A CLASSIFICATION OF PASTORALISM IN SPAIN: UNDERSTANDING THE PAST TO ADDRESS PRESENT CHALLENGES

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Abstract

After centuries as a flagship economic activity, pastoralism in Spain is today in danger of collapse due to the simultaneous processes of abandonment and industrialisation. With a consensus on the need to revert this decline, a characterisation of pastoralism is needed in the design of an efficient framework for action. Through a participatory process with experts, we carried out this characterisation of Spanish pastoralism, identifying the most representative systems and communities. We studied the causes and consequences of pastoral evolution over the last 250 years, explained by biophysical, technological, governance and social parameters. We achieved a harmonised classification of eleven pastoral systems, classified into four groups with mobility parameters (large migratory systems, short-distance transterminance, daily mobile grazing and semi-wilderness). Large mobility systems were subdivided into ten pastoral communities, characterised by strong sociocultural ties beneath farm management. The consideration of pastoral systems and communities in policy can orient effective rural development, while optimising the allocation of resources for environmental conservation and climate neutrality.

KEYWORDS: Circular food production, livestock ethnography, pastoral communities, pastoral systems, rural governance.

1. Introduction

Spain is a country whose identity is strongly rooted in pastoralism (San Miguel et al. 2016). Split into four main biographic regions (Alpine, Atlantic, Mediterranean and Macaronesian [EEA 2017]), Spain is home to forty per cent of the EU's 31 grassland Habitat Types of Community Interest, many of them linked to pastoralism (San Miguel et al. 2016). From mobile (in altitude and latitude) to sedentary systems, pastoralism in Spain covers a wide range

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of species (especially cattle, pig, goat, sheep and horse), products (meat, milk, wool, skins) and uses (transport, labour, clearing), with a high diversity of local breeds (San Miguel et al. 2016; Ruiz et al. 2017; de Oliveira Silva et al. 2021). This has built up habitat diversity, offering very different avenues for pastoral development (Gómez Sal 2001) and leading to variable management and social diversity (Ruiz et al. 2017; Köhler-Rollefson 2020). Yet following global trends (Fernandez-Gimenez and Le Febre 2006; Aryal et al. 2018), Spanish rangelands are in general decline, associated with external changes and pressures, such as the socio-economic context and governance systems (Collantes 2009; Lasanta et al. 2017; Levers et al. 2018; Quintas-Soriano et al. 2023). Pastoral transformation mainly derived from conversion to more intensive production systems, leading to land abandonment and homogenisation of management and breeds (Collantes 2009; Kuemmerle et al. 2016; Levers et al. 2018), to the point that more than half of all Spanish breeds are already catalogued as endangered (de Oliveira Silva et al. 2021). Vulnerability to climate change also adds new risks and uncertainties to Spanish pastoralism, requiring attention (Rubio and Roig 2017).

Paradoxically, the relevance of pastoralism is becoming more and more evident, with reasons including resource efficiency and renewability (Krätli and Schareika 2010; Scoones 2022), socioecological relevance (Huntsinger and Oviedo 2014; Guadilla-Sáez et al. 2019; Niamir-Fuller and Huber-Sannwald 2020; Behnke 2021), or adaptability (Krätli and Schareika 2010; Aryal et al. 2018; Scoones and Nori 2023). To reverse the decline, pastoralism must be addressed through a socioecological context beyond a mere productive activity, with cross-cutting implications for other aspects such as environmental management, governance or social organisation (Fernandez-Gimenez and Le Febre 2006; Agnoletti 2014; Manzano et al. 2021; García-Martín et al. 2022; Sa Rego et al. 2022; FAO 2023). This will help address the need to choose the most effective actions for the preservation of these landscapes and lifestyles (Agnoletti 2014; Ruiz et al. 2017).

In Spain, this framework is conditioned by a lack of harmonised pastoral knowledge from 1. high management heterogeneity, 2. deeply transformed dominant livestock systems and 3. low harmonised pastoral knowledge. It is necessary to harmonise pastoral knowledge, across both spatial and temporal scales (Ruiz et al. 2017). In countries where the pastoralist livelihood is an important component of ethnocultural identification, such an objective is more feasible, for example in Eastern Africa or Central Asia (Kerven, Robinson and Behnke 2021; Reid et al. 2021). However, in the Spanish literature, there is little differentiation among types of pastoralism (Ruiz et al. 2017). An important limitation is that most studies applying holistic perspectives are geographically restricted, so there is an urgent necessity to expand the knowledge on

functioning livestock systems to other regions. Such gaps in knowledge can be uncovered by a characterisation exercise that can overcome the diversity in pastoral management (Agnoletti 2014; Ruiz et al. 2017). Characterisations are already common tools in the study of Spanish livestock systems at restricted scales (Pardos et al. 2008; Toro-Mujica et al. 2011; Mena et al. 2016; Díaz-Gaona et al. 2019; López-i-Gelats and Bartolomé Filella 2020; Ruiz et al. 2020; Serrano-Zulueta et al. 2023a). Moreover, some recent studies advance aspects of the characterisation of grazing systems at a broad level (Gómez Sal and Lorente 2004; Casas-Nogales and Manzano 2007; Sineiro García and Lorenaza Fernández 2008; San Miguel et al. 2016; Ruiz et al. 2017). But a wide characterisation of pastoral systems and communities is still a pending task to develop information that, in turn, allows structure governance – a key component of adequate land management (Agnoletti 2014; Johnsen et al. 2019; Köhler-Rollefson 2020; FAO 2021; Manzano et al. 2023).

Our research objective is to better understand the trajectory of the Spanish pastoral and livestock sector on a broad spatiotemporal scale. For this, we provide a formal characterisation of Spanish pastoralism in a classification that includes the most important features, harmonising literature and expert knowledge. This will help to plan future management strategies, including the design of a post-fossil fuel food production system.

2. Methods

Even if useful, published literature as the unique source of information for characterising Spanish pastoralism is problematic. Studies considering many dimensions of pastoralism tend to be local and static in time, while wider contexts tend to focus on a few variables. Also, bias in the published literature derives from unbalanced attention paid to different pastoral groups. Culturally recognised pastoralism, such as transhumance or *dehesa*-based systems, or pastoralism in regions of high ecological value such as mountain systems, can distort the image of the reality of the traditional livestock activity. For example, while enormous in their historical importance, the sheep-cereal or polyculture systems have little documentary support. To avoid these two problems in the published literature, we opted for participatory action research (Knapp et al. 2019), which can combine published literature with expert perspectives and knowledge (Döringer 2021).

