuts of lamb, resulting in leanness becoming an important breeding objective for slaughter lamb production (Gilmour *et al.,* 1994).

Combining appropriate breeds in crossbreeding systems offers the opportunity to increase productive efficiency and the quality of market lamb production through both additive and non-additive genetic effects. Efficient crossbreeding systems exploit breed differences, capitalizing on the effects of individual and maternal heterosis and sexual dimorphism. Using later-maturing breeds as sire breeds may have the advantage of producing carcasses with optimal fat thickness and distribution at a heavier live weight compared to purebred Dorpers. Animals with larger frames have acceptable growth rates, but take longer to reach maturity and deposit fat at heavier live weights (Schoeman, 2000).

The objective of the study was to use a terminal crossbreeding system with Dorper ewes, to compare later maturing, fairly heavy carcasses, with less fat compared to early maturing, purebred Dorper carcasses.

These lambs would be better suited to meet the market requirements for heavier, leaner lamb carcasses. Sire breeds involved were the Ile de France (Idf), SA Mutton Merino (SAMM) and Merino Landsheep (ML) (Cloete *et al.*, 2006). Carcass traits, slaughter traits and sensory attributes of lambs belonging to the various breed combinations were compared.

Materials and Methods

A terminal crossbreeding trial, using Dorper ewes as a dam line, was conducted during 2000 and 2001 at the Nortier experimental farm on the West Cost near Lamberts Bay, South Africa. The climate at the site is Mediterranean, with 76% of the total long-term annual precipitation of 221 mm being recorded during winter (April to September). Sire breeds that were used included Idf, SAMM and ML, while purebred Dorpers were used as control. Ewe reproduction as well as early live weights and survival of the experimental animals were described by Cloete *et al.* (2006).

Approximately 250 ewes were used each year. As no records were available for ewe age or reproductive history, the ewes were randomly allocated to single sire mating groups (equal number of ewes were assigned to each of the terminal crossbred sires, but owing to replacement needs slightly more ewes were purebred – see Cloete at al., 2006 for ewe numbers assigned to each breed) and mated for a 6-week period on paddocks (containing the Strandveld Succulent Karoo vegetation type; Low and Rebelo, 1996) of 15 ha each from mid-January to the end of February. Each sire breed was presented by 2 or 3 rams per year. During 2000, two rams were used of each of the Idf and SAMM breeds, while three ML and Dorper rams were used. During 2001, three rams of each breed were used (one ram from the previous year and one new ram) except for the purebred Dorper genotype, which was represented by three sires, one ram from the previous year and two new rams.

The ewes lambed during June and July, and all lambs were weaned at a mean (± SD) of 99 ± 8 days of age (Cloete *et al.*, 2006). During 2001 a number (n = 160) of lambs born during the winter of 2000 were fed, because there was not sufficient feed available for the lambs to reach the slaughter weight of 43 kg. No supplementary feeding was provided to lambs born during 2001. Full body weight was determined 24 hours prior to slaughtering. The sheep were slaughtered at a commercial abattoir using standard South African slaughter techniques for this species (Cloete *et al.*, 2004a,b). One day after slaughter the dressed carcasses were transported from the abattoir to a deboning facility, where they were kept for another 24 hours prior to deboning and sampling.

The following carcass measurements were taken (according to the procedures described in Cloete *et al.*, 2004b): Cold carcass weight, fat depth at the 13th rib 25 mm from the midline and between the 3rd and 4th lumbar vertebrae 25 mm from the midline, carcass length, leg circumferences, hind leg length and eye-muscle area.

After 48 hours in the cooler, the carcasses were partitioned into South African retail cuts, which were weighed separately. These cuts consisted of the neck, shoulder, chuck, flatrib, prime rib, loin and hindquarters (Hoffman, 2000; Cloete *et al.*, 2004b).

The pH of the *M. longissimus dorsi* from the right side of the carcass was measured between the 11th and 13th rib at three different times, namely 45 minutes, 24 hours and 48 hours after slaughter (Cloete *et al*, 2005). The pH meter was equipped with a thermometer that allowed automatic adjustment for the temperature, and was calibrated with standard buffers at pH 4.0 and pH 7.0. Recalibration was done after every 10 animals measured.

The left loin retail cut was removed and taken to the laboratory for the measurement of various physical meat-quality attributes. The *M. longissimus dorsi lumborum* was dissected from the 1st to the 6th lumbar vertebrae and used for the following analyses as described in Cloete *et al.* (2005): cooking loss, drip loss, colour and meat tenderness.

The right legs of five male lambs from each group born in 2001, were taken after being partitioned into retail cuts for the purpose of deboning and the removal of the *M. semimembrinosus* and attached subcutaneous fat. The *M. semimembrinosus* cuts were coded, vacuum packed, and stored at -18 °C until further analysis. The samples were defrosted for 48 h at a temperature of 3-4 °C, wrapped individually in cooking bags and placed on the rack of an open roasting pan. The samples were cooked at 160 °C in two electric Defy 835 ovens connected to a computerised electronic temperature control system to an internal temperature of 70 °C (AMSA, 1978). Immediately after cooking, all visible subcutaneous fat was removed. Six 1.5 cm cubed samples were taken from the middle of each sample and wrapped immediately in aluminium foil marked with random three-digit codes. The samples were placed in preheated glass ramekins in a preheated oven at 100 °C and evaluated within 10 min.

Descriptive sensory analyses were performed on the meat samples. Seven panel members were selected and trained in accordance with the guidelines of the American Meat Science Association (AMSA, 1978). A six-member panel evaluated the meat for the following sensory attributes: aroma intensity, initial impression of juiciness, sustained juiciness, tenderness and lamb flavour by means of an eight-point structured line scale (Jeremiah & Phillips, 2000). The definitions of the sensory attributes are provided in Table 1.

The panel members were seated in individual booths in a temperature-controlled and light-controlled room and received a set of six samples served in a completely randomised order. Crackers and distilled water were used to cleanse the palate between samples (AMSA, 1978). The shear force of the remainder of the cooked *M. semimembrinosus* sample was also measured with the Warner-Bratzler, as described previously by Cloete *et al.* (2005).

Table 1 Definition of attributes for descriptive sensory analyses

Attribute and scale	Definition
Aroma intensity 1 = Extremely bland; 8 = Extremely intense	Aroma associated with animal species
Initial juiciness 1 = Extremely dry; 8 = Extremely juicy	The amount of fluid exuded on the surface when pressed between fingers
Sustained juiciness 1 = Extremely dry; 8 = Extremely juicy	Degree/amount of water perceived during mastication
First bite tenderness 1 = Extremely tough; 8 = Extremely tender	Force needed to compress the sample of meat between molar teeth on the first bite
Lamb flavour 1 = Extremely bland; 8 = Extremely intense	Flavour associated with animal species

The loin retail cut from lambs born in 2001 were randomly removed and taken to the laboratory for the measurement of proximate chemical analysis. All the subcutaneous fat was removed before the meat samples were minced twice through a 2 mm screen, vacuum packed and stored at -18 °C for later chemical analysis. The proximate composition of the *M. longissimus dorsi* was done according to the AOAC (1997). The analysis included determinations of moisture, protein and ash. The protein concentration was determined by a FP-428 Nitrogen and Protein Determinator (Leco). Ashing was done at 500 °C for 5 h. The moisture content was determined by drying at 100 °C for 24 h. Lipid content was determined by solvent extraction according to the method of Lee *et al.* (1996)

Least square procedures were used to assess the data statistically, to allow for uneven subclasses. The ASREML statistical package (Gilmour *et al.,* 1999) was used for this purpose. The software allows estimation for variance components for random effects and prediction of least square means for fixed effects. Fixed effects that were considered in the analyses of carcass traits, retail cut weights and meat quality attributes were birth year, sex, birth type, and sire breed as well as two-factor interactions between main effects. Since interactions were not significant in the vast majority of cases, only relevant main effect means were tabulated. Interaction effects are also provided in cases where they were significant. In the analysis of meat and carcass traits, service sire within breed as well as permanent environmental effects of dams were fitted as random effects. Back pedigrees were not available on the dam side and were not considered for sires since no genetic ties were present across breeds.

