Past, present and future of *Trashumancia* in Spain: nomadism in a developed country

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Spain presents exceptional ecological conditions for mobile pastoralism. Its semi-arid climate and its geography combine large biomass production in different places of the country at different times of the year. This creates an ecological rationale for the migration of large herbivores that was continued after the domestication of ruminants. Mobile livestock herding in Spain, known as transhumance, has been especially related to sheep husbandry and fine wool production and has been very important in the country's past. In spite of a decline in mobile pastoralism from the 19th century onwards, its traces are still clear in Spanish legislation as well as in Spanish animal husbandry practices.

But what are the reasons for this past importance? Why has mobile pastoralism declined and why, nevertheless, has it survived? In this paper we analyse the causes for its existence and for its past importance in Spain, and we describe the decline experienced in the two last centuries and present the present situation of transhumance and its future prospects.

Keywords: pastoralism, Spain, transhumance, ecology, history

Introduction

Grasslands represent a large portion of the world's continental surface and are the natural systems which support the largest herbivore biomass (Frank et al. 1998). Grasslands are usually represented in semi-arid areas of subtropical and temperate countries, as high rainfall leads to a forested landscape or to more productive agricultural uses. Nomadic pasturelands are estimated to occupy 26 million km^2, doubling the surface dedicated to agriculture (Grigg 1974).

Spain is one of the few semi-arid countries in the world having a highly developed economy (Huston 1993) and in this sense it is an exceptional country,

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doi: 10.3362/2041-7136.2010.005, ISSN: 2041-7128 (print) ISSN 2041-7136 (online)

because the resources available for scientific research are much higher than in other countries with comparable ecological conditions. Spain's long history is tightly linked with pastoralism and transhumance. Abundant documentation exists on drove roads used by pastoralists for centuries and, probably, millennia, including a rich cartography and some scientific works. This makes Spain a good example to analyse past and present trends of nomadic systems.

Ecological background

In semi-arid countries, animal migratory systems become very important for making efficient use of the primary productivity of the ecosystem, which is very variable between seasons (Fryxell and Sinclair 1988, Alerstam et al. 2003). The Mediterranean climate, in addition, has a high inter-annual variability of rainfall and plant productivity, a factor that enhances phenotypic plasticity of plants (Valladares et al. 2002); the same can apply to herbivores, who can adapt to climate instability through migration.

The first question that we should answer is why there are migratory animals at all. Migrations involve a large energy investment and risks that are not encountered among sedentary animals, and migration also involves the acquisition of evolutionary traits such as the ability to orientate (Alerstam et al. 2003). Migratory animals are, however, much more abundant in grazing ecosystems, exceeding the sedentary ones by even one order of magnitude (Frank et al. 1998).

The main reason to migrate is the availability of food, even though other factors may also be involved. In systems with differential biomass production between seasons and sites, the herbivore-carrying capacity of the ecosystem is determined by the food availability in periods of resource scarcity (Fryxell et al. 1988). If herbivores migrate following peaks of primary biomass production, their numbers will increase and they will become more abundant. Other factors may also be important, although not so evident. Migrations can have a positive effect in reducing predator pressure, as predators usually do not migrate.

The quality of the food also exerts a strong influence: the pastures have a high content in nutrients in systems with strong seasonal drought (Fryxell and Sinclair 1988) such as the wet season feeding grounds of wildebeest in the Serengeti. This phenomenon could be taking place in the southeast portion of the Iberian Peninsula, where rainfall seasonality is strongest (Clary 2008). The nutrient content of the vegetation may be related to the timing of the births in wildebeest (Fryxell and Sinclair 1988) and also in sheep from Spain, where lambs are born in the wintering areas (Arán 1944). The absence of herbivores is also important to allow the recovery of vegetation in systems where rainfall is constant throughout the year, increasing the stability of herbivore population dynamics (Fryxell et al. 1988). Hofmann (1989) makes a classification of ruminants according to their feeding

behaviour, distinguishing between browsers, which are more selective feeders, intermediate feeders, and grazers, which are adapted to process high quantities of low-quality food. Grazers such as wildebeest or sheep are additionally more prone to be constrained by water shortages, as they cannot extract enough moisture from food, in contrast with browsers (Fryxell et al. 1988). It is popularly believed that the risk of starving causes animals to migrate (Cabo Alonso 1992), as may have been the case in the evolutionary history of birds (Bruderer and Salewski 2008). In the case of grazing ecosystems, on the contrary, it is the abundance of available food for migrating animals which causes population increase.

