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Summary

The introduction of new technologies in the dairy sheep production systems in the Mediterranean area must take into account the delicate balances on which their durability is based, because of their permanent impact upon the resources used. Application of inadequate technologies in areas of genetics, reproduction or animal nutrition, for example, could endanger these ovine milking systems. For this reason, the selection of local breeds in their respective locations of historic use is almost always found to be the preferred choice for increasing milk production because it minimizes the problems of adaptation to the environmental limits and to the increase in the demands of nutrition. Actually, the introduction of exotic genotypes with higher milking potentials has had success only in some situations with intensive or semi-intensive systems for example in Israel and Spain. In the area of reproduction, artificial insemination (AI) remains the most important technical innovation as it allows the spread of ram semen in different production systems, thus permitting tests and controlled use in field conditions. Linking this technology to the synchronization of oestrus is also an asset in dairy sheep production systems by matching the productive cycle of animals with the available resources. In the area of nutrition, in addition to the essential role of adapting feeding systems to the management of feedstuffs, the development and use of better systemic models permits a greater improvement in feed resources in grasslands and range areas supplemented by appropriate management.

Keywords: Sustainability, dairy ewes, genetic improvement, feeding, reproduction.

Résumé

L'introduction de nouvelles technologies dans les systèmes de production d'ovins laitiers dans la zone méditerranéenne doit prendre en considération l'équilibre fragile sur lequel sa durabilité est basée à cause de l'utilisation des ressources. L'emploi de technologie inappropriée dans les domaines de la génétique de la reproduction ou de la nutrition animale par exemple peut mettre en danger le système ovins laitiers. Dans ce contexte la sélection de races locales dans leur bassin respectif de production s'avère presque toujours être la technologie la mieux adaptée pour augmenter la production laitière. Elle réduit le problème de l'adaptation aux limites de l'environnement et à l'augmentation des besoins alimentaires. En réalité l'introduction de génotypes exogènes avec un haut potentiel laitier est seulement valable dans des systèmes d'élevage intensif ou semi intensif en Israël ou en Espagne.

Concernant la reproduction l'insémination artificielle (IA) est la plus importante innovation technique assurant la diffusion du sperme de bélier dans différents systèmes de production qui permet de tester et d'utiliser les reproducteurs dans de réelles conditions d'élevage. Cette technique ainsi que la synchronisation de l'œstrus est aussi un atout dans les systèmes de production d'ovins laitiers permettant l'harmonisation du cycle de production avec les ressources disponibles. Pour ce qui est de la nutrition en plus du rôle essentiel du système d'alimentation le développement et l'utilisation de modèles plus améliorés rendent possibles une plus grande valorisation des ressources alimentaires des prairies et des parcours avec une complémentation appropriée.

Mots clés : durabilité, brebis laitières, amélioration génétique, alimentation, reproduction.

Introduction

Dairy sheep have traditionally been raised in harsh or small areas of Mediterranean countries. The challenge for Mediterranean dairy sheep systems arises from (i) the standardization of consumers' demands and (ii) the globalisation of milk sheep production. If unsuitable technological tools are introduced with the aim of increasing milk yield, then the sustainability of dairy sheep production systems in Mediterranean areas could be threatened. Consequently, the inclusion of new technology can be a paradox relative to sustainability.

Thessier (1979) defined technology as the ordered joining of operations which, based on scientific or empirical knowledge or both of them in most cases, facilitates a specific objective in a production system. This relationship between scientific knowledge and technology has characterized change in recent times. As a result, it has been assumed that technology is able to offer a production system which will provide specific solutions in existing situations.

Consequently, a new technology can be introduced without paying enough attention to the system. This approach could lead to standardization of production and consequently to possible exploitation of resources and risks to the environment.

