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Optimum management and quality pastures for sheep and goat in mountain areas

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SUMMARY – Small ruminants in mountain areas are used for their high efficiency in transforming low-quality forages into good-quality animal products. In the Alps, they are found only in areas where cattle production is not possible, and their importance is not merely related to their economic weight. In fact, small ruminants play a key role in the conservation of herbaceous variety due to different environmental and management conditions. Small ruminants also have an important role in keeping the grassland open for recreation and tourism. The effects of the major constraints on flock management (conflict with large carnivores, woody species encroachment) and possible answers to society's needs, land managers and breeders are analysed to define improved management solutions.

Key words: Small ruminants, Alps, conservation, large carnivores, quality products

RESUME *– "Gestion optimale des petits ruminants et qualité des pâturages montagneux". La présence des petits ruminants est fortement répandue grâce à l'efficacité avec laquelle ils fournissent des produits économiquement intéressants en partant d'une qualité très basse des ressources fourragères d'altitude. Dans les Alpes, ces animaux exploitent les secteurs les plus défavorisés et leur importance n'est guère liée à leur réel effet économique: ils jouent, effectivement, un rôle très important dans la conservation d'une certaine diversité de la végétation, qui représente le résultat de nombreuses conditions et d'interactions du milieu et de gestion pastorale, en permettant ainsi le maintien d'espaces ouverts au loisir. Dans l'intention de définir une gestion améliorée pour les petits ruminants, ce travail se propose d'analyser les effets des principales contraintes d'exploitation des troupeaux (prédation des canidés, embroussaillement) aussi bien que de répondre aux sollicitations des gestionnaires du territoire, des éleveurs et de la société en général, notamment au sujet de la qualité des productions animales.*

Mot-clés : *Petits ruminants, Alpes, conservation, grands prédateurs, qualité des produits de montagne.*

Introduction

Two different climatic regimes coexist in the mountains around the Mediterranean basin: Mediterranean and temperate. The former is typical of the regions facing directly the sea either from Europe or North-Africa (Italy except the North East, an important part of Spain, Portugal and the Middle East). Five climates can be identified within this regime (UNESCO-FAO, 1963), characterized by a period of summer drought and by different distribution and quantity of precipitations, that results in a limited productivity of vegetation and duration and distribution of the growing season. The latter (Italian Alps, French Alps, Switzerland, Austria, Pyrenees, Slovenia, temperate Balkans) is characterized by a chilly winter and extended snow cover, which limits the length of the growing season, but where vegetation often expresses a good productivity.

For centuries, the action of the different climatic regimes has deeply affected soil characteristics and water availability, making populations living under such conditions to develop very different agro-ecosystems. Needless to say that the organization of breeding systems (animal species, proportion of land used for rearing, the way that grasslands and rangelands are exploited) has been influenced by the availability and type of vegetation that animals could use (grazing plus hay or silage). In Mediterranean marginal lands, as a consequence of the presence of shallow and rocky soils, grazing-lands dominated by sclerophyllous or annual species and the shortage of water, animal husbandry rests on small ruminants, with better ability, compared to cattle, for utilizing poor pastures. Sheep and goats are predominant, representing about 85% of the livestock, on average. In the mountains with temperate climates, breeding systems are mainly based on cattle, that represents on average 68% of the livestock. This is a consequence of the presence of vegetation types dominated by perennial

grasses, the almost unlimited water availability for plants and animals and the abundance of high quality forages. The percentage of sheep (29%) is much lower than that in Mediterranean regions and goats are even less important, representing only 3% out of the total number of heads.

This work will focus on the role of small ruminants and options for grazing management, especially in the Western Alpine mountain, with particular regard to the experiences from the "Grazing-land Research Unit" at the University of Turin (Italy).