The physical configuration of Spain offers an ecological rationale for the practice of transhumance. The Iberian Peninsula is dominated by the Mediterranean climate, with only the most northern portion enjoying permanent moist conditions. If we examine its geographical configuration and how main drove roads are configured, we observe that there is a low-lying area towards the south-western part of the country, which is the area from which most drove roads depart in spring (see Figure 1). Other departure areas include the coastal plains and the Ebro valley. We can also observe that drove roads invariably end up in mountain areas, preferentially towards the north

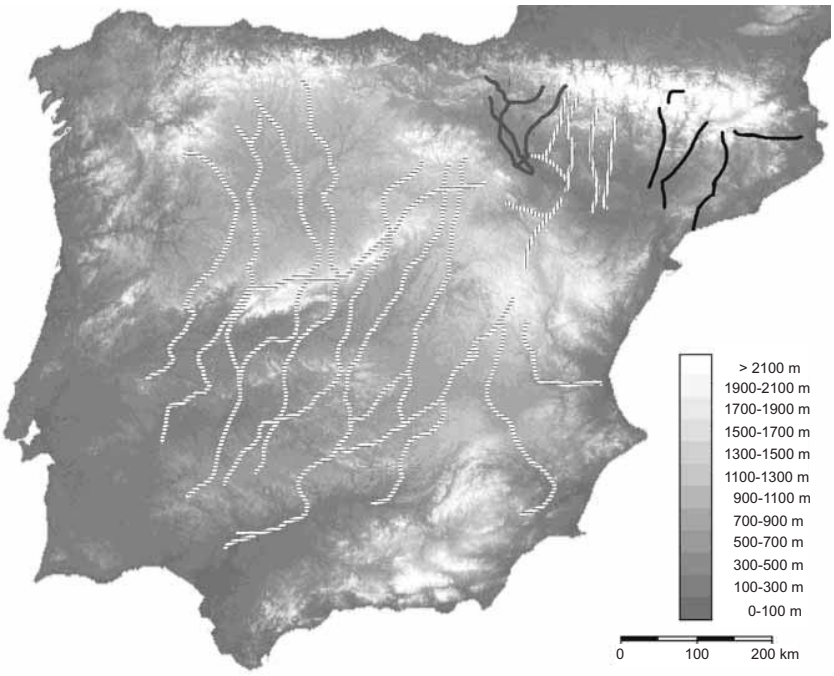

Figure 1: Mountain relief and main drove roads in Spain. Key for roads: horizontal strips, Castile; grey, Navarre; vertical strips, Aragon; black, Catalonia.

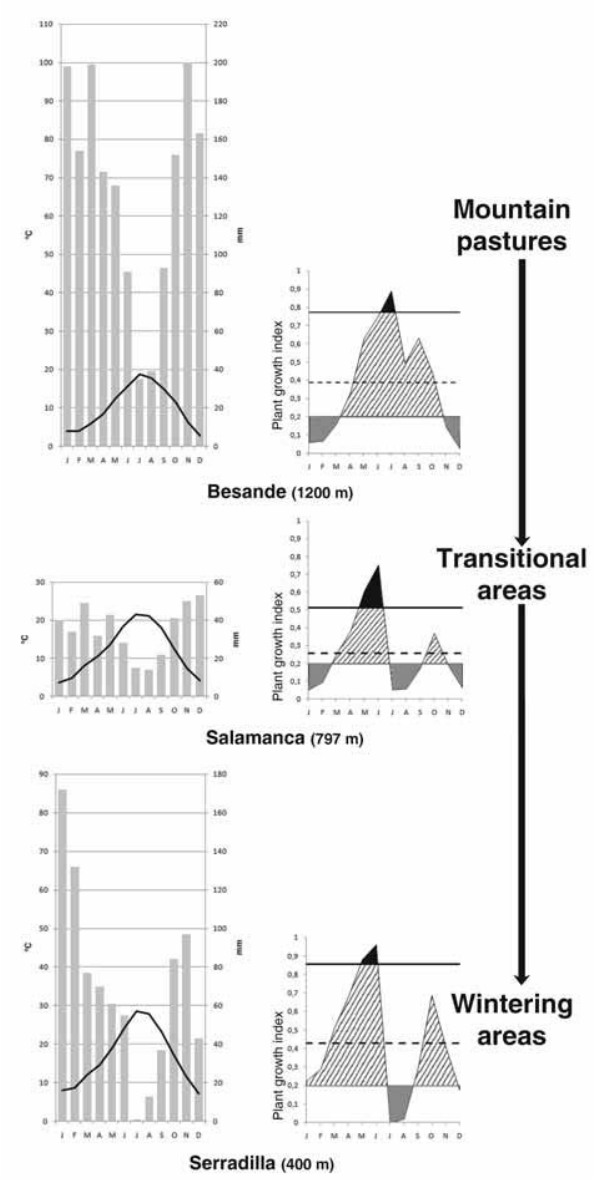

Figure 2(a)

Figure 2: Two examples of livestock routes in Spain, with their associated auxidiagrams (after Papadakis 1960). a) Cañada de La Plata (western Spain); b) Cañada Conquense (eastern Spain). Both show a consistent pattern of winter- and summer-productive areas and a transitional zone of spring and autumn productivity in spite of the different rainfall levels. Key: grey area: plant growth; black area: intense plant growth; dotted line: mean annual plant growth index; continuous line: double the mean annual plant growth index.

