The Role of Grazing in Agropastoral Systems in the Mediterranean Region and their Environmental Sustainability

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Abstract

Agro-pastoral systems have significantly contributed in shaping the landscapes of the Mediterranean basin. These systems vary widely according to the differing climatic, cultural and socio-economic conditions under which they developed; from the Parcours of the Maghreb steppes to the dehesas in the Iberian peninsula, and from the Mediterranean islands to inland mountain regions. Their present particularities developed both in response to internal needs within the farming systems (need to increase production while reducing costs) and external forces (competition with other activities for the use of land). In many cases recent changes evolved from increased grazing. Overgrazing represents one of the causes for desertification in many areas of the Mediteranean region. To mitigate this problem a better knowledge of agropastoral systems is first needed. Then, methods must be devised to model and assess environmental impacts, land suitability to grazing, and optimal stocking rate.

Keywords: Pastoral systems, grazing, sustainability, Mediterranean

Introduction

The present Mediterranean landscapes were shaped over centuries by agro-pastoral systems. However, agro-pastoral systems widely differ in their structure and functioning due to the climate and land conditions, as well as the cultural, social, and economic context in which they developed. Like all socio-economic systems, agro-pastoral systems went through a number of expansion and regression cycles and at present they are increasing - in line with the rest of the world - in the Mediterranean basin. This is particularly true for the systems based on small ruminants that represent the most important component of agro-pastoral production in the Mediterranean and constitutes the object of the present paper.

The current situation is summarized in Table 1 presenting the number of sheep and goats and the surface area of permanent pastures in countries of the Mediterranean basin. Table 2 summarises land use in Mediterranean countries. The data in Table 1 show that sheep and goats in the southern area of the basin amount to approximately 127.5 million units, while in the northern shore there

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are approximately 56 million units. The worldwide economic globalization has made the Mediterranean basin represents in all respects one macro area, though playing an important role as a link between Europe and Africa.

Table 1: Total number of goats and sheep and surface area of permanent pastures in countries of the Mediterranean basin

	Goats (1000)	**Sheep** (1000)	**Total** (1000)	**Total Area** (1000ha)	**Permanent pasture** (1000ha)
Morocco	5.000[1]	16.500[1]	21.500[1]	44.655[10]	21.000[10]
Algeria	3.400[1]	18.200[1]	21.600[1]	238.174[10]	31.800[10]
Tunisia	1.300[1]	6.600[1]	7.900[1]	16.361[10]	4.090[10]
Libya	2.200[2]	6.400[2]	8.600[2]	175.954[10]	13.300[10]
Egypt	2.878[1]	3.672[1]	6.550[1]	100.145[10]	480[10]
Israel	73[2]	340[2]	413[2]	2.106[10]	142[10]
Palestinian Authority	340[1]	660[1]	1000	38	9
Lebanon	400[1]	350[1]	750[1]	1.040[10]	16[10]
Syria	1.082[1]	13.119[1]	14.201[1]	18.518[10]	8.273[10]
Turkey	8.376[1]	30.328[1]	38.704[1]	77.482[10]	12.378[10]
Cyprus	3.786[3]	2.460[3]	6.246[3]	925[10]	4[10]
Goat and sheep in the southern basin			127.464		
Greece	2.975[4]	5.107[4]	8.082	13.196[10]	4.650[10]
Albania	-	-	-	2.875[10]	440[10]
Montenegro	-	-	-	10.235[10]	4.235[10]
Bosnia and Herzegovina	60[5]	554[5]	614[5]	5.120[10]	1.200[10]
Croatia	17[6]	63[6]	80[6]	5.654[10]	1.563[10]
Italy	1.368[7]	10.439[7]	11.807[7]	30.134[10]	4.379[10]
France	1.187[8]	10.556[8]	11.743[8]	55.150[10]	10.046[10]
Spain	2.605[9]	21.323[9]	23.928[9]	50.599[10]	11.450[10]
Goat and sheep in the northern basin			56.254		
Goat and sheep in the Mediterranean basin			183.718		

Data rounded in thousands, obtained from different source.

(1) (2) and (10) RADISCON and FAO statistical database in www.fao.org (2002);
(3) CYSTAT in www.pio.gov.cy;
(4) www.minagric.gr;
(5) Ministry of Agriculture and Foresty, Federation of Bosnia and Herzegovina;
(6) OV-KO mlijecni proizvodi. Lipnia, 2000;
(7) ISTAT data;
(8) INRA data in www.inapg.inra.fr;
(9) Ministerio de Agricultura, Pesca y Alimentacion in: www.ine.es

Grazing characterizes both shores of the Mediterranean sea. The related environmental issues require some reflection in order to better understand the future development of policies for integrating the economies in the world's wealthier and poorer areas. In the past two decades, the grazing sector significantly developed with an increase in the number of animals. On the island of Sardinia (Italy), for example, a five-fold increase was recorded in the past 100 years

(Table 3) both in absolute terms and with respect to the ratio to the population. The production of meat and milk increased accordingly, especially in more developed countries. The export of "pecorino romano" cheese increased from 6,400 t in 1980, to 26,900 t in 1996, partly a result of EC incentives. Sheep numbers grew accordingly, from about 2.3 million to about 4 million.

