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Management Strategies to Improve the Economics of Sheep Farms in Norwegian Coastal and Fjord Areas—The Effect of Animal Size and Capacities for Rangeland Utilisation

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Abstract: The morphological and productive aspects of Norwegian sheep have developed over time and adapted to the diverse environment of the country. Before 1900, native Norwegian sheep were crossed with UK breeds to attain higher body weight and reproductive efficiency. Subsequent selection programs eventually led to the creation of the heavier (adults often >90 kg) Norwegian White Sheep (NWS), today constituting 70% of the recorded ewes. The modern Norwegian (White) Spæl (NS) sheep, mostly <75 kg and accounting for 10% of the recorded ewe population, originated from the native short-tailed breeds that are smaller and are believed to prefer grazing at higher altitudes than NWS. Other registered breeds of the short-tailed spæl type account for another 12% of the recorded sheep. Rugged Norwegian terrain with rich summer pastures makes the NS a complementary breed to the NWS. Increasing demand for year-round fresh meat requires changes at the farm level. Efficient use of local feed resources by extensive feeding of smaller size ewes is an opportunity for attaining economic gains and for year-round fresh meat production. The NS has a lighter bodyweight, requiring less housing space, is efficient in grazing rangeland and local pastures, and is better suited to outdoor winter grazing in coastal and fjord areas. In this paper, we compare the farm profitability (gross margin) of two Norwegian sheep breeds (NS and NWS) using a linear programming model designed for the coastal and fjord areas. The impact of ewe body weight, housing capacity, and meat produced per unit of concentrate are discussed.

Keywords: ewe size; grazing; concentrates; Spæl sheep

1. Introduction

Norwegian sheep farmers operate within strict environmental and climatic boundaries, and the timing of production is strongly linked to the natural seasonal variation in plant growth. The farmers adapt to the winter season, mostly by feeding their flock in-doors from October to May, but some by feeding concentrates and silage outdoor. The availability of homegrown winter feed, mainly grass-silage is, however, limited due to the short growing season and often insufficient amounts of

cultivated meadows suited for baling. In the prevailing production system, sheep take up more than half (60%) of their annual feed consumption by grazing farm pasture in April and May, followed by high-quality rangeland pastures during the summer months from June to August, and farm pasture in September and October [1,2]. Farmers seek a maximum lamb crop in the autumn because of the considerably better price per kg of lamb than for hogget and sheep; this also coincides with rangeland plant production coming to a halt. The Age of the first lambing is 1 year, and triplets are common. It is often labour intensive to have more than two lambs per ewe during the summer: most young (1 year old) ewes will be unable to support more than one or two lambs, and even prime-age ewes should only be tasked with rearing triplets on good quality rangeland pastures [3].

The Norwegian (White) Spæl (NS) is the second most common breed in Norway, after the Norwegian White Sheep (NWS) breed, with approximately 10% of the recorded (43.4% of herds, and 55.4% of sheep are in the national recording system in 2019, [4]) sheep population. Other registered breeds of the short-tailed spæl type account for another 12% of the recorded sheep. The NS is, like the NWS, a dual-purpose breed kept for meat and wool. The average number of lambs per adult NS ewe at weaning/the start of slaughtering in September was 1.77, compared to 1.89 for the NWS. The mean live body weight (BW) of NS lambs in the fall was recorded as 41.8 kg, and the mature BW of ewes (5 years) was recorded as 80 kg [4]. In the Norwegian National Sheep Recording Scheme, one productivity index is the number of lambs per ewe per year, leading to an advantage for the heavier NWS. However, based on the lamb crop in the fall per 100 kg of ewe BW, the performance of NWS and NS was 83 and 100 kg [4]. NS thus produces more lamb meat per 100 kg of ewe body weight [5]. NS is also known as an efficient grazer of the rugged Norwegian rangelands [2,6]. The hoggets of NS were, according to the European Union EUROP classification, leaner than NWS [4], making hoggets from NS suitable for modern meat consumer preferences. The smaller size cuts also add value for modern, smaller families [7]. NS carcasses do, however, score lower on the EUROP carcass conformation scale, resulting in lower prices for farmers.