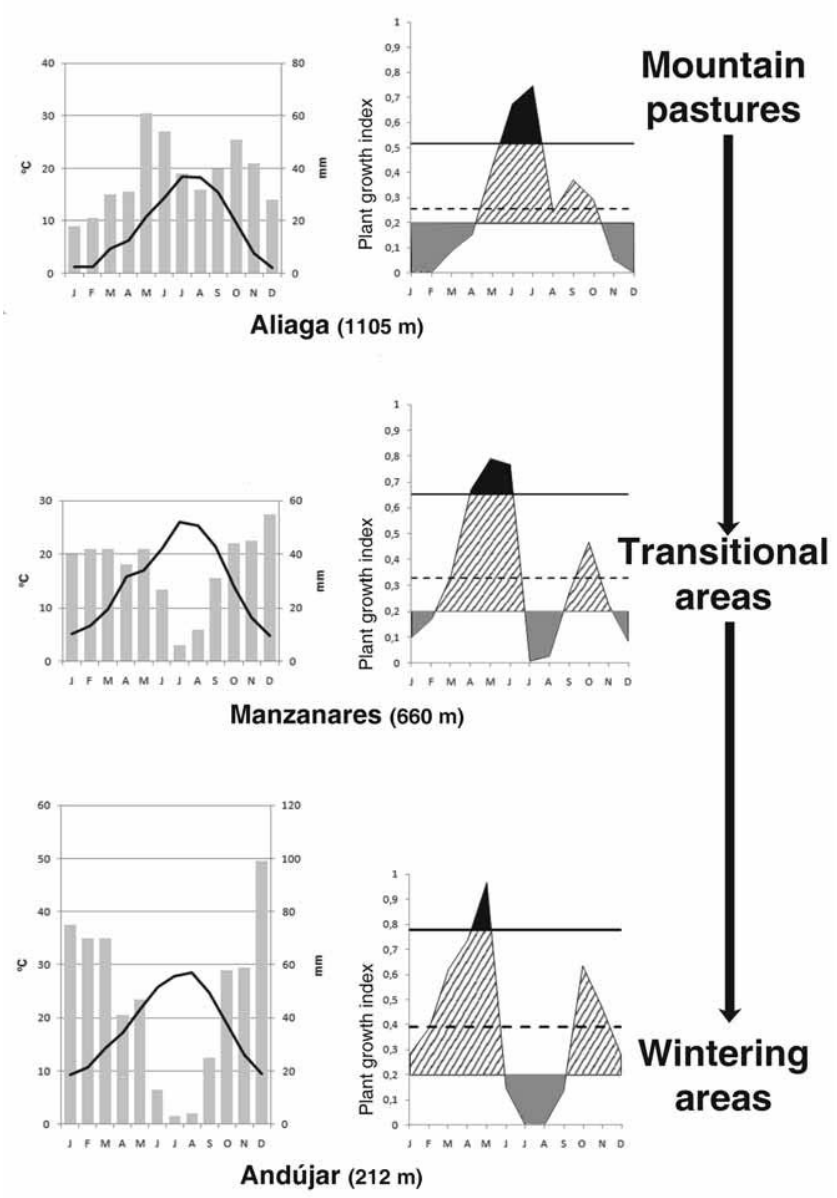
Mountain pastures
Transitional areas
Wintering areas
Aliaga (1105 m)
Manzanares (660 m)
Andújar (212 m)
Plant growth index
°C
mm
J F M A M J J A S O N D

Figure 2(b)

of the country. Winter pastures are always situated in areas where the mean temperature during the coldest month is above 6ºC, whereas summer pastures always lie in areas where the mean temperature in the hottest month does not exceed 17ºC (Garzón 2001).