The traditional systems of production, which are often more attractive to the consumer, have maintained and often improved the resources such as the soil or the livestock. These more natural systems have maintained the sustainability concept – namely to continue permanently without compromising future means of production (Brundtland report). Nevertheless, the sustainability of animal production systems does not imply ceasing their development. The relationship between the production systems and rural society requires an adaptation of the former to the changes in society. Consequently, production systems must adapted to integrate the new technological alternatives retain sustainability and its distinctive characteristics.

Integration of new technologies needs the dedication of people concerned with the production systems, as opposed to the liberal, individualistic development based on the activity of individuals (Boyazoglu, 1998). To reach this objective, appropriate available technology must be adapted to a particular way of production, that is to say, it must be translated into practice (Thessier, 1978). In turn, this requires:

- Training professionals working in the system, especially the livestock breeders (Alderman, 1991);
- Organizing these livestock breeders and the other professionals involved to make continuous assessments of the effects of new technologies.

Although the introduction of new technologies in some dairy sheep systems in the Mediterranean area has led to major modification of the production system with environmental and sociological consequences (Lavin, 1996), this is not the general situation. In most cases the new technologies are added to the sustainability of the historic production system.

Genetic improvement technologies

Unsuitable technological tools, if introduced into fragile dairy sheep production systems in Mediterranean areas, can severely endanger their sustainability, especially if possible higher demands and costs are not directly related to higher outputs.

In this sense, the use of exotic genotypes or careless selection programs could jeopardize the functional integrity and/or the resource sufficiency of grazing-based production systems. In the past, in dairy cattle, pig and poultry production systems, specialised and improved genotypes were introduced which required a substantial increase in the available resources of the farms. This was sustainable in the long term only in a few cases. Instead of improving stock performances in the local conditions, the use of these improved genotypes involving adapting the environment to the newly selected stock which approach can endanger the economic balance on which dairy sheep farms depend.

The need for improved stock suited to Mediterranean production systems has been amply discussed in the past, both for beef cattle and sheep production (Bibé & Vissac, 1979), as substantial modifications of livestock production lead to greater control or intensification. Specific crossbreeding schemes for dairy sheep production were studied in many Mediterranean countries, relying mainly on crosses between East Friesian and local breeds.

This kind of genetic improvement by introducing genes that directly influence milk yield while neglecting their interaction with the production environment reduces the capacity to cope with temporary decreases of available resources and other stresses which frequently occur in Mediterranean grazing-based systems. In fact, overlooking the animals′ adaptation to local farming systems could possibly lead to genotypes with an increased environmental sensitivity. Due to poor adaptation to local conditions or to higher requirements, these crosses were successfully introduced into only a few intensive or semi-intensive systems, such as those of Israel and Spain (Epstein, 1985; Ugarte *et al.*, 2000).

Pure-breed selection programs of local breeds, carried out across all environments in which the offspring are expected to produce milk, anticipates possible genotype by environment interactions (Sanna et al., 2000), though it can reduce the theoretical genetic gain of the selection programmes. In fact, selection activities can improve the sustainability of dairy sheep systems by means of the increased yields of the best local genotypes suited to their production environment on the one hand and by reducing the danger of uncontrolled introductions of exogenous genotypes on the other. Exotic breeds should be used with great care in dairy sheep systems to preserve the functional integrity of the system.

The assessment of the average capability to perform in different production conditions in Mediterranean dairy sheep systems can be estimated through a careful use of semen across all possible environments, using BLUP genetic evaluation (Gabiña & Barillet, 1991; Barillet *et al.*, 1992; Sanna *et al.*, 1994). In this situation, breeders could further improve the phenotypic response to selection by raising young rams for natural service that will sire within a peculiar environment, among the sons of the proven AI sires and ewes that expressed their genotype best in that environment (Sanna *et al.*, 2000). All these factors lead to consideration of pure-breed selection of local dairy sheep breeds in their respective area of production as the more suitable genetic technology for most of the Mediterranean breeding conditions (Barillet, 1997).

