

Consideration of breeding objectives in small ruminants used for vegetation control and landscape maintenance

E. MARTYNIUK

W. OLECH

DEPARTMENT OF GENETICS AND ANIMAL BREEDING

WARSAW AGRICULTURAL UNIVERSITY

UL PRZEJAZD 4

05-840 BRWINOW

POLAND

SUMMARY - The paper describes different possibilities of utilisation of small ruminants for vegetation control and landscape maintenance, and impact of such services on the environment. Some attempts to estimate value of environmental services are presented and difficulties to link quality of the service to traits measurable in livestock are analysed. The possible breeding objectives in production systems combining environmental services with slaughter lamb production are discussed.

Key words: Sheep, breeding programmes, landscape maintenance, vegetation control.

RESUME - "Prise en compte des objectifs de sélection chez des petits ruminants utilisés pour le contrôle de la végétation et la conservation du paysage". Ce document présente les différentes possibilités de l'utilisation de petits ruminants pour contrôler la végétation et la conservation du paysage ainsi que l'influence de ces services sur l'environnement. Il présente aussi quelques possibilités d'estimation de la valeur de ces services environnemental et il analyse les problèmes concernant les relations entre la qualité de ces services et des caractères mesurables des animaux. On y discute les objectifs possibles de l'élevage dans le système qui joint les services environnemental et la production d'agneaux de boucherie.

Mots-clés : Ovins, système d'élevage, conservation du paysage, contrôle de la végétation.

Introduction

In the recent years the alternative use of small ruminants to provide different environmental services has become more and more important. In western European countries extensification and fallowing are promoted, as a consequence of EU policy to decrease food production, while in the CEEC, transition in agriculture and breakdown of public sector lead to increasing areas of uncultivated land. It creates a serious public concern because such areas may easily become devastated if a proper national/regional policy to maintain the landscape is not adopted.

In several countries development of agriculture and environmental policies and subsidy system directed towards landscape management are already well advanced (Pals, 1991; Langholz, 1992; Garmo *et al.*, 1993; Peters and von Korn, 1993) while in others, like the CEEC, such policy is lacking.

Agricultural extensification programmes have got positive public perception as they allow to protect biological resources and provide more opportunities for outdoor recreation (Ziche, 1992). Animal production conducted in such systems is well-appreciated both because of growing concern over the quality of animal products and their impact on human health as well as society awareness of animal welfare.

The importance of small ruminants in extensive systems of production and in various environmental services to control vegetation and maintain landscape should also increase in the light of the Convention on Biological Diversity (1992) which has so far been ratified by 161 countries. The 3rd COP to CBD meeting in Buenos Aires adopted a package of 24 decisions on conservation and sustainable use of agricultural biological diversity (UNEP/CBD/COP/3/L.12) which *inter alia* recommend an integrated, multidisciplinary approach to planning, development and management of

land resources to achieve multiple objectives related to sustainable agriculture and rural development. Therefore technologies and farming practices which arrest degradation of environment as well as reclaim, rehabilitate, restore and enhance biological diversity should be promoted and introduced by the Parties.

It seems that in the years to come alternative utilisation will become an important issue in sheep and goat husbandry in many countries, Germany being a good example (Wassmuth, 1994).

Option for small ruminants alternative utilisation

Weed control

Weed control is one of the possible objectives in utilisation of grazing animals. The review of the subject by Popay and Field (1996) shows that with a proper management (fencing, stocking rate) grazing can provide a successful control of weeds of pastures but also of arable crops, forestry and waste places. There are differences between breeds and species in their ability to reduce biomass. For instance, the experiment on hill pastures of the Appalachians (Magadlela *et al.*, 1995) demonstrated that goats were able to reduce brush cover from 45 to 15% in one year while sheep required 3 years to bring the same results.

The agroforestry systems have been intensively investigated in recent years all over the world both at coniferous plantation (Bird *et al.*, 1995; Rapey *et al.*, 1994; Newsome *et al.*, 1995) and on plantation of high quality broad-leaved species (Rapey, 1994; Arthur and Ahunu, 1992; Guitton *et al.*, 1995); the integration of grazing into forestry proved to be a successful solution.