Table 2: Land use in Mediterranean countries (1000 ha)

	Permanent Crops	Arable Land	Permanent Pasture	Agricultural Area	Land Area	Total Area (land + water)
Morocco	970	8.750	21.000	30.720	44.630	44.655
Algeria	587	7.665	31.800	40.052	238.174	238.174
Tunisia	2.135	2.774	4.090	8.999	15.536	16.361
Libya	335	1.815	13.300	15.450	175.954	175.954
Egypt	480	2.858	480	3.338	99.545	100.145
Israel	86	338	142	566	2.062	2.106
Palestinian Authority	22	25	9	24	38	38
Lebanon	143	170	16	329	1.023	1.040
Syria	815	4.635	8.273	13.723	18.378	18.518
Turkey	2.550	23.805	12.378	38.733	76.693	77.482
Cyprus	41	72	4	117	924	925
Greece	1.132	2.720	4.650	8.502	12.890	13.196
Albania	121	578	440	1.139	2.740	2.875
Montenegro	0.34	3.752			10.136	10.235
Bosnia and Herzegovina	150	690	1.200	1.850	5.073	5.120
Croatia	127	1.459	1.563	3.149	5.592	5.654
Italy	2.804	8.172	4.379	15.355	29.411	30.134
France	1.138	18.447	10.046	29.631	55.010	55.150
Spain	4.929	13.019	11.450	29.938	49.994	50.599

Data rounded in thousands from different source.
RADISCON and FAO statistical database in www.fao.org (2002)

Table 3: Increase in the number of sheep between 1881 and 1994

Years	Sardinia	Italy
1881	845,000	8,863,000
1908	1,877,00	11,426,000
1930	2,054,000	10,268,000
1950	2,276,000	10,295,000
1970	2,558,000	7,948,000
1980	3,021,000	9,277,000
1985	3,822,000	11,451,000
1990	4,097,000	10,847,000
1994	4,297,000	10,651,000

The number of sheep and goats is thus increasing, though with different dynamics:

- in Italy, a 50% fall in the number of sheep and goats occurred during the the industrial boom (1950 to 1970), but since then a gradual recovery was

recorded up to the current total consisting of 1.3 million goats and 10.4 million sheep. In recent years, in particular, a qualitative increase of flocks and production was recorded. The Lazio and Toscana regions constitute typical examples of this dynamic. The pastoral sector of these regions was once almost exclusively based on merino breeding and the traditional practice of transhumance. At the beginning of the seventies the pastoral sector underwent a marked decline due to land tenure reform, rural land abandonment, extensive land reclamation and transformation of land formerly used for grazing into arable land.

- in Spain, the trend was basically positive over the past few decades, with a peak in the late 1980s, and now sheep and goats total 23 million;
- the trend in Algeria is similar to Italy. The number of sheep declined by half around the 1960s, mostly due to the war for liberation; later, a steady increase was recorded with approximately 18 million units today.

The countries situated on both shores of the Mediterranean sea are characterized by pastoral activities. However, the main production trend is clearly different. In fact, while meat production prevails in the southern regions, the milk and dairy industry dominates in the north. The total production of sheep and goat milk in the Maghreb and Middle-East countries amounts to approximately 250 thousand tons, while the total production in the Mediterranean region of the European Union is approximately 360 thousand tons. Note that production in the EU is obtained from 50% fewer animals as compared to the southern Mediterranean regions (Enne et al., 2002a).

Sheep and goat breeding and environmental sustainability

The agricultural sector in general and the breeding sector in particular are economically very significant in the Mediterranean basin. Following the modernization of this sector, agricultural activities had a significant environment impact over the past few decades, mostly related to the overexploitation of natural resources, which resulted in strong degradation processes in marginal and environmentally sensitive areas.

The severity of grazing in the European region causes the gradual disappearance of fauna, flora, and entire biotopes, pollution of surface and ground waters, increase in soil salinisation, and soil erosion and, ultimately, intense changes in the landscape. These problems are even more serious in the Mediterranean basin: a number of regions in the Iberian Peninsula are already so degraded as to be included in the world map of deserts.

The 1994 United Nations' Convention to Combat Desertification (UNCCD) acknowledges the severity of land degradation of the whole Mediterranean region. If on one hand, the countries on the southern shore suffer from the overexploitation of the scarce resources available, the countries on the northern shore are confronted with the problem of land abandonment in rural regions, especially in marginal areas.