The participatory process was conducted among members of the Spanish Platform for Extensive Livestock Breeding and Pastoralism (PGEP): the largest and most important umbrella organisation around Spanish pastoralism, with +500 members from all over the Spanish territory, including researchers,

PHASE	METHODS	OUTPUTS
Contextualisation	Participatory dynamics with the monitoring committee	Objectives Scope Set of indicators of pastoral communities
Classification	Literature review by the coordinators Rounds of contact with the task force	Drivers of pastoralism and livestock systems Preliminary classification
Validation	Evaluation and feedback provision from the monitoring committee	Harmonized classification

Figure 1.

Workflow of the participatory process.

technicians, farmers, farm association representatives and NGOs. Members hold wide knowledge of land use planning, livestock management and research. After the first meeting, three organisational groups were set according to implication levels: coordinators (2 participants), task force (10) and monitoring committee (15). The roles of each group, as well as the phases of the participatory process, are summarised in Figure 1; information about the participants is provided online,[1] including description of their expertise. Communication between the groups was mainly through email.

Contextualisation

A characterisation requires a contextualisation, including the aim, the scope and the expected outputs. The context was set by the monitoring committee, harmonising ideas on pastoralism, pastoral communities and pastoral systems. Differentiation between pastoral systems and pastoral communities was a hot topic that was considered in the classification. While pastoral systems share similar management decisions (Escribano 2014; Sharifian et al. 2023), communities differentiate by social contexts, including identity elements such as hierarchies, governance or even ethnicity. Due to the difficulty of identifying pastoral communities, we created a mind map to design the set of indicators that define pastoral communities (Figure 2). Characteristics were categorised and arranged and they were ranked as a function of the number of times they

1 https://www.whpress.co.uk/NP/NP28_2_Supplementary01_Serrano-Zulueta.pdf

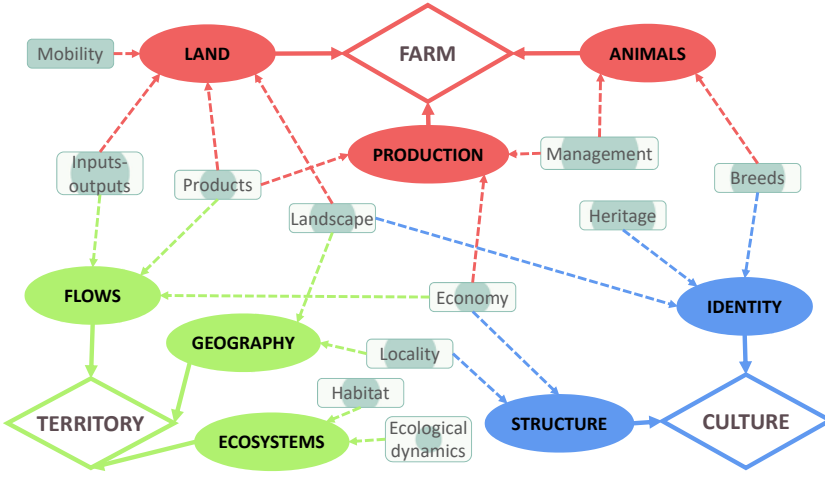

Figure 2.

Set of indicators of pastoral communities in Spain. Characteristics were grouped into different topics that are summarised in three headings: farm, territory and culture features, represented in three different colours. In each box, the percentage of filled area indicates the number of times a characteristic was cited during the brainstormwriting in relation to the most cited one (mobility=30 times).

were mentioned. Importantly, the division between pastoral systems and communities was done by considering the latter as a subdivision of the former. As pastoralism is widely heterogeneous, differentiations can be as fine as the measurement scale, following fractal dynamics (Manzano et al. 2021). Therefore, while pastoral systems can be easier to categorise through objective parameters, communities can be subjected to personal interpretation. We thus included only pastoral communities that are considered relevant at a regional scale and have a wide agreement, which is mainly those related to large migratory systems. A temporal scale encompassing the past 250 years was set to capture recent development and to include management that may have been historically important despite current irrelevance.

In this phase, the most highlighted indicators to classify pastoral communities were mobility, heritage and management (Figure 2). Other relevant elements were inputs and outputs, breeds or location, describing pastoralism as a complex and interrelated discipline. Most characteristics are used for similar purposes in Spain: mobility (García Martín 1992; Gómez Sal 2001), breeds

(Velado-Alonso, Morales-Castilla and Gómez-Sal 2022), landscape (MAPA 2003; McAdam et al. 2009; López-i-Gelats et al. 2011; Ruiz and Beaufoy 2015; Gómez Sal 2017), economy (Ripoll-Bosch et al. 2014), management (Castel et al. 2010; Urivelarrea and Linares 2020; Provacuno 2022) or ecological dynamics (Montserrat and Fillat 1990; Ferrer and Broca 1999; Mena et al. 2016). Social features are more difficult to use and find, so we identified anthropological features as a possible bias when addressing scientific literature to make the classification. Moreover, we considered that multidimensional classifications in farming systems do not use causal explanations (Madry et al. 2013), which might limit understanding in complex production systems like pastoralism.

Classification

The task force designed the classification of Spanish pastoralism. The harmonisation of knowledge was through a set of contact rounds between the members of the task force and the coordinators. The different backgrounds and expertise areas of the task force members allowed for a robust classification. However, previous literature was essential to verify the accuracy of the proposed classification. Checking previous classifications was especially relevant at this stage, combining agronomic, bioclimatic and political classifications. Apart from scientific literature, institutional information and grey literature were reviewed to avoid bias in academic research (Haddaway and Bayliss 2015; Sharifian et al. 2022). Past documentary evidence was especially relevant because of the weight of recent changes in agronomic systems. In this process of classification, an important task was to define the drivers of pastoral development, which helped in the evaluation of the past, present and future of pastoral systems and communities across time despite changes in their context.

Validation

The preliminary classification, harmonising expert knowledge with published literature, was subjected to the monitoring committee for validation three times. The suggestions were evaluated by the task force before applying changes by consensus. A final version was approved by the monitoring committee.

