SMARTER

SMAll RuminanTs breeding for Efficiency and Resilience

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Farmers and breeders' practices and preferences for breeding and genetics.

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About the H2020 SMARTER research project

SMARTER has developed and deployed innovative strategies to improve Resilience and Efficiency (R&E) related traits in sheep and goats.

SMARTER has found these strategies by: i) generating and validating novel R&E related traits at a phenotypic and genetic level ii) improving and developing new genome-based solutions and tools relevant for the data structure and size of small ruminant populations, iii) establishing new breeding and selection strategies for various breeds and environments that consider R&E traits. SMARTER with help from stakeholders chose several key R&E traits including feed efficiency, health (resistance to disease, survival) and welfare. Experimental populations have been used to identify and dissect new predictors of these R&E traits and the trade-off between animal ability to overcome external challenges. SMARTER has estimated the underlying genetic and genomic variability governing these R&E related traits. This variability has been related to performance in different environments including genotype-by-environment interactions (conventional, agro-ecological and organic systems) in commercial populations. The outcome is accurating genomic predictions for R&E traits in different environments across different breeds and populations.

SMARTER has also created a new cooperative European and international initiative that will use genomic selection across countries. This initiative has made selection for R&E traits faster and more efficient. SMARTER will also characterize the phenotype and genome of traditional and underutilized breeds. Finally, SMARTER propose new breeding strategies that utilise R&E traits and trade-offs and balance economic, social and environmental challenges. The overall impact of the multi-actor SMARTER project will be ready-to-use effective and efficient tools to make small ruminant production resilient through improved profitability and efficiency.

SMARTER assembles 27 partners from 13 different countries and has received a funding from the European Commission (through the H2020-SFS-15-2016-2017)) for a project period of 4 years (2018-2022).

Implications

Farmers' expectations concerning new selection traits to improve the sustainability of their farms are very different according to region and breeding system. The main differences observed between breeders and farmers, whether dairy, meat or wool production, indicate that breeding advice needs to further develop farmers' knowledge of the genetic tools available to them. New breeding programs will also need to take into account the diversity of production types and breeders' expectations, to enable them to use genetics as a means of adaption to global change.

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Summary

Small ruminant farming is of socio-economic and environmental importance to many rural communities around the world. SMARTER H2020 project aims to redefine genetic selection criteria to increase the sustainability of the sector. The objective of this study was to analyse the genetic management practices of small ruminant farmers and breeders linked with socio-technical elements that shape them. It is based on-farm surveys using semi-structured interview guide and conducted in five countries (France, Spain, Italy, Greece, and Uruguay) among 272 farmers and breeders of 13 sheep and goat breeds, and 15 breed × systems. The information was collected in three sections. The first section dealt with general elements of structure and management of the system and the flock. The second section focused on genetic management practices: criteria for culling and replacement of females, selection criteria for males, use of estimated breeding values (EBV's) and synthetic indexes, and preferences for indexing new traits to increase the resilience of their system. The third section aimed to collect socio-technical information. We used a data abstraction method to standardize the representation of these data. A mixed data factor analysis (MDFA) followed by a hierarchical ascending classification allowed the characterization of three profiles of genetic management: (1) a profile of farmers (n=93) of small flocks/herds, with little knowledge or use of genetic selection tools (index, artificial insemination (AI), performance recording); these farmers do not feel that new traits are needed to improve the sustainability of their system. (2) A profile of farmers (n=34) of multi-breed flocks/herds that rely significantly on grazing; they are familiar with genetic tools, they currently use AI and would like the indexes to include more traits related to health or robustness to make their system more resilient. (3) A profile of farmer-breeders (n=145) of large flocks/herds, with demanding culling practices; these breeders are satisfied with the current indexes to ensure the resilience of their system. These results are elements that can be used by selection organizations and companies to support their reflection on the evolution of selection objectives to increase the resilience of small ruminant breeding systems.

The study described below in the form of a manuscript will be submitted for publication to the journal 'Animal'.