Both climate and soil water reserves affect plant growth rates, which are summarized in Figure 2 based on Papadakis (1960). In a pattern that repeats itself all over the country, wintering areas are situated in places where plant production does not stop during the winter months, due to warm and moist conditions, and summer pastures are complementarily situated where summer drought is not severe enough to stop plant growth (Cabo Alonso 1992). Transhumant livestock also avoid both the extremely dry and hot conditions of the summer in south-western Spain and the extremely cold and snowy conditions of the mountains situated in the northern part of the country. Interestingly, transhumant livestock makes a very efficient use not only of the maximum productivity peaks of wintering as well as summer pasture areas, but also of the transitional areas that have to be crossed in the journey between winter and summer pastures. The production pattern in the transitional areas is bimodal, with peaks in spring and autumn and unproductive periods in summer as well as in winter. The pattern observed in Figure 2 repeats itself across the drove roads irrespective of the ancient Spanish kingdom they belong to, highlighting the efficiency of transhumance at making optimal use of the available natural conditions.

The consequences of this system are direct benefits for primary biomass production as well as on biodiversity and habitat connectivity. Grazing of pasture by large herbivores directly stimulates the re-growth of plants, increasing the productivity of the system (Frank et al. 1998) as well as the biodiversity through the relaxation of competition (Huston 1994). Those benefits are maintained, though, only if a certain threshold of overgrazing is not reached, a threshold which is determined by the natural equilibrium that is maintained by traditional systems of exploitation.

Drove roads also contribute to the maintenance of habitat connectivity in Spain, especially in a country affected, like other developed nations, by a process of habitat compartmentalization or fragmentation. In order to assess if the Spanish drove road network is effective against this process, we need to consider the network of secondary roads. Figure 3a shows how this network extends to every region of the country. But if we reduce the scale of our observation, such as in Figure 3b, we see that the network virtually covers every spot of the map. In fact, the Spanish drove road network, which presumably has inherited the ancient routes followed by wild herbivores, can be described as a natural fractal, as it is subdivided in third, fourth and fifth level roads that cover all the territory (Gómez Orea and Gómez Villarino 2006). Large domestic herbivores transport seeds and even insects (by sheep, as seen in Manzano et al. 2005 or in Fischer et al. 1996) across very long distances (Manzano and Malo 2006, Manzano et al. 2006). The role of drove roads as biological corridors is intimately related with their use for livestock transport,

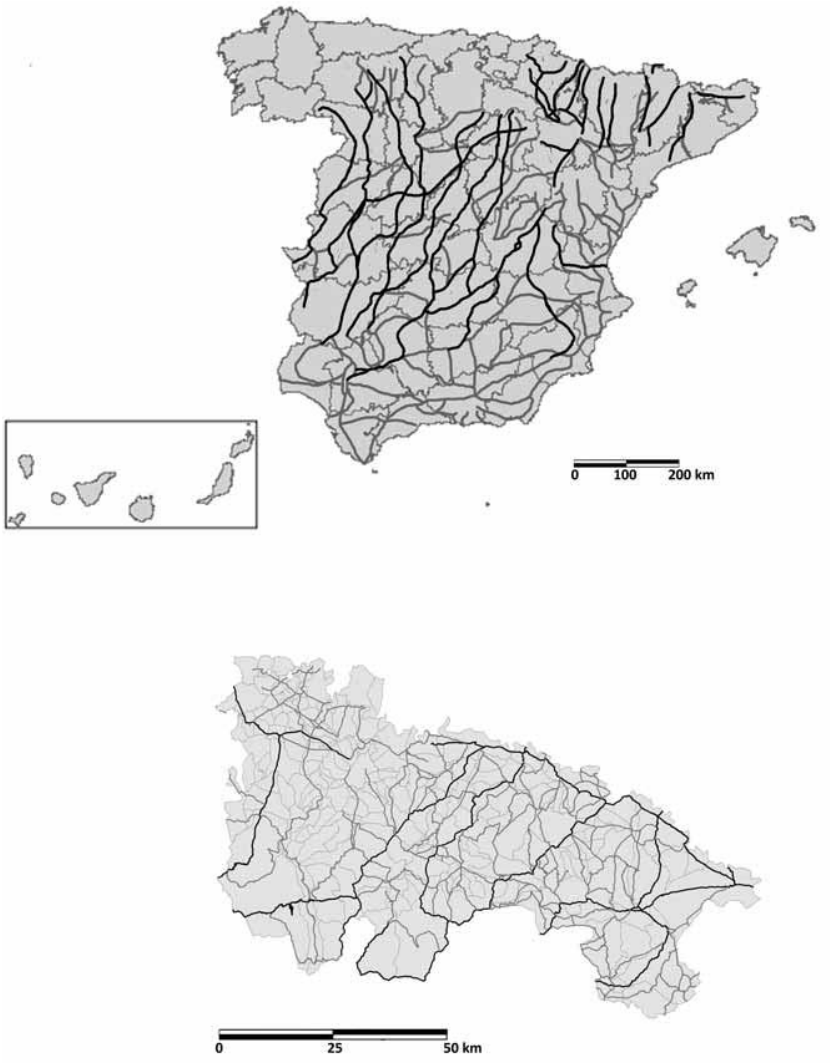

Figure 3. Drove roads at different scales in Spain. a) First (black) and second (grey) level drove roads in Spain, b) third (black) and fourth (grey) level roads in the province of La Rioja. *Source:* Wikipedia Commons, under the Creative Commons Attribution ShareAlike 3.0 license, http://commons.wikimedia.org/wiki/File:Vias_pecuarias_la_rioja.png.