Role of sheep and goats in the economic system of Western Alps

In the Mediterranean regions, small ruminants are often the only transformers of the available forages into good-quality animal products. With more than 130 millions of heads (source FAOSTAT), small ruminants play a key-role, especially in developing North-Africa/Middle East countries where the economy is based on agriculture. On the contrary, in the Alpine regions, sheep and goats generally use only the areas where cattle production is not possible (steep slopes, rocky soils, insufficient productivity of the sward), or is not profitable any more (difficult accessibility to the pasture, absence of buildings for operators, no possibility of mechanical milking). Consequently, until recent times rearing small ruminants has been considered as a marginal activity. Several factors are at the origin of such marginality:

(i) In the Alpine regions, the economic importance of the primary sector is often insignificant compared with the industrial and services sectors. For instance in North Italy, the added value of agriculture in 2002 was only 2.6% (INEA, 2003).

(ii) A condition of social alienation has almost always characterized mountain sheep and goats breeders, generally qualified just as "shepherds", which contrasts with dairy cow breeders, considered as agricultural entrepreneurs.

(iii) As the majority of breeding systems in the Alps is based on short-distance vertical transhumance and animal production at the plains or valley-floors is mainly based on cattle and, only few small ruminant heads are found at the mountains during summer, with the exception of France where a consistent number of sheep (620,000) still move from Mediterranean regions to the Alps (Legeard, 2002).

(iv) Under family self-sufficiency conditions, predominant in the past, cattle was reared more profitable than small ruminants.

Only in recent times, due to the EU policy and to the important changes that have affected the farm structure all over Europe, the profitability of small ruminants has been reconsidered. Renewed attention towards typical products, easier management compared to cattle (thus possibility for young people and for people working in other sectors to "migrate" to agriculture), economic subsidies, and political support have promoted the role of sheep and goat breeding, at least at a local level.

Sheep and goats grazing systems in the western Alps: Key issues

To understand the framework in which sheep and goats breeders operate at the beginning of XXI century is essential to improve management of mountain grazing systems.

Nowadays there is an increasing demand of well-preserved natural environments and balanced landscapes, especially for tourism and recreation. Sheep and goats have the ability not only to convert low-quality forages into protein, but also to be flexible tools for the maintenance and enhancement of the environment (Haeggström, 1990; El Aich and Waterhouse, 1999). Despite they represent no more than 11% on average of the overall stocking-rate in the Alps, small ruminants are important especially when exploiting those ecosystems, biotopes, and landscapes which, for their uniqueness, are the treasure of the Alps. These ecosystems, whose conservation is a priority, are generally fragile as a consequence of morphology, soil, climatic conditions, and ecologic unstableness. The well-known changes in socio-economic conditions have determined an extensification and abandonment of the mountains (Papanastasis, 1999) with a reduction of

agricultural activities pressure that has allowed the starting of naturalization processes. The first consequence is a botanical composition alteration of the grazing-lands, resulting in the encroachment by non-pastoral herbaceous species, followed by shrubs giving an homogeneous land cover not suitable for grazing. The action of grazing goats and sheep over encroaching vegetation may contribute to stop the succession back to naturalized ecosystems or to recover pastoral vegetation. Grazing may have several effects (Pearson and Ison, 1987; Cavallero and Ciotti, 1991) on the environment: (i) the conservation of a wide variety of herbaceous vegetation types that results from different environmental and management conditions; (ii) the conservation of forage quality; (iii) the conservation of floristic diversity and landscape heterogeneity; (iv) the prevention of disasters due to the flooding; and (v) the prevention of wild fires. Especially in the temperate mountains, the indirect benefits of conservation may exceed in value the animal production. The solutions for grazing management to maintain an area is a key-question to be answered by range scientists in the frame of a request of simplified tools to manage wide portions of land.

An effect of herds reduction and human presence in the mountains is the expansion of the habitat for wild animals that more and more frequently interact with the domestic ones. According to Lapeyronie *et al.* (2002), interactions may result in: i) overlapping, in space or in time, of trophic niches between wild herbivores and small ruminants; ii) predations by carnivores (wolf and stray dogs, lynx, brown bear) or large prey birds attracted by "low cost" food. The former is of great importance, especially in protected areas where excursionists are willing to meet wild animals (Aceto, 2002). The importance of the latter is increasing by the contrast generated among common people, naturalists, land managers and breeders as well as the effects produced on the grazing systems and the ecosystem as a whole. Nowadays the key issue is the breeders demand of solutions for grazing management in presence of predators.

