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A comparison of the performance under field conditions of woolled and mutton sheep flocks in a low rainfall region of South Africa

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A comparison of the performance under field conditions of woolled and mutton sheep flocks in a low rainfall region of South Africa

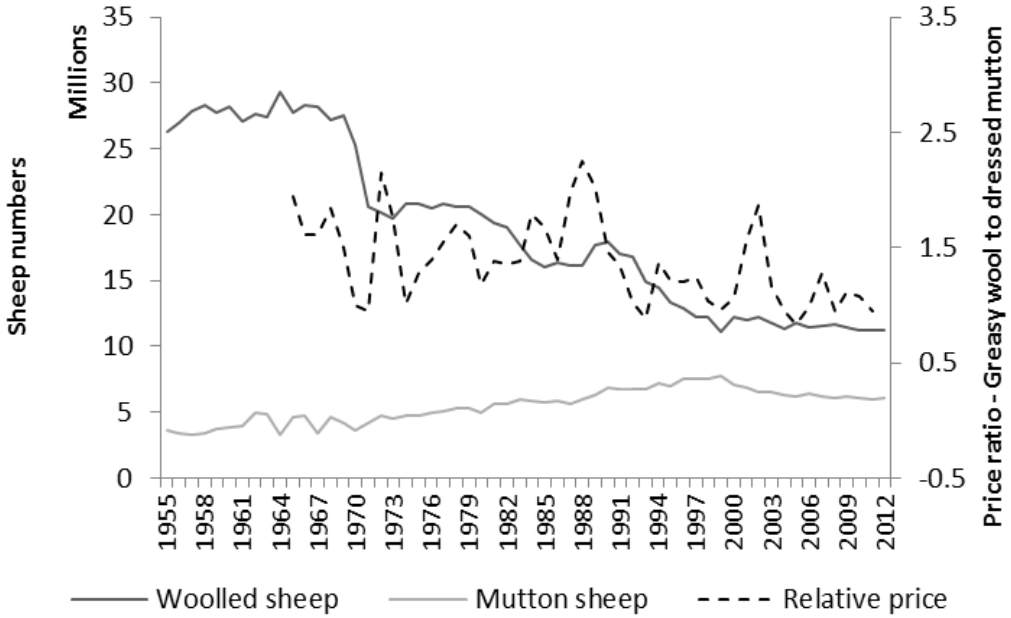
Abstract

This paper investigated the relative financial performance of woolled and mutton sheep and the determinants of woolled sheep ownership for 34 full-time sheep farms in Laingsburg South Africa, where rainfall is only 128 millimetres per annum. A comparison of fourteen woolled sheep flocks and eight similar sized mutton flocks revealed 1) a slightly but insignificantly higher unit production cost for wool producers, 2) a 21% but insignificantly higher net farm income per breeding ewe for woolled sheep, 3) a significantly lower tagging percentage for woolled sheep and 4) a significantly lower predation percentage for woolled sheep. The percentage of woolled sheep in the flock was a logit function of farm size, size of the irrigated (crop) area, tradition and terrain ruggedness, although the latter was not significant. Farmers in extensive grazing areas should take notice of woolled sheep's ability to compete and the wool industry should pay attention to further improving the reproductive performance of this sheep type. The finding of woolled sheep's apparent lower susceptibility to predators deserves further study as it could become a strong argument for why farmers ought to switch (back) to woolled sheep.

1 Introduction

According to the Abstract of Agricultural Statistics (DAEM, 1985; DAFF, 2013) the South African sheep flock underwent a structural change during the second half of the twentieth century. Between 1965 and 2012 the national woolled sheep flock (mostly Merinos) declined at a rate of 2.05% per annum, while the mutton sheep flock (mostly Dorpers) grew at a rate of 1.06% per annum. The change in the composition of the flock was driven by a change in the relative prices of mutton and wool; in the period 1965 to 1990 producers received 59% more per kilogram of greasy wool than per kilogram of dressed mutton sold at abattoir. From 1990 onwards the wool price premium dropped to just 16%. This statistically significant decrease in the ratio of wool to mutton prices was

probably the main cause of the rapid 30% decline in South Africa's woolled sheep flock in the early 1990s. Figure 1 suggests that the adjustment process was completed by the early 2000s, as both woolled and mutton sheep numbers had begun to stabilise at that point, but it is possible that the adjustment process overshot the optimal point and that therefore, at the margin, some South African producers who should have stayed with woolled sheep may have switched to mutton sheep. For these farmers it is clearly important to be aware of the financial implications of their actions. It should be of equal interest to the wool industry to investigate if woolled sheep are more profitable than mutton sheep and could potentially improve the financial position of all industry stakeholders.



