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Adding value to local breeds with particular reference to sheep and goats

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Summary
About 82 percent of the total known sheep breeds are local breeds, and for goats, the respective figure is 86 percent. From the scientific perspective, as local breeds are unique genetic resources, they are valuable. However, the relative value assigned to local breeds differs between interest groups. Using several strategies to improve the relative value of local breeds will strengthen the prospects of their sustainable use. In this context, marketing is perhaps the most powerful tool. Marketing strategies include identification and promotion of traditional meat, milk and wool products from sheep and goats linked to local breeds, highlighting the quality and culture associated with these products and facilitating access of farmers to commercial markets. Other important strategies relate to: promotion of local breeds as the best suited for use in landscape management, silvopastoral systems and organic farming; exploitation of unique characteristics of local breeds in agritourism (food, non-food products, souvenirs and recreation) and for educational purposes; sustainable use of local breeds in breeding schemes; educating people about the value and importance of local breeds; introduction of legislative measures; finally, research can serve as a very powerful tool to add value to local breeds by creating new knowledge and providing scientific evidence on particular biological characteristics.

Keywords: *Sheep, goats, local breeds, relative value*

Résumé
Environ 82 pour cent du nombre total de races ovines connues sont des races locales et pour les chèvres, le chiffre correspondant est de 86 pour cent. D'un point de vue scientifique et étant donné que les races locales constituent une ressource génétique unique, les races locales ont une grande valeur. Cependant, la valeur relative assignée aux races locales diffère selon les groupes d'intérêt. L'emploi de diverses stratégies visant à améliorer la valeur relative des races locales consolidera les perspectives de leur utilisation durable. Dans ce contexte, la promotion commerciale est peut-être l'outil le plus puissant. Les stratégies commerciales incluent l'identification et la promotion de la viande et des produits laitiers et lainiers traditionnels, des ovins et caprins, liés aux races locales, en mettant l'accent sur la qualité et la culture associées à ces produits et en facilitant l'accès des éleveurs aux marchés. D'autres stratégies importantes se rapportent à: la promotion des races locales comme étant les plus appropriées pour l'aménagement des paysages, les systèmes sylvopastoraux et l'élevage biologique; l'exploitation des caractéristiques uniques des races locales en tourisme rural (gastronomie, produits non alimentaires, souvenirs, loisirs) et à des fins éducatifs; l'utilisation durable des races locales dans les programmes de sélection; l'instruction de la population sur la valeur et l'importance des races locales; l'introduction de législations; et finalement, la recherche peut servir comme un outil très puissant pour donner de la valeur ajoutée aux races locales par le biais de la génération de nouvelles connaissances et en apportant des preuves scientifiques qui supportent la spécificité des caractéristiques biologiques.

Mots-clés: *Ovins, caprins, races locales, valeur relative*

Resumen
Alrededor del 82 por ciento del total de razas ovinas conocidas son razas locales, siendo el dato correspondiente para las cabras del 86 por ciento. Desde la perspectiva científica y dado que constituyen un recurso genético único, las razas locales son muy valiosas. No obstante, el valor relativo asignado a las razas locales difiere según los grupos de interés. El empleo de diversas estrategias para mejorar el valor relativo de las razas locales fortalecerá las perspectivas de su uso sostenible. En este contexto, la promoción comercial es tal vez la herramienta más poderosa. Las estrategias comerciales incluyen la identificación y promoción de los productos cárnicos, lácteos y laneros tradicionales, de las ovejas y cabras, vinculados a las razas locales, destacando la calidad y la cultura asociadas a estos productos y facilitando el acceso de los ganaderos a los mercados. Otras estrategias importantes están relacionadas con: el fomento de las razas locales como las más adecuadas para la ordenación del paisaje, los sistemas silvopastorales y la ganadería ecológica; la explotación de las características únicas de las razas locales en el turismo rural (gastronomía, productos no alimentarios, recuerdos, ocio) y con fines educativos; el uso sostenible de las razas locales en los esquemas de mejora; la educación de la población sobre el valor e importancia de las razas locales; la introducción de medidas legislativas; y finalmente, la investigación puede servir como una herramienta muy potente para dar valor añadido a las razas locales mediante la generación de nuevos conocimientos y proporcionando pruebas científicas que respalden la particularidad de las características biológicas.