Farmers and authorities are showing a renewed attention towards typical products originated by a cultural change in a wide group of people interested in high quality products. In the Alpine environments there is a wide variety of vegetation types (more than 200 types have been inventoried on the Italian and French sides of Western Alps) resulting in much diversified forages. The combination of such a diversified feed, breeds, grazing management and production technologies results in a high diversity of animal production: for instance in Piedmont (Italian side of Western Alps) about 60 different typical cheeses are produced, 50% of them from sheep and goats milk. The valorisation of such diversity through PDO, PGI or quality label certification gives a high added value to products that satisfies farmers request of profits and might be helpful for the sustainability of breeding systems. Sustainable solutions for quality products are increasingly demanded by farmers and producers associations to protect the typicality of their products, and by consumers to answer the demand of food safety.

In agriculture, as in any other sector of economy, the maximization of income is always the goal that entrepreneurs try to achieve by improving animal productivity with a simplification of breeding practices. Matching pursuit of profits and practices simplification (i.e. reduction of manpower for the control of animals, care during mating, milking, and shearing, cleaning of shelters) together with sustainability is another key-issue to take into account in the definition of every solution for improved grazing management of small ruminants.

Proposals for small ruminants grazing management in the Western Alps

In the alpine small ruminants grazing systems, plant-animal relationships are complex and influenced by several factors: physical environment, vegetation composition, sward structure, competition with wildlife, risk of predation and management. The combination of such elements generates a wide variety of unique situations, so that a single solution for improving grazing management cannot be suggested, but different strategies have to be developed taking into account productive and non-productive aspects. The main solutions could be empirically grouped in terms of: (i) management in relation to the presence of large carnivores; (ii) typical products quality; and (iii) environmental conservation.

Grazing management in relation to the presence of large carnivores

Large carnivores in the Alps are of great ecological importance as they select and control wild

herbivores. Furthermore, they represent an attractive for common people, who are not used to their presence, with positive effects on the mountains economy. Wolves are now widespread on both sides of the Western Alps while lynxes are still uncommon. Unfortunately, these predators not only interact with wild animals in the protected areas, but also with human activities such as hunting and small ruminants breeding (Primm and Clark, 1996). In the mountains, especially during summer, flocks increase dramatically the density of herbivores in comparison with the one of wild ungulates. Of course, wolves and lynxes, because of their opportunistic behaviour, may easily take advantage of such a wide availability of preys, becoming competitors of humans for the same food (Dorrance, 1983; Cugno, 2001). Opportunistic behaviour is also shown by a large number of stray dogs that wander in the mountains without control and may also take advantage from the presence of sheep and goats.

Whilst in the Italian Apennines carnivores have always shared lands with the small ruminants and their shepherds, in the Alps there has been a lack of their presence in the last century. Hence, until the early nineties flocks were not used to cohabit with predators, and measures to prevent attacks had not been adopted before (Cugno, 2002). In south Piedmont, for instance, summer pastures were almost always grazed by free ranging sheep that used to exploit even the more remote areas, spending the night outdoor without any protection and without any control, except for periodic shepherd's survey. Since the reintroduction of large carnivores, important changes have been made in the pastoral systems in order to prevent or reduce the effect of attacks. A major change was the generalisation of the grazing with shepherd and the abandonment of free grazing (the use of paddocks was uncommon in Italy as well as in France). While in France shepherds still used to drive their flocks along the "parcours", on the Italian side of the Alps shepherding is a tradition that was lost in the past years. Hence, with few exceptions, there was a lack of shepherds able to face the new situation. Many of them, unable to adapt management to the carnivores presence, gave up their activity, especially when breeding was a part-time or a minor farming activity. The solution to the problem of manpower lack for taking care of the flocks was often the convergence of small flocks into larger ones, at least for summer so flocks with 1000-2000 heads are now frequent on both sides of the Alps. The concentration of heads and the adoption of grazing with shepherd had important ecological consequences:

(i) Large flocks that are guided by a single shepherd exploit a limited number of pastures. In these conditions stocking-rates sometimes exceed carrying capacity, while many pastures that were exploited by smaller flocks are now abandoned and will probably be encroached by non-pastoral species and shrubs (Cugno, 2002).