Preliminary factorial analysis of variance, with session (four levels), panel member (identity of 7 members) and breed combination (as defined previously) was performed on the sensory data, using SAS version 8.12 (SAS, 1990). This analysis indicated that means were influenced by session and the identity of the panel member. Prior to the final analyses, the sensory scores were transformed to ranks. These ranks were adjusted for the effects of panel member and session prior to analyses. The analyses were rerun (SAS, 1990) to obtain adjusted rank means (and standard errors) depicting the effect of breed combination.

Results

The random effect of sire within breed group was generally not significant for the respective slaughter traits, and these effects are not presented. It was intended to slaughter all lambs at an approximate live weight of 45 kg but this objective was not reached. Lambs sired by IdF and ML rams were respectively 3.1 and 2.6 % heavier than purebred Dorpers at slaughter (43.4 ± 0.3 and 43.2 ± 0.4 vs. 42.1 ± 0.3 kg respectively; P < 0.05). Lambs sired by SAMM rams were of intermediate slaughter weight, and not different from either group at 42.7 ± 0.4 kg (P > 0.05). Lambs sired by IdF rams reached slaughter weight respectively 17 and 29 days earlier than SAMM crosses and purebred Dorpers (P < 0.05; Cloete *et al.*, 2006). Considering carcass components, the heads of purebred Dorper lambs were lighter (P < 0.05) than those of Idf and ML crossbred lambs (Table 2). The feet of purebred Dorper lambs were also lighter (P < 0.05) than those of the crossbred lambs. The feet of SAMM sired lambs were lighter than those of Idf and ML crossbred lambs (Table 2).

Table 2 Least squares means (± SE) depicting carcass traits and commercial retail cuts yields of Dorper and Dorper crossbred lambs

	Sire breed			
Trait	IdF (n = 78)	ML (n = 53)	SAMM (n = 70)	Dorper (n = 103)
Carcass characteristics:				
Head (kg)	1.96^{b}±0.02	1.97^{b}±0.02	1.93^{ab}±0.02	1.91^{ab}±0.01
Feet (kg)	0.91^{c}±0.01	0.93^{c}±0.01	0.88^{b}±0.01	0.84^{a}±0.01
Skin weight (kg)	3.16^{b}±0.06	3.08^{b}±0.08	3.07^{b}±0.07	2.79^{a}±0.05
Carcass length (cm)	73.9^{a}±0.5	76.3^{b}±0.5	74.5^{a}±0.5	74.5^{a}±0.4
Carcass depth (cm)	26.2^{a}±0.2	27.1^{bc}±0.2	26.7^{ab}±0.2	26.2^{a}±0.1
Carcass width (cm)	23.9^{c}±0.2	22.5^{a}±0.2	23.0^{b}±0.2	24.8^{c}±0.2
Leg length (cm)	29.9±0.2	31.1±0.2	30.4±0.2	29.1±0.2
Leg circumference 1 (cm)	40.1±0.3	39.6±0.3	40.6±0.3	40.0±0.2
Leg circumference 2 (cm)	25.1±0.2	25.2±0.3	25.4±0.2	25.3±0.2
Backfat depth (13^{th} rib) (mm)	1.68^{a}±0.16	1.62^{a}±0.18	1.76^{a}±0.18	2.16^{b}±0.13
Backfat depth (3^{rd} and 4^{th} lumbar) (mm)	2.22^{ab}±0.19	1.91^{a}±0.20	2.11^{a}±0.20	2.65^{b}±0.14
Retail cuts:				
Neck (kg)	0.77^{a}±0.01	0.86^{c}±0.02	0.81^{b}±0.02	0.82^{b}±0.01
Shoulder (kg)	0.88^{b}±0.01	0.88^{b}±0.02	0.86^{b}±0.02	0.81^{a}±0.01
Chuck (kg)	4.85±0.10	4.82±0.11	4.83±0.11	4.8±0.08
Flatrib (kg)	1.65±0.04	1.74±0.04	1.67±0.04	1.73±0.09
Prime rib (kg)	1.34±0.03	1.36±0.04	1.36±0.04	1.34±0.03
Loin (kg)	1.88±0.06	1.87±0.05	1.88±0.05	1.85±0.04
Hindquarter (kg)	5.46±0.11	5.54±0.12	5.52±0.11	5.53±0.08

[abc] Row means with different superscripts differ significantly (P < 0.05)

The same pattern was followed in skin weight, the skins of the lambs sired by wool breeds (Idf, ML and SAMM) being heavier (P < 0.05) than those of the hair breed (Dorper). Carcasses of ML sired lambs were longer (P < 0.05) than those of the other crossbred types and purebred Dorpers (Table 2). The carcass depth of the purebred Dorpers was less ($P < 0.05$) than those of crossbred lambs sired by ML rams. Lambs sired by ML and SAMM rams had narrower carcasses than Idf crossbred lambs and purebred Dorper lambs.

Table 3 Least squares means (± SE) depicting carcass traits and commercial retail cuts yields of the different sex, birth type and birth year classes of Dorper and Dorper crossbred lambs

	Sex		Birth type		Year	
Trait	Ram (n =158)	Ewe (n =146)	Singles (n =138)	Multiples (n =166)	2000 (n =145)	2001 (n =159)
Carcass characteristics:						
Head (kg)	$2.04^{b}\pm0.01$	$1.84^{a}\pm0.01$	$1.96^{b}\pm0.01$	$1.92^{a}\pm0.01$	$2.02^{b}\pm0.01$	$1.87^{a}\pm0.01$
Feet (kg)	$0.94^{b}\pm0.01$	$0.84^{a}\pm0.01$	$0.92^{b}\pm0.01$	$0.86^{a}\pm0.01$	0.89 ± 0.01	0.90 ± 0.01
Skin weight (kg)	3.00 ± 0.05	3.04 ± 0.04	3.08 ± 0.05	3.00 ± 0.04	$3.17^{b}\pm0.05$	$2.89^{a}\pm0.04$
Carcass length (cm)	74.9 ± 0.3	74.7 ± 0.3	$75.1^{b}\pm0.4$	$74.5^{a}\pm0.3$	75.1 ± 0.3	74.5 ± 0.3
Carcass depth (cm)	$26.8^{b}\pm0.1$	$26.4^{a}\pm0.1$	$28.7^{b}\pm0.1$	$26.3^{a}\pm0.1$	$26.7^{b}\pm0.1$	$26.4^{a}\pm0.1$
Carcass width (cm)	23.3 ± 0.1	23.3 ± 0.1	23.4 ± 0.2	23.2 ± 0.1	$23.8^{b}\pm0.1$	$22.8^{a}\pm0.1$
Leg length (cm)	$30.4^{b}\pm0.1$	$29.8^{a}\pm0.1$	30.2 ± 0.2	30.1 ± 0.1	30.2 ± 0.1	30.1 ± 0.1
Leg circumference 1 (cm)	40.1 ± 0.2	39.8 ± 0.2	$40.8^{b}\pm0.2$	$39.1^{a}\pm0.2$	$40.3^{b}\pm0.2$	$39.7^{a}\pm0.2$
Leg circumference 2 (cm)	$25.5^{b}\pm0.2$	$25.0^{a}\pm0.2$	$25.7^{b}\pm0.2$	$24.8^{b}\pm0.1$	25.3 ± 0.2	25.1 ± 0.1
Backfat depth (13th rib) (mm)	$1.45^{a}\pm0.11$	$2.16^{b}\pm0.11$	$1.94^{b}\pm0.13$	$1.67^{a}\pm0.10$	$2.10^{b}\pm0.12$	$1.51^{a}\pm0.11$
Backfat depth (3rd and 4th lumbar) (mm)	$1.94^{a}\pm0.13$	$2.51^{b}\pm0.12$	$2.38^{b}\pm0.14$	$2.07^{a}\pm0.12$	$2.58^{b}\pm0.14$	$1.87^{a}\pm0.12$
Retail cuts:						
Neck (kg)	$0.85^{b}\pm0.01$	$0.79^{a}\pm0.01$	$0.84^{b}\pm0.01$	$0.79^{a}\pm0.01$	$0.82^{b}\pm0.01$	$0.81^{b}\pm0.01$
Shoulder (kg)	$0.90^{b}\pm0.01$	$0.82^{a}\pm0.01$	$0.90^{b}\pm0.01$	$0.82^{a}\pm0.01$	$0.82^{a}\pm0.01$	$0.90^{b}\pm0.01$
Chuck (kg)	4.89 ± 0.68	4.76 ± 0.67	$5.10^{b}\pm0.75$	$4.55^{a}\pm0.66$	$5.02^{b}\pm0.72$	$4.64^{a}\pm0.61$
Flatrib (kg)	$1.67^{a}\pm0.03$	$1.73^{b}\pm0.03$	$1.79^{b}\pm0.03$	$1.61^{a}\pm0.03$	$1.76^{b}\pm0.03$	$1.64^{a}\pm0.03$
Prime rib (kg)	1.33 ± 0.02	1.37 ± 0.02	$1.42^{b}\pm0.02$	$1.29^{a}\pm0.02$	$1.42^{b}\pm0.02$	$1.28^{a}\pm0.02$
Loin (kg)	1.91 ± 0.03	1.84 ± 0.03	$2.00^{b}\pm0.04$	$1.75^{a}\pm0.03$	$2.09^{b}\pm0.03$	$1.65^{a}\pm0.03$
Hindquarter (kg)	5.50 ± 0.07	5.52 ± 0.07	$5.75^{b}\pm0.08$	$5.27^{a}\pm0.07$	$5.41^{a}\pm0.08$	$5.61^{a}\pm0.07$