3. Results

Drivers for the development of pastoral and livestock systems

We grouped the drivers of pastoral and livestock systems into four different categories: biophysics, technology, policy and society (Figure 3). However,

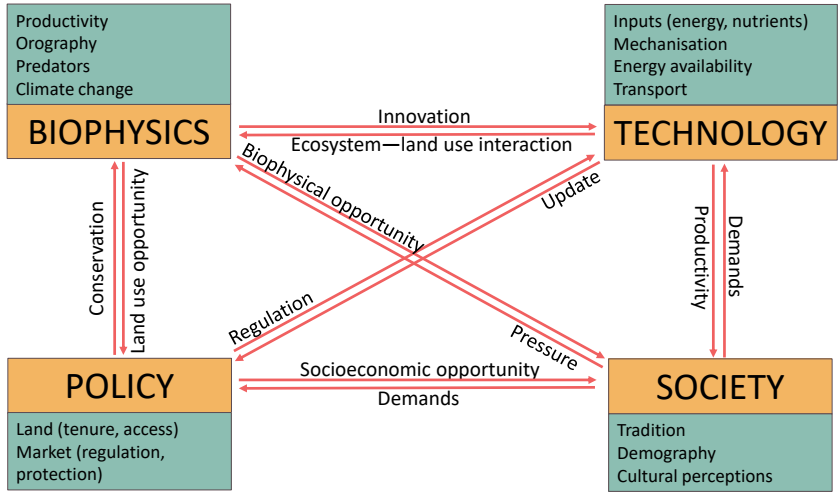

Figure 3.

Different drivers related to the development of pastoralism in Spain and their interrelations.

pastoral development is neither simple nor constant. Drivers that shape pastoralism are highly variable and even when constant, a single driver can have opposite effects depending on the context. For example, orographic isolation has been a protection for pastoralism until the twentieth century, when it became a reason for depopulation and abandonment. Recent decades of more complex socio-economic drivers exacerbate the sensitivity to changes, meaning that pastoralism requires special attention to survive (Manzano et al. 2021). In this section, we describe these drivers and their influence on Spanish pastoralism over the last 250 years.

I. Biophysics

Productivity: This is one of the main drivers to distinguish pastoral systems (Velado-Alonso, Morales-Castilla and Gómez-Sal 2020a), including not only the availability of forage but also its distribution throughout the year and the diversity in resources. In the north, the gradient of productivity is related to the proximity to the coast (due to milder temperatures), while in the south (Mediterranean), productivity is linked to mountain systems (due to orographic precipitation). The differences between the two biomes have materialised in the pastoral systems, so this explicit differentiation

is common in studies describing pastoral management (e.g. San Miguel et al. 2016; Velado-Alonso, Morales-Castilla and Gómez-Sal 2022). The low productivity due to the harsh climate (continental Mediterranean) is one of the causes of population loss in the inland country, highlands and mountains affected by a demographic crisis (the so-called emptied Spain).

Orography: Regional relief is a relevant subject in the seasonality of forage production and also in accessibility. Thus, orography has had a variable but significant effect on pastoral management throughout history. During the rural expansion throughout the eighteenth and nineteenth centuries, isolation served to preserve traditional systems. However, after major ensuing socio-economic transformations, isolation is related to a much steeper demographic decline than in other rural areas (Lasanta et al. 2021).

Predators: Top-down pressure by predators explains the development of identity elements such as the shepherd's presence and shelter structures. The almost complete disappearance of the wolf during the last century caused the abandonment of these traditions. With the recovery of wolf populations 50 years later, management needs to be updated, requiring non-refundable investments such as the presence of the shepherd, electric shepherds or the use of shelters. This adaptation can be a cause of poor financial status that requires attention (Pettersson et al. 2021).

Climate change: Despite high uncertainty, climate change impacts on all pastoral systems are probable, reducing productivity due to a generalised higher water stress, extreme drought or erosion events due to heavy rainfall (Herrero et al. 2016). This impact will most likely be greater in sedentary systems than in mobile ones, as the adaptability of mobile livestock makes them particularly resilient to shock events (Pauné 2023). Even so, the changes are likely to be intense enough to force profound changes in traditional systems (Herrero et al. 2016).

II. Technology

Energy availability: In the last century, fossil fuels have provided the Spanish agricultural system with vast amounts of energy at affordable prices. From coal to oil and natural gas, the increase in energy availability responds to the mechanisation of extraction and distribution processes, but also to consumption possibilities. In livestock systems, this includes input production (especially fertilisers), mechanisation of agricultural work and transport. Technological development is therefore strongly conditioned by the capacity provided by affordable energy.

Inputs (water and nutrients): Since the time of the Umayyad Emirate, there have been some large-scale artificial irrigation systems in Spain, starting with

the irrigation ditches of the Túria and Xúquer rivers or those in Granada. In the last 250 years, there has been an exponential increase in major hydraulic structures, with the Imperial Channel of Aragon (second half of the eighteenth century), the Castilla Channel (eighteenth and nineteenth century), the Urgell Channel, the Tajo-Segura water transfer (mid-twentieth century) and the Guadalquivir Canal (1940–1962). Together with the expansion of mineral fertilisation by the Haber-Bosch process during the green revolution, these technological developments favoured a shift towards agricultural land use to the detriment of livestock farming, as well as sedentary livestock farming – due to the availability of fodder, fallow land and stubble. Competition for land in irrigated areas also made wintering more expensive, hindering mobile or opportunistic pastoralism such as transhumance (Pauné 2023). With the agricultural surplus, grain as the major feed source became predominant in livestock systems in Spain.

Mechanisation: Food production has been the great historical consumer of anthropic energy, with draft animals as the great producers of mechanical energy (Fizaine and Court 2016). However, this changed with the acceleration of innovation from the three technological drivers (energy availability, inputs and mechanisation). This led to the delocalisation of production independent of biophysical opportunity, with a profound impact on mobile systems, which could meet their feed needs without having to travel such long distances (especially to wintering areas). This favoured short migration (transterminance) to the detriment of long migration (transhumance) – a very relevant factor in the decline of transhumant communities, with agricultural expansion overtaking the Duero and Ebro river basins and the Mediterranean coast. At the same time, with the mechanisation of agriculture, the breakdown of circularity in livestock utilisation of agricultural residues put an end to one of the major roles of livestock in the mid-twentieth century. If the relationship between the two activities had traditionally been one of conflict over land use, this decoupling meant that livestock farming was considered marginal. In addition, there was a shift from subsistence farming to surplus farming, geared to the production of large quantities of fodder, which favoured the sedentarisation of livestock.

Transport: Transport networks have had a logical impact on mobile systems, especially transhumance. The railway network came to define almost all the directions of the merino transhumance, with little development in the rest of the transhumances. There is no consensus on whether transportation contributed to pastoral preservation or was instead a further reason for its decline. This is because the transport revolution was parallel to many other factors that were driving the transition to new types of livestock farming. By the end of the twentieth century, trucks had replaced trains for being

more convenient in terms of time, cost and animal health (Pauné 2023). New means of transport, together with high energy availability, revolutionised the distribution networks for food and other goods, making it possible to participate in the global market and displace production centres from consumption poles.