and it is therefore lost if they are used for other purposes. Conservation of drove roads guarantees a connectivity needed for the conservation of biodiversity as well as of ecological processes (Castellano Jiménez et al. 2006) in a country where the massive construction of infrastructures for transport is especially problematic for habitat connectivity (Rosell et al. 2002).

Other movement systems involving shorter distances between summer and winter pastures are also possible in Spain, but much less profitable, at least in the portion of the country dominated by the Mediterranean climate. Those systems are similar to the transhumance practiced in Central and Northern Europe, which involves valley-summit transits (see Bunce et al. 2004a for a review, and Huband et al. 2009 this volume). This type of transhumance is more common in humid climates where the animals spend the summer months in the pastures that are snow-covered during the winter, while the grass of the lowlands is reaped, at least partially, at the end of the summer. However, moister conditions are not prevalent in the summer in Mediterranean mountains compared to adjacent lowland areas, and the mountains also exhibit certain water restrictions that limit plant productivity as well as food intake by livestock, as we have previously seen. Winter pastures in the lowlands do not produce grass during summer and reaping is hence not possible, while in winter they face frequent cold conditions that severely limit plant growth. All factors summed up make short-scaled transhumant systems much less productive than the broad-scaled ones in Spain.

Historical background

Large herbivores have been present in Spain since before the domestication of livestock (Rivals et al. 2004), and the grazers among them, i.e. aurochs and horses, probably undertook seasonal migrations since the end of the last glacial period (Garzón Heydt 1993). The length of their routes would be comparable to those of other large herbivores (Berger 2004). Possible traces of their ancient migrations can be seen in the routes followed afterwards by the Spanish drove roads. They cross valleys at steep inclines, which is more typical of quadrupeds than of bipeds (Gómez Sal and Lorente 2004). Other traces include the way roads cross mountain passes or river fords (Cabo Alonso 1992).

With time, wild herbivores would have been displaced by their human hunters, who started to breed livestock and followed the same routes they took when hunting. This process would have been similar to the way domestication of reindeer has occurred in the recent centuries (Ingold 1980) and would have also driven wild herbivore populations to extinction. It is noteworthy that this change from the dominance of wild herbivores to the substitution by domestic livestock and the eradication of their wild counterparts would have had negligible impact on the ecosystem processes. Domestic herbivores would have fulfilled the same ecosystem functions. The most common introduced herbivores are sheep (Zohary et al. 1998), which belong to the same herbivore functional groups as the displaced authoctonous ruminants, i.e. grazers (Hofmann 1989). Others, like cattle or horses, are tamed descendants of their wild counterparts.

It seems therefore obvious that the origins of transhumance in Spain date back to the very origins of animal husbandry, but unfortunately there is no

direct historical evidence. There is, however, some archaeological and indirect historical evidence that confirms this hypothesis. Untermann (1961) identifies a consistency among central Iberian place names that coincides with the transhumant routes that are present on the Atlantic side of the Peninsula. This consistency would have been caused by the seasonal movement of animals and people; in contrast, the place names on the Mediterranean side are more heterogeneous, which would reflect the lack of contact among different peoples due to their independent nomadic movements. A relationship between the distribution of autochthonous cattle breeds and the cultures populating the Peninsula described by the Roman historians has also been observed (Garzón 2001). Further evidence are the steles found in the southwest of the Peninsula that could be a sign for winter feeding areas (Sánchez-Corriendo Jaén 1997) or the different memorials of pre-Roman cultures that had livestock as their motifs (Cabo Alonso 1992).

Roman historians confirm the abundance of drove roads and the importance of transhumance in their metropolitan territory. They may have considered pastoralists from other countries as barbarians, in conformity with official propaganda (Sánchez-Corriendo 1997), an idea strengthened by conflicts between pastoralists and invaders when the former tried to reach their winter pastures. The importance of livestock husbandry at the time of the Roman conquest has been confirmed (Cabo Alonso 1992) and the pastoralist background of most Spanish soldiers in Hannibal's army was cited by Livy in his History of Rome, XXI, 43, 8, when he relates the impassioned speech of the general before the Tesino battle (Livio 1990). This testimony could be interpreted as the first historical proof of transhumance in Spain.