[ab] Row means with different superscripts differ significantly ($P < 0.01$)

Purebred Dorper lambs had a thicker ($P < 0.05$) fat cover at the 13th rib, 25 mm from the midline (Table 2). Similar results were found at the site between the 3rd and 4th lumbar vertebrae 25 mm from the midline, but the differences between Idf sired lambs and purebred Dorpers were not significant in this instance.

The only differences ($P < 0.05$) in retail cut weights were in the neck and shoulder cuts. Idf crossbred lambs had the lightest and the ML crossbred lambs the heaviest neck retail cuts, with SAMM sired and purebred Dorper lambs being intermediate (Table 2). The shoulder retail cut weights of purebred Dorpers were significantly lighter than those from crossbred lambs ($P < 0.05$).

With a few exceptions, means for carcass traits and retail cut weights were higher ($P < 0.05$) for ram lambs than for ewe lambs (Table 3). The exceptions were the two measures of fat depth where means for ewes were higher than those of rams ($P < 0.05$). No sex difference was obtained for carcass width, leg circumference 1 (taken at the maximum circumference of a line passing over the distal end of the iliac wings of the pelvis and the most caudal point on the median line between the legs) and a number of retail cut weights. Significant differences ($P < 0.05$) between single and multiple lambs were generally in favour of singles, except for fat depth where carcasses of multiple lambs were leaner. Carcass traits and retail cut weights of lambs born in 2000 were generally superior to the 2001 progeny, but the latter group were leaner ($P < 0.01$) than the former.

Table 4 Least squares means (± SE) for the weight of primerib and loin depicting significant ($P<0.05$) interactions between sire line and lambing year

Variable and	Sire breed			
year	IdF	ML	SAMM	Dorper
Primerib:				
2000	1.36^{a}±0.05	1.38^{a}±0.05	1.47^{b}±0.05	1.46^{b}±0.04
2001	1.33^{a}±0.04	1.34^{a}±0.05	1.24^{b}±0.05	1.22^{b}±0.04
Loin:				
2000	2.22^{a}±0.07	2.01^{b}±0.08	2.24^{a}±0.07	2.09^{c}±0.05
2001	1.48^{a}±0.06	1.74^{b}±0.07	1.52^{a}±0.07	1.62^{c}±0.05

^{abc} Row means with different superscripts differ significantly ($P < 0.05$)

The primerib weights of Idf and ML crossbred lambs were higher ($P < 0.05$) than those of SAMM crosses and purebred Dorper lambs during 2000, and lower in 2001 (Table 4). The average loin weights of Idf and SAMM crossbred lambs were higher ($P < 0.05$) than those of lambs from ML and Dorper rams during 2000, while their loin weights were less in 2001.

Table 5 Least squares means (± SE) depicting the meat quality parameters of Dorper and Dorper crossbred lambs

	Sire breed			
Parameter	IdF	ML	SAMM	Dorper
pH_{45m}	6.68±0.03	6.73±0.04	6.74±0.04	6.68±0.03
pH_{24h}	5.59±0.02	5.58±0.03	5.55±0.02	5.54±0.04
pH_{48h}	5.51±0.02	5.51±0.02	5.47±0.02	5.45±0.01
Cooking loss %	27.4±0.6	27.6±0.6	28.6±0.7	28.3±0.7
Drip loss %	1.00±0.05	0.90±0.05	0.99±0.05	1.03±0.05
Tenderness (N) ($1^{\#}$)	133^{ab}±6	143^{b}± 6	122^{a}± 6	144^{b}±6
Tenderness (N) ($2^{\#}$)	56.9±4.0	52.6±4.0	56.9±4.0	55.0±4.5
Color L*	39.4±0.8	38.3±0.4	37.7±0.4	37.5±0.8
a*	13.2±0.4	13.5±0.4	13.8±0.4	13.6±0.4
b*	8.82±0.45	9.35±0.17	9.53±0.17	9.90±0.2
Hue	36.3±1.4	35.0±0.7	32.2±1.9	36.1±0.7
Chroma	15.9±0.8	16.4±0.4	16.7±0.4	16.8±0.4

^{ab} Row means with different superscripts differ significantly ($P < 0.05$)
$^{\#}1$ = measurement on the *M. longissimus dorsi lumborum*
$^{\#}2$ = measurement on the *M. semimembrinosus*

Meat from the *M. longissimus dorsi lumborum* of purebred Dorper and ML cross lambs had higher ($P < 0.05$) average shearing values (tenderness 1) than that of SAMM crossbred lambs (Table 5). The shear values of the cooked *M. semimembrinosus* (tenderness 2) did not differ between the different crosses and purebred Dorper lambs (Table 5). No sire breed differences were found in any of the other meat-quality parameters between the different crosses and purebred Dorper lambs.

Table 6 Least squares means (± SE) depicting meat-quality parameters of ram and ewe lambs, singles and multiples and birth years of 2000 or 2001 for Dorper and Dorper crossbred lambs

	Sex		Birth type		Year	
Parameter	Ram	Ewe	Singles	Multiples	2000	2001
pH_{45}	6.77^b±0.02	6.66^a± 0.02	6.74±0.03	6.70±0.02	6.56^a±0.03	6.88^b±0.02
pH_{24}	5.61^b±0.02	5.52^a± 0.02	5.59^b±0.02	5.55±0.02^a	5.61^b±0.02	5.52^a± 0.02
pH_{48}	5.50^b±0.01	5.47^a± 0.01	5.48±0.02	5.49±0.01	5.53^b±0.01	5.44^a±0.03
Cooking loss %	29.7^b±0.5	26.2^a±0.4	28.1±0.5	27.8±0.5	26.6^a±0.4	29.3^b± 0.5
Drip loss %	1.03^b±0.03	0.93^a±0.03	1.02±0.03	0.94±0.03	0.90^a±0.03	1.03^b±0.04
Tenderness (1) (N)	137 4	134 ± 4	130^c± 4	141^d±4	125^a±4	146^b± 4
Colour L*	39.6^b±0.3	37.5^a±0.3	38.6±0.3	38.5±0.3	40.1^b±0.3	37.0^a±0.3
A*	12.9^a±0.3	14.1^b±0.3	13.3±0.3	13.7±0.3	14.0^b±0.3	13.0^a± 0.3
B*	9.71±0.13	9.62±0.12	9.61±0.12	9.72±0.13	10.2^b±0.1	9.10^a±0.14
Hue	37.2^b±0.5	34.6^a±0.5	36.2±0.5	35.7±0.5	36.8^b±0.5	35.1^a± 0.5
Chroma	17.3±1.2	18.3±1.2	17.6^a±1.2	18.0^b±1.2	19.3±2.0	16.3 ± 0.6

[ab] Row means with different superscripts differ significantly (P < 0.05)

Values for pH, cooking loss, drip loss and lightness (L* value) were generally higher (P < 0.05) for ram carcasses than for ewe carcasses (Table 6). Meat from the ewes were situated more towards saturated red on the red-green scale (a* value; P < 0.01). The mean hue angle was affected accordingly. Birth type did not affect the measured meat quality parameters markedly, although meat produced by multiples was somewhat less tender than that of singles (P < 0.05). Trends observed for pH values appeared to differ between years. Initial pH values were higher (P < 0.01) during 2001 than in 2000. The reverse was true in pH values obtained at 24 hours and 48 hours post slaughter. Cooking loss and drip loss were generally higher (P < 0.05) in lambs born in 2001. The meat of the *M. longissimus dorsi lumborum* from lambs born during 2001 was less tender (P < 0.01) compared to 2000. Means for the colour parameters were generally higher (P < 0.05) in 2000 than in 2001.