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Palabras clave: *Ovejas, cabras, razas locales, valor relativo*

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Introduction

According to the definition given by Food and Agriculture Organization of the United Nations (FAO), local breeds are those found in only one country (FAO, 2007a). In the present work, the term "local breeds" will not be used in this strict sense, but would rather indicate to large extent local indigenous and locally adapted breeds. It is worth noting that the overwhelming majority of local breeds are indigenous breeds. The importance of local sheep and goat breeds is indicated, among other things, by their uniqueness as genetic resources and by their large numbers compared with the total number of known breeds for each species. The proportion of local breeds to the total number of breeds reaches 82.4 and 86.3 percent for sheep and goats, respectively. The need of conservation and sustainable use of farm animal biodiversity is stressed by the Interlaken Declaration on Animal Genetic Resources (FAO, 2007b). Unfortunately, it seems that the value of local breeds is not well understood by the general public and by policy-makers. Moreover, local breeds are usually neglected by those considered as the most significant and powerful stakeholders of the livestock production sector (e.g. breeders). From the scientific perspective, local breeds constitute the major component of farm animal biodiversity and are characterized by their excellent adaptation to specific environmental conditions. Furthermore, local breeds are linked to traditional products of special qualities and to several practices that are part of cultural heritage. Therefore, every effort to add value to local breeds is worthwhile and will improve the prospects of their conservation through sustainable use.

The several strategies available to increase the value of local breeds can be arbitrarily grouped into three categories:

1. Linking local breeds with
    - 1.1 Traditional products
    - 1.2 Tourism/agritourism
2. Promoting use of local breeds in specific farming systems:
    - 2.1 Organic production
    - 2.2 Conservation grazing/silvopastoral systems
    - 2.3 Small low-input farms and hobby farms
3. General strategies:
    - 3.1 Marketing
    - 3.2 Legislation
    - 3.3 Organization of stakeholders
    - 3.4 Raising public awareness.

Needless to say, that generally, strategies are interrelated and overlapping, particularly those of the last category and the two others. In addition, these strategies apply to other species besides sheep and goats. It must be also mentioned, that a very powerful means, not actually a strategy but a tool, for adding value to local breeds is research. In the following part, each strategy is briefly described and, in most cases, is illustrated by examples related to local sheep and goat breeds.

Strategies to add value to local breeds

Linking local breeds to specific traditional products

This is a widely applied and effective way that increases the value of local breeds. The process implies labelling of traditional products according to national or international appellation systems. At the European Union (EU) level, the labels used for traditional food products including meat and milk products from sheep and goats, are the PDO (Protected Designation of Origin), PGI (Protected Geographical Indication) and TSG (Traditional Specialty Guaranteed). Some EU member states have their own appellation system, which runs in parallel with the EU system (e.g. Appellation d'origin controlee system in France). The significant contribution of local breeds to PDO/PGI products in 17 European countries was highlighted in a review paper by Zjalic *et al*. (2010). In this regard, it is of interest to note that in Mediterranean countries a larger number of local breeds are found compared with Northern European countries and this fact is reflected in the number and proportion of registered animal products from local breeds in the two regions, i.e. 207 of a total of 251 (82 percent) in the southern countries, 42 of a total of 77 (54 percent) in the northern countries (Table 1).

Furthermore, it is worth noting that EC Regulation 510/2006 does not exclude unprocessed wool products from EU labelling and this opportunity should be exploited.