Landscape management

Landscape management addresses various situations where grazing animals may provide service to the environment. It will include grazing "social fallows" and any other uncultivated or waste lands in order to control succession and to provide easy access for the public for recreation and leisure.

In many hill and mountains areas (Andrighetto *et al.*, 1993; Buchgraber, 1995) the maintenance of animal husbandry can prevent general degradation of the landscape because of succession of woody species, and conserve ecological advantages of these areas.

Grazing animals may be also used to rehabilitate and restore overgrown, neglected areas like grasslands in northern Hessen (Koenies, 1991), to maintain water resources in soil in semiarid rangelands (Duivenboden and Van Duivenboden, 1993) to prevent wild fires in Mediterranean zone (Nastis, 1993) and to fulfil other locally specific needs. In many programmes aimed to restore old traditional landscape, like permanent pastures in Haut-Verdon, France (Decaix, 1994), rural landscape in Extremadura, Spain (Blázquez *et al.*, 1995; Gallego *et al.*, 1995) or Thuringia, Germany (Roth and Berger, 1993), the small ruminants have got significant contribution, through grazing as well as being a part of the local culture, providing entertainment and special animal products for tourists.

The important task of small ruminants is associated with the preservation of different ecosystems like heather, moor, marsh wet meadow and other unique biotops present in national parks, nature reserves, landscape parks and all other kinds of protected areas.

Grazing animals have both direct and indirect effects on plant communities. Removing of palatable species as well as trampling, soil compaction and urine and dung paths alter botanic composition of the grasslands. If not grazed, the botanical composition is changing, the low growing plants decline constantly, as was shown in many areas, like in dune grasslands (Gibson, 1988), in hill pastures of North Wales (Hill *et al.*, 1992), Karst grassland in Slovenia (Vidrih and Kotnik, 1995) or permanent pastures in Japan (Ogawa and Mitamura, 1984). Grazing is the most effective method of removing biomass in these areas, which is crucial to maintain biodiversity in plant species.

Grazing in the nature protected areas is usually inflicted with many restrictions, like onset of the grazing and its duration, stocking rate, strict limits on fertilizers, etc. which obviously increase the costs of such services.

Economic evaluation of environmental services

In developing breeding programmes, when the breeding objectives are defined, it is most important to estimate economic parameters for these objectives. In the case of utilisation of small ruminants for landscape maintenance and vegetation management it is the most difficult task to estimate the value of such services, as most environmental benefits are strictly non-marketed goods. Contingent valuation studies (Brookshire *et al.*, 1992) conducted in Scotland (Doyle, 1993) and Denmark (Dubgaard *et al.*, 1994) demonstrated willingness of the society to pay for the access to the recreation areas, for maintaining biodiversity and providing better habitat for game.

In Austria, the possibility to impose tourist tax to fund payments for landscape maintenance was explored (Hackl and Pruchner, 1993). A system based on collecting money by tourists offices from visitors to make direct payments to local farmers was suggested (Pevetz, 1993) without any intervention of national/local government authorities.

In Germany, the value of grazing services is estimated on the basis of restriction level imposed by state environment authorities in close co-operation with the local sheep farming communities. The proper link between Environment and Agriculture should help to find solutions acceptable to sheep farmers, which ensure retaining economic sustainability and in the same time provide adequate services to protect nature (Peters and von Korn, 1993).

In case of agroforestry since the use of sheep to graze plantations may involve some loss of potential livestock performance, the forest managers may share the economic benefits of biological brush control with livestock owners as suggested by Leininger *et al.* (1989).

Generally, the evaluation of benefits derived from farming in maintaining the landscape and biodiversity, vegetation control and reduction of natural fires is extremely difficult. The transformation of this evaluation into breeding objectives is even more difficult, if possible at all.

Links of service function to breeding and production

As we have already shown, there is a great differentiation as regards grazing objectives, conditions and requirements depending on local situation. The local demands and environmental conditions will influence the choice of the breed, as different breeds have different preference and adaptation abilities as presented by Strittmatter (1990) and Terril *et al.* (1991). For instance only a few breeds are able to graze heather pastures, or shore marshlands. It is the best solution to utilise breeds indigenous for the region in question as they are best adapted to the specific environmental conditions.