III. Governance

Land: During the time of the Ancien Regime, pastoralism was protected and institutionally represented, with agricultural activities subordinated to their needs. The institutions of transhumance are well known, but other mechanisms, such as the *derrota de las mieses* (forcing stubble grazing, a remnant of communal grazing rights on land that had become private), were essential for keeping livestock in stables and for short mobility (Sánchez Salazar 2002). A strict organisation that included land sharing was not in agreement with liberal ideas. Land confiscations in the nineteenth century were key to boosting agriculture at the expense of privatising communal and collective lands (García Sanz 1994). Private tenure and land accumulation were the general trends until the twenty-first century, although with regional differences. In mountainous areas, communal land has been better preserved and private ownership has remained mostly in small holdings. On the other hand, arable areas, such as the Guadalquivir, Guadiana or Ebro river basins, have suffered from a greater concentration of ownership and a drift towards agriculture rather than livestock.

Market: Traditionally, consumption possibilities were limited by production possibilities, which shows the importance of biophysical characteristics in distinguishing pastoral systems. However, the expansion of trade with the Americas and Europe opened up these opportunities. For example, the spread of maize along the northern coast from the seventeenth century onwards was associated with more sedentary pastoral practices, both in these coastal areas and in the mountainous interior, where winter transhumance to the coast was no longer essential. Other common foods, such as potatoes and chickpeas, were crucial to agricultural expansion. Similarly, new and more productive livestock breeds had major impacts, especially Holstein cattle, which monopolised and expanded the small dairy cattle market by the beginning of the twentieth century (Junta Consultiva Agronómica (España) 1920). Such productivity improvements were reinforced by the growing population they could support. During the twentieth century, economic liberalisation with regulatory mechanisms favouring competitiveness (such as the Common Agricultural Policy of the EU), had a well-known impact on accelerating productivity trends. This was translated into industrialisation

trends or the rapid expansion of new meat-oriented livestock breeds, such as the Charolais or Limousin cattle or the Landrace or Large White pigs. In the last decades, an interventionist trend has been noticeable. Regarding environmental protection, the exclusion of grazing (especially goats) has been common as they have been considered detrimental to tree regeneration. For example, the prohibition of grazing pre-Pyrenean pastures reforested with conifers (to avoid reservoir clogging) led to a reduction in herds and a shift to using agricultural land through sedentarisation (Pauné 2023). Conversely, some traditional systems have been granted incentives, in relation to fire prevention, landscape conservation or gastronomy. Such recognitions have implied a specialisation due to market opportunities, which has reduced traditional productive diversity, with examples of increasingly dominant breeds by ecoregion, especially in the case of sheep, with breeds such as castellana, manchega, rasa aragonesa or latxa (Velado-Alonso, Morales-Castilla and Gómez-Sal 2022). In sum, there is no single direction in the influence of political measures.

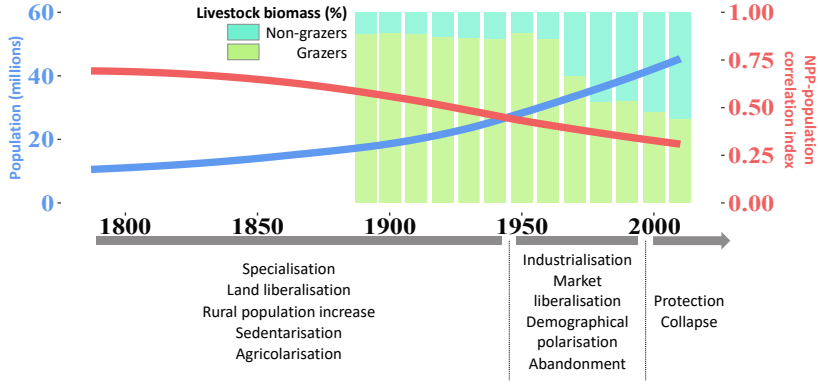

Figure 4.

Summary of changes affecting pastoralism in Spain in the last two centuries. Three illustrative variables are represented: 1. Human population (blue line); 2. Correlation index between Net Primary Productivity (NPP) and population density at province-level (red line); 3. Percentage of livestock biomass that usually grazes (cattle, sheep, goat, equids) and does not graze (pigs and poultry) (stacked columns). Data sources: INE 2023 (human population), Serrano-Zulueta et al. 2023b (Net Primary Productivity), Soto Fernández et al. 2016 (livestock biomass).

IV. Society

Demography: The demographic growth of the last three centuries and the need to satisfy food needs have stimulated competition for land and competition between agriculture and pastoralism, favouring the former due to the protection of private property and higher profitability. Another relevant driver is the distribution of population. The second half of the eighteenth century saw the beginning of a slow demographic polarisation, exacerbated by the rural exodus in the second half of the twentieth century. This ended with the traditionally strong correlation between biophysical production possibilities and population (Figure 4). This phenomenon feeds back into the loss of pastoral activity. On the one hand, the pressure of large population centres has pushed the agricultural sector towards industrial production, a relevant phenomenon in the Catalan mountains, in the area around Madrid and on the Mediterranean coast. On the other hand, the pressure for productivity in the context of great competition for land forced many shepherds to emigrate. Thus, in the twenty-first century, societies that maintain traditional pastoral practices are threatened with collapse by depopulation. This is the case in the rugged areas of Zamora and León, the Central and Iberian Mountain Ranges and the Cantabrian interior. This process of productive polarisation largely defines the last 40 years of Spanish livestock development (Fernández Nogueira and Corbelle Rico 2017).

Tradition: Traditionality has generally been a conservation instrument for agronomic practices. For example, pastoral activity used to have a strong hereditary component. But in the last century, the dependence on hereditary commitment to the activity has become a problem, since the ample range of work and student opportunities has put an end to the perception of livestock as heritage. Meanwhile, the plasticity of production models in recent centuries blurs the identification of what traditional systems are. For example, the current pastoral convention on excluding livestock from cereal and fruit crops or the division of land into plots is contrary to the tradition forged by ecological sense. Therefore, traditional pastoral management and ecological knowledge are very vulnerable to disappearance because they largely depend on the inheritance of traditional knowledge.