Official and recognized labelling adds value to the product, to the producer and to the specific breed(s) of farm animal linked to the product. It is also a form of guarantee for the consumer. The complete list of products protected by EU labels is available at: ec.europa.eu/agriculture/quality/door/list.html

There are numerous examples of which only a few could be mentioned here. Besides some well-known cases of protected sheep milk cheeses from local breeds, like the Roquefort from Lacaune sheep in France, the Queso Manchego from Manchega in Spain, the Pecorino Siciliano from Comisana sheep in Italy, additional examples are, lamb meat from the Manx Loaghtan sheep, a primitive local breed on the Isle of Man in the

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Table 1. Geographic indication animal products from local breeds in 17 states.[1]

State	Cow cheese	Sheep cheese	Goat cheese	Mixed cheese	Beef	Lamb and mutton	Pork[2]	Total
Northern	11	5	6		4	9	7	42
Mediterranean	15	18	15	36	30	24	69	207
Total	26	23	21	36	34	33	76	249

[1]Adapted from Zjalic *et al.* (2010).
[2]Fresh pork and products.

UK. This PDO product is less fatty, darker and with better taste and flavour than meat from commercial breeds. Following the PDO award, there has been an upward trend for the small sheep breed population. Also, the Corderex lamb from Extrermadura, Spain, with a PGI label and coming from the homonymous native breed which is considered as part of the local ecosystem. Another case is the Palmero (PDO) cheese from La Palma Canary Island, Spain, which is produced from goat milk of the local Palmera goat and enjoys good reputation and price, despite the low volume of production.

Linking local breeds with tourism/agritourism

The concept that local breeds are an integral part and contribute to the maintenance of the rural environment is worthwhile promoting in the case of tourism and agritourism programmes. For instance, local breeds were reintroduced in certain areas of Serbia and Montenegro to improve attractiveness to tourists, while in the Netherlands there are many farms keeping local breeds for recreation and country fairs (FAO, 2007a). In Hungary, the local sheep breed Racka is important for small-scale farms and tourism in rural areas (Ratky *et al.*, 2011). Also important is to link local breeds to specific food (preferably dairy and meat delicacies) and non-food (wool, leather) products and souvenirs. Local sheep breeds of Austria, exploiting mountain pastures, besides their very good quality meat, produce wool with special qualities and colours, and are used in traditional clothing (www.oengene.at/index.php). In all cases, the products should contain the elements of tradition and specialty.

Promoting use of local breeds in organic production

Organic systems of animal production are largely based on forages and have been associated with sustainability of resources, welfare of animals and product quality. In The State of the World's Animal Genetic Resources (FAO, 2007a), it is stated that the expansion of organic production potentially promotes the keeping of well-adapted local livestock breeds. Local breeds are genetically adapted to their environment, are more resistant to local parasites and diseases, more resilient to climatic stress, and utilize low-quality feed compared with commercial breeds (Van Diepen McLean and Frost, 2007). Therefore, local breeds are the obvious choice of organic livestock production. Moreover, the use of local breeds in such systems gives higher economic benefits to the producers, at least under the support scheme of the EU (Frost, Morgan and Moakes, 2009; Mena *et al.*, 2009).

It is quite interesting that a number of products registered with quality EU labels are produced either by conventional or by organic methods, although the organic part constitutes a small proportion of the total volume of production. Organic Roquefort, Pecorina Romana and Idiazabal cheeses are some of many examples. They have the advantage of being promoted both as organic and as registered quality products adding extra value to the products and the breeds involved.

Conservation grazing/silvopastoral systems

Grazing is an efficient tool for the sustainable management and conservation of forests and natural pastures. local breeds provide the best solution when it comes to utilization of farm animals for conservation grazing purposes in forests and rangelands of various forms (grasslands, shrublands, wetlands, etc.), especially in hills and mountains, as well as in marginal areas. Conservation grazing of hill and mountain pastures by local breeds is a routine practice in some countries, and in the case of sheep, pure-bred females of these breeds constitute the basis of systematic two- and three-way cross-breeding schemes aiming at meat production. The United Kingdom, where the sheep industry is stratified according to specific environments (hills, uplands and lowlands), is the best example of such successful schemes. Hard sheep, mostly of the local Scottish Blackface and the Welsh Mountain breeds, are kept as pure-breds in the hills and mountains of the country, exploiting and conserving these difficult environments. Older ewes not required to produce replacement stock are transferred into upland areas and crossed to long-wool breeds (e.g. Border Leicester) to give first cross ram lambs that are fattened, and ewe lambs that are transferred into lowlands to be crossed to a terminal sire breed (Texel, Suffolk) to produce slaughter lambs (Simm, 1998; Hybu Cig Cymru, 2009).