Rank means for sensory quality characteristics of the *M. semimembrinosus* samples are presented in Table 7. Actual means are also provided for the interpretation of the results using the rating scale. There were no differences in sensory quality between purebred Dorper lambs and the Dorper crossbred lambs for any of the sensory attributes that were assessed.

Values for moisture, protein, lipid and ash did not differ between the different crosses and purebred Dorper lambs (Table 8). Meat from ewes had, on average, lower moisture contents and higher lipid contents than meat from rams (P < 0.05).

Table 7 Rank means with corresponding standard errors of the mean (actual means from preliminary analyses are given in parenthesis) for the sensory quality characteristics of *M. semimembrinosus* of Dorper and Dorper crossbred lambs born in 2001

Sensory characteristic	Sire breed				
	IdF	ML	SAMM	Dorper	SE mean
Aroma	2.54 (6.82)	2.61 (6.86)	2.32 (6.75)	2.54 (6.86)	0.38
Initial juiciness	2.25 (6.43)	2.59 (6.75)	2.57 (6.68)	2.59 (6.68)	0.42
Sustained juiciness	2.14 (6.25)	2.55 (6.50)	2.75 (6.68)	2.55 (6.50)	0.42
First Bite	2.29 (6.29)	2.43 (6.46)	2.64 (6.61)	2.64 (6.64)	0.44
Flavour	2.41 (6.68)	2.64 (6.79)	2.45 (6.68)	2.50 (6.75)	0.32

Table 8 Mean (± SE) proximate chemical composition of the 11/13th-rib cut (*M. longissimus dorsi*) of Dorper and Dorper crossbred lambs born in 2001

Trait	Breed				Sex	
	IdF (n = 16)	ML (n = 16)	SAMM (n = 16)	Dorper (n = 16)	Ram (n = 32)	Ewes (n = 32)
Moisture	73.2±0.4	72.6±0.4	73.0±0.4	72.9±0.4	73.4^a±0.3	72.5^b±0.3
Protein	22.7±0.3	23.4±0.3	23.2±0.3	22.8±0.3	22.7±0.2	23.4±0.2
Lipid	2.55±0.19	2.75±0.19	2.22±0.19	2.77±0.18	2.37^a±0.13	2.77^b±0.13
Ash	1.11±0.10	1.20±0.10	1.17±0.10	1.08±0.09	1.11±007	1.17±0.07

^{ab} Row means with different superscripts differ significantly ($P < 0.05$)

Discussion

Although the number of rams used per breed in this investigation was low and these results should thus be interpreted with due caution, the variation between sires within breed group was generally not significant. The sampling of sires within crossbred group thus does not appear to have influenced the outcomes of the study markedly and any differences could thus be attributed to breed and not to the sampling of sires within breeds. Further research is required to confirm or refute the present results, in view of the relatively small number of rams sampled from each breed.

The lighter skin weight of purebred Dorper lambs as compared to other crossbred lambs could be attributed to the hair cover on the skin instead of wool, as in the crossbred combinations.

According to Campher *et al.* (1998) the ML is a large frame sheep and this could explain why ML crossbred lambs had a longer average carcass length at the same live weight. The purebred Dorper is considered an early-maturing breed (Cloete *et al.,* 2000) and therefore tends to deposit fat at an earlier age. This could then be the reason why purebred Dorpers generally had a thicker average fat depth on the same live weight compared to the later maturing crossbred genotypes. Although purebred Dorper lambs were generally fatter than the crossbred genotypes, their fat cover of between two and three millimetres is still acceptable for the best grades in the South African meat industry. The bulk of the carcasses produced would therefore still have qualified for the best prices. Dorper lambs in this study were much leaner than lambs slaughtered by Webb and Casey (1995) at almost an identical slaughter weight. In the study of Snyman and Olivier (2002), purebred Dorper lambs were slaughtered at eight to nine months, at a live weight of approximately 40 kg. The average fat depth between the 3rd and 4th lumbar vertebrae in their study was, however, substantially thicker, and averaged between 5.6 and 5.8 mm.

Gender influences in the present study are consistent with trends generally found in the literature, with ewe carcasses being fatter with a higher dressing percentage (Cloete *et al.,* 2004). Rams were also reported to have higher weights of neck and shoulder retail cuts in the study of Jeremiah *et al.* (1997). The observed lower fat depth means in multiples were consistent with the study of Greeff *et al.* (2003), using data of 829 Merino ram hoggets. Values for pH and colour measurements in the latter study were unaffected by birth type, thus in accordance with the general trend found in the present study. During 2000, lambs were slaughtered at an average age of 251 days compared to 169 days in 2001, as dictated by the poorer growth conditions in the former year (Cloete *et al.,* 2006). The difference in slaughter age could account for differences in fat depths between years. The 2000 lambs were stressed (nutrition wise) in the earlier phase of their growth, when insufficient feed was available. They subsequently showed compensatory growth that resulted in a higher level of fat deposition. Subcutaneous fat depth also increased with an increase in age, as was suggested by Lawrie (1998). This compensatory growth (in fat deposition), differs between physiological maturity at any given time and may account for the interaction between sire breed and year noted in the prime rib and loin retail cuts (Table 4) where the early maturing Dorper also had the fatter (Table 2) and heavier cuts in 2000.

The *M. longissimus dorsi lumborum* meat produced by purebred Dorper lambs and ML crossbred lambs had a higher shearing value than muscles of SAMM sired crossbred lambs. This trend was, however, neither supported by the taste panel assessment of tenderness, nor by the objective measurement of cooked meat samples of the *M. semimembrinosus*. Young and Dobbie (1994) compared intermuscular collagen content of purebred Romney lambs and lambs sired by a terminal sire breed (the Texel). They demonstrated that there was no effect of breed on the collagen content between ages of 100 – 215 days. This result suggests that use of terminal sires will have little effect on tenderness of lamb meat, as was experienced by the taste panel. In correspondence with the results from the present study, Hoffman *et al.* (2003) found no differences in cooking loss and drip loss between lambs from different crosses involving Merino ewe lines crossed to either Dormer or Suffolk rams. Greeff *et al.* (2003) reported limited genetic variation for meat pH and the respective colour measurements. These results are consistent with the lack of breed differences in the present study for these traits. Purchas *et al.* (2001) found no differences in meat pH between lambs sired by different sires used on Romney ewes. This finding accorded with the current study, where there were also no differences in pH between the different crosses and purebred Dorper lambs.

It has to be conceded that the number of samples assessed by the taste panel and in the evaluation of tenderness of cooked *M. semimembrinosus* samples was relatively small, while relatively few sires contributed data to these analyses. The meat samples were also obtained from progeny born in 2001, when the different crosses were evaluated at a younger age. Further research is thus needed to elucidate the effect of these breeds on meat tenderness at higher slaughter ages. None of the sensory attributes of lamb differed between the breed combinations. This outcome is consistent with the results of Hoffman *et al.* (2003) where it was found that neither dam breed (Merino, Dohne Merino or SAMM) or sire breed (Dormer or Suffolk) affected sensory meat attributes of lambs in a terminal crossbreeding experiment.