Cultural perception: Tradition and convention affect not only the production model but also consumption patterns. Productivity required by the ordinary consumption of animal products seems unattainable for traditional systems, despite the productivity of adaptive systems such as transhumance (Pardo et al. 2023). However, pastoral products have a good social perception for quality and association with socio-ecology. This recognition rewards some traditional production systems, such as *dehesa*, transhumance and mountain pastoralism, and products associated with these practices, such

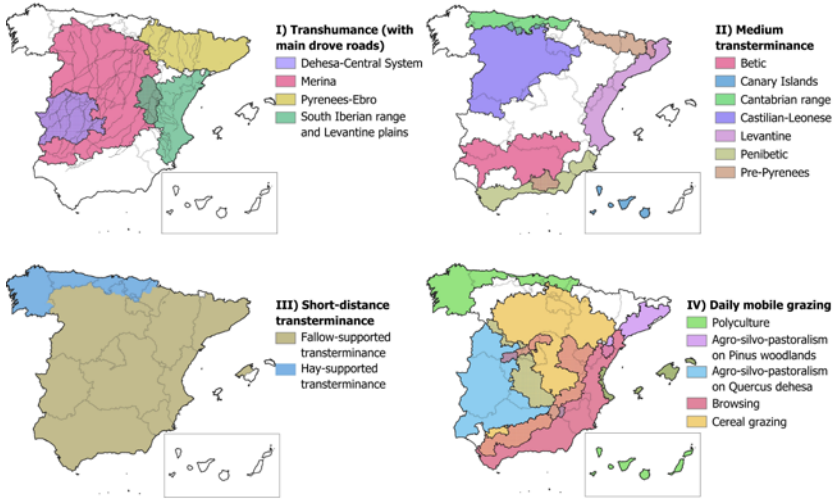

Figure 5.

Summary of the classification of Spanish pastoral systems, based on mobility: large migratory systems (I and II), short-distance transterminance (III) and daily mobile grazing (IV). Pastoral communities are described in large migratory systems and main drover roads are represented in the transhumant communities (MTERD 2021). Semi-wilderness is excluded in this representation due to its opportunistic character.

as acorn-fed pork and many cheeses and meats, often recognised by labels such as the Protected Designation of Origin. However, there are difficulties in marketing some culturally valued products, such as meat from transhumant livestock, because of a too intense flavour for the non-habituated consumer and the lack of specific labelling.

Classification

The final classification is summarised in Figure 5 and Tables 1 and 2, with further description provided online.[2] Based on mobility, we propose a first classification of pastoral systems: large mobility (Figure 5 I and II), short transterminance (Figure 5 III), daily mobility (Figure 5 IV) and semi-wilderness. Each category is subdivided into several pastoral systems. Semi-wild grazing systems are not further described because their opportunistic basis makes them

2 https://www.whpress.co.uk/NP/NP28_2_Supplementary02_Serrano-Zulueta.pdf

too heterogeneous and variable in time, but examples are provided online.[3] In large mobility, the distinction between transhumance and transterminance is mostly related to the migrating distance, with the former moving longer distances than the latter. We assumed an approximate limit of 100 km distinguishes both mobility types, as they are well-established, common-knowledge concepts in Spanish pastoralism. In large migratory systems, cultural ties and historical cohesion are so strong that they can be considered pastoral communities, so we subclassified these communities by paying special attention to such cultural and historical dimensions (Table 2).

4. Discussion

Pastoralism in Spain: Collapse and adaptation

In Spain, multiple pastoral systems and communities coexist with very different ways of management or culture. We propose the consideration of eleven pastoral systems (grouped into four categories depending on mobility patterns) and ten communities of large migratory systems (transhumant and transterminant). In the past, the most important drivers for shaping pastoralism were those related to the opportunity of production, i.e., biophysical conditions (Lasanta et al. 2021). But technological development has greatly impacted pastoralism and, more recently, society and policy have also become especially critical. Thus, there is a web of relationships between drivers that complicate the identification of explanatory factors that are independently manageable.

Pastoralism as a predominant production system in Spain ended in the mid-nineteenth century (Correal and Sotomayor 1998) (Figure 4). Nearly two centuries later, many pastoral systems and communities have already collapsed (Lasanta et al. 2017), in line with the global situation (Manzano et al. 2021). Shepherds are increasingly scarce and older, mobility is almost lost and pastoral shelters and structures are in ruins. Most impacted systems are those of low specialisation, such as polyculture, or of low-profitability, such as bush browsing (Levers et al. 2018). These struggled to adapt to new market realities that led to a continuous decrease of profitability (Levers et al. 2018). The rest of the pastoral systems and communities were also negatively affected, and many of them are in a critical state. Most large migratory communities suffer from social hurdles such as lack of renewal and the desire for more conventional lifestyles, parallel to depopulation processes in mountainous or little-industrialised regions (Collantes 2009; Guadilla-Sáez et al. 2019). The survival of most traditional pastoral systems is currently on the edge.

3 https://www.whpress.co.uk/NP/NP28_2_Supplementary02_Serrano-Zulueta.pdf

Table 1.

Main Spanish pastoral systems. * Conservation status of traditional pastoralism: 0 Extinct; 1 Almost extinct; 2 Decreasing; 3 Conserved. ** Information is provided with more detail in Table 2.