Apart from breed selection, the management of flock should be adjusted to grazing regime. Mating/lambing season and lambs rearing procedures have to be matched with service requirements, as they influence mobility of the flock. Feeding system has to be based on evaluation of nutrient resources available at grasslands and possibilities to provide supplementary feeding, if necessary.

Breeding objectives

When breeding objectives are considered in relation to vegetation control and landscape management, grazing behaviour seems to be the most relevant issue. Plant preference usually describes what the grazing animal has eaten whereas selectivity refers to preference as a function of available vegetation. Although the grazing behaviour has been widely investigated, there is still no standardisation as regards terminology or techniques used to determine plant preference and selectivity by sheep and other herbivores (Garmo *et al.*, 1993). In a comparative study carried out in

Southern Norway, Garmo *et al.* (1990) showed that sheep select the diet of grass and forbs, typical for grazers while goats select large part of their diet from leaves, shrubs, bark of trees and bushes as typical browsers.

The differences in preference and selectivity between small ruminants were also demonstrated in other studies (Fisher *et al.*, 1994; Sharp *et al.*, 1995) - so the species specific behaviour should be taken into consideration to better fulfil service objectives (for instance restoration of old pastures infested by woody species succession versus controlled grazing in national park). At present, sheep are more frequently used to provide environmental services than goats.

In most cases, the successful grazing service means complete/uniform removal of the plant cover of the grazed areas. It means a low level of selectivity, as all plant communities should be grazed to the similar extent, with similar bite dimension. It is extremely difficult to achieve, if possible at all, especially as little is known yet about genetic background of grazing behaviour - whether the plant preference and selectivity is inherited and what criteria could be used to measure genetic variation in such traits within the flock. Previous experience and familiarity with the environment may influence feed preferences and diet selection as was found by Scott *et al.* (1996). It was also suggested (Thornley *et al.*, 1994) that the upper limit for daily intake in many swards is the result of behavioural adaptation rather than physiological or morphological constrain.

It seems that at the present state of knowledge it is not possible to include in breeding programmes any objectives directly connected with the quality of environmental services. Even if adequate measures of grazing "success" were developed, they would require a complicated and expensive test as well as extensive studies to estimate their genetic parameters. Also, as was already mentioned, there is no direct estimation of economic parameters for behavioural traits which may be important in performing such services.

At present, a payment for controlled grazing should compensate additional costs and difficulties connected with the service, and increase in value when the requirements/restrictions are harder to meet. The payment for performing environmental services is never sufficient to retain profitability, so the income from prime lambs sale is an important part of total output of the flock. Because of that, the breeding objectives have to be directed towards improving profitability of production in such specific husbandry systems, to achieve economic sustainability.

The breeding objectives therefore have to address separately ewe flock, which should perform well in extensive production system, and at the same time optimise lamb production, to provide a saleable product, matching market demands.

In ewe flock, a limited mature size is an advantage. Smaller ewes with lower maintenance requirements are able to spend more time on selective grazing. Ewes should be able to utilise different sorts of roughage and generally have rather low feed requirements. Early maturity is also desirable in maternal flock. Strong flock instinct is most important as it allows easier handling of the flock during mobile grazing. These traits are breed-specific and should be considered while choosing the breed.

In ewe flock, reproduction performance is of great importance. Prolificacy of the flock has to be balanced with available feed resources, as indicated by Bradford (1985). In many flocks there is still "space" for increasing litter size as well as for improvement of maternal abilities of ewes.

In some cases, because of the grazing regime, compact lambing season or early beginning of the breeding season are of interest so they may become one of the breeding goals in these flocks.

Hardiness, fitness and longevity should also characterise maternal flocks. Ewes have to perform reasonably in extensive and sometimes difficult conditions so they should be in good health and present certain level of resistance. Longevity is desirable as it decreases costs of replacement but also allows better adaptation to specific management systems, which is required in performing environmental services.

