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L.J. Asheim*, L.O. Eik and I. Mysterud*****
*Norwegian Agricultural Economics Research Institute, PO Box 8024 Dep, 0030 Oslo, Norway, e-mail: leif-jarle.asheim@nilf.no
**Department of Animal Science, Agricultural University of Norway, PO Box 5003, 1432 Aas-NLH, Norway, e-mail: lars.eik@ihf.nlh.no
***Department of Biology, University of Oslo, PO Box 1050 Blindern, 0316 Oslo, Norway, e-mail: ivar.mysterud@bio.uio.no

SUMMARY – The paper discusses the economics of substituting some ranging sheep with cashmere goats, employing a linear programming model. Studies of the grazing pattern reveal that trees and bushes constitute about 50 percent of feed intake of browsing goats, compared to 10 percent for sheep. Goats are thus more efficient than sheep in reducing pasture encroachment. Under Norwegian climatic conditions encroachment of bushes and trees will not affect the probability of wildfires. However, maintaining open landscapes is considered an important goal for the development of the rural countryside. A comprehensive shift from sheep to cashmere goats with eight month old kids averaging 11 kg slaughter weight, is unprofitable, assuming equal labour input of goats and sheep. However, goats are smaller and require less feed, thus the labour input of goats may be lower. Due to the low fibre yield cashmere goats are not as profitable as sheep, even excluding subsidies for wool. The fibre yield could be improved by breeding or by feeding the kids until 20 months (19 kg), making goats as profitable as sheep. The current agricultural support system treats sheep and goats alike. However, if Norway's position in the ongoing World Trade Organization (WTO) negotiations to allow for extra payment for preserving the cultural landscape (multifunctional agriculture) gains sufficient support, extra compensation for browsers should become interesting to the government in implementing the policy.

Key words: Norway, sheep farming, cashmere goats, linear programming, encroachment.

RESUME – *"Analyse par programmation linéaire de systèmes de production d'ovins et de caprins de Cachemire". L'article a pour objectif d'évaluer l'intérêt économique de remplacer une partie des troupeaux ovins au pâturage par des chèvres du Cachemire en utilisant un modèle de programmation linéaire. Les études sur le pâturage révèlent que les arbres et les buissons constituent environ 50 pour cent de l'ingestion des chèvres au pâturage, contre 10 pour cent pour les moutons. Les chèvres sont ainsi plus efficaces que les moutons pour réduire la dégradation du pâturage. Dans des conditions climatiques norvégiennes l'envahissement par les buissons et les arbres n'affectera pas la probabilité des feux de forêt, mais néanmoins le maintien de paysages ouverts est considéré comme un objectif important pour le développement des zones rurales. Le remplacement total des moutons par les chèvres du Cachemire avec des chevreaux de huit mois avec un poids moyen à l'abattage de 11 kilogrammes n'est pas rentable, si on considère des charges de travail égales pour les brebis et les chèvres. Cependant, les chèvres sont plus petites et exigent moins d'alimentation, le travail pourrait donc être moins important. En raison de leur faible productivité en fibres les chèvres du Cachemire ne sont pas aussi rentables que les moutons même en excluant les aides à la laine. Le rendement en fibres pourrait être amélioré par la sélection ou en engraissant les chevreaux jusqu'à 20 mois (19 kilogrammes), ce qui rendrait les chèvres aussi rentables que les moutons. Le système agricole courant de soutien considère de manière identique les moutons et les chèvres. Cependant, si la position de la Norvège dans les négociations de l'Organisation Mondiale du Commerce (OMC) pour permettre un paiement supplémentaire pour la préservation du paysage culturel (Multifonctionnalité de l'Agriculture) recueille un soutien suffisant, la compensation supplémentaire pour les animaux au pâturage permettrait au gouvernement d'appliquer de manière intéressante sa politique.*

Mots-clés : *Norvège, élevage des moutons, chèvres Cachemire, programmation linéaire, embroussaillement.*

Introduction

Due to both climatic changes and reduced grazing, especially by cattle and horses, encroachment of the natural range pastures has become a serious problem in many parts of Norway. During the second

half of the 19th century and the 20th century, the traditional farming lost much economical importance (Austrheim, 1998). In total, the harvest decrease in outlying fields has been dramatic; 740 versus 285 million feed units were harvested in 1939 and in 1996 respectively (Edelmann, 1997). The impact of grazing on different land use regimes is thus on the verge of being highly significant both on historical and ecological scales, a suite of vegetation communities has already been suggested red-listed (Fremstad and Moen, 2001). The attractiveness of the traditional open cultural landscape with its mixture of pasture and forest is affected by the reduced biodiversity (see Austrheim, 1998) and accessibility. Norway has a cool fire regime (Mysterud *et al.,* 1998), and under present climatic conditions forest and range fires will never become a management tool to suppress the present succession of bushes and trees. More profitable grazing is probably the most realistic solution to the problem; this will require the development of an efficient anti-encroachment management strategy.