(*Source*: DAEM, 1985; DAFF, 2013)

Figure 1: The relative price of wool to mutton and national sheep numbers

The relative performance of woolled and mutton sheep hinges on the size and value of the wool clip versus the size and value of the additional fertility that can be achieved with mutton sheep. This relationship is probably modified by rainfall; Olivier *et al.* (2001) recorded the detrimental effect of low rainfall on long run fertility of Merino sheep, while Dorper sheep are believed to be less sensitive to adverse grazing conditions than woolled sheep (Cloete *et al.*, 2000). With this in mind, the current study investigated the relative financial performance of woolled and mutton sheep flocks for a sample of full time sheep farmers in one of the driest grazing areas in South Africa. Our key questions were: 1) "What is the relative performance of woolled and mutton sheep flocks?" 2) "What explains woolled sheep ownership?" and 3) "What do these results mean for a wool industry extension strategy?" The choice of Laingsburg

as a study site represents a worst case scenario for woolled sheep, as the area's low rainfall is expected to favour Dorpers. If woolled sheep outperform mutton sheep in Laingsburg it is likely that they will do so everywhere in South Africa; if there is no difference or if mutton sheep do better than woolled sheep in this area, the question for the wool industry becomes one of appropriate geographic boundaries industry extension efforts.

The paper follows the usual structure of methods in Section 2 and results and discussion in Section 3 and ends with conclusions about the implications of these results for a wool industry extension strategy.

2 Methods

2.1 The Laingsburg dataset

This study relies on a cross-section dataset collected in a questionnaire survey. The survey took place during a three week period in November 2012. It targeted all landholders in the Laingsburg district and its immediate surrounding regardless of whether these landholders were full-time or part-time ("weekend") farmers, or owners, tenants or managers. The resulting convenience sample achieved good coverage; of the 64 landholders approached 58 agreed to be interviewed (91%) and 54 returned questionnaires complete enough to be analysed (84%). The sample of 64 farmers and the 36,000 small stock units on which data were collected, represent 80% of the farmers and 77% of the sheep recorded for Laingsburg in the 2002 farm census (Statistics South Africa, 2006). The unit of observation is a farm or flock which can consist of multiple types of small stock.

In the human wildlife conflict literature, farmers have been accused of "grossly exaggerating loss estimates" (Knowlton *et al.,* 1999: 402) and trust is recognised as being able to substantially improve "the accuracy and reliability of the [farm management] data gathered" in questionnaire surveys (Robel *et al.,* 1981). To build trust, local community leaders (a church elder, the chairman of the Land Care committee and farmers' union representatives) were recruited into the Laingsburg survey first and then asked to assist with compiling the convenience sample. Interviews were conducted in Afrikaans by an Afrikaans-speaking person with a formal qualification in agriculture who was approved of by the community leaders. Interviews took place in the home of each respondent as a conversation during which the semi-structured questionnaire was filled out but many additional notes were taken as well. On average interviews took about an

hour, but in one instance it took an entire day and in several other cases an entire morning or afternoon. To minimise strategic responses, the Laingsburg survey collected raw livestock numbers rather than reproductive or predation percentages. It intentionally also did not collect the number of ewes kept back for replacement, but instead calculated this figure as the difference between the number of lambs born and the sum of lamb sales and losses. Farmers tell us that a ewe's productive life in their area is between five and six years. This age range provides a convenient check of internal data validity. The sample average replacement rate of 17% and the fact that 80% of the observations fell inside a plausible range were quite reassuring, but we noted the high standard deviation of 11% on this variable as a possible red flag regarding data quality.

Ostensibly the survey covered the 2012 production and the 2012/13 financial year, but local conditions make it difficult to determine precisely when one season stops and the next begins. Laingsburg's low and highly variable annual rainfall pattern (mean =128mm, SD=69mm) means that the start of each year's breeding season depends on whether it has rained or not. As insurance against poor conditions farmers tend to keep rams with ewes for longer periods or to opportunistically reintroduce them whenever the rains arrive. Nonetheless, most producers try to target their main mutton crop to the Christmas season and almost all farmers' financial years run from March to February, which makes November a suitable time for an annual survey.