On the other hand, breeding objectives aiming to improve efficiency of lamb production should focus on high growth rate and carcass yield in prime lambs. Comparative studies on application of

different crossbreeding systems which analyse combining abilities of dam and sire breeds and heterosis effect in progeny should be promoted to develop most effective systems. Crossbreeding methods and breed contribution should be adjusted to environmental and husbandry conditions, feed resources, market requirements which are different in different regions - therefore the solutions should be also regionally specific.

Attempts to develop a production system which would combine extensive management of ewe flock with production of high quality prime lambs have been already made (Frederiksen, 1993; Peters and von Korn, 1993) and the results are encouraging.

It is also necessary to underline the possibility of utilisation of endangered indigenous breeds in landscape management services. In many countries rare breeds are subject to special conservation subsidies provided by state authorities or NGOs. Including such breeds in environmental service systems will help a lot in-situ conservation programmes and may result in increasing of their population size. Of course, breeding objectives for breeds which are regarded as genetic reserve are totally different. The main effort is directed towards maintaining genetic variation and decreasing inbreeding, which involves different breeding methods and procedures.

Summing up, the breeding objectives although similar in general, have to be considered separately for regions, for local farming communities or even for single flocks, as differentiation of all factors influencing production conditions as well as requirements of environmental services may be enormous.

Selection criteria and response

The breeding objectives described above have often generated an interest in sheep breeding. The possibilities of genetic improvement of litter size through selection, crossbreeding with prolific breeds and introduction of major genes are extremely well documented in literature (Bradford, 1985; Elsen *et al.*, 1994). Selection on maternal abilities, estimated on the basis of early growth of lambs (10-30 days) (Bodin and François, 1995), although successful, requires frequent body weight recording in the flock. Advancing of the breeding season may be achieved through selection as was well demonstrated by Smith *et al.* (1992 and 1995).

It is also possible to improve longevity through careful management and performance recording system. Additionally if ewe breeding value is estimated on the basis of 3 or more reproduction cycles, the accuracy is increasing and selection response can be higher than when applied on the basis of a single cycle, as proved by Brash *et al.* (1994a and 1994b).

Although changing of the mature body weight does not seem to be a breeding objective, monitoring the changes of ewe body weight or body condition (MLC procedure) between seasons might be of a great value. It is worth considering if the ability to maintain similar body weight or condition before each breeding season can be regarded as a general indicator of adaptation to management system, feeding resources and the evidence of general fitness of the ewe. The body weight or body condition should be expressed as standardised deviation of the flock mean - in order to make allowance for variation between seasons; the results of the previous lambing season should also be taken into consideration. Maintaining similar ranking within the flock through successive seasons is a desirable trait and the evidence of a good adaptation to production system.

Conclusions

In alternative utilisation of small ruminants, specially sheep, for vegetation control and landscape maintenance, the breeding objectives regarding ewe breed should be similar to those in other extensive systems.

Crossbreeding, where possible, is strongly recommended to allow utilisation of genetic potential of heavier and more intensive ram breeds and heterosis effect in crossbred progeny, which will help to achieve economic sustainability of sheep husbandry.

The value of environmental services is difficult to estimate directly, and not acknowledged yet in many countries. There are no relevant solutions as regards transformation of service value and requirements into traits describing grazing behaviour which may be possible to measure.

Combining service constraints and demands with the necessity to produce prime lambs of a good quality call for comprehensive breeding programmes which should be adopted to specific local/regional conditions.