Data is available here and will be made open access when the manuscript is published:

https://zenodo.org/record/8279981

1. Introduction

Small ruminants are reared in a wide diversity of environments. Sheep and goat farmers are mostly located in less favoured areas with harsh, arid and humid environmental conditions, such as mountains, hills and rangelands. Small ruminants are better adapted to such conditions than cattle (Ernst and Young France, 2008). Moreover, in many of these areas, small ruminants are the only source

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of livelihood. In addition, these areas are characterised by low-quality forage resources, poor access to alternative good quality feed and/or by a more important impact of climatic constraint and global warming. Small ruminants are able to use such rangelands and contribute to maintaining biodiversity, providing meat, wool, and milk, sustaining livehood, food security and heritage and preventing fire damage in dry areas among other ecosystem services.

In the Mediterranean region, for example, small ruminants make the most of heterogeneous plant resources of variable availability included non-mechanizable or poor land, with difficult relief conditions. ((De Rancourt et al., 2006); (Gabiña D., 2011)). They are also adapted to cope with drought and high temperatures ((Petit & Boujenane, 2018); (Aboul-Naga et al., 2014)). Among small ruminant populations, local breeds are considered a genetic resource particularly well adapted to these difficult biophysical environments ((Hoffmann, 2013; Hubert B., 2011; Lauvie et al., 2015)), which helps maintain low-input production systems.

To maintain these benefits in environmentally and economically vulnerable areas, small ruminant farms must preserve their sustainability. One way of keeping the farms' sustainability means to increase their adaptive capacity. This adaptive capacity is based on farmers' dedication to their systems' transition and local resources' mobilisation ((Darnhofer et al., 2010)). This is the case of agroecological transition, in which system sustainability is based on the diversity of resources used in a given area ((Thenard et al., 2021)). To develop more agroecological livestock systems (Dumont et al., 2012) many studies have investigated how the development of forage autonomy in livestock farming enhances the sustainability of farms (Lebacq et al., 2015; M. A. , Magne et al., 2019; Ripoll-Bosch et al., 2013; Thenard et al., 2016).

Moreover, genetics also seem to be able to improve the adaptability or resilience of livestock farming systems, and genetic resources are one lever usable by farmers (Thénard & Sturaro, 2022). In dairy production for example, selection indices have been evolving throughout the world, in order to propose more balanced selection objectives aimed at improving production, milk fat and protein quantity and also longevity, udder health, conformation, and reproduction ((Miglior et al., 2005)).

Faced with the multiple challenges of sustainability, farmers have also used other technical means of rearing to adapt, relying on the genetic characteristics of certain breeds such as dual-purpose, local or hardy breeds, and crossbreeding ((M. A. Magne et al., 2016; Quénon & Magne, 2021)). While the role of hardy breeds in helping livestock adapt to difficult environments is well known ((Hoffmann, 2013; Hubert B., 2011; Lauvie et al., 2015)), more recently the development of new selection traits to be integrated into genetic programmes is a promising way to address the growing environmental, economic and social challenges facing livestock production systems (Olesen et al., 2000; Tixier-Boichard et al., 2015; Phocas et al., 2016). For instance, to cope with harsh environments and limit the workload on Mediterranean farms, the diversification of selection objectives for small ruminant populations is incorporating also functional traits (Dwyer & Lawrence, 2005; Marie-Etancelin et al., 2001; Phocas et al., 2014).

In this context, the European SMARTER (SMAll RuminanTs breeding for Efficieny and Resilience) project is seeking to find new selection traits to increase the resilience and efficiency (R&E) of the sheep and goat sectors at different levels: the animal, the breed population and the livestock farming system ((Moreno-Romieux et al., 2020)). New breeding and management strategies could be analysed with different approaches. At farm level, Theodoridis et al. (2023) designed a mathematical programming model to assess the economic impact of new R&E traits used in different farming profiles. Another

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approach proposed in this project was to understand and analyse how farmers integrate or fail to integrate new R&E traits into their breeding practices' management.

Selection practices' management has been little analysed, and mostly in relation to dairy ewes breeding (Labatut (Perucho et al., 2020; Perucho, Hadjigeorgiou, et al., 2019; Perucho, Ligda, et al., 2019)). These studies have been focused on evaluating farmers' practices regarding collective genetic improvement tools, and the choice of selection for their future breeding animals. The ambition of the SMARTER project, at farm level, is to establish new breeding and management strategies including new R&E related traits in accordance with their importance and relevance to various systems, breeds and environments. The aim of this article is to analyse small ruminant farmers' genetic management practices, including socio-technical elements defining farmers' choices.