Grazing sheep are most important in utilising mountain pasture (counting for about 2/3 of the feed intake) followed by cattle (1/3) whereas grazing by horses is insignificant. An appropriate mixture of grazers and browsers would be most efficient in reducing encroachment and ensuring good pasture utilisation, however browsers like goats are currently present in insignificant numbers only. Most of the cows and goats are also kept for the milk which, except in the dry period, necessitates concentrating the grazing by these animals to areas close to a summer milking shed. The sheep however, can disperse widely into the range pastures where they tend to form small flocks of just a few animals per square kilometre. A production system with suckling goats, quite similar to that of sheep, is currently being tested in Norway. A new classification system of goat meat has been introduced and the producer price has been raised through opportunity for contract production. The demand for goat meat is high from restaurants and from immigrants with traditions for goat meat. The price of the cashmere fibre is also satisfactory. For the farming system either a pure cashmere breed or a crossing with the local breed seems most promising.

The paper discusses the environmental impact of substituting some ranging sheep with cashmere goats. The current support scheme with the same rates for sheep and goats is compared to a system with extra payment in accordance with a more positive influence on pasture tree and shrub encroachment by goats. Also the importance of the goat fibre yield is studied. The discussion is based on calculations in a linear programming (LP) model, worked out for sheep farms in rural areas of the Southern and South-western parts of Norway, two important regions of interest for the new farming system. LP analyses are widely employed in farm management studies. For a general overview of the comprehensive literature on LP, see, for instance Hadley (1974) or consult Barnard and Nix (1979) on how LP can be applied in managing farms, maximizing gross margins.

Materials and methods

The LP-model is based on 54 farm accounts for the years 1998 and 1999, taken from the random samples of accounts collected by the Norwegian Agricultural Economics Research Institute (NILF, 1999, 2000a). The average breeding stock of the farms was 88 ewes with 25 kg of meat per ewe. Most farms in the area have the Norwegian cross breed type of sheep (Norwegian white sheep) or the Norwegian Landrace (Spel). The agricultural area was 10.8 ha. The model calculates total farm profit and return per hour[1] and has been worked out in Norwegian kroner for the price level and support regime of the year 2000[2]. The results have been transferred to euro at the exchange rate of 811 Norwegian kroner per 100 euro.

Some LP-model input coefficients for sheep and cashmere goats are displayed in Table 1. The labour input on sheep farms in the area has been assessed to 361 h plus 14.2 h per ewe (Brattgjerd, 1990). Of this respectively 153 and 4.6 h are conducted during the grazing period. In the main alternative

[1] The profit of owner occupied farms is farm output less the sum of variable and fixed costs (including interest, ownership charges and labour costs). Return per hour is calculated by adding back cost of paid labour divided by total number of hours worked on the farm.

[2] The model has been worked out in the spreadsheet Excel and consists in 24 processes; 11 for plant crops and pasture, five for purchased feed, four for animal husbandry, two for support, one for hired labour and one for the fixed costs. The maximum farm profit is determined within 26 restrictions; five on area, four on labour input, 11 on feeding and five on support for feed production and animal husbandry. The final restriction balances the relationship between the number of sheep and goats on the farm.

(alternative A) the same labour input for goats and sheep has been employed, however for kids kept a second year an extra input of 4 h is assumed. Goats require less feed than sheep and have seldom any difficulties during birth. They flock well on pasture and are easily gathered. It is on the other hand necessary to feed the kids longer than lambs before slaughtering. During grazing in paddocks, electrical fencing and more supervision are also needed for the goats. In a separate alternative (alternative B) labour input of goats is assumed to be 15 percent lower than for sheep. The farm family worked 1688 h a year on the recorded farms, this figure being available labour force in the model. The labour input and variable costs of the pasture and forage crop processes are based on The Farm Management Handbook (NILF, 2000b), labour input ranging from 12 to 78 h per hectare.