(ii) Shepherds drive flocks along the grazing circuits, controlling animals during the whole day. The uniformity of grazing and also the exploitation of remote pasture sectors depend on the experience of shepherds, who decide whether a circuit should go through the areas with lower forage value or partially encroached by shrubs. Generally shepherds prefer to exploit zones close to the farm centre (especially when stocking-rates are lower than carrying capacity), and abandon the remote ones (Lapeyronie *et al.*, 2002). Ecologically, such a situation results in a definite lost of fragile vegetation types and environments.

(iii) During the night, sheep are sheltered inside small corrals close to the buildings. During the grazing season night paddocks are seldom moved (otherwise the shepherd would not be able to control animals), while with the traditional management sheep used to rest mainly on mountain ridges, changing their place every night (Cugno, 2001). With such a limited number of paddocks and without dung management, concentration of nutrients from the pasture may occur. Cugno *et al.* (2002) assessed that about 50% of seasonal faeces production (27 tons DM per year, corresponding to 1,200 kg N per year, for the experiment they carried out) was released inside night paddocks by a 500 sheep flock. Unfavourable effects on the nutrient budget were 55 kg faeces per hectare per year and 5 kg N per hectare per year lost since the introduction of night corrals (Fig. 1). The same authors found a good correlation ($r = 0.62$; $P<0.01$) between the quantity of dung distributed on the pasture and the intensity of defoliation by sheep. Hence, though some nutrient transfer is always unavoidable (Hilder, 1966), without night corrals the supply would at least counterbalance the removal by grazing. Losses of nutrients from the grazing area may be worsen by the adoption of stocking-rates lower than the carrying capacity (Fig. 1), whose effect was a reduction of 14 kg N per hectare per year. In spite of the little amount, nutrient deficit may facilitate the spreading of non-pastoral species, even in short time (Loiseau, 1991; Cugno, 2001).

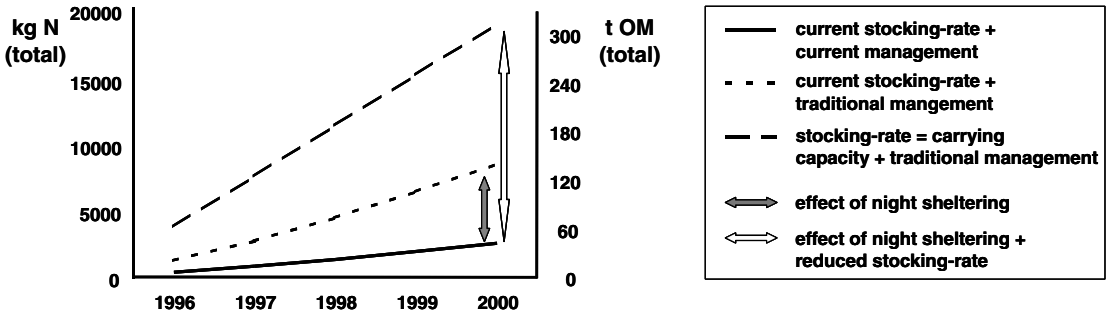

Fig. 1. Effect of night paddocks on the total return of organic matter (OM) and N to the pasture (243 ha) for three different combinations of management and stocking-rate (from Cugno, 2001).