Technologies related to reproduction

Concerning reproduction, several techniques have been proposed in the last decades to increase sheep production, but only a few of them can actually be used in Mediterranean dairy sheep flocks. The reproductive technologies used to improve, or to grant, the sustainability of dairy sheep systems can be classified as: i) means which directly improve production or, ii) tools required to achieve any genetic improvement of breeds. Of course, some techniques proposed as genetic tools could also have an effect in increasing reproduction rates and production.

i) In Mediterranean dairy sheep systems, seasonal availability of pastures and the lamb market often demand out-of-season breeding. In this situation, oestrus synchronisation with FGA or MAP, with or without PMSG injection at withdrawal, can provide earlier and more grouped lambings than those achieved by exposing ewes only to the ram effect (Bodin, 1997; Matos *et al.*, 1997). Fertility rates obtained after synchronisation, especially on ewe lambs mated at 8-9 months of age, can provide a higher fitness of the sheep production cycle compared with that on pasture. Hence, a better exploitation of pastures can increase the overall sustainability of dairy sheep systems, both in terms of functional integrity and resource sufficiency (Thompson & Nardone, 1999). Higher production has also been observed in flocks with the most concentrated lambing season. This result may be related to the advantages that these flocks have when the feeding management is the same for all milking ewes (Fraysse *et al.,* 1996; Ruiz, 2000).

ii) In selection programs carried out on field conditions, the use of some reproductive techniques, such as AI, is crucial for genetic improvement. As pointed out by a number of authors (see Bodin, 1997 for detailed references), the space dissociation between production and utilisation of semen is the simplest and most efficient way to set up a reliable genetic evaluation and to perform the best assortative matings. Nowadays, it is obvious that there is no chance of producing sound and stable genetic gain within a specific environment of production without reliable genetic evaluation.

Experiences in Mediterranean breeding programs reveal different levels of utilization of AI, related to different production systems. The Lacaune breeding scheme in France shows an annual genetic gain close to 2,5 % of the average yield with 80% of registered ewes inseminated (Barillet *et al.*, 1996). French and Spanish Pyrenean breeding schemes and the Sarda program in Sardinia reveal an annual genetic gain between 1,5 and 2 %of the respective average yields with an AI utilization rate ranging between 20 and 40% on registered ewes (Sanna *et al.*, 1995; Ugarte *et al.*, 1995; Barillet, 1997). These experiences show that using AI on a large number of sheep can dramatically increase pair-wise or multiple comparisons between sires, providing a considerable improvement of the accuracy of natural mating sire proofs. Thus, careful use of AI together with natural service techniques can be an efficient way to improve the sustainability of dairy sheep systems.

Field experiences in several countries (Perret *et al.*, 1997) clearly indicate that AI provides the best results if associated with oestrus synchronization. Fertility rates are higher and costs can be reduced by inseminating 50-100 ewes at the same time. In most schemes fresh semen is preferred because of its simplicity and low cost. On the contrary, an extensive utilization of laparoscopy, both for AI with frozen semen or for embryo transfer, is not justified in sheep production systems. In some circumstances, though, it can be used efficiently. For instance, the use of this technique in Sardinia has shown sceptical breeders the advantages of Sarda selected lines and has allow to incorporate them into co-operative selection activities.

Table 1. Residual Standard deviation (RSD) for the organic matter digestibility estimation (OMD) according to different laboratory methods (Hvelpund et al., 1995; Andrieu &, Guerin, 1996)

Method of OMD estimation	RSD (Perceptual unites)
From cell wall composition (CB, FAD, LAD)	2.0-6.0
In vitro digestibility, with ruminal liquid or purified enzymes	2.0-3.0
In situ digestibility method	2.0-3.0
NIRS (Near Infrared Reflectance Spectrometry)	1.5-2.5

Technologies related to nutrition, feeding, and management

One of the most important outcomes of the huge growth in knowledge on ruminant nutrition in the second half of the 20th century has been the development of different feeding evaluation systems (AAT-PBC; ARC; CNPCS; INRA; …) that are used at present. These systems can be considered as technologies because they permit organization of feeding operations including the optimum utilization of feeds.