Large migratory systems		Anthropic version of wild megaherbivore migrations. High self-subsistence and ecological optimization. Supported by major mountain ranges.	Difficulties to adapt to new socio-economic circumstances such as sedentarization or mechanization. Lack of shepherd renewal.		
	**Transhumance**	Altitudinal and latitudinal migrations over 100km. Communities with a long history of management, cultural ties and governance structures.	Sensitive to historical changes: conflicts, crisis and technological development. Centuries of decay, with problems for profitability and renewal.	**	**
	**Medium mountain-valley transterminance**	Altitudinal migrations to inner pastures. High agricultural inputs in scarcity periods (winter), especially stubbles and fallows. Silvopastoralism is frequent in wintering areas.	Favoured by crop expansion from modern irrigation systems. Increasing cattle proportion during the last decades.	**	**
	**Medium mountain-coast transterminance**	Altitudinal migrations to coastal pastures. Shortest distances in large migratory systems, in the stript between numerous mountain ranges and coastal pastures. Sea humidity and soft temperatures support productivity during summer.	High competence for land on the coast (high human density, urbanization). Inland shepherds emigrated to the coast, leading to depopulation of inner areas.	**	**
Short distance transterminance		Migration across the same region (<30 km). High management diversity and adaptation technics.	Enhanced by sedentarization of large migratory systems.		
	**Fallow-supported transterminance**	Winter: post-harvested agricultural valleys Summer: medium-size mountains and mountain ranges. Valley use usually oriented to grain in the inner plains and to horticulture on the coast.	Increased in the last centuries due to reduction of long-distance migration, and increase of crop fields. Lost link with agriculture and trend towards stabulation	Sheep: castellana, churra, ojalada soriana, alcarreña, guirra, segureña, ripollesa. Cattle: pajuna Goat: agrupación de las mesetas, verata, retinta, catalana	1-2
	Hay-supported transterminance	Winter: rangeland valleys. Summer: medium-size mountains and mountain ranges. Especially related to cattle and horse. Linked to communal land tenure.	Rangeland expansion in lowlands in the last decades due to agricultural abandonment. Better conservation status in more densely populated areas.	Horse: pura raza galega, asturcón, monchina, losina, pottoka, jaca navarra, pirenaico catalán Cattle: pirenaica, asturiana de montaña, asturiana de los valles, tudanca, pasiega Sheep: latxa, sasi ardi, xalda Pig: celta branch	2
Daily mobile grazing		Related to small herds. High resource diversity supports the lack of forage during scarce periods, especially during summer. Usually dependent on agriculture.	Generally affected by land competition. Subjected to specialization due to competitive disadvantages. Affected by restrictions in animal mobility.		
	Agro-silvo-pastoralism on *Pinus woodlands*	In the Mediterranean Catalan valleys. Resource diversification: crops in the valleys, forests in the mountains and animals shift between both. Potentially *Quercus* landscape but afforested with *Pinus*.	Specialization in agriculture or intensive livestock farming. Increasing use for fire prevention. Increase of cattle, e.g., bruna and allochthonous breeds.	Sheep: ripollesa Goat	2
	**Agro-silvo-pastoralism on *Quercus* dehesa**	Antropic *Quercus* silvopastoral landscapes, with different degrees of openness and low shrub cover. Mainly *Q. ilex and Q. suber* due to acorn production. Other dominant trees can include *Q. pyrenaica*, ash or wild olive. Hosts most cattle breeds of Mediterranean Spain. Difficult achievement of self-sufficiency, agricultural complementation (grain). Emblem of Spanish pastoralism.	Low land value for agriculture preserved pastoralism. Key importance of sheep grazing in their origin and maintenance. Problems of substitution or increasig by other livestock species. Current specialization in cattle (north) and pig (south). High cultural appreciation. Problems for tree renewal.	Pig: ibérico branch Cattle: morucha, negra avileña ibérica, sayaguesa, cacereña, retinta, berrenda en negro, berrenda en colorado, lidia, cardena andaluza Sheep: entrefina, merino, merino negra Goat: blanca serrana andaluza, retinta	2
	**Cereal grazing**	In large river agricultural basins: Ebro, Duero, Tajo, Guadiana, Guadalquivir. Based on high availability of stubbles and fallows. Sheep as the predominant species. High historical relevance in all areas with continental climate. Combined with many other systems: transterminance, silvopastoralism, browsing...	Agronomic specialization, in the past, competition for grazing land. Dissociation of agronomy and livestock with the green revolution. Cereal as feed, instead of a sub-product, enhances intensification.	Sheep: churra, castellana, rasa aragonesa, manchega Goat: florida, agrupación de las mesetas	2
	**Polyculture**	In all of Spain. Until recent times, in the Atlantic coast (highlighting Galicia), Mediterranean coast and non-mechanizable mountain areas. Historically very relevant, associated with smallholding. Diverse and highly adapted to local conditions, combining agronomy, pastoralism and silviculture. Strategies such as crop rotation, forest as a fertility source and animals in the agrarian metabolism. Linked to subsistence and familiar scale, usually around the family house.	Highly productive, but focused on self-sufficiency. Not very profitable in current market economy. Sensitive to population growth pressure. With green revolution, no need to integrate farm metabolism Different regional trends: milking cattle in the Atlantic area, agriculture in the Mediterranean and abandonment in the mountains.	Cattle: rubia gallega, menorquina Pig: celta gallego, gochu astur-celta, euskal txerri, porc negre Sheep: mallorquina, roja mallorquina, eivissenca Horse: mallorquí, menorquí Goat: mallorquina, eivissenca	0
	**Browsing**	In semi-arid shrubby regions. Ecotypes adapted to shrub intake as a major feed source. Browsing of of tree regrowth kept rear to ground level, especially *Q. pyrenaica* (bardales, barderas) in the Central System and the Mediterranean. Associated with specialised cattle and goats. Complementation with by-products (olive, almond, vineyard, palm tree). Small herds and land tenure.	Little goat market (kids). Low productivity. Intensification and confinement. Milk orientation.	Goat: murciano-granadina, malagueña, florida, blanca celtibérica, blanca de Rasquera, payoya, majonera, tinerfeña Sheep: segureña, guirra Cattle: Avileña-Negra Ibérica	1
Semi-wilderness		High heterogeneity. Remarkable presence of equine breeds.	Often due to high productivity or to abandonment.	Horse: pura raza galega, caballo de monte del País Vasco, pottoka, caballo de las retuertas, marismeño. Goat: Mallorquina Sheep: sasi ardi Cattle: albera, marismeña, betizu	3

Table 2.

Pastoral communities associated to large migratory systems. * Conservation status of traditional pastoralism: 0 Extinct; 1 Almost extinct; 2 Decreasing; 3 Conserved.