A review of different mediterranean breeding systems, as related to the environment, highlights the importance of small ruminants in the conversion of resources into products, as well as their role in economic diversification. Sheep

and goats play a crucial role in the farming economy of the Mediterranean basin thanks to their ability to exploit marginal areas, and as well for the limited labour and capital required for their growth. In very difficult and degraded areas, or in harsh climates, this breeding type is the only possible primary activity able to prevent land abandonment, especially in the south-eastern Mediterranean regions.

Strategies to combat land degradation should provide for the recovery of the compromised areas as well as, in particular, determine a set of instruments to prevent degradation in threatened and high-risk regions (Zucca et al., 1998).

Interaction between land tenure and small-ruminant breeding

Land tenure significantly affects the opportunities to exploit natural resources; more specifically, the interaction with small-ruminant breeding is important in some Mediterranean regions. The general trend is towards the transformation of privately-owned pastures, usually more productive, into arable lands, while poorer and publicly-owned lands are still used for grazing. If the transformation of pastures into arable lands results in the production of crops (and by-products) such as grain cereals, straw, and stubbles, it is offset by the shrinkage of surfaces available for grazing, often limited to public areas for common use, leading to serious degradation (El Aich and Watherhouse, 1999). In addition, the use of publicly-owned lands as pastures is often associated with a complete lack of monitoring and planning of stocking rates to avoid overstocking and over-exploitation of such areas (the well known "tragedy of the commons", Hardin, 1968) (Amri, 1992).

Loss of cultural heritage and of traditional practices

In Europe, where long-distance transhumance was a typical sheep and goat breeding system adopted in the inland mountain regions of Italy, Greece, and Spain, this form of breeding was virtually abandoned in favour of more intensive types, more desirable for young farmers who, in view of increased individual productivity, also demand a nutritionally better feeding. This resulted in a decline in the use of hay in favour of silage, with a negative impact on the environment. Herbs, in fact, are only fed to the animals as hay after blooming and seed maturation, thus allowing the natural self-sowing of the lawn, whereas ensilage occurs before blooming; hence, in the long run, the vegetation becomes exhausted, with losses in terms of biodiversity. In addition, the abandonment of pastures promoted shrubland areas that increase the risk of fire.

In Europe, traditional sheep and goat breeding systems were also abandoned due to a severe reduction in the availability of farming labour and the significant aging of rural populations. This is due to the reduced profitability of such production systems and the migration of people towards industrial areas. Another reason for deep changes in traditional breeding systems is the introduction of new cosmopolitan breeds. These are more productive than native ones, but have generally higher nutritional needs, both in qualitative and quantitative terms, which force the breeders to exploit the grazing surfaces to a greater extent and to

introduce new crops, often causing serious environmental imbalance (El Aich and Waterhouse, 1999).

Positive effects of small-ruminant grazing

Grazing is a process that controls natural succession dominated by shrubs and trees; but also creates an opportunity for the settlement of rich consociations of plants and of related eco-systems. A rational stocking rate on pastures ensures the regrowth of the grass, as well as a significant provision of organic fertilizers to the soil.

Grazing in sylvopastoral systems typical of some regions of Spain and Portugal (Dehesas and Montado) also allows one to carry out an ongoing and effective control of the underwood, while dramatically reducing the risk of fire (El Aich and Waterhouse, 1999).

Negative effects of small-ruminant grazing

The negative effects of small-ruminant grazing mostly concern inappropriate land management. Major consequences include a decrease in the vegetation cover, which contributes to an increase in soil-erosion related problems. The loss of "soil" due to erosion, on average, is five times faster than the formation of new soil. Throughout the world, small-ruminant overgrazing promotes 29% of erosion due to fluvial action of water and 60% of erosion is caused by the wind; such phenomena are particularly relevant in Africa. In dry areas overgrazing, as well as the extensive cutting of forests for fuel production and the farming of marginal lands, results in significant losses of vegetation cover and in dramatic changes in the botanical composition (El Aich and Waterhouse, 1999).

Overgrazing as a major cause for environmental degradation

Overgrazing is the use of grazing lands beyond the limit of their production capacity, or an improper use in terms of grazing period and/or duration. The effects of uncontrolled grazing, along with increasingly frequent droughts, accelerates desertification processes. Overgrazing is usually the result of a long-lasting inappropriate use of grazing lands, due to animal overstocking, generally associated with a reduction in available land. The increase in the number of sheep and goats, typical of the countries on the southern Mediterranean shore, is related to the demographic explosion that took place in these areas at the end of the first post-colonial period. The increase in the population, in fact, caused a strong growth of the meat market. The increase in the number of sheep and goats was also due to low-cost labour availability in rural areas.