On free-range summer pastures, the NS, compared with NWS, stay together in larger flocks, cover longer distances on the range [6], are more robust towards environmental variation [8], and choose a diet containing more woody plant species [2]. The Norwegian terrain is rugged with rich pastures in-between, making the lighter NS suited as a complementary breed to the NWS for optimal rangeland pasture utilisation. Since the NS sheep chooses more woody plant in its diet than the NWS, it may also be more suitable for maintaining traditional flowering meadows and other vegetation communities threatened by woody plant encroachment [2,9].

The large price difference between lamb meat and mutton make systems producing more lambs and less older animals more profitable. A recent study, based on sensory characteristics of meat from the NS and NWS breeds, indicated little difference in the meat quality between hoggets (17 months old female ewes) and lambs for the NS, while the difference was substantial for the NWS [10]. The meat from hogget and lamb from the NS breed were similar in terms of meat tenderness in that study.

Coastal and fjord farmers, due to the mild winter climate, may graze their sheep in high-mountains during summer, lower-mountains during the spring and fall (Figure 1) and along the fjords in the winter. Both inland and coastal farmers routinely sell the main crop of lambs for slaughter in September–October, resulting in the pressure of slaughtering facilities and a shortage of fresh lamb meat in the off-season. Due to the huge price difference between meat from lambs and hoggets/older sheep, farmers prefer to raise lambs for slaughtering in the fall before indoor winter feeding.



Figure 1. View of typical Norwegian farm pasture on the west coast, with some arable land (green near river) for silage. Photo: Torstein Lund Eik.

In Norwegian coastal and fjord areas, a less intensive production system with less use of concentrates and more winter grazing could be a viable alternative. A well-managed hogget production system based on locally grown feeds and pastures can offer an opportunity for the farming industry to increase the availability of fresh meat and improve the regularity of cash flow throughout the year. It could make sheep farming more sustainable in terms of better economic performance, being more environmentally friendly, and being more efficient in terms of resource utilisation. Increasing demand for fresh meat year-round may favour production changes. Such extensive production systems will allow for more lambs and hoggets to be slaughtered in the winter and following spring.

This study examines the farm profitability by using the NS breed and compares the two breeds (NS vs. NWS) in an extensive system in the Norwegian coastal and fjord areas with four alternative practices to the current: delayed season, hogget production, first lambing at two years and longer lifespan.

2. Materials and Methods

Linear programming was used to compare farm economics, measured as the gross margin (GM) of alternative scenarios, with the model details described by Asheim, Thorvaldsen [11]. The prices in the model reflect the level in 2018 (Table 1) and the model was parameterised with data from 18 sheep farms in the Vestland and Agder counties. Agricultural subsidy payments for the 2019–2020 season were applied.

The LP (Linear Programming) technique uses constrained optimization to identify the composition of non-negative activities resulting in the maximum objective function within the constraints. The mathematical model of an LP problem is as follows [12]:

$$\text{Max } Z = c'x \text{ subject to } Ax \leq b, x \geq 0 \quad (1)$$

Here, Z is the farmer's objective function or gross margin (GM), i.e., total yearly returns from livestock and governmental payments, minus variable costs. Since the fixed costs were not affected in any of the solutions examined, a ranging of alternatives according to GM would be similar to a ranging according to farm profit. Moreover, x is a vector of activity levels and c' the vector of marginal net

returns. A is the matrix of technical coefficients showing resource requirements by the activities; b is the vector of right-hand side values of resources such as farmland and semi-cultivated farm pastures, farm workforce, and constraints due to, e.g., area and feeding requirements.