Transhumance continued in the Early Middle Ages, first with the Visigoths who invaded the country in the 5th century, and afterwards with the Arab invasion in the 8th century. The first documents regulating transhumance in Spain date from the Early Middle Ages, when the Visigoth kings enacted the *Fuero Juzgo* (Klein 1981). After the Arab invasion, Spain experienced some centuries of political division and instability. Initially, the Muslim kingdom occupied most of the country, leaving the more humid northern territories to Christian warlords, who slowly formed the kingdoms that would lead the Reconquest. Three centuries later, the Muslim kingdom fell into decline and was divided into several territories, which lost land to their Christian enemies until the last surviving kingdom, Granada, surrendered in 1492. Especially in the early Middle Ages, pastoralists often had to cross many frontiers. For this period, documentation of transhumance becomes scarce, but it continued even on routes that went across borders (Viguera Molins 1997, Fernández Otal 2006); at times, obviously, it was affected by war, but once peace was restored, pastoralists could have been able to continue their seasonal movements. It was probably at this time when the local sheep, whose good-quality wool was known in Rome, were crossed with Moroccan sheep to create the merino breed with its unique wool (Klein 1981). The importance of livestock husbandry during the

Islamic times is clear because of the contribution of Arabic to the specialized vocabulary of sheep husbandry.

The influence of transhumance and merino sheep husbandry was greatest during the Late Middle Ages and the Modern Era, associated with the Mesta. In 1273 the Castile king created a professional association of merino breeders that would be the equivalent to a modern lobby. It was named *Concejo de la Mesta* and it enjoyed privileges over the following five centuries, providing the country in exchange with its most valuable export commodity (García Martín 2004), the finest wool in the world. The more profitable long-distance transhumant regime was reserved for the merino wool sheep, leaving the less profitable short-distance movements for sheep breeds specialized in milk production. The Mesta acquired legal recognition and classification of drove roads to protect them against invasions from the farmers who cultivated adjacent lands and guaranteed rights over pasturelands, thus deepening the age-old conflicts between both communities (Klein 1981). The legal enforcement of the protection of drove roads made possible their conservation until modern times, and as the administration of the country became more centralized, these benefits were extended to the drove roads in the kingdoms neighbouring Castile. The Mesta was active throughout the modern era, although not without trouble; its transhumant movements and organization were affected by the secession of Portugal from Spain in the 17th century (Marín Barriguete 1991) and its members suffered from reprisals when they took sides in the war of the Castilian *Comuneros* in the 16th century (Klein 1981). The subsequent concentration of sheep property in a few hands caused a reduction in wool production, which recovered during the next century as the number of sheep reached a maximum in 1765 of 3.75 million transhumant sheep. With the loss of its monopoly at the time of the Napoleonic Wars, the merino wool economy entered a decline from which it did not recover (García Martín 2004).

During this time transhumance was also practised in other Spanish regions. As the Reconquest progressed, first the territories of the Crown of Aragon and then Andalusia consolidated their own models of transhumance. Although not as broad-scaled and productive as in Castile, these movement systems maintained transhumant practices from the Islamic period (Fernández Otal 2004). Aragonese shepherds even formed their own professional associations, called *ligallos*, which protected their interests and their drove roads. Although their *entrefino* wool did not have the high quality of merino, it was good enough to be exported to countries in the Mediterranean basin, boosting the herders' economies.

The exploitation of merino wool outside Spain and its territories at the end of the 19th century (Arán 1944, García Martín 2004) destroyed the economy of herders as prices sank. This trend continued with the commercial launch of artificial fibres after World War II (Ruiz 2001), making it impossible to cover shearing costs through the sale of wool, even for sheep with the best fibre quality.

One last event further changed transhumance in Spain: the revolution in transportation with the introduction of railroads and trucks. During the late 19th century the basic Spanish railroad network was built, converting the traditional trip on foot that took one month in spring and another month in autumn into a quick one-day journey. This left drove roads unused and, consequently, victims of all kinds of misuses. The situation was made worse with the introduction of trucks for livestock transport, reducing even more the travel time and the use of drove roads. Many herders intensified their production and stopped doing transhumance, bringing food to the animals instead of bringing the animals to where the peak in food production was located. The rural exodus after the industrialization of the country has added to the process, turning transhumance into a marginal activity. Even if livestock is largely extensive now (Casas Nogales and Manzano Baena 2007), keeping livestock in the ancient wintering areas throughout the year prompts overgrazing problems, while the abandonment of summer pastures is causing severe losses in biodiversity (Garzón 2001, Ruiz 2001).