2. Material and methods

The consortium of the SMARTER project included 27 partners from 13 European countries with 14 Academic & research organisations and 13 non-academic organisations. SMARTER project focused on several animal populations, including different breeds and types of production in diverse environments. The analysis of a variety of situations is intended to reinforce this project's results. It is within this general framework that research work of Work Package 7 (WP7) has been carried out, with the overall aim of producing balanced breeding objectives for agro-ecological resilience.

The identification of these balanced selection objectives is assessed through three tasks based on three approaches: i) the evaluation of the economic, environmental and social value of new selection traits (Theodoridis et al., 2023); ii) the estimation of the non-economic value of selection traits through breeders' choices modeling (Sautier et al., *to published*), and iii) the understanding of the selection traits that breeders would like to see integrated into the selection scheme. In, WP7 partners from 5 countries were involved (France, Greece, Italy, Spain and Uruguay).

In this paper, we focus on the third point and our work's target is the analysis of farmers and breeders' practices in relation to local and farm features. This work is based on face-to-face interviews with farmers during the years 2021-2022. After partners in each country defined the relevant breed to study and were responsible for collecting data from the farmers they identified. The general methodological approach is detailed in Figure 1.

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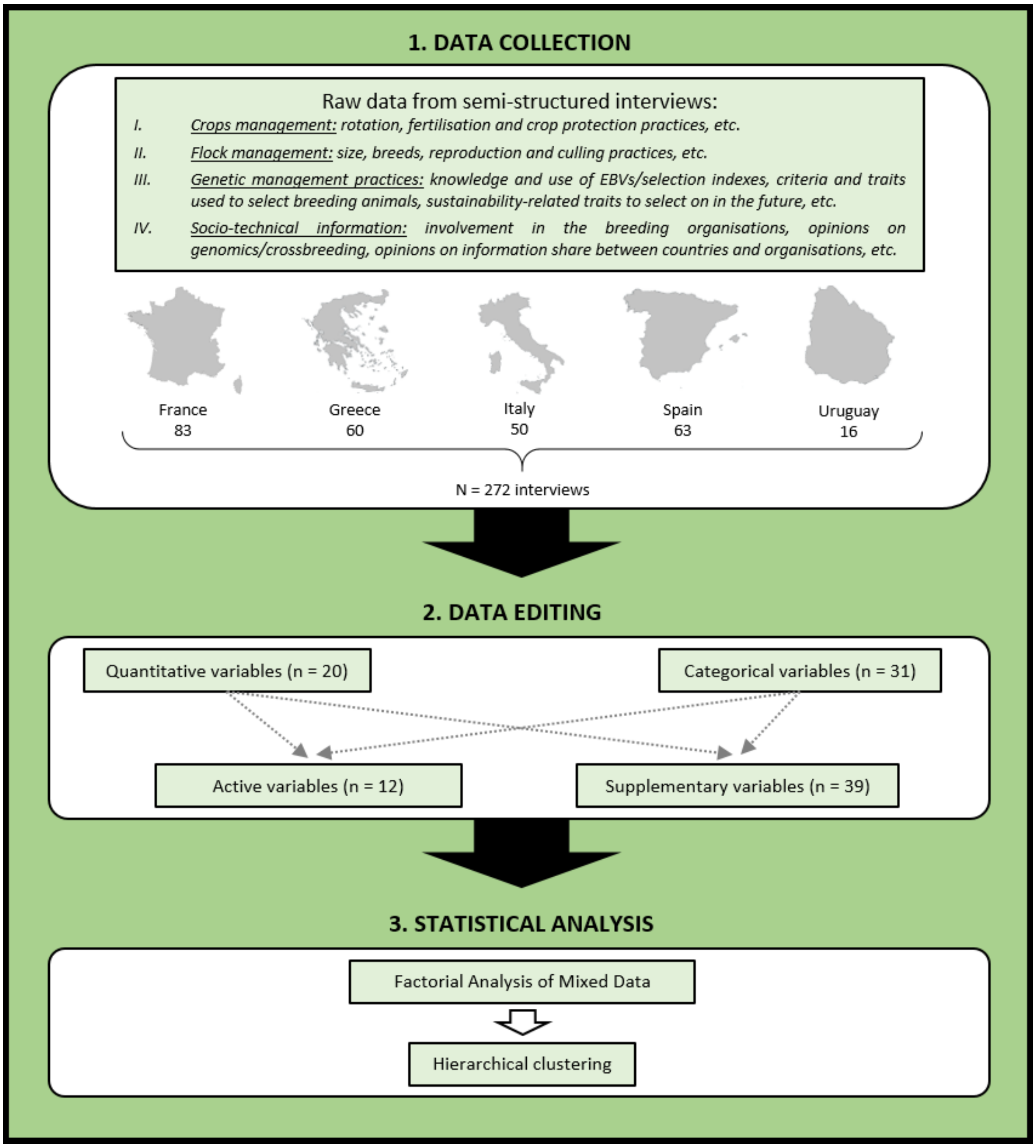