Grazing is also considered an efficient fuel break management method, while at the same time it contributes to diversification of low-diversity forest areas (RCC, 2006). A good example comes from Andalusia, Spain. Scientists of various disciplines, together with farmers keeping the local breeds Raza Segurena (sheep) and

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Cabra Malaguena (goat), participate in a network that was formed with the support of the local government. About 7 500 sheep and goats guided by shepherds graze a mountainous area of 910 ha clearing fuel breaks. For the service they provide, farmers get paid €34–€70/ha/year according to several criteria. It was estimated that the cost of this fuel break clearing method is about 23 percent of alternative methods (Ruiz-Mirazo, Robles and González-Rebollar, 2009). This is an efficient tool for adding value to local breeds and is financially supported by the EU through agri-environmental measures of the Common Agricultural Policy (CAP). The question regarding who has to pay for the valuable environmental service local breeds provide by grazing rangelands and forests, always arises. If there is a demand on the part of the society to enjoy the environmental benefits forests and rangelands offer, then it is rational to assume that the society has to bear at least part of the cost. In this regard, the relevant CAP measures are in the right direction.

Concerning silvopastoral systems, they combine forest tree cultivation with low-input livestock production based on grazing. They fulfil the concept of sustainability and are friendly to the environment. Though there are similarities from the management point of view with forest conservation grazing systems, a major difference is that silvopastures are man made, whereas forests to a large extent are natural. In any case, local breeds fit very well within silvopastoral systems and such systems may actually contribute to the conservation of local breeds at risk (Rigueiro-Rodriguez *et al.*, 2008).

Small-scale farms and hobby farms

Many of the existing livestock breeds have survived thanks to smallholders and hobby farms. Smallholder production is much closer to agro-ecological farming practices, contributes to biodiversity conservation and is characterized by a diversity of products. There is nowadays increasing support for small-scale farms as an alternative to commercial large-scale farming operations that have been blamed for farm animal biodiversity loss (Report of the Pew Commission on Industrial Farm Animal Production 2008; Van't Hooft, 2009). In the Netherlands, the number of small-scale and hobby livestock farms is on the increase and many of them keep rare local breeds (Country Report in FAO, 2007a).

Several Organizations and Networks encourage and provide support for small-scale, low-input production from local breeds (ELBARN, Heifer Project, World Initiative of Sustainable Pastoralism, etc.), and it is anticipated that this kind of efforts will be intensified in the near future to the benefit of local breeds through utilization. In a recent report by the Small Scale Farming Organisation (www.smallscale-farming.org/), the qualities and advantages of using local breeds in small-scale livestock farming, and the role of this type of farming in climate change and food security, are highlighted.

Marketing

Marketing is the most powerful strategy to add value to local breeds. Finding or creating markets for meat, milk and wool products from local sheep and goat breeds substantially improves the prospects of their sustainable utilization. Marketing strategies include identification of special characteristics of local breeds associated with their products, highlighting the quality characteristics and cultural aspects linked to traditional products from local breeds, facilitating access of local breed farmers to commercial markets, using special approved labelling, conducting market research for identification of likely users, informing consumers through promotion campaigns about the unique distinctive quality characteristics of products, attempting to change current market attitudes towards product differentiation instead of standardized products and a number of other actions that contribute to better marketing prospects.