Social and cultural reasons also determine the increase in the number of sheep and goats, albeit indirectly. Among the populations in north-African rural areas, in fact, flock ownership is a measure of a family's economic power and social standing. The increased water availability also favours animal over-stocking in certain areas and at certain times of the year; thus a poorly controlled

well-opening policy in marginal areas is one of the factors triggering land degradation (El Aich and Waterhouse, 1999).

Breeding systems and their sustainability

Parcours in the Maghreb steppes

Characteristics

The steppe population, mostly made up of shepherds-breeders, carries out nomadism and transhumance, the latter being the management system that best fits these dry environments and allows the preservation of the ecological equilibrium and ability to overcome stressful periods arising from the cyclic and sometimes prolonged droughts that characterize these regions. This practice includes two basic steps, (i) the *Achaba*, carried out during the summer (3-4 months) with the flocks brought to graze on flat lands, where feed is represented by cereal stubbles, and (ii) the *Azzaba* carried out in the 3 winter months, with the flocks brought to the feet of the northern Saharan Atlas Mountains.

Transhumance allows to the use of steppe forage resources in the 3-4 spring months, the time of maximum vegetation development, especially of the annual species whose high value as fodder largely compensates for the very low value of perennial species. This traditional management practice allows the optimization of natural resource use. The *Parcours* are therefore grazed only during one-third of the year, thus allowing natural regeneration of the pasture.

Evolution

Today, however, pastoral society is undergoing a significant socio-economic transformation. During the second half of the past century, a demographic boom was recorded, and the population in the Algerian steppes rose from less than one million in 1954 to almost 4 million in 1998. This growth involved both the settled and the nomadic population. At the same time, however, a sharp decline in nomadism occurred and now the transfers of people and flocks linked to transhumance only involves 5% of the settled population. The rest of the traditional nomadic population did not become fully settled, but flock transfers are by now confined within an area of 10-15 km from the farm. Shepherds also changed their production systems and combined breeding with cereal crops.

The change in breeding management models, traditionally governed by the land use rules set by "traditional institutions" (chief of the village, council of the elders) acknowledged by the population in these areas, was also due to the political upheavals that took place during the colonial time, followed by the introduction of "European" laws unfit for the management of these territories, and later, after the wars for national liberation, with the introduction of rules limiting animal transfers. These rules were aimed at promoting the development of more profitable and, most of all, settled farming activities and resulted in the rejection of the traditional rules for pasture exploitation and accordingly led to a reduction in grazing lands as well as a decline in nomadism.

A direct consequence of this is the remaining overgrazing of the available areas, both in terms of number of units and of duration, which inevitably results in the degradation of the pasture. This phenomenon is aggravated by changing climatic and economic conditions and by the sharp increase in demographic pressure (Amri, 1992).

Strengths and weaknesses

A distinction should be made between transhumance and nomadism. Transhumance can be seen as a transfer for economic purposes, aimed at enhancing the available fodder resources, at a given time of the year, in areas other than the one where the flocks usually graze. This is therefore a breeding technique that does not depend on the political organization of the populations involved.

The preservation of transhumance could ensure a more rational use of the steppes and the complementarity of the different areas (plain and piedmont) in some Maghreb regions. Nomadism, on the other hand, is a lifestyle based on a well-defined political and social organization and on an economy founded on collecting, rather than on farming. This breeding system, however, should be reviewed and organized according to the current developments involving agriculture in north-African countries.

In fact, in the light of an increased animal stocking rate (in terms of number of units), a shrinking of grazing land occurred due to the development of other crops (cereals, fruits, etc.), whose introduction was promoted by governments and sometimes generated conflicts, occasionally violent, between farmers and breeders. This is why an agreement should be found between these two parties, allowing for the best possible exploitation of the Parcours lands and, at the same time, an improvement in fodder and cereal production (Benrebiha and Bouadellah, 1992).

Sustainability

Awareness building of the breeders of the Parcours lands should be on the basis of sustainable development programmes related to grazing in the Maghreb. Such programmes should provide for the following:

- delimitation of the Parcours within the framework of the agricultural landscape of the steppes and definition of their management and type of use;
- definition of the juridical status of these lands. Two options may be considered in this respect:
  a. monitoring their exploitation. allow the individual or associated breeders to become the owners of these lands.
  b. The State would only grant ownership if the interested parties undertake to manage the pastures properly, to enjoy a technical support service, and to accept that the State may supervise management and take measures if the agreed conditions are not fulfilled.

The rules that need to be complied with to conserve the production potential may include:

- unambiguous identification of the breeding facility (i.e. the farm) through its manager's name, its location, and its boundaries;
- identification of the surfaces and the type of Parcours used;
- assessment of the animal stocking rate (according to the season and the type of Parcours);
- guardianship duties;
- identification of technical activities and actions required for the improvement of fodder crops;
- definition of conservation and crop-rotation activities;
- duty to seek regular technical support (Benrebiha and Bouadellah, 1992).