The meat samples used for proximate analysis were obtained from progeny born in 2001, when the different crosses were leaner and slaughtered at a younger age. With reference to the gender difference in fatness, Teixeira *et al.* (1996) stated that ewes were fatter than rams of the same age. Similar results were noted in this study, regarding the proximate chemical analysis of the *M. longissimus dorsi* (Table 8). Ram carcasses contained a correspondingly higher percentage of moisture in the *M. longissimus dorsi* than ewe carcasses, which agrees with the results of Kemp *et al.* (1976).

Conclusion

Terminal crossbreeding of Dorper dams with Idf, ML or SAMM rams did not have any adverse effect on meat quality, carcass or sensory attributes of lamb produced in this way. Differences that were found were mostly in favour of the crossbred genotypes, i.e. a reduced fat depth in all crossbred genotypes and lower shearing values of the *M. longissimus dorsi* in SAMM sired lambs. It has to be conceded that environmental conditions during the trial did not sustain the early deposition of adipose tissue. The full potential of crossbreeding Dorper ewes with late-maturing leaner breeds was thus possibly not realised. It thus seems that terminal crossbreeding is likely to enhance slaughter attributes in lambs, with no evidence of traits of economic importance being compromised in any way. The benefits will probably be more pronounced under more favourable environmental conditions. Further work is required for the confirmation of this argument.

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References

AMSA, 1978. Guidelines for cookery and sensory evaluation of meat. American Meat Science Association, National Livestock and Meat board, Chicago, IL.

AOAC, 1997. Official methods of analysis of the Association of Official Analytic Chemists (16th ed.) Arlinton, Virginia, USA, AOAC International.

Campher, J.P., Hunlun, C. & Van Zyl, G.J., 1998. South African Livestock Breeding. South African Stud Book and Livestock Improvement Association. PO Box 270. Bloemfontein 9300, South Africa.

Cloete, J.J.E., Cloete, S.W.P. & Hoffman, L.C., 2005. Behaviour of Merinos divergently selected for multiple rearing ability in response to external stimuli. Small Rumin. Res. 60, 227-236.

Cloete, J.J.E., Cloete, S.W.P., Hoffman, L.C. & Fourie, J.E., 2004a. Slaughter traits of Merino sheep divergently selected for multiple rearing ability. S. Afr. J. Anim. Sci. 34, 189-196.

Cloete, J.J.E., Cloete, S.W.P., Olivier, J.J. & Hoffman, L.C., 2006. Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Ewe production and lamb performance. Small Rumin. Res., in press.

Cloete, J.J.E., Hoffman, L.C., Cloete, S.W.P. & Fourie, J.E., 2004b. A comparison between the body composition, carcass characteristics and retail cuts of South African Mutton Merino and Dormer sheep. S. Afr. J. Anim. Sci. 34, 44-51.

Cloete, S.W.P., Snyman, M.A. & Herselman, M.J, 2000. Productive performance of Dorper sheep. Small Rumin. Res. 36, 119-135.

Gilmour, A.R., Cullis, B.R., Welham, S.J. & Thompson, R., 1999. ASREML – Reference manual. NSW Agricultural Biometric Bulletin No. 3. NSW Agriculture, Orange Agricultural Institute, Forest Road, Orange 2800, NSW, Australia.

Gilmour, A.R., Luff, A.F., Fogarty, N.M. & Banks, R., 1994. Genetic parameters for ultrasound fat depth eye muscle measurements in live Poll Dorset sheep. Aust. J. Agric. Res. 45, 1281-1291.

Greeff, J.C., Davidson, R.N & Skerritt, J.W., 2003. Genetic relationship between carcass quality and wool production traits in Australian Merino rams. Proc. Assoc. Advmnt. Anim. Breed. Gen. 15, 330-333.

Hoffman, L.C., 2000. The yield and carcass chemical composition of impala (*Aepyceros melampus*), a southern African antelope species. J. Sci. Food Agric. 80, 752-756.

Hoffman, L.C., Muller, M.M., Cloete S.W.P. & Schmidt, D., 2003. Comparison of six crossbred lamb types: sensory, physical and nutritional meat quality characteristics. Meat Sci. 65, 1265-1274.

Jeremiah, L.E. & Phillips, D.M., 2000. Evaluation of a probe for predicting beef tenderness. Meat Sci. 55, 493-502.

Jeremiah, L.E., Jones, S.D.M., Tong, A.K.W., Robertson, W.M. & Gibson, L.L., 1997. The influence of chronological age, slaughter weight and gender on yield and cutability. Int. Sheep & Goat Res. J. 13, 39-46.

Kemp, J.D., Johnson, A.E., Stewart, D.F., Ely, D.G.& Fox, J.D., 1976. Effect of dietary protein, slaughter weight and sex on carcass composition, organoleptic properties and cooking losses of lamb. J. Anim. Sci. 42, 575-583.

Lawrie, R.A., 1998. Lawrie's Meat Science. 6th ed. Woodhead Publ. Ltd. Cambridge, England.

Lee, C.M., Trevino, B. & Chaiyawat, M., 1996. A simple and rapid solvent extration method for determining total lipids in fish tissue. J. Assoc. Off. Agr. Chem. Intern. 79, 487-492.

Low, A.B. & Rebelo, A.G., 1996. Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria, South Africa.

Purchas, R.W., Silva Sobrinho, A.G., Garrick, D.J. & Lowe, K.I., 2001. Effects of age at slaughter and sire genotype on fatness, muscularity, and the quality of meat from ram lambs born to Romney ewes. N. Z. J. Agric. Res. 45, 77-86.

SAS., 1990. SAS/STAT User's guide, Version 6 (4th ed.). Cary, NC: SAS Institute Inc.

Schoeman, S.J., 2000. A comparative assessment of Dorper sheep in different production environments and systems. Small Rumin. Res. 36, 137-146.

Snyman, M.A. & Olivier, W.J., 2002. Productive performance of hair and wool type Dorper sheep under extensive conditions. Small Rumin. Res. 45, 17-23.

Teixeira, A., Delfa, R. &Treacher, T., 1996. Carcass composition and body fat depots of Galego Bragnançano and crossbred lambs by Suffolk and Merino Precoce sire breeds. Anim. Sci. 63, 389-394.

Webb, E.C. & Casey, N.H., 1995. Genetic differences in fatty acid composition of subcutaneous adipose tissue in Dorper and SA Mutton Merino wethers at different live weights. Small Rumin. Res. 18, 80-88.

Young O.A. & Dobbie, J.L., 1994. Characteristics of intermuscular collagen. N. Z. J. Agric. Res. 37, 97-105.

Chapter 11

Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Ewe production and efficiency

Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Ewe production and efficiency

Abstract

The effect of crossing Dorper ewes with Ile de France (IdF), Merino Landsheep (ML) and SA Mutton Merino (SAMM) rams in a terminal crossbreeding program was investigated for effects on the economic output of ewes subjected to the respective regimes discuss in Chapter 9. Data obtained from the study in Chapter 9 were entered into the SM2000 economic simulation model to assess the economic output of the respective breed combinations. No real differences were found for income per small stock unit between the different crossbred combinations and purebred Dorper lambs. Terminal crossbreeding could thus be implemented in commercial Dorper flocks, without compromising productivity and/or product quality.

Keywords: Dressing percentage, fat depth, lamb output, reproduction, weaning weight

Introduction

The Dorper is a composite breed derived in South Africa from a cross between the Dorset Horn and the Blackheaded Persian, and is the second largest sheep breed in South Africa at present. Dorper sheep are regarded as early-maturing and therefore tend to put on fat at a relatively early age (Cloete *et al.*, 2005). Since Webb & Casey (1995) reported that the subcutaneous fat cover of Dorper wethers were about double that of South African Mutton Merino (SAMM) wethers at the same age, it was hypothesised that it may be economically viable to use Dorper ewes in a terminal crossbreeding program with leaner terminal sire breeds (Cloete *et al.*, 2005). Production parameters of ewes subjected to these crosses were reported by the latter literature source.