The area constraints encompassed arable and pasture able farmlands as well as constraints relating to crop rotation, the use of manure and area and cultural landscape (ACL) payments. The feeding requirements were developed based on Madsen, Hvelplund [13] and encompassed energy for milk production measured in feeding units (FEm), roughage dry matter (DM), and amino acids absorbed in the small intestine (AAT), each relating to specific constraints. 1 FEm = 6900 Mega Joule or approximately the amount of energy in one kg of barley. AAT refers to Amino acids Absorbed in the small intestine. Its composition relates to all AAs needed for growth and do take into account special need for, e.g., the Sulphur containing AAs cysteine and methionine for growth of wool. The amount of AAT was measured in proportion to the amount of energy in different feeds (g AAT/FEm) and in the amount needed on a daily basis by animals (g AAT/day). Constraints also accounted for the production of manure, used by the land activities, and herd replacement. The work constraints encompassed one constraint for the grazing season and one for the whole year, assuming farmers would be willing to work longer days in shorter peak periods of work within these periods as long as the total work requirement in the whole period were not exceeded.

Table 1. Farmgate meat prices, input prices and support premiums, Norwegian kroner (NOK), 2019.

Description	NOK	Description	NOK
Basic price cull ewe meat, per kg	7.18	Support per sheep, 1–150	883
Basic price hogget, per kg	10.28	Support per sheep, >150	194
Basic price lamb, per kg	66.10	Lamb support, grade O, per carcass	450
Basic support meat, per kg	3.81	Lamb support, grade <O, per carcass	41
Shearing costs, per kg of meat	0.52	Concentrate Lamb, (92, 11) * per kg	3.69
Wool, per kg	53.8	Concentrate Fibre, (86, 11) * per kg	3.72
Relief support, per sheep	458	Concentrate Sheep, (96, 12) * per kg	4.21
Grazing farmland, per animal	50	Diesel, per Liter	11.52
Grazing rangeland, per animal	205	Mineral fertiliser, 22-2-12, per kg	3.72

* FEm per 100 kg and gram AAT per FEm. Feeding unit (Föreining mjølk-FEm) = 6.9 MJ [14].

The net number of lambs per adult ewe in the fall was set to 1.33, like the number for the NWS breed, similar to the average in these 18 farm records representing sheep farms in the study area. We assumed weights and growth rates of NS to be 75% of those for the NWS breed. The daily feeding requirements for maintenance feed, as well as the minimum amounts of concentrates, were lowered by 25% compared to the rates for the NWS breed.

In the current practice, we assumed the age of first lambing to be one year, a lifespan of ewes to be 3.3 years, that lambing took place around 15 April, and that the slaughtering of lambs was on 20 September.

The alternative, more extensive systems of rearing NS sheep included four practices (Table 2):

Alternative 1—Delayed season: Delaying lambing for 16 days until the start of grazing (around 1 May) and a corresponding 15 days delay in slaughtering until around 5 October.

Alternative 2—Hogget production: Overwintering of female lambs and marketing them as hogget in July or August.

Alternative 3—As with Alternative 2, and with first lambing when 2 years old

Alternative 4—As with Alternative 3, but assuming longer ewe lifespan. The first lambing at two years of age, and, in addition, increasing the ewe life span to five (5.3) years.

Table 2. Description of the investigated alternative scenarios.

Alternative Scenarios	Description
1. Delayed season	Delayed lambing for 16 days until the start of grazing (around 1 May) and a corresponding 15 days delay in slaughtering until around 5 October.
2. Hogget production	Overwintering of surplus female lambs and marketing them as hogget in July or August.
3. First lambing when 2 years old	As with Alternative 2, but with first lambing when ewe is 2 years old.
4. Longevity increased to 5.3 years	As with Alternative 3, but assuming longer ewe lifespan (5.3 years).

The comparison between NS and NWS was made by running the same methodology as NWS while changing the weights and growth rates of NS to 75% of those for the NWS breed. In case of NS, the feeding requirements for maintenance feed, as well as the minimum amounts of concentrates, were lowered by 25% compared to the rates for the NWS breed. The EUROP carcass classification was same for both breeds (NS and NWS).