2.2 Defining the subsample of full-time sheep farmers

The Laingsburg dataset contains two income composition variables, one for household income and another for farm income. Farm income varies from 1% to 100% of household income with an average of 78%. Sheep's share of farm income varies from 7% to 100%, with mean 81%. In this analysis we restricted these ranges to observations where agriculture (including farm-based tourism and game farming) accounts for at least 60% of household income and sheep account for at least 70% of farm income. It should be noted that despite the restrictions our sample of 34 farms represents a reasonable sample size by international standards (Milan et al., 2003; Gaspar *et al*., 2008; Tolone et al., 2011).

The restricted sample was divided into wool and mutton producers based on the type of sheep each farmer keeps; farmers who reported any number of Merinos, Dohne Merinos or Afrinos were classified as wool producers regardless of the percentage woolled sheep in their flocks (n=14) and the rest (n=20) were mutton

producers by default. The initial partitioning resulted in a 40% difference in average farm size between the two groups. We controlled for farm size by dividing the mutton group into two groups of farms above and below 6,000 hectares. This resulted in a median farm size for the large mutton group which was within 20 hectares of median farm size for the wool producers. In the cross category comparisons which follow we present two sets of ANOVA results, one which tests for differences across all three categories and therefore does not control for farm size and one which tests for differences across similar sized wool and mutton flocks only and therefore in a way that does control for farm size. The analysis of variance tests were conducted in Excel.

2.3 Profitability calculations

On the advice of Winter *et al.* (2007), sensitive income questions were omitted to protect response rate. However, the survey did collect data on production cost and the income composition variables allowed us to calculate net farm income per breeding ewe, as follows: In November 2012 the local going rate for a live slaughter lamb was R1000 per unit, which together with the average sales rate of 57% implies an income of R570 per ewe from lamb and mutton sales. Wool revenue was calculated by dividing the estimated meat income per ewe by each observation's share of farm income from meat and multiplying by the corresponding share of farm income derived from wool. For example, if farm income comprises 67% meat and 33% wool, the estimated wool revenue per ewe is R570/0.67*0.33=R281 which gives total revenue per ewe as R570+R281= R851.

While the difficulty of assigning overhead costs to a particular enterprise often limits enterprise comparisons to the gross margin[1] level (Standard Bank, 1988; Geyer *et al.*, 2011), overheads were allocated in this study according to sheep's share of gross farm income. The calculation presented here is pre-tax and represent payments to own (e.g. owner's salary) and foreign fixed factors (e.g. cost of finance). In two cases missing cost data were assumed to be same as that of similar sized peers. To simulate profitability over time, 2012 wool and mutton revenues were projected backwards in nominal terms using the pastoral products (wool, mohair) and sheep slaughtered price indices reported in the 2013 Abstract of Agricultural Statistics (DAFF, 2013). These nominal figures were inflated to 2012 prices using the all items consumer price index published in the same source.

[1] Gross margin = Gross income – Directly allocated variable cost (i.e. feed, animal health, genetic improvement); Net farm income = ∑Gross margin of all enterprises – overhead costs (i.e. fuel, transport and electricity, repairs and maintenance and labour)

2.4 Specification of the woolled sheep ownership model

A histogram of the percentage woolled sheep in the flock suggested the need for a limited dependent variable model such as logit which was run using the maximum likelihood routine in Stata 13.0. According to Baum (2006:248) one must think of the logarithm of the odds ratio as proxying an unobserved latent variable which measures the "net benefit" of woolled sheep ownership.

$$\log\left(\frac{p_i}{1-p_i}\right) = \alpha_0 + \alpha_1 \text{Opportunity cost of the owner's time}_i + \alpha_2 \text{Management skills}_i + \alpha_3 \text{Resource endownment} + \alpha_4 \text{Tradition}_i + \varepsilon_i \quad [1]$$

Half of the woolled sheep ownership model was built on the assumption that woolled sheep which need more attention to fertility, nutrition and perhaps animal health than Dorpers, are more demanding of management than Dorpers. We expected that the percentage of woolled sheep in the flock would be negatively correlated with the opportunity cost of the manager's time and positively correlated with management quality. The opportunity cost of the farmer's time could be proxied with the size of irrigated crop land (Elliot *et al*., 2011) or the share of household income from off-farm sources (Kumm, 2009). However, since the way in which the sample was restricted virtually eliminated male off-farm employment, it was decided to use irrigated area only to model opportunity cost. The quality of management skills were proxied with farmer education (years of schooling) and the availability of rainfall records, which we argued is an indication of quality of record keeping skills. We also experimented with years of farming and farm management experience, but abandoned both these variables as they were highly correlated (r >0.7) with farmer age. Since neither counting interval (the number of days between two events during which sheep are handled and counted) nor a dummy variable indicating the use or not of a regular breeding cycle is entirely exogenous to breed selection, neither could be used to model management quality.