References

- Andrighetto, I., Cozzi, G., Berzaghi, P. and Zancan, M. (1993). Avoidance of degradation of alpine pasture through grazing management: investigations of change in vegetation nutrition characteristics as a consequence of sheep grazing periods of the growing season. *Land Degradation and Rehabilitation*, 4: (1) 37-43.
- Arthur, P.F. and Ahunu, B.K. (1992). Integration of sheep with plantation tree crops in the humid tropics. *World Rev. Anim. Prod.*, 27: (3, 5, 9) 75-83.
- Bird, P.R., Kellas, J.D., Kearney, G.A. and Cumming, K.N. (1995). Animal production under a series of *Pinus radiata*-pasture agroforestry systems in South-West Victoria, Australia. *Aust. J. Agr. Res.*, 46: (6) 1299-1310.
- Blázquez, M.S., García-Adamez, M.M.A., Flamant, J.C., Portugal, A.V., Costa, J.P., Nunes, A.F. and Boyazoglu, J. (1995). Le tourisme rural dans les régions défavorisées: une approche globale impliquant les animaux comme alternative pour le développement. Animal production and rural tourism in Mediterranean regions. In: *Proceedings of the International Symposium on Animal Production and Rural Tourism in Mediterranean Regions*, EAAP, FAO, CIHEAM and SNFEZ of Portugal, Evora, Portugal, 10-13 October 1993, Flamant, J.C., Portugal, A.V. and Costa, J.P. (eds). EAAP Publication No. 74, pp. 271-274.
- Bodin, L. and François, D. (1995). Organisation of sheep breeding in France - suckling breeds - I. General description. *Cahiers Options Méditerranéennes, CIHEAM*, 11: 33-44.
- Bradford, G.E. (1985). Selection for litter size. In: *Genetics of Reproduction in Sheep*, Land, R.B. and Robinson, D.W. (ed.), 1: 3-18.
- Brash, L.D., Fogarty, N.M. and Gilmour, A.R. (1994a). Genetic parameters for Australian maternal and dual-purpose meatsheep breeds. II. Liveweight, wool and reproduction in Corriedale sheep. *Aust. J. Agr. Res.*, 45: (2) 469-480.
- Brash, L.D., Fogarty, N.M. and Gilmour, A.R. (1994b). Reproductive performance and genetic parameters for Australian Dorset sheep. *Aust. J. Agr. Res.*, 45: (2) 427-441.
- Brookshire, D.S., Eubanks, L.S., Randall, A., Markandya, A., Markandya, A. and Richardson, J. (1992). Estimating option prices and existence values for wildlife resources. In: *The Earthscan reader in Environmental Economics*, Markandya, A. (ed.). pp. 112-128.
- Buchgraber, K. (1995). Österreich braucht die Wiesen, Weiden, das Vieh und seine Landwirte. *Forderungsdienst*, 43: (11) SB1-SB8, (Sonderbeilage zum Thema Grünland).
- Decaix, G. (1994). Sylvopastoralisme dans le Haut-Verdon. *Agroforesterie en zone tempérée. Revue Forestière Française*, 46: 49-58. (Special issue).
- Doyle, C.J. (1993). Economic evaluation of the environmental benefits from grazing with small ruminants. In: *Proceedings of the 44th EAAP Meeting*, Aarhus, Vol. II: 214-215.