3. Results and Discussion

The farm-level economics of rearing NWS in an extensive pasture-based system with four alternative practices using a Linear Programming (LP) model shown in Table 3. Since NS is smaller and lighter, the ewe number increased within each farm given the existing resources used in the model. The same daily work input was assumed per sheep irrespective of breed in the modelling. The solution of the model for the NS is presented in Tables 4 and 5, and the difference compared to the NWS breed in Table 6. Since the NS breed is smaller and requires less space; the model allows for 1–25 more NS sheep than NWS on a farm, and the model solution was with a slightly lower (0.4–3%) yield of roughages when keeping NS. Profitability, measured as farm GM, was higher for NS compared to NWS. However, the difference (NS–NWS) in the amount of hired work was 184, 253, -10, -100 and 106 h for current practice, delayed season, hogget production, first lambing when 2 years old, and Longevity increased to 5.3 years respectively (Tables 3 and 4).

One reason for the overall improved profitability for NS sheep was that the Norwegian lump-sum subsidy payments per animal favour lighter sheep. While the general lump-sum subsidy payment per sheep is lowered when the number of breeding sheep is 150 or more, this is not the case for the payment for lambs that get a lump-sum payment based on certain carcass traits (EUROP). Moreover, subsidies meant to promote grazing are based on the number of grazing animals.

Table 3. Gross margins (GM), hours of hired work, as well as the number of breeding sheep and hogget of Norwegian White Sheep (NWS) for the baseline and the alternative scenarios studied.

	Gross Margin, 1000 NOK	Breeding Sheep	Hoggets for Meat	Lambs (0–1 years)	Hired Work, (hours)
Current practice, lifespan 3.3 years	401	119	0	53	570
Alternative scenarios ^a					
1. Delayed season	369	116	0	52	510
2. Hogget production	279	99	52	44	593
3. First lambing when 2 years old	354	157	0	70	693
4. Longevity increased to 5.3 years	417	163	0	38	612

^a Detailed description of alternative scenarios is given in Table 2.

Table 4. Farm GM, the hours of hired work, the number of breeding sheep and hoggets per farm of the Norwegian Spæl (NS) breed for the Current baseline and the Alternative scenarios.

	Gross Margin, 1000 NOK	Breeding Sheep	Hoggets for Meat	Lambs (0–1 years)	Hired Work (hours)
Current practice, lifespan 3.3 years	423	132	0	59	754
Alternative scenarios ^a					
1. Delayed season	389	134	0	59	763
2. Hogget production	372	112	59	50	583
3. First lambing when 2 years old	388	160	0	72	593
4. Longevity increased to 5.3 years	451	163	0	38	718

^a Detailed description of alternative scenarios is given in Table 2.

Table 5. Use of concentrate feed and roughage per sheep in terms of energy (FEm), as well as grazing offtake per ha, and use of concentrate per kg of meat for the different scenarios studied for Norwegian Spæl (NS) breed.

	Concentrates FEm */Sheep	Roughage FEm */Sheep	Yield FEm */ha	Concentrates FEm */kg Meat (overall)
Current practice, lifetime 3.3 years	98	348	2699	3.59
Alternative scenarios ^a				
1. Delayed season	117	325	2550	4.33
2. Hogget production	105	409	2700	3.00
3. First lambing when 2 years old	81	285	2694	4.31
4. Longevity increased to 5.3 years	68	330	2701	3.10

* 1 FEm = 6.9 MJ net energy ^a Detailed description of alternative scenarios is given in Table 2.

Table 6. Calculated difference (NS–NWS) between the Norwegian Spæl (NS) and the Norwegian White Sheep (NWS) breeds in gross margins, numbers of breeding sheep per farm, the use of roughages and the use of concentrates per kg of meat.

	Gross Margin, 1000 NOK	Breeding Sheep	Roughage FEm */Sheep	Concentrates FEm */kg Meat
Current practice, lifetime 3.3 years	22	13	−39	−0.28
Alternative scenarios ^a				
1. Delayed season	20	17	−55	−0.02
2. Hogget production	94	13	−58	0.15
3. First lambing when 2 years old	34	3	−11	−1.30
4. Longevity increased to 5.3 years	33	0	−1	−1.68

* 1 FEm = 6.9 MJ net energy ^a The detailed description of alternative scenarios is given in Table 2.