When predators are a problem, the improvement of grazing management should consider proposals that not only reduce the risk of attacks but also the ecologic impact of management changes (Audino, 1997). To minimize the risk of attacks, as only grazing with the shepherd allows the complete control of the flock, improving shepherds qualification becomes a matter of primary importance. Furthermore, the adoption of guarding dogs, whose effectiveness has been proved scientifically (Landry, 1998), especially when the number of dogs is proportional to the flock size (1 every 50-100 sheep), would allow the use of light electrifiable nets instead of heavy fences, so that the multiplication of night paddocks becomes feasible. An improved shepherding (Baumont *et al.,* 2000) together with periodic night-corrals displacement and use of mobile prefabricated refuges for shepherds, would result in a more uniform removal of herbage by grazing (even from remote and encroached zones), which is beneficial in terms of return of nutrients, conservation of swards, and animal production, and reduces the effects of spots dung concentration.

Solutions for quality typical products

Typical mountain products (mainly cheese and meat) have appearance, taste, flavour and texture that reflect the environment in which they are produced that is characterized by vegetation, air, climate, breeding system, transformation technologies and cultural heritage (Coulon, 1997). Spontaneous vegetation generally represents the basis of the small ruminants diet, and may contain compounds which can give to the product characteristics of uniqueness and, sometimes, allows traceability. Even if the scientific research about aromatic compounds, that may be used as markers to detect the origin of many dairy/meat products, still is at the very beginning, it is clear that volatile hydrocarbons and other markers can be found, especially in dicotyledons which are abundant in natural pastures when they are managed extensively (Grime, 1979; Reyneri *et al.*, 1999; Aceto, 2002).

For the production of quality cheese or meat, extensified grasslands, even if they may not supply best-quality forage from the point of view of fodder value, they are probably the best quality pastures because of their richness in aromatic species and influence on milk fatty acids (Zeppa *et al.*, 2002). In the elaboration of grazing management proposals for such extensified grasslands, the wide diversity of alpine vegetation types should be considered as an important source of animal production diversity to be preserved. Equilibrium between nutrient removal from plants by grazing and nutrient supply to plants by excreta is the key for the conservation of vegetation "as it is". Several factors may move this fragile balance from stability: (i) grazing pressure not at equilibrium with forage availability (localized over/under-grazing); (ii) inadequate distribution of night corrals (producing the above mentioned effects); (iii) inadequate distribution of watering places and mineral dispensers; and (iv) moment of exploitation not coincident with optimum vegetation quality.

As the grazing with shepherd is the only technique applicable to alpine pastures, a solution to the problem of grazing pressure will only be possible with more experienced shepherds who can understand the patchy structure of the grazing-land, effectively draw circuits and dimension the surfaces daily assigned to animals. Furthermore, pastoral plans, including intelligible maps of vegetation, maps of pastoral equipments distribution, and exploitation schedules, would guide the shepherds in their choice and facilitate the solution of the water distribution problem and mineral

dispensers. On the contrary, setting the best moment for exploitation, that is crucial for the quality of animal production, requires further knowledge. Because of a fall in forage digestibility may, in fact, have direct consequences on intake and productivity, pastures should be exploited at their optimum forage quality whenever possible. A model for a grazing management compatible with maximization of the quality of intake, sward conservation and regeneration has been proposed for small ruminants by Cugno (2001). It is the model of "quality circuits" where shepherds drive flocks, searching to exploit the different vegetation types, at different altitudes, always near to the maximum possible level of digestibility. According to Rattray (1987), there is a good correlation between digestibility and the proportion of green material that sheep actively select against the dead components of the sward, i.e. an optimum intake corresponds to maximum digestibility. An example of quality circuit is reported in Fig. 2 for a summer pasture in South Piedmont characterized by four main vegetation types, grazed extensively by sheep. E1 to E7 indicate a sequence of exploitation intervals following the best digestibility of each vegetation type, taking into account its variation according to the phenological stage. For instance, the exploitation should start (E1) very early in the season from *Festuca nigrescens* swards, whose quality decreases rapidly, so animals have a short period of grazing. Then, *Festuca paniculata* types could be exploited (E2) as they have slower decrease, followed by *Nardus stricta – Trifolium alpinum* types (E3), which preserve their quality for a longer period. High altitude swards have constant digestibility, so that their exploitation (E4) is always possible during the grazing season. Then, the exploitation should continue up to the end of the season by grazing the vegetation re-growth (E5-E7).