Under resource endowment we considered farm size and terrain ruggedness (and would have liked to include rainfall, which was only available in a third of cases). We expected the probability of woolled sheep ownership to increase with farm size as smaller properties are more likely to experience the cash flow constraints which would make mutton sheep an attractive proposition. On the other hand, due to Dorper sheep's greater hardiness and larger farms' lower management intensity, one would expect Dorpers to dominate on larger farms. Terrain ruggedness was expected to increase with farm size and to favour Dorpers, that is, to be negatively correlated with the percentage woolled sheep in

the flock. Our proxy for terrain ruggedness is the percentage a farm's area that is mountainous. The argument around tradition was simply that given the historical dominance of woolled sheep in the area (Conradie *et al.,* 2013), older people and individuals with a longer family history on the land would have more experience with woolled sheep and therefore more likely to continue to farm with it than newcomers and younger farmers.

3 Results

The average flock varies from 187 to 1850 ewes with an average of 782 ewes. Most flocks consist of Dorpers sheep only or of Dorpers farmed in conjunction with other sheep. Sixteen of the twenty mutton sheep farmers farm only with Dorper sheep; for the remaining four mutton farmers, Dorpers comprise between 55% and 94% of ewes in the flock. Boer goats and other sheep are present, but only at low numbers. The wool category consists of the 14 farmers who indicated that they farm with Merinos, Dohne Merinos or Afrinos. Woolled sheep make up between 23% and 100% of this group's flock and wool sales contribute 33% of their farm income. About a third of this group produce only woolled sheep, usually Merinos rather than Dohne Merinos or Afrinos.

Almost 90% of the land in the sample is owner operated and 79% of farmers reported operating on more than one parcel of land (original farm). A third of farms were reported to be above 10,000 hectares, while 21% of farms were said to be below 4,000 hectares. Almost 60% of farms have no irrigated land; for the remainder, irrigated area varied from 0.5 to 17 hectares, with fodder crops accounting for two thirds of the irrigated area and fruit and vegetable seed production for the other third. Farmer age was reported to vary from 29 to 79, with one in three farmers being aged sixty or above. Education varies from incomplete high school to postgraduate degrees, with a two-year agricultural diploma being the most frequently reported qualification. Family history on the land varies from four to 192 years, with an average of occupation of 87 years.

3.1 Profitability of woolled versus mutton sheep

Table 1 presents the relative performance of woolled and mutton sheep flocks in the sample. The average tagging percentage (lambs tagged per 100 ewes in the flock) for 2012 was 87%. The corresponding sales percentage (lambs sold per 100 ewes in the flock) was 58% and the total loss percentage (lambs killed or lost per 100 ewes in the flock) was 12%, of which predators accounted for nine percentage points (75% of losses). Compared to Snyman's (2010) figure of

predators accounting for 39% of kid losses in angoras, Laingsburg's predation rate as proportion of all losses was high.

The general lack of significant differences in Table 1, whether one controls for farm size or not, means that despite the 21% difference in net farm income per ewe in the flock one cannot currently claim woolled sheep to be more profitable than mutton sheep, or *vice versa*, under Laingsburg conditions. The lack of significance may be due to the small sample size of the current study, but with the high degree of coverage there is no guarantee that increasing the scope of the study will reduce the standard errors. The non-significant trends nevertheless follows the expected patterns, namely that woolled sheep ought to be more expensive to produce but more profitable than mutton sheep if one controls for size, and that small-scale systems ought to have higher unit costs than large-scale operations. There was a surprisingly small difference in unit labour expenditure and a large difference in unit energy expenditure which, especially for small mutton operations, suggests a home consumption element.