Table 1. LP-model input coefficients for sheep and cashmere goats

	Sheep	Cashmere goats
Live weight	70 kg	40 kg
Indoor feeding period	206 days	206 days
Feed requirement indoor	203.6 FEm	132.3 FEm (65% of sheep)
Marginal labour input, alternative A	14.2 h/ewe	14.2 h/goat
Marginal labour input, alternative B	14.2 h/ewe	12.1 h/goat (85% of sheep)
Extra labour input for kids kept a second year	–	4.0 h/kid
Cost of veterinary service, medicine, etc.	17.3 euro/ewe	17.3 euro/goat
Price of sheep and lambs and kids (adult goats)	4.51 euro/kg	4.62 (1.23) euro/kg
Rural support for meat	0.81 euro/kg	0.81 euro/kg
Extra cost of housing for kids kept a second year	–	3.1 euro/kid

We employ the same times for in-house feeding, springtime lambing or kidding and release on pasture for sheep and goats. The same feeds can also be used but feed requirements for goats are only 65 percent of sheep due to different metabolic weight. For the same reason higher density of goats can be maintained in the pens, and extra housing is not required in spite of a larger number of animals in the alternative with cashmere goats. For the goat kids no extra housing is required when slaughtering at eight month of age, but cost of housing during the second barn-feeding period is included.

The same costs of veterinary service, medicine and different animal articles have been assumed for goats and sheep. The goats are smaller, however all male kids have to be castrated which is not necessary for lambs sold during the autumn. The general support rates are about equal for sheep and suckling goats. The kids are slaughtered at eight month (11 kg slaughter weight) or 20 month (19 kg). Assuming a contract delivery the price will be 4.62 euro per kilo whereas adult goats are sold for 1.23 euro per kilo only. The average price of sheep and lamb meat is 4.51 euro.

Economical results and discussion of the systems

In the basic solution (reference run) with sheep only, the agricultural area was utilised with 85 sheep, compared to 88 on the accounted farms. The crop yield of the LP-model was about the same as on the farms, however somewhat less concentrate feed was purchased. The family labour input was fully utilised in the basic alternative and an additional 211 h were hired, which corresponds reasonably well to 252 h for the accounted farms. The farm profit was 5654 euro and the return per hour 4.6 euro. The corresponding figure of the accounted farms was 5432 euro and return per hour 4.4 euro, measured as an average for the years 1998 (4.7 euro) and 1999 (4.2 euro). Taking into account that the divergence was less than five percent and that the rate of inflation was 3.1 percent in 2000 (Statistisk Sentralbyrå, 2001), the model seems to give a reasonable representation of the economy of sheep farming in the area. It has thus been employed to assess the economy of changing the farming and the farm support systems.

Result with the current support scheme

Table 2 shows the farm profit as well as return per hour with specialised sheep farming and mixed sheep and goat farming in the relationship 4:1, 1:1 or goats only. Compared to sheep, production of eight

month old goat kids is currently not profitable; the return per hour will decrease from 4.6 to 3.2 euro. If the kids are fed until 20 month the return will increase to 4.4 euro per hour, still somewhat below sheep. If there are only goats with eight month old kids on the farm it will become difficult to utilise the agricultural area completely. The labour resource will be exploited before all the farmland is utilized. Farmers may adjust for that by increasing pasturing on agricultural land or reducing input of fertiliser, i.e. a less intensive use of the land thus requiring more land per animal.

Table 2. Agricultural area in use, number of sheep and goats, farm profit and return per hour (euro) on a specialised sheep farm in rural areas of Eastern and South-western Norway compared with specialised goat farming or a mixed system

	Area (ha)	Breeding ewes	Breeding goats	Farm profit	Return per hour
Basic solution, sheep only	10.8	85	0	5654	4.6
Mixed: 80% sheep, 20% goats					
8 month old kids	10.8	68	17	5417	4.4
20 month old kids	10.8	65	16	5674	4.6
Mixed: 50% sheep, 50% goats					
8 month old kids	10.4	42	42	4764	3.9
20 month old kids	10.8	38	38	5455	4.6
Only cashmere goats					
8 month old kids	8.8	0	87	3359	3.2
20 month old kids	10.5	0	70	5069	4.4
Only goats, labour input 85% of sheep					
8 month old kids	10.2	0	101	5616	4.6
20 month old kids	10.8	0	82	7378	5.7

Another option would be to work more on the farm, however this has to be considered in relation to outside farm work. Outside farm employment is quite common on Norwegian sheep farms and generally more profitable than sheep farming. Since it is a possibility that goats will require less work than sheep, an alternative with 15 percent less labour input for goats than sheep has been worked out. In that case the farm profit will be 5616 euro and return per hour increases to 4.6 euro, which is about the same as for sheep. By producing 20 month old kids the profitability increases to 5.7 euro an hour.