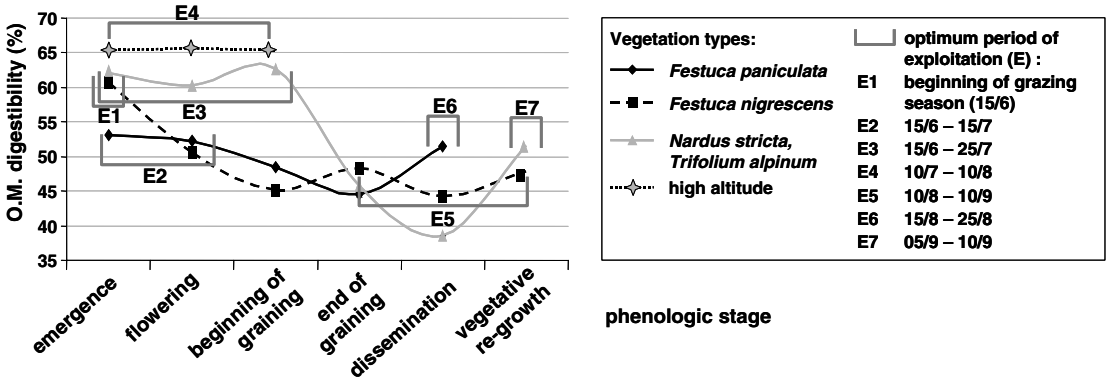

Fig. 2. Example of quality circuit (from Cugno, 2001).

Solutions for the conservation of the environment

Grazing animals, when grazing is properly managed, are the most convenient and inexpensive control tool of woody species encroachment, as the use of mechanical and chemical weed control is often ecologically and economically unsustainable (Lombardi *et al*., 1999; Rahmann, 1999). Due to their limited diffusion compared with cattle, the use of sheep and goats for conservation is restricted by a reduced availability of heads, now generally concentrated in large size flocks. In Northern Italy, for instance, a 28% reduction of the livestock was recorded during the period 1960-1990 (Cavallero *et al*., 1997) with some recovery (7%) for small ruminants during the last years (ISTAT, 2002). The problem of avoiding undesiderable succession (Spatz and Papachristou, 1999) using a limited number of heads, i.e. the use of light stocking-rates to maximize the exploited area, has been recently investigated by several research groups in Europe (Byrne et al., 1993; Garmo *et al*., 1993; Lombardi and Cavallero, 1996; Lombardi, 1997; Lombardi *et al*., 1999; Cavallero *et al*., 2000; Sabatini *et al*., 2000).

The conservation of pastures only partially invaded and still with fairly good quality forage, presents different problems than recovery of completely encroached swards. In fact, when the invasion is limited, the effectiveness of control depends on palatability and tolerance of woody species to repeated disturbance, and on animal behaviour. When non-palatable encroaching species are present, animals can dodge woody patches leaving shrubs untouched. Lombardi *et al.* (1999) reported that large size and tough subalpine species (*Juniperus* spp., *Rhododendron ferrugineum*) were seldom controlled by sheep (Fig. 3), though they were damaged by trampling. Nevertheless,

grazing sheep could at least stop the spread of woody species, even with 1.7 ewes per hectare per season, namely about 40% of the carrying capacity (computed with the pastoral value method – VP – of Daget and Poissonet, 1972). Sabatini *et al*. (2000) observed with the same species that on very poor pastures (VP = 10-14, shrub cover 10-30%), the invasion was arrested with 0.8 ewes per hectare per season, corresponding to 25% of carrying capacity. Rousset and Lepart (1999), and Spatz and Papachristou (1999) confirmed that sheep cannot generally control junipers but, according to the latter authors, up to 95% of their leaves was browsed by goats.