Qualitative and quantitative components contributing to overall lamb output of Dorper ewes crossed with Ile de France (IdF), Merino Landsheep (ML) and South African Mutton Merino (SAMM) rams and purebred Dorpers as control was obtained from the study of Cloete *et al.* (2005), and entered into an economic simulation model, to get an indication of the relative economic yield expected from terminal crossbreeding as well as a purebred system based on Dorpers only.

Materials and Methods

The experiment was carried out on the Nortier experimental farm in the West Coast Strandveld area of the Western Cape, as described by Cloete *et al.* (2005). Production parameters from the former studies were tabulated here, to provide readers with an indication of the relative performance of the respective genotypes. Since these results were discussed in detail in the previous paper, no detailed discussion are included, the results are purely presented for reference purposes.

Data obtained from the former study were entered into the SM2000 economic simulation model (Herselman, 2002). Information on the details required by SM2000 for an economic simulation is provided in the latter literature source. In the simulation, live weight and growth rates were used as an indication of the energy requirements of ewes and lambs (ARC, 1980). Energy requirements were used for calculation of small stock units (SSU), where 1 SSU is equivalent to 11.25 MJ ME/day. In order to provide an outcome, average meat prices (2005) were considered for each carcass classification group (Table 5).

Results and Discussion

Production parameters from the genotypes involved and discussed by Cloete *et al.* (2005) are provided in Tables 1 to 4 respectively.

Table 1 Sire breed means for lamb birth weight, weaning weight at an average weaning age and survival (standardise – survival or mortality) prior to weaning as corrected for the environmental effects of birth year, sex and birth type

Fixed effect	Birth weight (kg)	Weaning weight (kg)	Lamb mortality
Sire breed:			
Ile de France	4.6	34.5	0.18
Merino Landsheep	4.4	32.9	0.22
SA Mutton Merino	4.2	31.1	0.22
Dorper	4.1	31.3	0.24

It was evident that performance in the group of ewes joined to ML sires was inferior to that of those ewes joined to IdF and Dorper sires (Cloete *et al.*, 2005; Table 2), while the difference between the ewes joined to ML rams and those joined to SAMM rams also approached significance. This result was mainly caused by an inferior lambing rate in ewes joined to a specific ML ram during 2000. Since these results were possibly coincidental, it was decided to conduct two sets of analyses. Firstly reproduction figures derived in the study of Cloete *et al.* (2005) were used, and secondly an average lambing rate per ewe mated of 130 lambs born per 100 ewes mated was considered,

Table 2 Lambing rate of ewes in the terminal crossbreeding study, as affected by the breed of the service sire

Breed of sire	Number of ewes mated	Ewes lambed per ewe mated
Ile de France	111	0.72
Merino Landsheep	110	0.50
SA Mutton Merino	101	0.68
Dorper	170	0.75

Number of lambs born and number of lambs weaned per ewe lambed were not influenced by the breed of the service sire (Table 3). When weight of lamb weaned per ewe lambed was considered, there was some evidence of higher lamb outputs in ewes joined to IdF and SAMM sires (Cloete *et al.*, 2005). Purebred Dorper lambs or ewes did not outperform crossbred progeny for any of the traits that were considered, although it could have been reasoned that they were supposedly better adapted to the arid conditions experienced in the study reported by Cloete *et al.* (2005). The intention to slaughter all lambs at an approximate live weight of 43 kg was not reached, and some evidence of variation in slaughter weight was evident (Cloete *et al.*, 2005; Table 3).

Table 3 Sire breed means for ewe joining weight and reproduction corrected for production year. All reproduction traits were expressed in relation to ewes that lambed

Effect	Ewe joining weight (kg)	Number of lambs born	Number of lambs weaned	Weight of lamb weaned (kg)
Sire breed				
Ile de France	63.5	1.50	1.22	45.9
Merino Landsheep	64.0	1.42	1.11	40.4
SA Mutton Merino	63.7	1.59	1.29	43.0
Dorper	62.9	1.49	1.12	38.4

Lambs sired by IdF rams were generally slaughtered earlier than SAMM crosses and purebred Dorpers (Cloete *et al.*, 2005; Table 4). This led to a slightly shorter production cycle in this combination. The importance of a shorter production cycle on the number of breeding ewes maintained is highlighted by Olivier *et al.* (1999).

The study of Cloete *et al.* (2005) found that purebred Dorper lambs had a thicker fat cover than all crossbred combinations at the 13th rib, 25 mm from the midline (Table 4). Similar results were found at the site between the 3rd and 4th lumbar vertebra, 25 mm from the midline. The Dorper being an early-maturing breed (Cloete *et al.*, 2000) it is understandable that the purebred Dorpers had a thicker average fat depth on the same live weight as compared to crossbred lambs. Despite these significant differences, a fat cover of between two and three millimetre is still acceptable for the best grades in the South African meat industry. No penalty for excessive fat deposition was thus incurred under the conditions of the present study (Cloete *et al.*, 2005). Although this result is in contrast with most literature sources cited by the latter study, it reflected the outcome of the study. Further research is thus indicated to determine conditions under which possible monetary advantages could be derived from the crossing of Dorper ewes with leaner specialist terminal sire breeds.

Table 4 Sire breed means for slaughter age, dressing percentage and fat depth

Effect	Slaughter age (days)	Dressing %	Backfat depth at the 13th rib (mm)	Backfat depth between the 3rd and 4th lumbar vertebra (mm)
Sire breed				
Ile de France	195	40.5	1.68	2.22
Merino Landsheep	209	40.7	1.62	1.91
SA Mutton Merino	212	40.9	1.76	2.11
Dorper	224	41.6	2.16	2.65

In Table 5 average meat prices (for 2005) are provided for lambs according to their grading. The percentage of carcasses from each breed combination is also provided. This was needed to calculate an average meat price for each sire breed group for usage in the economical analysis. Although the fat cover of the Dorper lambs were generally higher than that of the other breed combinations, the fat cover of Dorper carcasses was not sufficiently high to compromise the average price per kilogram used in the economical analysis, as was also stated previously.

Table 5 Grading of lamb carcasses of the respective breed combinations, as well as meat prices used in the economical analysis

		Ram line (% of lambs in each grading group)			
Grading	Price/kg	Ile de France	Merino Landsheep	SA Mutton Merino	Dorper
A0	R19.00	20	21	24	16
A1	R22.00	13	12	11	12
A2	R23.50	67	65	59	60
A3	R23.50	0	2	6	10
A4	R22.00	0	0	0	1
A5	R21.00	0	0	0	1
Average price per kg used in analysis		R22.41	R22.38	R22.26	R22.56

When considering the income as simulated by SM2000 (Herselman, 2002), the crossing of ML rams to Dorper ewes resulted in the lowest income per ewe in absolute terms when considering the actual lambing percentages realised (Table 2). This result can be ascribed to the fact that ewes mated to a specific ML ram had a markedly lower lambing rate than those in the other crossbred combinations, as was stated previously.

When considering a fixed lambing percentage of 130% for all the breed combinations no real differences were found in ewe income. There were correspondingly no differences in income per small stock unit. Dorper lambs did not reach the high fat levels reported in previous studies (Webb & Casey, 1995) in the present study. Moreover, the South African meat industry discriminated more against very lean meat (A0 grade) than against fatter meat (A5 grade) (Table 5). These results contributed to a slightly higher average meat price for purebred Dorper lambs, while no marked differences were attained in the overall economic yield of ewes subjected to the respective regimes.