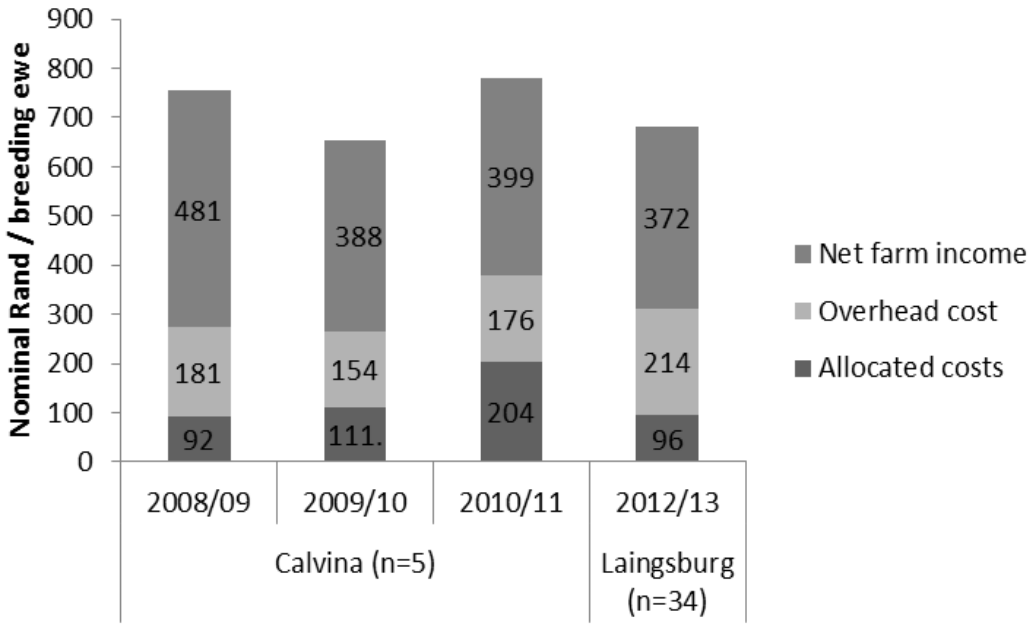
For the pooled sample of fulltime sheep farmers, total revenue was R682.78 per ewe in the flock and comprised 85% meat sales and 15% wool income. The total cost of production was R310.20 per ewe. Overheads, consisting of labour (22%), fuel, transport and electricity (30%) and repairs and maintenance (17%), accounted for 69% of total costs. Purchased feed and fodder accounted for three quarters of directly allocated variable costs which made up 31% of total cost. Net farm income (before payments to fixed factors) was R372.38 per ewe in the flock.

In Figure 2 the financial performance of Laingsburg's 34 full-time sheep farmers is compared in nominal terms to the performance of the five members of the Calvinia study group who all run Merino flocks (Geyer *et al.*, 2011). The Calvinia results reflect the impact of a drought which substantially affected reproductive success and/or wool production during the 2009/10 season and caused an almost 300% increase in the fodder bill in the following financial year. Although some Laingsburg farmers indicated that they experienced a drought during 2012, on the whole the Laingsburg figures are for a "normal" year. Despite the Laingsburg figures being characterised by 39% higher overhead costs than the Calvinia figures, Laingsburg still produced a profit margin just 14% lower than the best Calvinia performance in the series.

Table 1: Financial performance of woolled versus mutton sheep flocks in 2012 (Rand per ewe).

	Mutton >6,000ha n=8	**Wool n=14**	**Mutton <6,000ha n = 12**	**ANOVA F-stat not controlling for size[2]**	**ANOVA F-stat controlling for size[3]**
Purchased feed and fodder	49.82	62.61	100.98	0.813	0.136
Animal health	6.07	8.53	13.32	0.619	0.455
Ram purchases	12.50	9.82	17.71	0.468	0.153
Fuel, transport, electricity	46.63	79.64	136.58	3.775**	2.429†
Repairs, maintenance	62.75	50.79	52.00	0.151	0.284
Labour	66.38	66.43	72.00	0.035	0.000
Total cost[2]	243.88	277.71	392.33	1.272	0.206
Mutton gross revenue	568.42	424.02	774.47	3.582***	2.201
Wool gross revenue		245.52		16.52***	13.175***
Total gross revenue	568.42	669.55	774.47	0.800	0.581
Net farm income for sheep	324.63	391.86	382.00	0.085	0.206

[1] ***p <0.01, ** p<0.05, *p<0.10, †p<0.15
[2] Three way comparison
[3] Two way comparison of large farms only



(*Source*: Geyer *et al*., 2011; own survey)

Figure: 2: Nominal revenue, cost and profitability of sheep flocks in Calvinia and Laingsburg

We expected there to be more of a difference in the performance of the two districts, not so much on account of the difference of rainfall (+/-10%), but because the one set of results derives from a study group while the other derives from a general population survey. It is typically expected that study group results ought to be better than the results of a general population survey since better managers are over-represented in study groups. For example, Geyer *et al*. (2011) reported a lambing percentage of 129% for the Calvinia group for the 2010/11 season, which was 48% (42 percentage points) higher than the corresponding Laingsburg figure for 2012. However, the top five producers in the Laingsburg group achieved an average lambing percentage of 121% which was only 6% worse than the average performance of the Calvinia group.