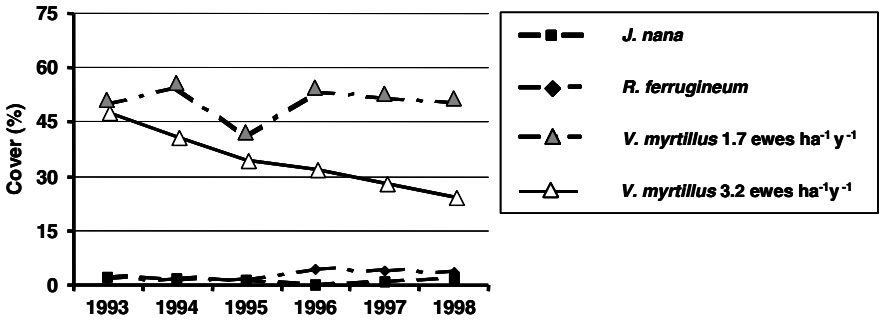

Fig. 3. Effect of sheep grazing on the evolution of the woody subalpine species cover inside shrub patches. MANOVA highlighted no significant differences between stocking-rate levels for *J. nana* and *R. ferrugineum*. (From Lombardi *et al.*, 1999).

When pastures are encroached by more palatable woody species, leaves, sprouts and small branches become part of the diet of sheep and goats (whose preferences for shrubs are well known; Ramirez, 1999). Consequently, the possibility of controlling the invasion depends on the reaction of plants to disturbance. With regard to subalpine small shrubs, Lombardi *et al.* (1999) reported that *Vaccinium myrtillus* leaves and apexes were often remarkably browsed because of their herbaceous consistency (plants were also damaged by trampling and dung deposition), but only at relatively heavier stocking-rates (Fig. 3). With regard to trees and shrubs invading clearing of the mountain belt (*Populus tremula*, *Betula pendula*, *Rubus* spp., *Rosa* spp., etc.), the effects of light stocking-rates in alpine environment are reported by few papers in the literature. Lombardi and Cavallero (1996) observed a browsing efficiency on young tremble and birch above 50% at stocking-rates of 20% of carrying capacity (corresponding to 1 ewe per hectare per season). Repeated defoliation affected the growth and regeneration of trees (the majority of birches died at the end of the experiment), as it was also observed by Haeggström (1990) with comparable stocking-rates, and by Nedkvitne and Garmo (1986) with low stocking densities for a long time.

Scientific information about how the action of grazing animals affects encroaching vegetation is essential for the definition of grazing management for environmental conservation. They should be used within a pastoral plan, including data about the extension of the area that has to be maintained, the sharing between herbaceous and encroaching species cover, the type of vegetation that has to be controlled, the forage value of pastoral vegetation, the definition of carrying capacity (on the base of vegetation) and of reduced stocking-rates, the grazing technique (rotational grazing or shepherding), and the exploitation schedule.

For the stocking-rates specification, it should be considered that, with non-palatable species, the use of stocking-rates much lower than carrying capacity seems to give still the possibility of stopping the invasion (as outlined above); the depressive effects of grazing over small shrubs are closely related ($r = 0.81$; $P<0.01$) to stocking-rate (Cavallero *et al.*, 2000). For the different subalpine environments, Staglianò *et al.* (2000) and Lombardi *et al*. (2001) suggested that about 80 hectares of low pastoral value pastures may be managed with a flock of 100 sheep, with stocking-rates ranging from 25% to 50% of the carrying capacity and a grazing season of 100 days. The probability of controlling shrubs would increase by planning a mechanical shrub removal or prescribed fire every 10-12 years. On the contrary, in presence of palatable trees and shrubs, sheep browsed regardless forage allowance (Lombardi and Cavallero, 1996), i.e. damages to plants and stocking-rates are not related. Theoretically, stocking-rates could be up to 20% of the carrying capacity and could probably depend just on the degree of encroachment (the effects of grazing with different degrees of invasion