However, due to the conditions that currently characterize these fodder crops, measures are also needed to ensure their recovery. These include both direct actions for reconstitution of the pasture, and indirect ones on the health status and on the genetic improvement of flocks, in order to increase their productivity without raising the number of units, and thus identify a stocking rate that does not cause degradation. Direct actions on the pasture may include:

- natural improvement, which consists of the spontaneous regeneration of fodder species through perennial fallow. This method can only be applied to areas that are not too badly degraded, where at least perennial species still grow and the vegetation cover is able to recover within an acceptable period of time;
- artificial improvement, which consists of sowing of herbs or shrubs on surfaces where overstocking caused the disappearance of perennial species too; this should preferably be done with autochthonous species (Chaieb, 1991).

Dehesas in the forest areas of the Iberian Peninsula

Characteristics

From an ecological viewpoint, the dehesas is defined as a pasture covered by a sparse oak-forest (holm and/or cork oaks), where grazing has been performed for centuries. The oak-forest was originally used especially for the production of sweet acorns and cork, thus the cover pattern was rather scattered (40-50 plants/ha), with high-trunk trees that were regularly pruned and decorticated in the case of cork-trees. The main products of the grove included cork, acorns, and leaves, but secondary products, including firewood and coal, also had some economic significance. However, the term dehesas also identifies the farming unit, which also includes extensive sheep, goat, and pig breeding.

By the late 1950s, the tree-planted surfaces were grazed by sheep, goats, and pigs whose breeding was primarily aimed at meat, as well as milk and wool production. The use of these systems as pastures obviously required an adaptation of the grazing period to the fodder-production period. This is why births, for sheep, were concentrated in autumn, so that the lambs could be fattened up during spring, when the maximum development of vegetation occurred, and sold before the summer droughts. Similarly, pig fattening coincides with acorn ripening and spans from late October to early February. Finally, from mid-July to the early autumn rains, transhumance was performed

through the lowlands to allow the flocks to feed on cereal stubbles. Thus the feeding of sires is ensured even in the dry season, when the pastures on the Sierra can no longer provide fodder for the animals. Without any corrals, the management and supervision of the animals were ensured by shepherds.

The frequent practice of night animal grazing in limited areas, created with mobile barriers, is referred to as *redileo* and aims at ensuring the consistent organic fertilization of the soil through animal dejections. A serious traditional problem in the dehesas was the struggle against the invasion of rockroses (*Cistus* ssp.), typical shrubs of the Mediterranean maquis, traditionally performed in either of two ways:

- manual weeding out of the shrubs in the central areas of the estate under exploitation;
- deforestation and ploughing in peripheral areas.

These areas were tilled by land-less farmers (*pegujaleros*) who owned draught animals. These farmers, in exchange for their work, were allowed to grow cereals on the cleaned plots and to collect some of the coal produced with the uprooted shrubs. The trees, instead, were cut by day workers. Thus the system turned out profitable as a whole, in spite of low productivity, especially thanks to the low cost of labour (Joffre et. al., 1991).

Evolution

Until the early 1960s, the dehesas were managed as described, but in the following decade the salaries of day workers experienced a five-fold increase, whereas the prices of produce only doubled. The quick development of breeding starting from the 1970s included an increase in the number of units, which did not correspond to an increase in fodder supplies. The result, in general terms with respect to land management, implied a break of the balance between animal and vegetal production. The management of the tree-planted top-soil often became discontinued, while breeding was increasingly addressed towards the use of intensive methods (sheep and goats were often replaced with cattle), and the mechanical deforestation of the surfaces covered with maquis was strongly sponsored by the State.

Breeding today is often characterized by a serious imbalance between the period of maximum productivity (reproduction and production) and the period of greater fodder supply. The abandonment of the traditional management of the dehesas forces the breeders to buy a significant share of the feed required for cattle breeding, while greatly increasing the risk of fire in grazing areas. This quick change in the management of the dehesas corresponds to a shift from a sustainable use of territorial resources to an intensive and strongly degrading use of it (Joffre et. al., 1991).

Strengths and weaknesses

The pastures of the dehesas are dramatically different from all others in the Mediterranean basin, in that they are characterized by a strong incidence of annual species. Perennial gramineae (*Dactylis glomerata, Lolium perenne,*

Phalaris acquatica, etc.), however, do exist, although in limited quantities. This special floral composition has important consequences on fodder production in these areas, which is generally poor and closely linked to the seasonal development of annual species. Two hypotheses have been suggested to account for this peculiarity of the dehesas. The first attributes it to human activities in terms of fire, continuous grazing, and regular processing; while the other attributes it to climatic factors, including irregular rains and long, dry seasons; both hypotheses are probably true. Another distinctive element is the tree cover as it has a very positive impact on microclimate and fodder production, because:

- it promotes the early development of the herbal vegetation in autumn;
- in winter the period of vegetal stasis is shorter;
- in spring, the period during which the grass dries up is 3-4 weeks shorter.