	Pastoral community	Mobility	Characteristics	Development	Species and breeds	Status*
Transhumance						
	**South Iberian Range and Levantine plains**	Winter: Mediterranean coast (between Ebro and Segura rivers). Summer: South Iberian Range (Sierra de Albarracín, Maestrazgo, Gudar, Serranía de Cuenca, coastal ranges).	Productive constraints (hydric stress and land competition in winter) that lead to small herd size and the relevance of spontaneous adaptation	High competition with agriculture in wintering areas. Major depopulation in summering areas.	Sheep: rasa aragonesa, alcarreña, segureña, cartera, guirra Goat: blanca celtibérica	1
	**Dehesa-Central System**	Winter: dehesas (Extremadura, Sierra Morena). Summer: middle altitude mountains and plateaus in the north face of Central system, Gredos, Paramera de Ávila.	Lack of historical and governance cohesion. More related to a management system rather than a pastoral community. Water and pasture scarcity in summer.	Increasing relevance by having replaced merino transhumance. High profitability and market access. Current problems of land degradation/overgrazing.	Cattle: avileña-negra ibérica, lidia	2
	**Merina**	Winter: dehesas and plateau rangelands. Summer: mountain ranges of the Northern half (especially Southern face of Cantabrian mountains and Iberian System).	Largest distances travelled and largest drover road network in Spain.	High historical relevance and political influence until 1836. Sensitive to socio-economic changes: wool devaluation, land and market liberalisation, sedentarisation, landscape fragmentation… Cuenca and Gredos are the only major drover roads still travelled on foot.	Sheep: merino Goat: agrupación de las mesetas Cattle	1
	Pyrenees-Ebro	Winter: valleys and steppes the Ebro basin. Summer: Pyrenean pastures above the tree line.	Greatest altitudinal gradient. Decentralized organisation (ruled by Pyrenaic valleys). Differences between Eastern and western shepherds.	Affected by land abandonment in the Pyrinees. Conversion of winter pastures to crop fields due to irrigation. Recent increase of cattle.	Sheep: rasa aragonesa, tensina, xisqueta, ripollesa Goat	1
Medium mountain-valley transterminance						
	**Betic**	Winter: Sierra Morena. Summer: Betic mountains (especially Cazorla, Segura and Sierra Nevada).	Limited yet nutritious pastures. Small herds without shepherd associationism.	Difficulties to compete due to low productivity. General abandonment.	Sheep: segureña, montesina Goat: blanca andaluza, negra serrana Cattle: pajuna	1
	**Castilian-Leonese**	Winter: Central plateau (Leon, Zamora, Palencia, Burgos, Caceres, Ávila, Salamanca, Soria, Navarre and La Rioja). Summer: Cantabrian Mountains, Central System, Northern Iberian System.	High availability of both mountain pastures and fallows. Ovine specialization.	Enhanced with irrigation expansion. Increasing cattle pressure. Severely depopulated areas.	Sheep: merina, castellana, churra, chamarita Cattle: alistana-sanabresa, parda de montaña Goat: agrupación de las mesetas	1
	Pre-Pyrenees	Winter: Pre-Pyrenean valleys. Summer: Pyrenaic alpine pastures.	Short but intense altitudinal gradient. High livestock, agriculture and forest diversity.	Better preservation than transhumance. Livestock industrialization in the valleys, especially in Catalonia. Rural abandonment and shift to other economic activities (tourism).	Sheep: rasa aragonesa, aranesa, ansotana, churra tensina, xisqueta, tensina Cattle: parda de montaña, roya pirenaica, pirenaica, bruna pirenaica, pallaresa Goat: pirenaica Horse	2
Medium mountain-coast transterminance						
	Canary Islands	Winter: Coastal pastures and farmlands. Summer: Inner volcanic mountains.	Centuries of adapted ecotypes from Africa and Spain. Shepherd's leap as a cultural element.	Conflicts with forest preservation led to grazing restrictions in mountains after 1950. Severe recent decadence.	Sheep: canaria, palmera Goat: majorera, tinerfeña, palmera	1
	Cantabrian range	Winter: Coast and lowlands (Asturias to Guipuzcoa). Summer: Cantabrian Mountains (Montes de León to Urbasa).	High productivity. High livestock diversity: especially cattle and horse. Strong identity groups: Vaqueiros de Alzada and Pasiegos.	High antropization in the coast limits migration from mountains to inner lowlands. Intensification and milk specialization in the valleys in the last decades.	Cattle: tudanca, asturiana de los valles, asturiana de la montaña Sheep: latxa Goat: azpi gorri	1
	**Levantine**	Winter: Mediterranean Eastern coast. Summer: Smaller mountains along the mediterranean coast.	Relevant to catabolizing horticultural residues. Shepherds from the mountains.	Lost link with agriculture. Sedentarization in the coast. Competition for land on the coast. Livestock intensification and industrialization.	Sheep: guirra, ripollesa Goat Cattle: murciano-levantina	1
	**Penibetic**	Winter: Mediterranean Southern coast (Almeria to Malaga). Summer: Southern coastal mountains (highlight Sierra Nevada).	Very variable distances (up to 100km). Traditionally low livestock density due to low productivity.	High anthropization in the coast, lack of grazable area. Specialization in milking goats. Industrialization.	Sheep: merina de Grazalema Goat: murciano-granadina, malagueña, payoya	1

But with adaptability as one of the features of pastoralism, land abandonment has led to a process of extensification (Fernández Nogueira and Corbelle Rico 2017) that has opened up new pastoral or pseudo-pastoral possibilities. This is the case for semi-wilderness, which is becoming increasingly popular along northern mountain ranges and in some Mediterranean areas. This may also explain cattle expansion in the sub-Mediterranean mountains, where shepherding was abandoned, for example in the Cantabrian mountain range, the interior Catalan mountains and the Pyrenees (Lasanta et al. 2017). Other pseudo-pastoral communities are those emerging from entire regions shifting to agricultural land use, leading to crop-based sedentary pseudo-pastoralism, such as the riparian shepherds in the Castilian plains (Cruz Sánchez 2016). Currently, the conventional livestock sector is facing increasing pressures, such as cost of inputs (MAPA 2023) or water scarcity from climate change (Tugjamba et al. 2023). This may increase the exploitation of opportunistic feed sources, resorting to traditional pastoralism or to new adaptive management that evokes traditional strategy (Sharifian et al. 2023; Serrano-Zulueta et al. 2023a).

More than a bucolic heritage: Pastoralism in an urgent moment

Apart from the socio-economic relevance of pastoralism, it has been claimed that the ecological knowledge from traditional practices is key to optimal land management (Oba 2012; Agnoletti 2014; García-Martín et al. 2022; Hartel et al. 2023). Pastoralism often replaces natural ecological dynamics (Gordon et al. 2021; Serrano-Zulueta et al. 2023b; Thompson et al. 2023) and provides similar ecosystem services (Bengtsson et al. 2019). In addition, adaptation and knowledge of pastoralism foster circularity in terms of energy and nutrition (Tugjamba et al. 2023). Other relevant ecological benefits cannot always be measured in economic terms, such as the preservation of biodiversity or landscape diversity (Havstad et al. 2007; Seid, Kuhn and Fikre 2016; Guadilla-Sáez et al. 2020; Morales-Jerrett et al. 2020). Regarding climate change, the impact of livestock is well known and generally accepted, but the role of pastoralism is not clear for several reasons: first, difficulties in telling apart the anthropogenic and natural identity of pastoralism (Manzano, del Prado and Pardo 2023; Pardo et al. 2023); and second, uncertainties about its contribution to the increase in radiative forcing, because of both circularity of the carbon emitted (Chang et al. 2021) and short residence time of the CH_4 emitted (del Prado et al. 2023).