Many organizations promote the marketing of products from local breeds at the national, regional and international level. Breeders associations and societies play an important multifunctional role in the conservation, development and promotion of local breeds. Apart from keeping the necessary records in herd books, they provide information on the special characteristics of the breed and its products, they promote the marketing of products in various ways including, whenever this is justified, the registration and official labelling of traditional products, they participate in farm animal fairs, etc. At the European level, besides a number of breed societies, associations, networks, foundations, etc. operating within countries, the SAVE foundation and SAVE Network (www.save-foundation.net) in cooperation with the European Ark Network (www.arca-net.info), the Agrobiodiversity Net (www.agrobiodiversity.net) and the European Livestock Breeds Ark and Rescue Net (ELBARN, www.elbarn.net) have decided to introduce a special label "… as a trademark for small scale, extensive production from local breeds and plant varieties…". The procedures for awarding this label will be much simpler than when applying for the three EU trademarks (PDO, PGI and TSG), but conditions will be strict and more meaningful in terms of production requirements for the voluntary certification of the relevant products. At the global level, of particular interest is the initiative by the Slow Food Organization (www.slowfood.com) to link a product to a specific breed.

Legislation

Legislation is a political strategy that can be used to support local farm animal breeds either directly (subsidies) or indirectly (via several administrative measures). Through agri-environmental measures and headage payments for local breeds in danger of being lost to farming, the CAP of the EU is an example of this type of strategy. It is also true that some provisions of existing EU legislation do not favour genetic diversity, as it is the EU carcass classification system of lambs which is based on

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conformation and fat class and does not make any distinction between commercial and local breeds, operating, therefore, against the latter. For the sheep and goat sector, the European Parliament has called on the European Commission "to introduce an additional payment for farmers in mountain regions and other areas facing particular difficulties who are engaged in farming with rare traditional and regional breeds of sheep and goat in order to maintain biodiversity in agriculture and to preserve sheep in sensitive areas" (EC, 2008). It remains to be seen whether such measures will be included in the new CAP (2014-2020) considering that there is much debate going on around the CAP reform.

Organization of stakeholders

In a number of countries, breed societies are well established, especially in the cattle sector, and operate quite successfully. In many other countries, this useful strategic tool does not exist, and in these cases the establishment of breed societies would be a very important step towards conservation and utilization of local sheep and goat breeds, and should be encouraged and supported by state and private institutions within countries. In any case, it should be remembered that, according to the Global Plan of Action (FAO, 2007b), it is the responsibility of each country to establish national inventories of animal genetic resources and to contact periodic monitoring of relevant trends and associated risks.

At the regional level, cooperation between neighbouring countries leads to initiatives like the Nordic Genetic Resource Center (NORDGEN), which deals with plants, farm animals and forests. Within NORDGEN, the Farm Animal Division works on promoting "the genetic, economic, cultural, historical and social values of farm animal diversity. . ." (www.nordgen.org). At the European level, a number of organizations are actively involved in local breed conservation and utilization efforts, among which, as already mentioned, is the SAVE foundation which is linked to, and cooperates with a number of European NGOs operating towards the same directions. A product-oriented organization, ATELIER (http://atelier.laine.pagesperso-orange.fr), promotes European wool and wool products not necessarily from local breeds, although such breeds constitute an important part of its activities. At the international level, the Rare Breeds International organization (http://www.rarebreedsinternational.org/) is primarily concerned with conservation of rare (usually, but not always local) breeds, and the Slow Food Organization.

Raising public awareness

There is a real need to raise awareness about farm animal genetic resources, particularly about local breeds, among the general public, government officials and policy-makers. local breeds are living cultural heritage and for economic, biological, scientific, cultural and historical reasons (Maijala, 1987), it is necessary to conserve and utilize them in a sustainable way. In many countries, animal genetic resources are not considered a priority area and very little is being done with the consequence that "some breed populations and their unique characteristics may decline significantly, or be lost before their value is recognized. . ." (FAO, 2009). Public pressure is needed to change official attitudes when things follow this path. For raising public awareness, concerted actions are essential with the involvement of scientists, breed societies, farmers' associations, environmental groups and public media. To this end, science journalists may play an important role. Issues of tradition and culture, product quality, animal welfare, sustainability of resources, preservation of biodiversity, alternatives to mass production, etc. to which the general public is quite sensitive should be highlighted, and be associated with particular local sheep and goat breeds within the country.