The tree-planted top-soil as a whole allows extension of the vegetation period of pasture herbs. The global productivity of the herb-tree system turns out definitely higher than for "bare" pasture. Under the trees' foliage, a substrate is formed rich in nutrients and organic matter, with a greater water-retention ability and macro-porosity, promoting the pasture development. On the other hand, the exploitation of the dehesas forces the movement of flocks over long distances (long-distance transhumance, 300-600 km), since this kind of pasture may only be exploited in the winter months, while in the summer months the animals need to be moved to the mountain slopes in northern Spain (Joffre et al., 1991).

Sustainability

Improving productivity of the dehesas necessarily requires amending the animal breeding system as a whole, including both the strictly zoo-technical aspects, from the genetic background of the animals to their reproduction efficiency, and the agronomic aspects, by developing the ability to produce fodder and an efficient transformation of it into animal products. As in most Mediterranean systems, this necessarily adds up to an improved marketing of the generated products, their standardization, and their homogenization resulting in high-quality products. Equally important is the ability to convey to the consumer the issues and the attributes that the products acquire in terms of environmental quality, animal well-being, and food safety.

The above steps require actions in the following strategic areas:

- fodder production: increase fodder production and quality using cattle management techniques (redileo, majadeo: shelter use), fertilization and sowing, adjustment of the animal stocking rate (avoiding under-grazing, overgrazing), actions on forest lands promoting the development of grass;
- genetics: preserve autochthonous genotypes as well as breeds at risk of extinction, avoiding the acquisition of foreign breeds or indiscriminate cross-breeds. After performing an action truly aimed at preserving the autochthonous species, genetic improvement plans need to be set;
- reproductive efficiency: improve classical reproduction indexes, control supplemental feeding at grazing, use practical systems for supervision of the animals' physical conditions (BCS) for reproduction purposes, implement modern reproduction techniques;

- production techniques: improve flock management techniques, develop unusual production techniques (feed supplements in the extensive system), develop appropriate healthcare, feeding, and reproduction facilities in farms;
- marketing: enhance institutional campaigns, normalize productivity, strengthen and involve producer associations in the industrial processes, develop quality brands, e.g. DOP and IG;
- rural development: diversify production, introduce alternatives for development before any restrictions or changes in production trends, ensure an appropriate yield;
- nature preservation: animal breeding must be compatible with the preservation of the system and its resources.

Extensive breeding in the Mediterranean islands

Characteristics

Sheep and goat breeding is one of the main economic activities in major Mediterranean islands, and in the Italian islands in particular. The agro-pastoral system in Sardinia, for example, with over 4 million sheep, is traditionally based (in hill and mountain areas) on grazing with or without fertilization and on short-term fodder crops. Intensive fodder crops are usually based on a rotation between short-cycle crops, directly grazed in winter, and spring cereal crops.

The agro-pastoral system in Crete, in the inner mountain areas of Psilorites or Idi, is also based on the exploitation of pastures in forests, shrubland, and public grazing areas using local goat and sheep breeds, to obtain both milk and meat. During the six-month summer period, the nomadic grazing system prevails in the Psilorites region, while in the remaining six months the flocks are moved to the winter pastures, usually privately owned (Papanastasis, 1998).

Evolution

In Sardinia between 1950 and 1960, a decline took place in the traditional crop-rotation system between cereals and grassland, mostly due to land abandonment or to newly introduced land uses (urbanization, tourism). In addition, between the 1970s and the 1980s, the sharp increase in the price of sheep milk resulted in a significant increase in sheep numbers (Enne et. al., 2000a). The decline in grazing surfaces and the increase in the number of heads broke the balance between crops and pastures, with subsequent increases in slow-growing grazing species on the abandoned lands and a reduction in fodder supplies. The irrational use of pastures (overgrazing in autumn and underuse in spring) caused a gradual reduction of more palatable species and an increase of areas with bare soils, where soil erosion is often observed, especially on slopes. In order to expand the grazing surfaces, farmers carried out massive deforestation of the maquis or forest lands and stone-removing operations that, especially in sloping areas, resulted into a dramatic loss of the fertile topsoil.

Strengths and weaknesses

This system is generally unable to ensure synchrony between maximum vegetation development, which occurs in spring, and the time of highest feed demand by the animals, which occurs in the autumn-winter period, at the time of births, and at the onset of lactation. This problem was solved by introducing vertical transhumance or, more frequently, by feeding the sheep on hay and concentrated products. However, due to the scarcity of flatlands, fodder is also grown on the hills using techniques such as ploughing, which in many cases favours soil erosion (Enne et. al., 2000b).