Figure 3 provides a historical perspective on the current relative profitability of the three sheep production systems. The dark and light shaded areas represent the size and composition of net farm income per ewe in the woolled sheep system. The solid line traces out net farm income on large (>6000 ha) mutton farms while the higher dashed line does the same for small (<6000ha) mutton flocks. Since Figure 3 is based purely on the non-significant differences in net farm income estimates reported in Table 1 and historical commodity prices from the Abstract of Agricultural Statistics (DAFF, 2013), it excludes real input price changes, technical change and changes in the composition of the flock.

Therefore there is a constant percentage difference over time in net farm income derived from mutton across the three systems.

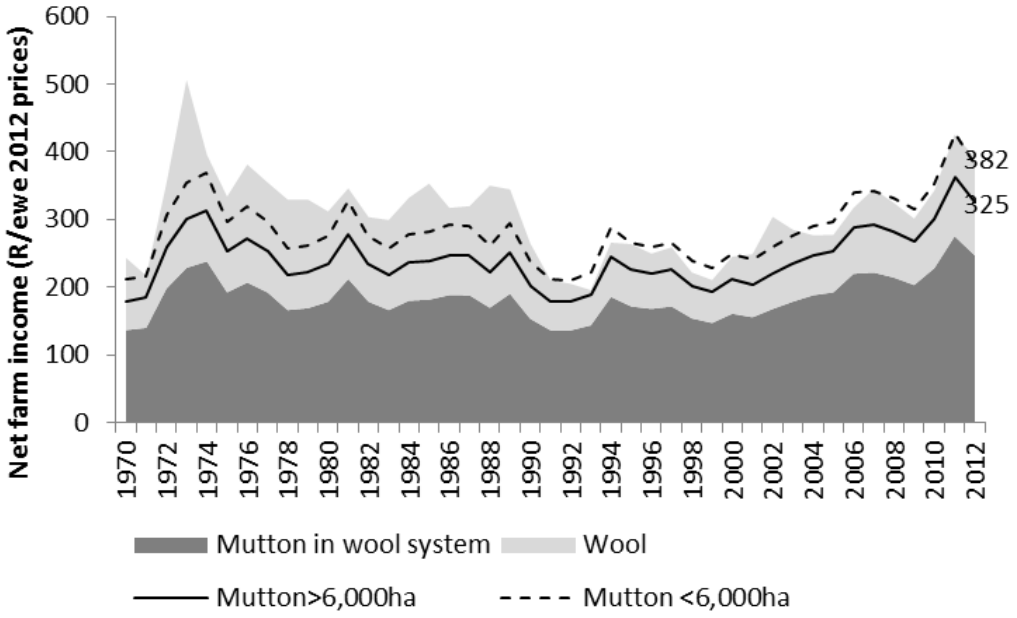


Figure 3: Current performance at historical commodity prices

In the simulation small mutton sheep flocks yield an 18% higher net farm income per ewe in the flock than large mutton flocks, while woolled sheep flocks yield 24% less mutton income than similar sized (i.e. large) mutton flocks. Figure 3 also shows that if one takes wool revenues into account, woolled sheep flocks consistently outperformed mutton sheep flocks in the period 1970 to 1990. After 1990 this has no longer been the case; small mutton flocks currently yield the same net farm income per ewe as woolled sheep flocks. The difference in net farm income between similar sized mutton and woolled sheep flocks have shrunk from 38% between 1970 and 1990 to a mere 15% difference.

The three systems stock at the same rate and use similar proportions of natural grazing and irrigated pastures. We found some difference in terrain ruggedness, which disappeared when we controlled for farm size. Pregnancy testing (by means of sonar scan or visual inspection) was considered more important by the owners of woolled sheep than by mutton sheep managers, who think of it as unimportant. Woolled sheep and small mutton farmers both indicated an animal health routine to be important, while the managers of large mutton sheep flocks tended to consider it unimportant. Although the average reported counting interval (days between events during which sheep are handled) varied by a factor of two across groups, the difference was insignificant. Together these results support the idea that farmers perceive woolled sheep to need more care than Dorpers.