Current situation

In the last few decades, Spanish agriculture and pastoralists have experienced great changes. The last half of the 20th century in Spain has been a time of great economic development that has accelerated the process of intensification in agriculture (Pineda 2001), further reinforced by the CAP (Common Agricultural Policy) of the European Union. Although livestock numbers have not declined, the agricultural workforce has, mainly due to industrialization (see Table 1). The increasing number of pigs and cattle (up 25 per cent in the last 20 years) results from a shift in Spanish eating habits, from a Mediterranean diet to one based more on low quality meat that is dependent on fodder rather than natural forage. Statistics also reflect a decline in the number of self managed farms and an increase in the number of workers who are employees. These changes are the result of policies that

Table 1. Evolution of the number of workers in the agricultural sector and of livestock in Spain since joining the European Economic Community, later European Union. (The figures for the animals are for breeding stock as well as for animals destined for consumption.)

Year		*1987*	*1995*	*2004*
Workers	Total in agriculture	1,726,500	1,141,000	1,031,800
	As employees	572,400	412,200	511,100
Animals	Cattle	5,094,000	5,512,000	6,653,000
	Sheep	22,994,000	21,323,000	22,672,000
	Pigs	17,303,000	18,161,000	24,895,000
	Goats	2,888,000	2,605,000	2,833,000

Source: Instituto Nacional de Estadística (2007).

favour intensification on large scale farms that are not located in marginal pastoral areas, and a loss of family farms engaged in pastoralism.

Transhumance is still practised in Spain by the owners of about 1 million animals (Gómez Sal and Lorente, 2004). The broad-scale livestock movements of 500-800 km are now made by truck, and only some of the short-scale movements are done on foot. As a consequence, drove roads are not used and suffer changes from diverse quarters. Ploughing from nearby fields is the most common form of encroachment. Highways and housing developments have often been built directly on drove roads (Cabo Alonso 2004), as authorities usually consider that they are not useful any more if they are kept for their traditional uses. Therefore, these secondary uses frequently result in the destruction of the drove roads.

The best picture of transhumant herders' current situation and the problems they face is given by the herders themselves. Álvarez de Toledo y Urquijo (2006) relates that, even for a short-distance transhumance in Central Spain, costs are always higher on foot than by truck (about 20 per cent more). However, for short-distance transhumance, costs are acceptable if several small herders put their animals together to reduce labour costs. Even in this case, only spring transhumance is done by foot, because the higher number of cows with calves and the shorter duration of daylight in autumn entail higher costs that herders cannot afford. Herders also practice transhumance not for economic reasons but because they know that the long term sustainibility of their pastures depends on periodically resting them.

Animal healthcare problems, such as brucellosis or bluetongue disease, have recently increased the suspicion of government officials concerning mobile herds and have complicated the practice of transhumance. As a consequence, bureaucracy has increased, while the political organization of Spain, divided into several regional autonomous entities, further complicates procedures. Older pastoralists in particular do not welcome any changes that mean more paperwork.

The advancing age of the pastoral population is something that herders are aware of and worry about (Gómez Benito and González 2002). The low involvement of young people in the sector is mainly caused by the perception that shepherding is a low-prestige profession (Cánoves et al. 2004), but all of rural Spain has been affected by the abandonment of small municipalities, which are left to its oldest inhabitants (Table 2). The lack of employment

Table 2. Changing Rural and Urban Population in Spain

Year	*1950*	*1970*	*1981*	*1991*	*2001*	*2006*
Settlements < 5,000 inhabitants	9,420,141	7,658,596	6,590,631	6,266,647	6,152,912	6,008,095
Settlements > 5,000 inhabitants	18,697,732	26,297,451	31,155,629	33,197,225	34,694,459	38,700,869

Source: Instituto Nacional de Estadística 2007

opportunities for women unbalances rural sex ratios and, in turn, makes rural life less attractive for young male herders.

Transhumance in Spain has a deep cultural heritage. Knowledge that has been transmitted from generation to generation (Rodríguez Pascual 2004), gives transhumance added value in terms of the intrinsic cultural richness it bears. But the ageing of the pastoral population endangers the whole system, which cannot be recovered once it is lost.

In order to achieve a change in these trends, in 1995 the Spanish Government passed Act 3/1995 on drove roads. This law protects the whole network and gives priority to livestock use, to avoid the destruction and usurpation of the common heritage that the roads represent (Mangas Navas 2004). The Ministry of Environment is seriously committed to the protection of drove roads, but the responsibility for environmental issues rests with the Spanish regions. Unfortunately, many policy makers from the local regional authorities ignore the requests of society to commit themselves to supporting transhumance. Instead, they concentrate their efforts on secondary uses such as tourism and leisure activities (see contributions by local politicians in Ministerio de Medio Ambiente 2006).