Production of 20 month old kids has several advantages. The feed requirement will be low during the autumn and the kids may be released early from the barn the second year. During late autumn or early springtime they may utilise shrub or under-bush vegetation, making them especially efficient as landscape preservers. While meat from 20 month old kids generally is tasty and of good quality, the market for such meat is uncertain and the farmers have not yet been offered an option of contract production.

Since sheep and goats utilise different parts of the vegetation, replacing some sheep by goats would likely improve the pastures for the remaining sheep. A high number of sheep on pastures may lead to losses in meat production per ewe due to gastrointestinal nematodes. In some parts of the country the lamb disease *alveld* is a serious problem, and whereas the mechanisms associated with the disease are unclear, the current hypothesis is that it is caused by grazing of the lily plant bog asphodel (*Narthecium ossifragum*) which is found in bogs (Flåøyen, 2000). Although the plant also contains the nephrotoxic principle 3-methoxy-2(5H)-furanone which affects the kidneys of goats, its impact is assumed of less significance as goats to a larger extent than sheep prefer drier habitat types (Nedkvitne *et al.,* 1995). The effects of goats on sheep pastures have not been considered in the model, but would make the mixed enterprises more competitive.

Effect of cashmere fibre yield

The results in Table 2 are based on an assumed production of 200 gram of cashmere fibre on adult

goats and 90 gram on eight month old kids, i.e. a "moderate yield" of the fibre. By an efficient selection within the existing Norwegian breeding stock, such amounts could be achieved over a five-year period. Half of these amounts, i.e. 100 gram for adult goats and 45 gram for eight month old kids has been termed "low yield". The cashmere goats were imported from New Zealand in 1995. Whereas the fibre quality has been good, farmers may expect even lower yields when the goats are kept in insulated houses (Todnem and Eik, 2003). Since the growth of the fibre will depend upon the temperature we have assumed that 100-gram for adults and 45 grams for kids can be achieved in non-insulated houses. If embryos or semen are imported from the best goats in Scotland, a 50 percent fibre yield increase is possible ("high yield", 300 gram for adults and 135 gram for kids). In Table 3 the farm profits of the different levels of cashmere yield have been worked out with and without subsidies for wool.

Table 3. Agricultural area in use, number of sheep and goats, farm profit (euro) with and without subsidies for wool on a specialised sheep farm in rural areas of Eastern and South-western Norway compared with a mixed sheep and goat system

	Area (ha)	Breeding ewes	Breeding goats	Farm profit with wool subsidies	Farm profit without wool subsidies
Basic solution, sheep only	10.8	85	0	5654	4088
Moderate cashmere fibre yield					
8 month old kids	10.4	42	42	4764	3982
20 month old kids	10.8	38	38	5455	4746
High cashmere fibre yield					
8 month old kids	10.4	42	42	5464	4682
20 month old kids	10.8	38	38	6539	5829
Low cashmere fibre yield					
8 month old kids	10.4	42	42	4064	3281
20 month old kids	10.8	38	38	4371	3662

The world market price of wool is low and governmental subsidies amount to 18.5 euro per ewe. Without the subsidy, the profit of specialised sheep farms (reference alternative) is strongly reduced and goats with eight month old kids are almost as profitable as sheep even with a moderate yield of cashmere. The cashmere fibre is not subsidised. However, with the current low fibre yield sheep farming is more profitable than goat farming with eight month old kids, even without price subsidies for wool. Further work to increase the amounts of cashmere thus seems desirable.

For the alternatives with 42 goats and production of eight month old kids the farm profit will increase by 1400 euro or 34-43 percent if the fibre yield level can be raised from low to high. The fibre price (93.7 euro a kilo) is based on average price to Scottish producers in July 2000. The value of the fibre also depends upon the costs of collecting and grading the fibre. These costs that will depend upon volume, have not been subtracted. The cashmere fibre will be growing until December. The goats are combed while the kids can be sheared before slaughtering.