Table 2: Selected productive and reproductive flock statistics

	Mutton >6,000ha n=8	**Wool n=14**	**Mutton <6,000ha n = 12**	**ANOVA F-stat not controlling for size[1,2]**	**ANOVA F-stat controlling for size[1,3]**
Natural pasture (ha/ewe)	12.9	11.5	10.8	0.532	0.447
Irrigation (ha/100ewes)	0.11	0.18	1.40	0.429	0.163
% mountain	11	13	2	1.744	0.070
Pregnancy testing[4]	2.3	3.5	2.0	2.998*	2.696†
Animal health routine[4]	3.3	4.4	4.3	4.003**	7.754**
Counting interval (days)	89	44	76	0.888	1.821
Rainfall data (1=yes)	0.375	0.571	0.417	0.472	0.741
Tagging percentage	0.94	0.70	1.03	4.790**	6.855**
Predation percentage	0.19	0.07	0.06	11.154***	15.077***
Other loss percentage	0.01	0.04	0.01	2.058†	2.172

[1] ***p <0.01, ** p<0.05, *p<0.10, †p<0.15
[2] Three way comparison;
[3] Two way comparison of large farms only;
[4] Importance of practice on a 5 point Lickert scale where 1 = unimportant

There were significant differences in the tagging and predation percentages between groups. We recorded a 26% lower tagging rate for woolled sheep than for mutton sheep and found woolled sheep to have a substantially lower (63% lower) predation rate than mutton sheep flocks. Together with the terrain ruggedness result in Table 3 (below) these results lend some support to the idea that woolled sheep are more resilient against predators than mutton sheep, a theory which is consistent with Snyman and Herselman's (2005) data on total lamb losses for Merinos and Dorpers in two farms in Middelburg. In the absence of detailed studies of lamb mortalities in sheep we can only speculate about the reason for the difference in predation rates. It is possible that a higher proportion of twins in Dorpers may make it harder for the ewe to protect her lambs against predators or that differences in the grazing pattern of the two breeds explain why the lambs of one breed are caught more frequently than lambs of the other breed, but it seems more reasonable that this result simply signifies a systematic difference in management input as various items in Table 2 suggests. For example, Hoon *et al.* (2000) documented the importance of adequate nutrition for perinatal lamb survival in Merino sheep. However, if the owners of Merino flocks paid more attention to nutrition in this period, one would have expected a smaller discrepancy in tagging rates rather than lower predation rates for woolled sheep. Therefore there is still a possibility that one might be dealing with inherent breed differences with respect to the vulnerability to predators.

The logit models of woolled sheep ownership identified tradition, farm size, the opportunity cost of the manager's time and terrain ruggedness as explaining most of variation in the percentage woolled sheep in the flock. The lack of significance on individual coefficients in Model 1 illustrates the restrictiveness of the current sample, but the marginal effects of Model 1 jointly predicted a woolled sheep ownership rate quite close the actual ownership rate of 26.4%. Although insignificant, the signs on irrigated area, farmers' education and the dummy variable indicating the keeping of rainfall records were as expected. The coefficient of farm size was positive and significant, thereby suggesting that woolled sheep's poor cash flow characteristics may be a significant disadvantage on smaller properties, while their greater management intensity is not so much of a disadvantage on larger properties. The coefficient on the % mountains variable was positive, and not negative as expected. Assuming a link between terrain ruggedness and predator densities, this result provides further support for the idea that woolled sheep might be less vulnerable to predators than mutton sheep. The sign on farmer age was negative, which suggests that instead of age functioning as a proxy for tradition, it operates like an opportunity cost variable; older farmers find it harder to keep up with farming activities and are therefore forced to switch to less demanding breeds. The coefficient on family history on the land was positive as expected; those with more experience in woolled sheep are more likely to continue to farm with it than newcomers.

Table 3: Logit results of models explaining the percentage woolled sheep in the flock

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Irrigated area (ha)	-0.2718 0.2013 -0.0497†		-0.0667 0.1076 -0.0161		-0.2836† 0.1950 -0.0545*
Education (years)	0.0793 0.3779 0.0145				
Rainfall records D	1.3556 1.4405 0.2457				
ln(Farm size)	5.6534** 2.9156 1.0333***	2.1061** 0.9051 0.5090**	2.2132** 0.9570 0.2255**	3.7398** 1.5819 0.8505***	5.5452** 2.7882 1.06489***
Mountains (%)	0.0348 0.0408 0.0064			0.0190 0.0334 0.0043	0.0407 0.0359 0.0078
ln(Farmer age)	-1.3142 3.2942 -0.2402				
ln (Family history on land)	4.0673† 2.6857 0.7434**	1.6554* 0.9464 0.4001*	1.9093* 1.0689 0.4607*	2.7845* 1.5356 0.6333*	4.5977* 2.6075 0.8829**
Constant	-65.235* 34.043	-26.286** 10.808	-28.240** 11.743	-46.071** 19.463	-70.120** 35.494
Observations	30	32	32	30	320
Wald LR stat	19.16***	9.42***	9.80**	15.53***	18.12***
McFadden's R^2	0.4668	0.2148	0.2234	0.3784	0.4414
Akaike's info criterion	38	40	42	34	33
Schwartz's BIC	49	45	48	39	40
Predicted % woolled sheep	24%	41%	41%	35%	26%