Figure 1 Methodological approach

2.1. Sampling design

Sampling design aims at covering diverse breeding situations across and within task-partners' countries (France, Greece, Italy, Spain and Uruguay). Therefore, task-partners defined combinations of farming systems and small ruminant breeds that were relevant to investigate for each country (Table 1). Finally, 15 combinations (system × breed) were defined and approximately 20 interviews with farmers were conducted as defined at the beginning of the project. In each country and for each breed, we co-constructed an initial sample with experts (agricultural advisers and technicians, geneticists) from private breed companies and associations, as well as from public organisations. For each system × breed, we aimed at covering diverse breeding situations, regarding:

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-The features of geographical area (e.g. lowland / Pre-Pyrénées / mountain for systems breeding Manech tête rousse). The characteristics of the geographical area (e.g. for Manech tete Rousse cattle, we have distinguished between plain / piedmont / mountain areas).

- The breeder's role within the organization (for example, for the Causses du Lot breed, we have distinguished between purebred ewe and ram breeders / purebred ewe breeders / producers of crossbred ewes - F1 Causses du Lot × Île de France).

-The enrolment in ICAR protocol.

-Some specific breeding practices such as lambing period, prolificity, stocking rate, conventional or organic farming, transhumant or non-transhumant systems.

-Products destination: industry, on-farm processing

Table 1 Description of the combinations of farming systems and breeds that were investigated.

Country	Description of the combination System × Breed	Specie/Sector	Intensiveness level of the management of the farming system	Breed	Productivity level of the breed
France	Intensive and extensive dairy sheep milk in Roquefort area	Dairy sheep	++	Lacaune	++
	Semi-extensive system milk sheep for cheese in Pyrénées area		-/+	Manech Tête Rousse	+
	Extensive system of lamb production	Meat sheep	-/+	Causses du Lot	-
	Livestock& Mixed livestock-crops system with semi-extensive husbandry		-/+	Romane	+
Greece	Semi intensive system with dairy sheep	Dairy sheep	-/+	Assaf	++
			-/+	Chios	-+
			-/+	Frizarta	-+
			-/+	Lacaune	++
	Transhumance system with dual-purpose sheep (milk & meat)	Milk - meat sheep	-	Boutsko	-
	Very extensive system with dairy goats	Dairy goats	-	Skopelos	-+
Italy	Semi-intensive system in Alps mountain with dairy goat	Dairy goat	-/+	Alpine	+
				Saanen	+
Spain	Intensive system of dairy sheep	Dairy sheep	++	Assaf	+
Uruguay	Extensive system beef cattle & sheep production (wool/lamb) grazing native pastures	Wool-meat sheep	-	Corriedale	-
				Merino	-

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Interview design and process

A semi-structured interview guide was developed that was organised in four main sections (Supplementary Table S1).

The first and second section dealt with general elements of structure and farm management regarding crops (agricultural area, crop rotation, use of fertilisation and pesticides) and livestock (species, breeds, replacement and culling practices including rate and criteria, reproduction management including use of artificial insemination and/or natural mating, etc.), respectively.

The third section focused on specific genetic management practices. Farmers were asked to rate their level of agreement on a 7-point scale (from 1 = "Strongly disagree" to 7 = "Strongly agree", with 4 = "Neither agree nor disagree") with a series of statements that aimed to assess their knowledge on, use of and views on estimated breeding values (EBVs) and selection indexes (see example Figure 2). We also asked farmers to rate out of 10 a series of general criteria they used to select breeding animals (e.g. EBVs, health status, pedigree, purchase price, farming system) and a series of specific breeding traits they pay attention to, for which EBVs are available (milk quantity, protein and fat contents, wool traits, litter size, birth and 8-week weight, etc.). If relevant to them, they were then asked to specify any criteria or breeding traits that they use, which had not been mentioned. Farmers were also asked for their preferences regarding breeding traits, for which no EBVs were available, but were nevertheless important to them in order to improve the sustainability of their farming system.