This is why the risk of soil erosion in hilly areas increases during summer and autumn, when rains are more intense and ploughing has just been performed. Furthermore, agro-pastoral activities are a major cause of fires. More than 90% of the total number of fires in Sardinia are started deliberately, and are historically and traditionally related to human activities. Fire has been considered an important practical and economical tool for clearing lands for grazing. Land fragmentation and the heterogeneity of land cover, typical of Mediterranean environments, have in many cases favoured fire propagation from grasslands to shrublands and wooded areas, thus compromising forested eco-systems (Enne et. al., 2002b). Similar conditions are also observed in the other main insular areas of the Mediterranean sea (Sicily, Corsica, Greek islands).

Sustainability

Based on the results achieved in different areas of the main Mediterranean islands, a major problem is the degradation of semi-natural systems, which were introduced in these areas characterized by unfavourable environmental conditions. The degradation of these eco-systems is a cumulative phenomenon, which develops after long-term environmental perturbations. Pasture exploitation, if too intensive, harms the vegetation and causes soil erosion. Other human activities, including ploughing or fire-cleaning of the pasture, significantly contribute to the degradation of the ecosystem. A careful review of the causes of environmental degradation and an action aimed at discouraging high-risk behaviours, combined with assertive support for appropriate breeding and farming practices, represents a possible strategy that, if shared by farmers, may turn out to be successful in the short-term.

Extensive breeding in inland mountain areas

Characteristics

In the Mediterranean region, in the summer season, grazing resources are limited and resulted in the development of extensive sheep and goat breeding, characterized by long-distance transhumance. The typical route of transhumance in the Pyrenees follows pasture development from June to October. In spring the flocks are fed on cereals stubbles in the valley of the Ebro river, then moved to the mountain slopes over distances of more than 150 km, to reach higher pastures

(El Aich and Waterhouse, 1999). In Greek inland mountains the small-ruminant breeding is mostly performed extensively with direct pasture feeding. The sheep and goat sector is characterized by small and medium farms (4.5-15 ha of farming surface), with the number of units from 50 to 140; grazing surfaces are partly privately owned (48%) and partly publicly owned. The flocks usually include both sheep and goats, and are made up of equal shares of local breeds and cosmopolitan breeds (Zervas et. al., 1996).

Evolution

The practice of long-distance transhumance has deep cultural roots and, in time, contributed to shaping and preserving the landscape in different countries on the northern shore of the Mediterranean basin, including Italy, Greece, and Spain. In inland mountain areas in Greece, where Feneos of Korinthos is a representative model, the pastures dedicated to this ancient practice are mostly natural, sometimes planted with trees or with trees and shrubs; however their productivity is usually rather low. Only a small share of the nutritional demand is covered by grazing on crop residues, including barley, hop, or vetch stubbles. Stubble exploitation traditionally occurred in the summer period. Grazing on stubbles was recently substituted with direct feeding on winter cereal and legume grass, in the January to April period, and with feed supplements; these are also produced by the farms and basically made up of hay (Spanish clover, hop, vetch, etc.) and by cereal grain or bran (Zervas et. al., 1996).

In Spain, further confirming the ancient diffusion of the transhumance system, there are over 125,000 km of tracks that were traditionally used for this purpose, but 15 to 40% are now estimated to be abandoned. In the past, over 20% of Spanish sheep were managed using the transhumance technique. However today only 2% still follow this route, a clear sign of a radical change in the Spanish farming and breeding model (Gomez-Sal, 1997).

Strengths and weaknesses

The typical feeding schedule of flocks on the Greek mountains depends on the animals' physiological periods. In fact, in the period from October to March, corresponding to the end of pregnancy and the onset of lactation, the animals settle in the villages and during the day graze on lawns-pastures characterized by relevant heterogeneity in grazing values. Only in the case of particularly adverse weather conditions, the animals are kept in the stables and fed on hay and concentrated feed. During this period the animal feed is poor, in that the supplied energy is not enough to satisfy the productive performance of the animals, especially after birth and at early lactation. In the middle and late-lactation period (from April to June) the pasture is the only source of feed, thus, at this time, milk production is strongly affected by the quantity of fodder supplies which, in turn, closely depends on weather conditions. In the summer period, corresponding to the mating season and the onset of pregnancies, the flocks move to arable lands feeding on cereal stubbles, sometimes integrated with the

residues of agro-food processes (olive residues, green residues, etc.). All this highlights significant nutritional fluctuations in the system, with impacts on the physical conditions and the productivity of the animals (Zervas et al., 1996).