The yield (Table 5) is lower in Alternative 1 (Delayed season) and the concentrates per sheep is higher compared to current practice because of more pasturing of farmland in the fall that gives lower pasture yields than silage production. More supplement concentrates were used for the ewes grazing on pasture due to the lack of silage. The amount of concentrates used was higher for Alternative 3 (first lambing when 2 years old) compared with Alternative 4 (Longevity increased to 5.3 years). Since the lifespan of the ewe was increased to 5.3 years, it requires 3.10 kg of concentrates to produce one kg meat in Alternative 4.

In all investigated scenarios, the difference in profitability from wool is trivial and hence not included in this study.

Under the “current practice”, the overall GM was 5.5% higher for NS compared to NWS. The NS lambs are lighter in BW than the NWS lambs. The later are favoured by the EUROP classification system, which is based on body conformation [10]. This price difference per kg was not accounted for in the modelling. Getting a poorer EUROP carcass conformation grade, and thus a lower price, for NS

lambs, may lead to the GM difference being reduced to a level where it is insufficient for choosing the NS breed under the “current practice”.

The first alternative scenario, delaying lambing for 16 days, was less profitable than the current scenario since the amount of autumn pasture became a critical factor. However, the autumn pasture might not be an important issue in all cases of small sheep farms along fjords and in coastal areas. Given the abundant pasture available in the fall, either as near-farm outfields or fenced farm pastures, later lambing may prove more profitable for both breeds. Moreover, the NS sheep may extend the time in more remote pastures (in coastal and fjord area) compared to the larger NWS breed, thus not needing so much autumn pasture at the farm.

For the Hogget production (Alternative 2), NS is more profitable than NWS, with a GM of NOK 372,000 compared to NOK 279,000, or an increase by 25%. In addition, NWS hoggets may not serve the demand for fresh meat supply adequately because of negative changes in the meat sensory quality from lamb to hogget [10] and due to heavier carcass weights and more subcutaneous fat compared to the NS. In the alternatives investigated in this study, lambs were supplemented with concentrates due to a shortage of grazing areas in the fall. Increased grazing on cultivated pastures will result in a lower production of silage for winter feed. The amounts of concentrate needed to produce one kg of meat under the scenarios are shown in Figure 2.