Table 6 Simulated income figures derived for the respective breed combinations, as well as for purebred Dorper ewes

	Ram Line			
	Ile de France	Merino Landsheep	SA Mutton Merino	Dorper
Income per ewe with different lambing %	R525.27	R488.86	R528.42	R501.33
Income per ewe with fixed lambing % (130%)	R509.45	R495.58	R489.03	R489.00
Gross income per ewe	R292.55	R287.07	R289.29	R283.56
Income/small stock unit	R288.41	R289.03	R279.08	R280.20

Conclusions

Despite some significant variation in production traits that could be contributed to breed combination (Cloete *et al.*, 2005), these differences could not be extended to economic advantages under the prevailing conditions experienced in the present study. Although it was the first study of this nature, a number of limitations should be noted. Firstly, it has to be conceded that the number of rams used to represent a genotype was low, since the experiment had to be conducted within constraints imposed by the available animals and finances. The ewe resource flock, as well as the sires sampled to represent each of the terminal sire breeds, could also not be quantified adequately, as recommended by Fogarty (2006). Compared to results obtained from the National South African Dorper flock as described by Olivier & Cloete (2006), most production parameters reported in this study were quite favourable. The study therefore involved a first step in the better quantification of the available resources available to commercial producers, and need to be followed by better designed studies not suffering from the same constraints. On the positive side, it was evident that terminal crossbreeding could be implemented in commercial Dorper flocks, without compromising productivity and/or product quality.

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References

ARC, 1980. The nutrient requirements of farm livestock. No 2: Ruminants. Agricultural Research Council, Commonwealth Agricultural Bureaux, London.

Cloete, J.J.E., Cloete, S.W.P, Olivier, J.J. & Hoffman, L.C., 2005. Terminal crossbreeding of Dorper ewes to Ile de France, Merino Landsheep and SA Mutton Merino sires: Ewe production and lamb performance. Small Rumin. Res. doi:10.1016/j.smallrumres.2005.12.005.

Cloete, S. W. P., Snyman, M.A. & Herselman, M.J., 2000. Productive performance of Dorper sheep. Small Rumin. Res. 36, 119-135.

Fogarty, N.M., 2006. Utilization of breed resources for sheep production. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 04-10.

Herselman, M.J., 2002. The role of simulation models in agricultural extension. Proc. 1st Joint Cong. Grassl. Soc. S Afr. Soc. Anim. Sci., 13-16 May 2002, Christiana Aventura, pp 46a-46c.

Olivier, J.J., Bezuidenhout, A. G., Greyling, A. C. & Cloete, S.W.P., 1999. Evaluation of genetic fine and strong X fine wool Merinos on irrigated pasture. Proceedings of the Association for the Advancement of Animal Breeding and Genetics. 13, 62-65.

Olivier, J.J. & Cloete, S.W.P., 2006. Genetic analysis of the South African Dorper sheep. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 04-10.

Webb, E.C. & Casey, N.H., 1995. Genetic differences in fatty acid composition of subcutaneous adipose tissue in Dorper and SA Mutton Merino wethers at different live weights. Small Rumin. Res. 18, 81-88.

Chapter 12

General Conclusions

Individual chapters included in this thesis already carry conclusions. This chapter therefore summarizes the objectives and outcomes generated in this study. It will also provide readers with suggestions regarding the future management of the South African small stock genetic resource.

Part 1: Comparison of breeds

The fact that early maturing breeds, (Dormer) are fatter at the same age than late maturing breeds (South African Mutton Merino) was highlighted in Chapter 2. Meat sensory evaluation indicated that meat from late maturing Merino sheep had lower scores for juiciness, which is related to their lower fat cover, although there were no differences in flavour. Further studies are necessary to see whether there are differences in cooking loss, drip loss and sensory evaluation if the carcasses of these four breeds had the same fat content at a younger age and not at 18 months of age. From Chapter 3 it was evident that the dual-purpose Dohne Merino and South African Mutton Merino (SAMM) outperformed Merinos as far as lamb output was concerned. However, Merinos outperformed the other two breeds with regard to wool production traits and were generally the most profitable when modeled under a range of wool and meat prices. However, it must be remembered that the literature has indicated that economic differences between individuals within breed often surpass differences between breeds (Fogarty, 2006). A breeding program for maximum economic gains is expected to make use of both the available variation between breeds and that within breeds.

Chapter 4 reviewed production traits for three divergent livestock breeds (Merino, Dorper and Boer Goats) in an extensive environment with limited nutritional resources. The average levels of performance of the animals were acceptable, and consistent with the objectives strived for. The populations used were relatively small and not well defined relative to overall population means as derived from industry flocks (Fogarty, 2006). The obtained results will thus not necessarily be robust across a variety of environments. However, results of the economic evaluation in the present study are in accordance with those of Snyman & Herselman (2005) as far as the comparison between Dorpers and Merinos is concerend. Further studies on larger and better defined populations are required to confirm or refute tendencies noted in the present study.

It is conceded that the numbers of animals used in Part 1 of the thesis is not high. However, given the scarcity of corresponding results on local breeds, the study contributed to a better definition of the South African small stock genetic resource. Research on South African small stock breeds should continue. If it is considered that South African small stock breeds are exported throughout the world, a better characterization of the resource is imperative for the maintenance and possible future expansion of this lucrative export market.

Part 2: Assessment of Merino and Merino type ewe breeds as terminal dam lines

Although the number of rams used per breed in this investigation was low and those results that were obtained should thus be interpreted with due caution, the variation between sires within breed group was generally not significant. The sampling of sires within crossbred group apparently did not influence the outcomes of the study markedly. Results pertaining to breed differences could thus be attributed to breed and not to the sampling of sires between breeds (Chapter 5 – 7).

From Chapter 5 it was evident that SAMM cross and Dohne Merino ewes performed at least as well as purebred SAMM ewes with regard to lamb output in the terminal crossbreeding situation, while they had a clear advantage in terms of wool production. Advantages in wool weight and wool quality resulted in Dohne Merino ewes being more efficient in economic terms than SAMM ewes (Schoeman, 1990). The same reasoning applies to Rep+ Merino ewes. It has to be conceded that the slower growth of progeny from Merino ewes may increase the risk involved in a crossbreeding program based on such ewes under conditions where a seasonal short supply of nutrients is expected. Terminal crossbreeding of five Merino-type ewe lines did not have serious adverse effects on the meat quality and retail cut weights of the lamb produced. The utilization of heterosis in terminal crossbreeding systems with specialist meat breeds thus seems to be a viable proposition in South Africa, as is experienced elsewhere in the world (Fogarty, 2006). Part of the adaptability of a terminal crossbreeding system is the opportunity to maintain only the ewe breeding flock over a period of nutritional short supply. The slower growth by progeny of both Merino lines that were included in the study may make a system based on such ewes more risky. This element of risk will be compensated for by additional security in terms of a higher and more stable wool income from such dams during periods when the wool price is high. The combination of relatively small ewe size with acceptable reproduction and high levels of fibre production resulted in the Merino types being extremely competitive in terms of economic yield when assessed as terminal crossbreeding dams.

Further research on the establishment of specialist terminal dam lines in terms of meat production is indicated, since it appears to be one of the avenues available for commercial sheep producers to enhance flock efficiency at a limited cost, while exploiting the advantages of heterosis and sexual dimorphism. Up to now, no attention has been given to this possibility in the local small stock industry. Elsewhere this principle is well established. In Australia, there is a formal Maternal Sire Central Progeny Test (MCPT) for the evaluation of sires from several maternal breeds (Fogarty *et al.*, 2006). Results suggest that there is considerable variation in the economic efficiency of daughters of sires in the MCPT within breeds (Fogarty, 2006). Such variation in the South African small stock genetic resource has so far not even been considered, let alone being exploited. The system in the United Kingdom where hill breeds are used to provide dams for terminal crossing in high productivity lowland farming systems is also a prime example of the optimal utilization of ovine genetic resources (Conington *et al.*, 2006).

Chapter 8 indicated that crossbred lambs (progeny of Dormer, Ile de France, Merino Landsheep, Suffolk and Dorper rams mated to Merino ewes) reached slaughter weight at an earlier age than purebred Merino lambs. No conclusive advantages in favour of any of the terminal sire breeds on Merino ewes were obtained as far as growth and objectively measured meat quality traits are concerned. These breeds thus all seem to be acceptable as terminal crossbreeding sires on Merino dams.