Research

Farm animal research provides the insight for several important biological characteristics, and benefits from the genetic variability among the large number of breeds, most of which are local ones. At the same time, local breeds benefit from research results that reveal and identify some special biological characteristics of economic and scientific importance related to aspects of disease resistance, reproduction, longevity, adaptation to climate change, behaviour, quantity and quality of products, ability to utilize poor quality feed, etc. Certain networks and cooperative research projects on sheep and goat research have significantly contributed to the current scientific knowledge on these species. To name a few in the Euro-Mediterranean region, the ECONOGENE project (http://www.econogene.eu/default.asp) which addressed several aspects of sheep and goat genetic resources and rural development in marginal European agrosystems, the LowInputBreeds project (www.lowinputbreeds.org/project.html), aiming, among others, at improving organic and "low–input" sheep production systems, the HERITAGE sheep project (http://www.heritagesheep.eu/), the FAO/CIHEAM Network (http://www.iamz.ciheam.org) on sheep and goats.

Concerning results of research on local breeds, of a non-exhaustive list, only a few examples will be given. The Red Maasai sheep breed of Kenya, was shown to be resistant to parasitic diseases (Bishop and Morris, 2007) and this finding has provoked interest in this breed by countries with developed sheep industry (e.g. Australia). Resistance to many of the intestinal parasites and to foot rot was demonstrated for the Gulf Coastal local sheep of the Southeastern United States (Miller *et al.*, 1998). This, together with other properties like heat tolerance, these sheep possess, has led to the rediscovery of this breed by farmers in that region. Fat-tailed sheep breeds show

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remarkable adaptation to the harsh environmental conditions found in dry areas, and with the ongoing climate change, these breeds may prove extremely valuable (Iniguez, 2008). Research on indigenous goat breeds of South Africa has indicated the potential of adding further value to these animals through the production of cashmere (Braun, 2000). Several studies of the Skopelos goat breed in Greece have revealed a number of good characteristics about this local breed, in 1998 a breed society was established and a genetic improvement project was initiated in 2003. Both the population and the number of farmers keeping Skopelos goats are on the increase. In Portugal, for the PDO Nisa cheese, superior cheese making yield and better quality characteristics were shown when milk from two local sheep breeds was used and compared with milk from a foreign breed (Martins *et al.*, 2009). In theory, this research finding adds value to milk from the local breeds, but in practice, it is not known whether this milk enjoys a higher price than milk from the foreign breed.

Conclusions

The majority of known sheep and goat breeds are local. These animals are genetically adapted to their environment and have special characteristics that differentiate them from commercial breeds. The special and, quite often, superior characteristics of local breeds over foreign breeds in their native environment provide the basis for promoting their use in several production systems that guarantee the sustainability of resources and the quality of products. Several strategies are available and may be used to improve the prospects of utilization of local sheep and goat breeds, thus adding real value to these animals and safeguarding their survival. Depending on the breed and the existing situation, combining appropriate strategies increases the probabilities of success.

References

Bishop, S.C. & Morris, C.A. 2007. Genetics of resistance in sheep and goats. *Small Ruminant Res*. 70: 48–59.

Braun, L. 2000. Adding further value to South African indigenous goats through the production of cashmere. CSIR Research Space (available at http://researchspace.scir.co.za/dspacehandle/110204/1198).

EC. 2008. European Parliament Resolution of 19 June 2008 on the future of the sheep/lamb and goat sector in Europe (available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2009:286E:0041:0045:EN:PDF).

FAO. 2007a. *The state of the world's animal genetic resources for food and agriculture*, by B. Rischkowsky & D. Pilling. Rome (available at: www.fao.org/docrep/010/a1250e/a1250e00.htm).

FAO. 2007b. Global plan of action for animal genetic resources and the Interlaken Declaration. Rome (available at www.fao.org/docrep/010/a1404e/a1404e00.htm).