- Dubgaard, A., Dubgaard, A., Bateman, I. and Merlo, M. (1994). Valuing recreation benefits from the Mols Bjerger area, Denmark. In: *Proceedings of a Workshop organized by the Commission of the European Communities Directorate General for Agriculture*, Brussels, 7-8 June 1993, Dubgaard, A. (ed.). pp. 145-163.
- Duivenbooden, N. van and van Duivenbooden, N. (1993). Grazing as a tool for rangeland management in semiarid regions. *Agr. Ecosyst. Environ.*, 43: (4-3) 309-324.
- Elsen, J.M., Bodin, L., Francois, D., Poivey, J.P. and Teyssier, J. (1994). Genetic improvement of litter size in sheep. In: *Proceedings of the 5th World Congress on Genetics Applied to Livestock Production*, Vol.19: 237-244.
- Fisher, G.E.J., Scanlan, S., Waterhouse, A., Mannetje, L. and Frame, J. (1994). The ecology of sheep and goat grazing in semi-natural hill pastures in Scotland. *Grassland and Society*. In: *Proceedings of the 15th General Meeting of the European Grassland Federation*, 6-9 June, Mannetje, L. (ed.). pp. 286-289.
- Frederiksen, J.H. (1993). Behaviour and performance of ewes and lambs when grazing heather areas and their resulting influence on vegetation. In: *Proceedings of the 44th EAAP Meeting*, Aarhus, Vol. II: 222-223.
- Gallego, F.L., Urban, F.P., Gonzales, L.G., Flamant, J.C., Portugal, A.V., Costa, J.P., Nunes, A.F. and Boyazoglu, J. (1995). Model of animal production integrated in the programme of rural tourism, in "La Serena" region (Extremadura, Spain). Animal production and rural tourism in Mediterranean regions. In: *Proceedings of the International Symposium on Animal Production and Rural Tourism in Mediterranean Regions*, EAAP, FAO, CIHEAM and SNFEZ of Portugal, Evora, Portugal, 10-13 October 1993, Flamant, J.C., Portugal, A.V. and Costa, J.P. (eds). EAAP Publication No. 74, pp. 233-242.
- Garmo, T.H., Hansen, H.H. and Skjevdal, T. (1993). Use of small ruminants to maintain environments in the Nordic countries. In: *Proceedings of the 44th EAAP Meeting*, Aarhus, Vol. II: 212-213.
- Garmo, T.H., Pedersen, Q., Hove, K. and Staaland, H. (1990). Diet quality of goat and sheep grazing indigenous mountain pastures in Southern Norway. *Paper presented at the 41st Annual Meeting of the European Association for Animal Production*, Toulouse, France, 9-12 July, Vol. II: S.2.4.
- Gibson, D.J. (1988). The relationship of sheep grazing and soil heterogeneity to plant spatial patterns in dune grassland. *J. Ecol.*, 76: 233-252.
- Guitton, J.L., Balandier, P., Rapey, H., de Montard, F.X. and Montard, F.X. (1995). Mise au point d'une agroforesterie moderne: Avancement du programme de recherche/développement en Auvergne. *Forests Fr.*, No. 382, pp. 10-14.
- Hackl, F. and Pruckner, G. (1993). Touristische Präferenzen für den ländlichen Raum: Problematik ihrer empirischen Erfassung und Internalisierung. *Arbeitspapier Johannes Kepler Universität Linz*, No. 9309.
- Hill, M.O., Evans, D.F. and Bell, S.A. (1992). Long-term effects of excluding sheep from hill pastures in North Wales. *J. Ecol.*, 80: 1, 1-13.
- Koenies, H., Hakes, W., Hollstein, B., Legner, D. and Wassmann, T. (1991). Halbtrockenrasenpflege mit Schafen. Erste Ergebnisse von Langzeit-Beweidungsversuchen mit Deutschen Schwarzkopfigen Fleischschafen zur Regeneration verbuschter und verfilzter Enzian-Schillergrasrasen in Nordhessen. *Verhandlungen Gesellschaft für Ökologie*, 19: (3) 87-98.
- Langholz, H.J. (1992). Extensive Tierhaltung in Landschaftspflege und als produktionstechnische Alternative. *Zuchtungskunde*, 64: (3-4) 271-282.
- Leininger, W.C., Sharrow, S.H. and Rhodes, B.D. (1989). Sheep production in coastal Oregon Douglas-fir plantations. *Northwest Sci.*, 63: (5) 195-200.