Payment for preserving the cultural landscape judged by effect on encroachment

In the negotiations regarding world trade in agriculture [through World Trade Organization (WTO)] Norway and some other countries have proposed that "multifunctional agriculture" should become a reason for allowable national agricultural support. The idea is that agriculture in addition to marketable goods like food and fibre, also produces several common goods like open landscapes, rural settlement or contributes to maintenance of the cultural heritage and of species richness in vegetation communities. If such support should become allowed, and not be perceived as yet another suspicious agricultural subsidy, the support scheme must be specifically targeted so as to achieve such goals. When encroachment of trees and shrubs on pastures is to be prevented by grazing and browsing animals the support may have to be determined by the number of animals on pasture and the rate would have to be graded in accordance with their assumed effect on the encroachment problem.

To stimulate use and care of the range pastures, Norwegian farmers are currently paid a support of 4.3 euro per animal for sheep and goats grazing on natural ranges. The rates do not reflect the different grazing habits of grazers and browsers and an alternative with separate rates has therefore been worked out. In areas with moderate encroachment we have assumed that trees and bushes constitute about 50 percent of the feed ration of goats, compared to 10 percent of sheep. When adjusted for different body weight, goats are about three times more efficient than sheep in reducing encroachment and the support has therefore been raised to 12.3 euro for goats. As for 20 month old kids they may have a longer period on pasture and the support has been estimated to 21.6 euro per animal. With a considerable encroachment the goats are even more efficient because they can debark the trees (Nedkvitne *et al.,* 1995). Table 4 shows the results with these rates. For the sheep the current subsidy has been used and a moderate production of cashmere is assumed for the goats.

Table 4. Agricultural area in use, number of sheep and goats, farm profit and return per hour (euro) on a sheep farm in rural areas of Eastern and South-western Norway with specialised sheep or goat farming or a mixed system with extra payment to goats for reducing encroachment

	Area (ha)	Breeding ewes	Breeding goats	Farm profit	Return per hour
Basic solution, sheep only	10.8	85	0	5654	4.6
Mixed: 80% sheep, 20% cashmere goats					
8 month old kids	10.8	68	17	5782	4.6
20 month old kids	10.8	65	16	6389	4.9
Mixed: 50% sheep, 50% cashmere goats					
8 month old kids	10.4	42	42	5677	4.4
20 month old kids	10.8	38	38	7142	5.4
Cashmere goats only					
8 month old kids	8.8	0	87	5234	4.2
20 month old kids	10.8	0	72	8157	6.2

With the proposed changes it will become profitable to substitute more sheep with goats. The alternatives with production of 20 month old kids are probably the best in areas with considerable encroachment. With 50 percent sheep and 50 percent goats the farm profit increases by 1489 euro (26%) and return per hour from 4.6 to 5.4 euro compared to the basic alternative with sheep only. For eight month old kids a complete transfer from sheep to cashmere goats still would not be profitable unless assuming lower labour input for goats than sheep.

Conclusion

The results for rural Eastern and South-western Norway indicate that a comprehensive change in farm enterprise from sheep to cashmere goats is not profitable in the current situation unless labour input of goats is about 15 percent lower than that of sheep. The average yield of fibre on Norwegian cashmere goats is still low and in spite of a high price for the fibre, sheep farming will be more profitable even without subsidies for wool. It is possible to increase the amount of fibre by feeding the kids another year (19 kg slaughter weight) before marketing or by breeding either on the native goats or by importing more high fibre yielding goats. If the price of 20 month old kids can be raised to that of eight month, goat farming will become as profitable as sheep.

Goats are more efficient than sheep in reducing encroachment of trees and bushes on pastures. If future support for grazing animals will be targeted to effect on the vegetation of outfield rangeland in *an anti-encroachment management strategy*, the cashmere goats may also become as profitable as sheep. A mixed enterprise with both sheep and goats will be especially favourable for sheep farming in areas with limited supply of good sheep pastures for instance in areas with alveld. Sheep and goats will complement each other on pasture and the enterprises are quite similar.

It is not possible to predict the outcome of the current WTO negotiations and even though it will be

possible to pay extra support for grazing animals and to differentiate between grazers and browsers, it is not at all certain that the national government will do so. However, if the national government should want to stimulate care for the future landscape on mountainous ranges by using grazing animals, mixed grazing by small ruminants can be given priority. In that case extra support for goats and other browsers might become meaningful to consider.

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