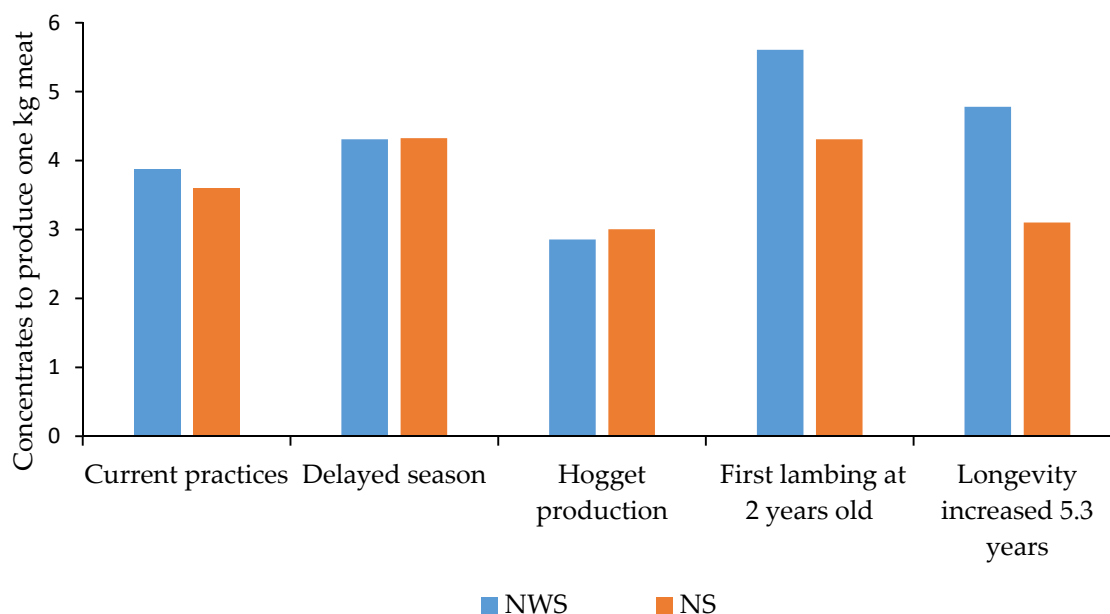


Figure 2. Estimated amount of concentrates required per kg of meat produced for the scenario practices and the two breeds studied.

NS also maintains the “lamb’s meat characteristic” better for overwintered hoggets, thereby making it a suitable complementary breed for an extended fresh-meat season [10]. During the winter season, ewe-lambs reared for marketing as hogget will graze, but with the available winter pasture only sufficient for maintenance level feed intake, an additional supplementary feeding of 0.15 kg concentrates is offered per animal per day.

The NS are smaller in size and believed by farmers to prefer to graze higher up in the terrain than NWS and also sustain for longer periods under rangeland grazing compared to the NWS. For the first alternative scenario, NS will exert less pressure on the farm pasture during autumn and require less supplementary feeding of concentrates compared to the NWS sheep. However, the modelling could not take into account any impacts over season upon the rangeland grazing, nor any impacts of that rangeland upon sheep performance.

The higher meat prices in June–July (when lower national lamb slaughterings) and similar meat quality of NS hogget with NS lamb [10] would increase the GM of the second alternative by getting

better market price for the hogget meat. Another option is grazing half of the winter-flock outside while the rest remains indoors and is fed concentrates and silage (or hay), thereby increasing the shed's carrying capacity.

Given the huge price difference between mutton (meat from hogget and sheep) and lamb meat, the offtake of sheep meat needs to be as low as possible. This is aided by a longer productive life of ewes.

The production of NS hogget was most profitable (34% higher GM for NS compared to NWS). The high GM for NS hogget makes it suitable for increasing the year-round fresh meat availability. Regarding the use of concentrates to produce one kg of meat, both breeds (NS and NWS) were similar in the case of the first alternative (delayed season). For the second alternative (hogget production), the NS gives the highest GM, but also uses 5% more concentrates per kg of meat compared to the NWS. As compared to NWS, the NS uses 7%, 23% and 35% less concentrates per kg meat for current practice, the third scenario (first lambing when 2 year old), and the fourth scenario (longevity increased to 5.3 year), respectively.

In the current practice (with lifetime 3.3 years), and delayed lambing (16 days), the model was solved with more hired work (32% and 50% more hired work, respectively) in the case of the NS breed compared to NWS. GM was higher (5% for both the current and first scenarios) for NS—keep in mind that there were more NS breeding sheep (11% and 15%, respectively) than NWS breeding sheep per farm unit. The overall more suitable NS will improve the efficiency and sustainability of the production system [15,16].

4. Conclusions

The dominating practice of the Norwegian sheep industry is to produce lamb meat from the heavy NWS breed. Increased use of the NS or similar breeds, either as a substitute, or complementary, to the NWS might be a way forward, particularly in the coastal and fjord areas of the country. This study shows that the overwintering of NS ewe lambs will benefit the maintenance of open landscapes and biodiversity in addition to higher profitability. Consumers must also be made aware of the hoggets' (NS) meat eating quality as a marketing tool for the hogget sale. Moreover, whenever possible, the breeding life of ewes should be prolonged to increase the offtake of lamb or hogget meat per ewe to keep the cost of recruitment to a minimum. In a situation with an overall declining meat consumption in the country, a transfer to a system based on more NS sheep grazing with less use of concentrates and greater adoption of a grass-fed production system may be a sustainable and consumer-appreciated way forward. It will help reduce the use of concentrates, thus shifting the sheep forage use towards more human non-edible feed.

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