All these methodologies have two main elements, the estimation of nutritive requirements, maintenance and production requirements of animals on the one hand and the estimation of nutritional value of feeds for this given category of animals on the other. These nutritional systems, however, have been developed in intensive production conditions, with the aim of obtaining a maximal production, in conditions of abundance and high nutrient density feeds availability (Jasiorowski, 1991). In these conditions, the estimation of nutritive value of feeds is founded on energy and protein values. For the estimation of these values, and taking into account the improvement in ruminant digestion knowledge, a series of evaluation techniques with increasing precision has been developed. Table 1, for example, records the precision of organic matter digestibility estimation, according to different laboratory methods.

Most small ruminant production systems in the Mediterranean area, however, are based on different features. Their objective is to obtain sufficient production to assure their feasibility, using local resources - a great part of which are pastoral resources limited in quantity or quality, and irregular in time and space.

Under these conditions, securing regular feed intake per animal (Landais & Lasseur, 1995) is as important as improving the quality of forages (Jasiorowski, 1991) or knowing their nutritive value. Consequently, the ingestibility of feeds plays a major role in the estimation of the feeding value. The precision in the estimation of this characteristic is, however, well below the previously cited one (RSD=5.0-6.0) (Demarquilly *et al.*, 1981), probably due to the limited past interest in studying this aspect. Only in the recent years has interest increased, due to the difficulty of dealing with the nutritional needs of high milk yield dairy cows (Forbes, 1995). But this interest mainly focuses on high quality and conventional roughages.

This and other aspects, such as the effect of anti-nutritive factors related to the utilization of some forages (Hervás *et al.*, 2000), open new criteria to account for adapting the nutritional systems to

Mediterranean production conditions. Within this framework, the use of limited and irregular resources can be improved by:

Grazing management practices: to favour proper daily use of grazing zones, differing in species composition and forage availability, to optimize feed intake (Meuret, 1995) and to avoid the concentration of animals in the best zones (Marijuan, 1996) with detrimental effects on soil and vegetable cover.

Pasture supplementation: not only for production purposes, but also as a tool of grazing management. Casu *et al.* (1996) pointed out the possibility of using supplementation to save grass and to enlarge the period of use in situations of limited resources, as in the milking period.

The use of forage conservation as a complement of grazing. The new technologies of conservation, big-ball dehydration or silage, provide good quality products which are well adapted to forage production and animal needs.

However, the implementation of these technologies in extensive or semi-extensive systems will be favoured by the use of complex models, such as Decision Support Systems (DSS) (Dent, 1996), which can take into account the great number of variables involved. These include systems related to feed and ratio characteristics or to the flock management, as well as to the forage availability and its spatial and temporal distribution. (Lecomte *et al.*, 1996; Sauvant, 1996). In addition to their interest as a management tool, the elaboration or adaptation of these models to a concrete situation implies the possibility of identifying the importance of different elements in the system and of directing the work towards those more important and less known components of the production system. Moreover, in the conception or adaptation of these models, promoting the collaboration of farmers with experts and researchers, with the aim of identifying and introducing priorities and needs is very important (Leaver *et al.*, 1998).

To achieve these objectives the development of computer technologies is useful, as it integrates and treats a wide range of information of different origins even in an interactive way with the livestock producer.

Conclusion

Finally, it is relevant to use a global approach including simultaneous genetic, reproductive, nutrition and feeding technologies or others not described in this paper, such as milking machines, hygiene monitoring or product technologies. Such a comprehensive approach combined with training professionals (especially livestock producers) appears suitable for the choice and adaptation of technologies compatible with the sustainability of Mediterranean dairy sheep systems. The successful development of this approach in several countries indicates that the decision to select local breeds within the area of production seems to be essential in this strategy.

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