***p <0.01, ** p<0.05, *p<0.10, †p<0.15

Model 2, in which only the logarithm of total farm size and the logarithm of family history on the land were used to explain woolled sheep ownership, is inferior to Model 1 in many respects including a 50% smaller R-squared value, worse Akaike and Bayesian information statistics, a predicted ownership rate which was double of what it should have been and very different marginal effects. In Model 3 we unsuccessfully added irrigated area as a third explanatory variable. Model 4, in which we replaced irrigated area with the percentage mountains variable, failed to produce a significant coefficient on the latter but achieved a better overall fit than Model 3. Model 5, in which both irrigated area and the percentage mountains variable were used with the natural logarithm of farm size and the logarithm of family tenure on the land, produced the best overall fit according to all three specification measures. Model 5's McFadden's R-squared value was just 5% lower than that of Model 1, its Akaike and Bayesian information statistics were better and its marginal effects correctly predicted actual woolled sheep ownership. Three of its four marginal effects were significant; the impact of an extra hectare of irrigated land was a 0.0545% decrease in the likelihood of woolled sheep ownership, while 1% increases in farm size and duration of family tenure on the land produced increases of 1.06% and 0.88% respectively in the likelihood of woolled sheep ownership.

4 Implications for a Wool Industry Extension Programme

It is widely accepted that maintaining adequate reproductive efficiency is a critical element of financial success with woolled sheep (Olivier *et al*., 2001; Snyman and Herselman, 2005; Geyer and Van Heerden, 2009; Geyer et al., 2011), which makes the low lambing percentage for woolled sheep recorded in the Laingsburg area an issue. Importantly, however, this analysis showed that the financial performance of woolled sheep is still on par or many even be somewhat ahead of that of mutton sheep in Laingsburg. Consequently, a wool industry programme should pay attention to the area and could make a substantial impact on the livelihoods of local producers by addressing the 26% gap in tagging percentage reported here. All management and extension efforts should be focussed on improving Laingsburg's reproduction/lambing percentage.

When it comes to rebuilding the wool industry in extensive grazing areas, most of the key variables we identified (tradition, farm size, competing claims on the managers' time, terrain) seems to be outside the control of wool industry extension staff. However, it might be possible to overturn the limiting effects of farm size and tradition by cultivating an industry image of inclusiveness with

programmes that involve all sheep producers regardless of current farm size or experience with woolled sheep. The on-going monitoring of the relative performance of different breeds could be an important element of such an outreach programme. Ultimately market forces will determine the impact of competing interests going forward, but it is important that recommendations coming out of the wool industry extension service are cognisant of these competing claims on their target audience's time, and that such recommendations are as labour and management saving as possible. Despite its lack of significance, there was some indication that more education and/or better recordkeeping might benefit woolled sheep adoption. Of the two, deficient recordkeeping skills are perhaps easiest to fix. It could be done cheaply and effectively through study group membership provided that study group membership is not too time consuming or intimidating for participants and becomes the social norm. The wool industry might even influence sheep farmers' level of formal education through a combination of bursary programmes, dedicated academic programmes at agricultural schools and colleges or by supporting modular tertiary training programmes that will allow young farmers to work and study at the same time.

5 Conclusions

It was shown that during the 2012 season woolled sheep flocks did as well as, or perhaps slightly better than, Dorper flocks under field conditions in Laingsburg district. This result was achieved despite a lower average tagging percentage and perhaps because of a lower predation percentage for woolled sheep. We also found evidence that woolled sheep flocks are more actively managed than mutton sheep flocks. Farmers should know that woolled sheep can be competitive with mutton sheep under extensive grazing conditions provided that reasonable reproductive rates can be achieved and a wool industry extension programme can include Laingsburg in its programme of work provided that it focusses on improving the relative reproductive rates of woolled sheep under extensive grazing conditions.

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