However, it needs to be stated that decision-making on sire breed for crossbreeding was mainly based on factors such as the availability of rams, and considerations like the probability of contamination with coloured fibres in the case of the Suffolk and Dorper breeds (Erasmus *et al.*, 1983). Ideally more scientific methods should be used, including breeding values from breed analyses on the available sire breeds. Breed analyses are available for major South African terminal sire breeds like the Dormer, Ile de France and the Merino Landsheep (Olivier *et al.*, 2004). The Dorper is the second largest breed in South Africa, and has been subjected to comprehensive breed analyses (Olivier *et al.*, 2004; Olivier & Cloete, 2006). Breeding values for usage in the terminal crossbreeding situation should readily be obtained from these analyses. Future efforts should seek to combine information derived from breed analyses on potential terminal sire breeds with information on potential dam breeds in the National South African Small Stock Improvement Scheme (NSIS).

The good performance of Merino ewes in economic terms as portrayed in Parts 1 and 2 requires further comment. The relatively low live weight of ewes and progeny of this breed contributed to this outcome, together with good levels of reproduction and very efficient fibre production. It has been alleged that this result is misleading, since it implies that the same resource should be able to sustain more Merino ewes compared to the heavier dual-purpose genotypes. Support for arguments that this is indeed the case stems from research of Nolte & Ferreira (2004), where it was demonstrated that the nutrient intake of Dohne Merino and Merino wethers were similar when expressed per unit metabolic weight. The only breed difference was for nitrogen retention, where Merino wethers performed slightly better than Dohne Merinos. In another study it was demonstrated that sheep with higher breeding values for live weight consumed more feed to sustain their heavier live weights, and that they were not more efficient in their utilisation of nutrients (Kuselo, 2005). Therefore, although the feed efficiency of ewes from the respective breeds has not been studied explicitly, the assumption that heavier ewes consume more of the available resource seems to be reasonable. As part of this reasoning it should also be stated that Roux (1992) considered the improvement of efficiency of female breeding animals as very difficult, if not impossible to attain.

Part 3: Importance of carcass quality using leaner sire breeds on early maturing Dorper ewes

In Chapter 9 – 11 the use of early maturing Dorper ewes in a crossbreeding trial was discussed. Ewe reproduction and lamb performance were not compromised by the crossing of Dorper ewes with Ile de France, Merino Landsheep or South African Mutton Merino rams. Terminal crossbreeding with these sire breeds accordingly did not have any adverse effect on meat quality, carcass or sensory attributes of lamb produced in this way. Differences that were found were mostly in favour of the crossbred genotypes, i.e. a reduced fat depth in all crossbred genotypes and lower shearing values of the *M. longissimus dorsi* in South African Mutton Merino sired lambs. It has to be conceded that environmental conditions during the trial did not sustain the early deposition of adipose tissue. The full potential of crossbreeding Dorper ewes with late-maturing leaner breeds was thus probably not fully realised. However, the lack of differences between Ile de

France, Merino Landsheep or South African Mutton Merino rams with regard to the lambing rate of ewes indicates that acceptable conception rates are possible when Dorper ewes are joined to other breeds. The outcome from this study also indicates that terminal crossbreeding of Dorper ewes with leaner specialist mutton breeds may become a viable proposition for commercial Dorper producers. Although it was the first study of this nature, a number of limitations should be noted. Firstly, it has to be conceded that the number of rams used to represent a genotype was low, since the experiment had to be conducted within constraints imposed by the available animals and finances. The ewe source flock, as well as the sires sampled to represent each of the terminal sire breeds, could also not be quantified adequately, as was recommended by Fogarty (2006). Compared to results obtained from the National South African Dorper flock as described by Olivier & Cloete (2006), most production parameters reported in this study were according to expectations. The study therefore involved a first step in the better quantification of the available resources available to commercial producers, and needs to be followed by more comprehensive studies not suffering from the same constraints. On the positive side, it was evident that terminal crossbreeding could be implemented in commercial Dorper flocks, without compromising productivity and/or product quality.

Recommendations

In South Africa the genetic evaluation program for slaughter lamb production is not well structured for the exploitation of heterosis and sexual dimorphism involving specialist sire and dam breeds. The NSIS provides good infrastructure for the recording and evaluation of all the major small stock breeds. Marked progress was also made pertaining to within breed analyses (Olivier *et al.*, 2004; Olivier & Cloete, 2006; Van Wyk *et al.*, 2006). However, so far no effort has been made to differentiate the local breeds according to possible usage as terminal sire or dam breeds, although the basic framework for such differentiation exists within the NSIS. In theory, many of the available dual-purpose breeds with high ewe numbers may play an important role as maternal dam breeds. Research to differentiate the local small stock resource and to structure the industry should thus continue.

It is therefore recommended that part of the ovine genetic resource available for research should be devoted to designed studies for the assessment of various managerial systems involving pure breeding as well as crossbreeding. All major ewe breeds available in the South African ovine genetic resource (Merino, Dorper, Dohne Merino and SA Mutton Merino) should form part of this research. Various options for terminal and maternal crossbreeding should be included in projects conducted within the constraints of the available monetary and animal resources. The design of the proposed research projects should be based on the extremely encouraging outcomes of the present study.

It is anticipated that the increased knowledge base stemming from the proposed future research projects will encourage seed stock breeders and slaughter lamb producers to work closer together to utilise the available commercial ovine genetic resources in an optimal way. Such a step will represent a major adaptation for the local small stock industry. Since such a restructuring will represent a bold step all roleplayers may not necessarily identify with the challenges that will follow, as is often found in times of structural change. Therefore, the proposed research projects demonstrating the anticipated benefits of a restructured industry are of paramount importance, and should receive a high priority. Care should be taken to ensure that animal resources used for experimental purposes are adequately benchmarked against industry standards, using breeding values derived from NSIS breed analyses (Fogarty, 2006).

References

Conington, J., Lambe, N., Bűnger, L., McLean, K., Bishop, S. & Simm, G., 2006. Evaluation of responses to multi-trait selection indexes and genetic parameters for computer-tomography derived carcass traits in UK hill sheep. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 04-19.

Erasmus, L.S., De Kock, J.A. & Grobler, J.W., 1983. Slaglamproduksie in die Suid-Kaap. Els. J. 7:13-32.

Fogarty, N.M., 2006. Utilization of breed resources for sheep production. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 04-10.

Fogarty, N.M., Ingham, V. M., McLeod, L., Gaunt, G. M. & Cummins, L. J. 2006. Genetic resources to increase the profitability of crossbred lamb production. Aus. J. Exp Agric. 46, 799–802

Kuselo, M.M., 2005. Feed intake and digestibility of sheep with varying estimated breeding values for mature body weight. Research report of the Grootfontein Agricultural Development Institute, September 2005. Department of Agriculture, Republic of South Africa.

Nolte, J.van E. & Ferreira, A.V., 2004. Energy and nitrogen retention of Merino and Dohne Merino lambs receiving a feedlot diet. S. Afr. J. of Anim Sci. 34, 77-79.

Olivier, J.J. & Cloete, S.W.P., 2006. Genetic analysis of the South African Dorper sheep. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 04-10.

Olivier, J.J., Rautenbach, L. & Taylor, R.F., 2004. Efficiency of selection in some South African sheep and goat breeds. Book of Abstracts – 2nd Joint Congress of the Grassland Society of Southern Africa and the South African Society of Animal Science, 28 June – 1 July 2004, Goudini, 100.

Roux, C.Z., 1992. Maximum herd efficiency in meat production III. Feeder-breeder dimorphism. S. Afr. J. Anim. Sci. 22, 11-15.

Schoeman, S.J., 1990. Productivity of purebred Dohne Merino, SA Mutton Merino and Dorper sheep under an intensive accelerated lambing system. Proceedings of the 4th World Congress on Genetics Applied to Livestock Production., Edinburgh, UK. p. 373-376.

Snyman, M.A. & Herselman M.J., 2005. Comparison of productive and reproductive efficiency of Afrino, Dorper and Merino sheep in the False Upper Karoo. S. Afr. J. Anim. Sci., 35, 98-107.

Van Wyk, J.B., Swanepoel, J.W., Delport, G.J. & Cloete, S.W.P., 2006. Estimates of genetic parameters for yearling body weight and fleece traits in the South African Dohne Merino population. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Bello Horizonte, Brazil. Communication 05-20.