Future perspectives

Transhumance in Spain has experienced a sustained crisis lasting two centuries, but there are reasons to be optimistic. In the last few years, scientists have documented the environmental values of extensification, and especially of transhumance. Its maintenance is needed for the preservation of specific habitats of high ecological value (Bunce et al. 2004b), including systems such as *dehesas* or *montados*, which are open savanna-like formations of evergreen oaks typical of south-western Spain and southern Portugal. These are considered to be a paradigm for the sustainable use of the landscape (Olea and San Miguel 2006). The role of drove roads as ecological corridors has been proved (Manzano and Malo 2006) and it has been shown that extensive livestock production provides indirect economic services that exceed by far the monetary revenues they generate (Casas Nogales and Manzano Baena 2007). The value of grasslands as carbon sinks adds interest to these systems (Tennigkeit and Wilkes 2008), whose indirect values may have been underestimated so far. A future perspective of rising fuel costs is predicted to add market value to an activity already extremely efficient in the use of natural resources. Such a sustainable high-production system turns out to be particularly attractive in a global society that faces the challenge of looking for sustainable production-consumption systems (Lebek and Lorek 2008).

The increasing mistrust of consumers about the products of intensive animal husbandry, as a consequence of 'mad cow disease' and other problems, is awakening the interest of the general public to certified high-quality products. This opportunity should be used by transhumant pastoralists, whose

extensive production procedures guarantee, in principle, the highest quality. The implementation of agri-environment schemes since 1992 in the EU has helped to reduce the negative effects of intensification in the last few years (Peco 2001).

Modern technologies are contributing to shaping a pastoralism of the 21st century. Mobile phones are much appreciated among Spanish pastoralists, because they have caused a small revolution in their lives. They are not so isolated on their farms and have access to communications just as any other citizen, contributing to their self-appreciation as a collective group. The wider use of GPS devices at affordable prices also opens very promising possibilities for transhumance.

Conservationists are also modifying their attitude towards livestock husbandry. The historical conflicts between pastoralists and iconic species of the Spanish fauna, such as wolves or bears, contributed to reciprocal mistrust. Scientific evidence, however, has shown in recent years the importance of livestock for maintaining ecological processes, and conservationists are now opting for approaches that benefit both wildlife and herders. The use of guard dogs to protect livestock against wolf attacks is well documented (Gómez Sal 2004, Garzón-Heydt 2004, Rodríguez Pascual 2004) and their distribution has proven to be a successful tool to prevent conflicts with wildlife. Spain may not be exceptional in the use of guard dogs for conservation issues; they are also successfully used in India to prevent tiger attacks and reduce conflicts with locals (Khan 2009).

Thanks to improved public awareness, an initiative exists since 1993 to recover the traditional use of livestock roads in Spain. The Project 2001 (Garzón 2001, Garzón-Heydt 2004) has been organizing long distance transhumant movements of about 2,000 sheep by foot every year, with different objectives. If drove roads are used, they will be increasingly protected against misuse. Their use, in conjunction with modern technologies, such as mobile phones or four wheel drive vehicles, or in response to the needs of contemporary herders, helps to identify problems that may not be visible if the road is just a line on the map. For transhumance to be economicly sustainable, flocks have to be bigger than in the past, and the drove roads must be used in order to know if the roads are wide enough to accommodate larger herds. But making transhumance visible is probably the most important objective achieved by the project. The image of flocks crossing Madrid, with thousands of people enjoying the spectacle, has been seen in TV stations worldwide, making the general public aware of a crisis that affects us all.

Note

The plant growth index (I_{PG}) of the auxodiagrams is calculated after the following formula:

$$I_{PG} = \frac{h}{12} * \frac{(8H^2T^2)}{(1 + 4H^2)\,(20^2 + T^2) + 10^{-6}\,(1 + 2H)T^6}$$

where *h* is the duration of the day in hours, T is the mean monthly temperature in ºC and H is the humidity index. Data for the different stations are taken from Elías Castillo and Ruiz Beltrán (1977). Papadakis (1960) considers plant growth to be stopped for $I_{PG} < 0.2$, and to be intense for values that double the mean annual I_{PG}.

Acknowledgements

This paper originated from a work commissioned and funded by the World Initiative for Sustainable Pastoralism (WISP) under the International Union for Conservation of Nature (IUCN). The authors would like to thank Jesús Garzón and Jonathan Davies for their support, as well as Nacho Izquierdo Misiego and Laura Cortada for their help with the manuscript.

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