This is why many authors have called for the recognition of grazing as an ecological intervention tool, to the extent that it is defended as a renaturalisation mechanism (Gordon et al. 2021; Lasanta et al. 2021; Pauné 2021; Corson

et al. 2022; Fraanje and Garnett 2022; Pérez-Barberia 2023). This type of consideration is institutionally interesting because it helps to minimise efforts in conservation and restoration areas. For example, pastoralism in Spain contributes to the preservation of predators such as the Iberian lynx (*Lynx pardinus*), saving efforts for conservation (Casas-Nogales and Manzano 2007). The relationship between wild biodiversity and domesticated biodiversity, estimated through the number of local livestock breeds present in the territory, is positive for several groups of fauna (Velado-Alonso et al. 2020b). In the case of fire prevention, the usability and profitability of grazing (Varela-Redondo et al. 2008) is such that in Spain it is becoming common to pay for this function, in regions such as Catalonia, Andalusia, Valencia, Castilla-la Mancha, Madrid and the Canary Islands.

Strengthening relations for the twenty-first century

The main challenge for the twenty-first century seems to be the reversal of the abandonment of pastoral activity. Rural livelihood is often conscious of the risks of abandonment (Quintas-Soriano et al. 2023) but social dynamics are still too determinant, with renewal as the most difficult step in pastoral conservation. Renewal is insufficient, still relying on family tradition (Góngora Pérez et al. 2020) or more recently, on immigration (Nori and López-i-Gelats 2020). The lack of specialised labour is one of the main difficulties for the maintenance of extensive pastoral systems and their mobility (Pauné 2023), and current academic structures have not been able to generate professionals with the necessary systemic knowledge. Thus, strategies to foster pastoral activity must be conscious of the human perspective, which is not frequently done (Facchini et al. 2023; Serrano-Zulueta et al. 2023a). This human dimension is different for each system and community, and covariables that constrain continuation can be varied: hard climatic conditions, competition for land or lack of profitability.

A successful strategy in supporting the social aspect of pastoralism is community-building, not only at the marketing level but also in defending shared interests in pastoral preservation and creating a feeling of identity (Upton 2014). Groups have been very useful in pastoral or livestock preservation, formed around management systems, breeds, products or territories. Yet in the twenty-first century, a new concept of representation is becoming relevant, emerging from new grouping possibilities, in which a territorial link is not necessary. This is the case of regenerative rangeland management (RRM), analogous to traditional daily mobile systems. Other groups may not be linked to specific pastoral management, but rather to social characteristics, such as neorurals (Sansilvestri et al. 2022), women's networks (Ganaderas

en Red) or ecological aims (Nuss-Girona et al. 2022). Outside the producer groups, there are also Spanish networks at the lobbying level (Plataforma por la Ganadería Extensiva y el Pastoralismo; Aliança Pastoral), technical (Fundación Entretantos), academic (Sociedad Española de Pastos) or multidisciplinary (Asociación Trashumancia y Naturaleza).

We encourage strengthening institutional relations with the sector by understanding shepherds as active agents with specific needs in declining ecosystems (Serrano-Zulueta et al. 2023a) and by increasing public-private partnership governance (Zabalza et al. 2021; Pauné and Alba 2022). This implies paying attention to both traditional realities, such as mobility infrastructures (Ortiz Borrego 2004; Herrera, Davies and Manzano Baena 2014) or social behaviour (Fernandez-Gimenez and Le Febre 2006; Góngora Pérez et al. 2020); and emerging situations, such as climate change (Herrero et al. 2016; Tugjamba et al. 2023) or coexistence with predators (Franchini et al. 2021; Pettersson et al. 2021). An example of this approach is the strategy for extensive livestock proposed by Zabalza et al. (2021). Pastoral characterisations provide valuable information on these strategies according to biophysical opportunities and social well-being. Considering traditional systems and communities in agricultural and climatic policies will thus be relevant for the preservation of the rural socioeconomies (Fernandez-Gimenez and Le Febre 2006; Dong et al. 2011; Manzano et al. 2021) and climate action (Herrero et al. 2016).

5. Conclusions

The historical dimensions of pastoralism in Spain show great relevance and social value, but multiple causes threaten its collapse. In this context, collecting traditional knowledge and searching for strategies to promote pastoral recovery are urgent priorities. An important step is the characterisation of the different pastoral systems, but also of pastoral communities in which cultural identification is a central axis. Our study proves an expert participatory process collecting literature to be an effective way to achieve such a task in the context of Spain.

The drivers that have historically shaped pastoralism in Spain are diverse, variable and interdependent. They include the persistence of biophysical parameters, the constant evolution of technology, profound shifts in governance systems and fluctuations in social behaviours. On this basis, we have constructed a classification of pastoral systems and associated traditional communities at the national level. Using mobility as a primary characteristic, we distinguish between large migratory systems, short-distance transterminance, daily mobile grazing and semi-wilderness. Classified in these mobility

categories, we describe eleven pastoral systems. Among large migratory systems, we describe ten different pastoral communities.

The survival of pastoralism gets complicated with past trends and future uncertainties. Most of these pastoral systems and communities, as well as livestock breeds, have already collapsed or are at risk of collapse. The most affected systems are those of large migratory systems and those economically unproductive, such as browsing or polyculture. However, pastoralism is of great interest in the twenty-first century, linked to food security, environment (in terms of circularity, adaptation or conservation) and social welfare. Efforts for pastoral preservation (especially renewal) must be very conscious of rural realities where social constraints are still fundamental, though little studied. The proposed classification is valuable for designing these strategies by grouping pastoral systems and communities with similar contexts and backgrounds. This knowledge is useful for strategies enhancing mobility, improving infrastructures or managing land use. Finally, the detailed contextual description of Spanish pastoralism can help to fill gaps in global pastoral knowledge.

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In memory of Suso Garzón

This is the last academic contribution of Suso Garzón, who sadly passed away last Christmas Eve. He was a key figure not only for Spanish pastoralism, but for understanding and advocating for the importance of pastoralist mobility worldwide. A nature conservationist who started working with Spain's renowned nature documentarist Félix Rodríguez de la Fuente, Suso quickly understood the importance of mobile herbivores for maintaining crucial ecosystem processes, and how mobile pastoralism has preserved them in a world increasingly devoid of wild herbivores. His pioneering vision marks a milestone in establishing an alliance between conservationists and pastoralism advocates. His vision for effective advocacy included collaboration with some Spanish regional administrations (for example, declaring Natural Parks in Extremadura and Cantabria) or the recovery of use of many Spanish drove roads, but also mentoring countless academics and showcasing Spanish millenary transhumance through an annual crossing through Madrid's city centre. This image reached all continents, giving a voice and media attention to pastoralism worldwide, and triggered the formulation of Spain's national Act 3/1995 that protected the country's pastoralist corridors. Suso was a friend and a reference for many of us, and he will be greatly missed. May our gratitude accompany you in your final transhumance.

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