Sustainability

In these regions too, the challenge for the new millennium may be founded on the pursuit of the product's intrinsic quality, which is one of the last ways available to reply to the industrial trend towards the production of standardized dairy products. Hence the importance of producing through Protected Origin Appellation (DOP) brands or through guarantee brands, or focusing on ethical production forms (organic, etc.) capable of protecting intrinsically disadvantaged areas. Different types of "quality" of animal products should be considered, which can often hardly be separated:

- hygienic and health quality,
- diet and nutritional quality,
- taste and gastronomic quality.

One struggle to be fought and won is certainly related to the hygiene and quality of dairy products, using the milk quality parameter at the first production level, i.e. the stable. A milk should be produced, whose somatic cell count (SCC) is controlled and in line with the reference parameters provided for by the by-now well known CE norms. The struggle against mastitis should also represent a necessary step towards a quality founded on a steady and long-lasting base.

For the future, the typical products of these areas should be able to support and protect their production brands and, possibly, to develop their potentials by adapting to sales strategies capable of preventing the product from losing any of its original and authentic value. For these products, which include a significant cultural component, all actions aimed at final consumers should be carried out to provide comprehensive information on the complexity of the production system, which ensures the origin, the traceability, and the authenticity of the product (Boyazoglu and Morand-Fehr, 2001).

Assessment of the environmental impact of grazing systems

A balanced approach to the use of land for grazing implies that the system's components be rationalized and that the interactions among such components be quantified (Pulina et al., 2000). The pastoral system is a complex one in that it comprises several factors, including soil, plants, animals, man, and the interactions between them. A further complication is introduced by the weather.

A possible approach to the study of these systems uses models capable of simulating their behaviour. Models should allow one to determine the sustainable stocking rate for different agrosilvopastoral systems. Grazing is a crucial step in the interaction between breeding (animals and human activities) and the environment, and obviously produces an impact on the environment. Such impact can hardly be modelled and quantified, due to the complex existing interactions, and should be analyzed both with respect to the specific

management systems and the ecological features of the environment with which the animals interact.

According to the logical scheme typical of environmental-impact assessment practices, the interaction between man's activities and the environment can be broken down into actions, effects, and impacts. The actions consider all the activities, interventions, and transformations that may result in an altered ecological state of one or more environmental components, thus producing changes. The consequence of these in terms of quality, sustainability, or ecological/socio-economic acceptability constitute the impacts. With reference to the grazing systems, the actions may be directly performed either by the animals or by man; they may be farming activities or have a different nature, aimed at promoting the feeding or transit of the animals or the productivity of the pastures (creation of new grazing surfaces, processing, sowing, shrub removal, etc.). These, especially in the Mediterranean region, make up a complicated set of actions that may have very different effects according to multiple factors: extent, intensity, seasonality, geomorphological and pedological conditions, type of vegetation cover, etc. The effects generally concern different environmental components - land, water, vegetation, animal and vegetal communities - and are not always visible.

The assessment of the impacts and of the acceptability levels is even more complicated, in that it involves functional considerations that can hardly be objective. The need to tackle and solve some of the typical problems of sustainable territorial management requires the development of different methods and techniques, with different objectives and at different spatial scales. These can seldom serve as models for the whole system; hence the need to use different instruments in an integrated approach. Modelling may be referred to the following areas:

1. planning of the use of the territory to prevent over-exploitation and to optimise the use of resources;
2. assessment of environmental impacts on a farm scale, also taking into account the peculiarities of the different species bred in mixed systems, typical of the Mediterranean basin;
3. identification of expert indicators and systems for the direct assessment and field monitoring of the impacts of animals grazing on the environment.

Conclusions

In order to restore the pastoral activity's original territorial conservation function, actions are required in different respects:

1. define the areas where the development of agro-pastoral activities is a priority and, for each of them, define a single action plan shared by all socio-economic entities, in order to prevent the fragmentation and the overlapping of objectives and irrational or ineffective actions;
2. assess land suitability evaluations before introducing crops or performing any actions aimed at increasing productivity. This assessment is the only way to prevent soil degradation and should be carried out by taking consideration into the physical (geology, pedology, and morphology) and biological

(pasture productivity and quality) characteristics of the environment, as well as the socio-economic context within which the actions are performed;
3. when using marginal areas and forest lands as pastures, precisely define the breeding stocking rate and the best grazing season in the different crop systems;
4. promote, in the abandoned marginal areas, the implementation of low-impact systems and the multiple use of agrosylvopastoral surfaces in view of enhancing man's presence in these areas and thus ensuring territorial preservation and economic support to rural communities. This also reduces the risk of fire spreading due to poor territorial protection;
5. strengthen the link between research and politics in view of managing the needs and planning the activities of the community. Rapid disclosure of the results of research is required so that they can be used to define technical guidelines as a necessary support to political decisions.

Furthermore, plans for the recovery and development of areas threatened by desertification should be quickly implemented based on detailed studies on the state of the land and on its grazing capacity, also including an assessment of ecological implications and of the socio-economic conditions of the communities that live on these territories.

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