FAO. 2009. Status and trends report on animal genetic resources – 2008. Rome (available at ftp://ftp.fao.org/docrep/fao/meeting/016/ak220e.pdf).

Frost, D., Morgan, M. & Moakes, S. 2009. *Organic upland beef and sheep production*. Aberystwyth, UK, ADAS Pwllpeiran, IBERS and Organic Centre Wales.

Hybu Cig Cymru (HCC; Meat Promotion Wales). 2009. Cross Breeding Welsh Mountain ewes (available at: www.hccmpw.org).

Iniguez, L. 2008. *Small ruminant breeds in west Asia and North Africa*. ICARDA Publications, Caravan Issue No. 22, Aleppo, Syria, International Center for Agricultural Research in the Dry Areas.

Maijala, K. 1987. *Possible role of animal gene resource in production, natural environment conservation, human pleasure and recreation*. Animal Production and Health Paper No. 66. Rome, Italy, Food and Agriculture Organisation of the United Nations.

Martins, A.P., Belo, A.T., Vasconcelos, M.M., Fontes, A.L., Pereira, E.A. & Belo, C.C. 2009. Characterisation of production system of Niza cheese (PDO): effect of sheep breed on milk composition and coagulation properties. *Options Mediterr*. 91: 221–226.

Mena, Y., Ligero, M., Ruiz, F.A., Nahed, J., Castel, J.M., Acosta, J. M. & Guzmán, J.L. 2009. Organic and conventional dairy goat production systems in Andalusian mountainous areas. *Options Mediterr*. 91: 253–256.

Miller, J.E., Bahirathan, M., Lemarie, S.L., Hembry, F.G., Kearney, M.T. & Barras, S.R. 1998. Epidemiology of gastrointestinal nematode parasitism in Suffolk and Gulf Coast Native sheep with special emphasis on relative susceptibility to Haemonchus contortus infection. *Vet. Parasitol*. 74(1): 55–74.

Ratky, J., Egerszegi, I., Sarlos, P., Brussow, K.P., Kikuchi, K. & Berger, B. 2011. Reproductive methods in low input animal breeding (available at:www.Lowinputbreeds.org/symposium-2011.html).

RCC. 2006. Dispositif agroenvironnemental appliqué à la prévention des incendies de forêt en région méditerranéenne. Résultats de 20 ans de réalisations et propositions pour lavenir. Document de synthèse. Éditions La Cardère - ÍÉphémère, Laudun, France.

Rigueiro-Rodríguez, A., Fernández-Núñez, E., González-Hernández, P. *et al.* 2008. Agroforestry systems in Europe: productive, ecological and social perspectives. *Adv. Agrofor.*, 6(I): 43–65.

Ruiz-Mirazo, J., Robles, A.B. & González-Rebollar, J.L. 2009. Pastoralism in natural parks of Andalucía (Spain): a tool for fire prevention and the naturalization of ecosystems. *Options Mediterr*. 91: 141–144.

Simm, G. 1998. *Genetic improvement of cattle and sheep*. Tonbridge, UK, Farming Press, Miller Freeman UK Limited.

The Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America (available at: http://www.ncifap.org/bin/s/a/PCIFAPSmry.pdf).

Van Diepen, P., McLean, B. & Frost, D. 2007. *Livestock breeds and organic farming systems*. Aberystwyth, UK, ADAS Pwllpeiran and Organic Centre Wales.

Van't Hooft, K. 2009. Livestock: friend or foe? ECT Foundation, Netherlands (available at: http://www.eldev.net/docs/Livestock_Friend_or_Foe-KHO-20091201.pdf)

Zjalic, M., Rosati, A., Dimitriadou, A. & Murelli, E. 2010. Geographic indication of animal products and farm animal biodiversity – case of twelve Northern and five Mediterranean Member States of the European Union. In *Proceedings of the XI Mediterranean Symposium*, Zadar, 2010.

https://doi.org/10.1017/S2078633612000495 Published online by Cambridge University Press