- Magadlela, A.M., Dabaan, M.E., Bryan, W.B., Prigge, E.C., Skousen, J.G., D'Souza, G.E., Arbogast, B.L. and Flores, G. (1995). Brush clearing on hill land pasture with sheep and goats. *J. Agr. Crop Sci.*, 174: (1) 1-8.
- MLC. (1983). *Sheep Improvement Services. Body condition scoring of ewes*, 83/215.
- Nastis, A.S. (1993). Effect of grazing small ruminants on landscapes and wild fires prevention in the Mediterranean zone. In: *Proceedings of the 44th EAAP Meeting*, Aarhus, Vol. II: 208-209.
- Newsome, T., Wikeem, B. and Sutherland, C. (1995). Sheep grazing guidelines for managing vegetation of forest plantations in British Columbia. *Land Management Handbook Ministry of Forests*, British Columbia, p. 34.
- Ogawa, Y. and Mitamura, T. (1984). Studies on cessation of grazing on a permanent pasture ecosystem. 6. Effect of cessation of grazing on vegetational structures. *J. Jpn. Soc. Grassland Sci.*, 30: (1) 74-78.
- Pals, L.S. (1991). Landschaftspflege - neue Einkommensmöglichkeit im Dienste der Natur. *Tierzucht*, 45: (5) 208-210.
- Peters, K.J. and von Korn, St. (1993). Use of grazing small ruminants for sustainable landuse in central Europe. The case of Germany. In: *Proceedings of the 44th EAAP Meeting*, Aarhus, Vol. II: 210-211.
- Pevetz, W. (1993). Subsidiarität - Partnerschaft - erleuchteter Eigennutzen. Mitfinanzierung bauerlicher Lndschaftspflege durch die Fremdenverkehrswirtschaft? *Monatsberichte über Österreichische Landwirtschaft*, 40: (4) 273-280.
- Popay, I. and Field, R. (1996). Grazing animals as weed control agents. *Weed Technol.*, 10: (1) 217-231.
- Rapey, H. (1994). Les vergers a bois precieux en prairie paturee: objectifs, principes et references. *Agroforesterie en zone temperee. Revue Forestiere Francaise*, 46: 61-71, (Special issue).
- Rapey, H., Montard, F.X., Guitton, J.L. and de Montard, F.X. (1994). Ouverture de plantations resineuses au paturage: implantation et production d'herbe dans le sous-bois apres éclaircie. *Agroforesterie en zone temperee. Revue Forestiere Francaise*, 46: 19-29, (Special issue).
- Roth, D. and Berger, W. (1993). Extensivierung und Agrarraumgestaltung - Ziele, Flächenbedarf, Kosten. *Zeitschrift für Kulturtechnik und Landentwicklung*, 34: (4) 215-223.
- Scott, C.B., Banner, R.E. and Provenza, F.D. (1996). Observations of sheep foraging in familiar and unfamiliar environments: familiarity with the environment influences diet selection. *Appl. Anim. Behav. Sci.*, 49: (2) 165-171.
- Sharp, P., Knight, T.W. and Hodgson, J. (1995). Grazing behaviour of alpaca and sheep. In: *Proceedings of the New Zealand Society of Animal Production*, 55: 183-185.
- Smith, J.F., Johnson, D.L. and Reid, T.C. (1992). Genetic parameters and performance of flocks selected for advanced lambing date. In: *Proceedings of the New Zealand Society of Animal Production*, 52: 129-131.
- Smith, J.F., Parr, J., Murray, G., Harris, C. and Duganzich, D.M. (1995). Effect of selection for early lambing on the expression of hogget oestrus activity. In: *Proceedings of the New Zealand Society of Animal Production*, 55: 154-156.
- Strittmatter, K. (1990). Möglichkeiten zur verstärkten Einbeziehung von Schafbeständen in die Natur- und Landschaftspflege auf dem Territorium der ehemaligen DDR. *Tierzucht*, 44: (11) 505-507.

- Terrill, C.E., Slee, J. and Majjala, K. (1991). Breed differences in adaptation of sheep. *Genetic resources of pig, sheep and goat*, pp. 95-233; *World Animal Science*.
- Thornley, J.H.M., Parsons, A.J., Newman, J. and Penning, P.D. (1994). A cost-benefit model of grazing intake and diet selection in two-species temperate grassland sward. *Funct. Ecol.*, 8: (1) 45.
- UNEP. (1992). Convention on Biological Diversity. Full text and COP-3 decisions available <http://www.unep.ch/biodiv.html>.
- Vidrih, T. and Kotnik, T. (1995). Controlled grazing of small ruminants as a tool for the sustainable management in Karst grassland. *Sodobno Kmetijstvo*, 28: (5) 235-242.
- Wassmuth, R. (1994). Perspektiven der Schafzucht un-haltung im Deutschland. *Arch. Tierzucht*, 37: (SP ISS) 57-63.
- Ziche, J. (1992). Beurteilung von landwirtschaftlichen Extensivierungsprogrammen durch Wohnbevölkerung auf dem Lande. *Land Agrarwirtschaft und Gesellschaft*, 9: (1) 79-99.