are poorly described by literature). Nevertheless, the effects on environmental conservation of leaving important quantities of herbaceous forage/dead tissues unexploited should be carefully considered, especially in the forest belt, where vegetation productivity may be high (up to 10 tons per hectare per year). Argenti *et al.* (2001) and Lombardi *et al.* (2001) suggested for mountain environments that during a 150 days grazing season, the surface that might be managed with a flock of 100 sheep (with stocking-rates ranging from 25% to 50% of carrying capacity) would be about 40 hectares of medium pastoral value pastures. The probability of controlling shrubs would increase by planning a mechanical shrub removal every 7-8 years.

The effectiveness of the application of a light stocking-rate depends also on the grazing technique. The rotational grazing with animals fenced inside paddocks 24/24 hours has many advantages, the most important being the uniformity of exploitation and an homogeneous distribution of excreta. Unfortunately, the generalized use of fenced paddocks cannot be proposed. With the actual size of flocks, the cost of fences installation in wide areas (up to 800-1000 ha) would exceed the salary of shepherds, moreover, the installation would be complicated by unfavourable land morphology. Grazing with the shepherd may have several advantages for conservation: (i) an experienced shepherd (with expert dogs) drives the flock and regulates the intensity of the herbaceous forage removal, as well as of shrubs; (ii) high stocking density, resulting from the large flock size, improves the effect of trampling and might improve the overall effect on woody species, even if animals move quickly to maximize exploited area (Rousset and Lepart, 1999); and (iii) night penning (1.0-1.3 m^2 per sheep per night) may be useful to recover small areas with a high degree of invasion. The transfer of dung from the grazing-land to night paddocks and further depauperation of vegetation is a possible disadvantage.

With regard to the moment of exploitation, literature reports that the best period to curb shrubs growth and development are: (i) early spring (Tolvanen *et al.*, 1993), when plants are intent on flowering and fructification; and (ii) late summer and autumn (Machinski and Whitham, 1989; Bailey *et al.*, 1990), when plants spend their energy for the accumulation of winter reserves. Anticipating the ascent to summer pastures and playing with altitude (to which vegetation stages are related), a concentration of exploitations during critical periods may be possible.

Conclusions

Taking into account the complexity of small ruminants grazing systems in Alpine regions that results in a wide variety of unique situations, a depth analysis of the whole system is required to define optimum-management strategies. In spite of the complexity of the systems, some major trends in small ruminant breeding may be outlined:

(i) There is a generalized adoption of grazing with the shepherd (often forced by increasing risk of predation) to which milk producers are prepared as, traditionally, they used to watch the animals during the day and collect them for milking. On the contrary, meat producers are less accustomed to control the flock uninterruptedly and might be unwilling to support additional costs of shepherding.

(ii) Flock enlargement is a consolidated way to reduce the cost of grazing, achieving a better control of the predation risk.

(iii) the adoption of grazing with the shepherd is at the origin of an increasing demand of manpower, but the qualification of operators is often inadequate (the number of courses in shepherding is very limited in Europe) and sheep and goats may become a cause of environmental deterioration.

(iv) There is an increasing interest towards small ruminants development in the mountains. For instance, there is a large number of breeders who are willing to increase the size of their flocks, as reported also by Dolek and Geyer (2002), showing mainly that sheep and goats may produce profits.

(v) Only where profits are produced grazing systems still exist, i.e. where there is a possibility to distinguish typical from mass productions, or where the community is willing to pay for an environmental maintenance service.

(vi) medium-long distance transhumance is becoming a reality in the Alps, which contributes to the reduction of grazing-pressure in the plains as well as in the Mediterranean area.

Several important problems affect sheep and goats grazing systems, but range scientists should have the means to put the technical basis to solve them. At the mean time, politicians should put the political basis of the promotion of small ruminant extensive breeding, which is a feasible way to create favourable conditions for environmental conservation of mountains and for viability of alpine economy.

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