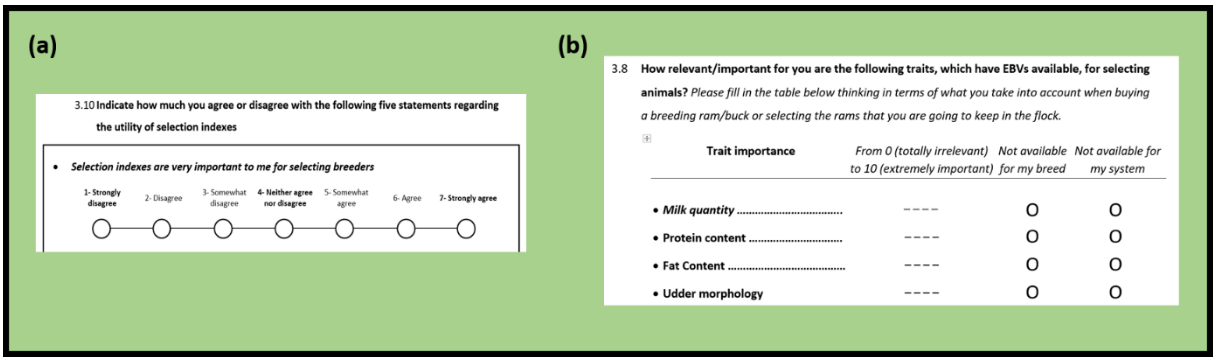

Figure 2 Examples of questions modes used in the interview guide: (a) level of agreement on a 7-point scale and (b) assignment of score out of 10

The fourth section aimed to collect socio-technical information on the farmer's status and involvement in the breeding organisations (farmer using genetic progress or breeder), the tools they used and the preferred channels for obtaining information on developments and news on genetics, the most important issues lessening genetic gain or increasing adoption of breeding practices in the industry according to them. We also asked farmers to rate their level of agreement with a series of statements regarding the demands for performance recording, the benefits and disadvantages of genomics and DNA technology, as well as crossbreeding. Finally, farmers were asked to assess their own level of agreement regarding the sharing of information between countries and organisations on pedigree, phenotypes (i.e. performances) and genotypes (i.e. genetic evaluations), and to express how they feel this sharing would be beneficial or not.

The final number of interviews that were conducted per country and breed is detailed in Table 2. A total of 272 on-farm interviews in five countries (France, Greece, Italy, Spain and Uruguay), of both farmers and breeders of 13 sheep and goat breeds were conducted.

Table 2 Number of conducted interviews per country and breed

Country	Specie/Sector	Breed	No. of interviews	Total
France	Dairy sheep	Lacaune	22	83
		Manech tête rousse	21	
	Meat sheep	Causses du Lot	21	
		Romane	19	
Greece	Dairy sheep	Assaf	6	60
		Chios	11	
		Frizarta	13	
		Lacaune	21	
	Milk-meat sheep	Boutsko	5	
	Dairy goats	Skopelos	4	
Italy	Dairy goat	Alpine	35	50
		Saanen	15	
Spain	Dairy sheep	Assaf	63	63
Uruguay	Meat-wool sheep	Corriedale	9	16
		Merino	7	
Total				**272**

2.2. Data editing

In order to standardise the collection of information from the 5-countries surveys and to facilitate their compilation, task members agreed to develop and use a common semi-computerised file template. Raw data in each corresponding section of the interview guide were gathered. While some questions in the interview guide resulted in standardised (e.g. closed-ended questions) and quantitative data, others provided by design a wide range of responses, resulting from the expression of the singularity of interviewed farmers. Therefore, a data abstraction method from knowledge engineering (Girard et al., 2008) was used that consisted in building categorical variables broken down into classes to characterise the diversity in farmers' practices regarding genetic management. A total of 12 active variables (Vi.j, i = 1–10, j = 1–5 for categorical variables), both categorical (n = 10) and quantitative (n = 2) that best reflected such diversity among the sampled farmers were selected (Figure 3).

Three variables aimed to describe general practices of flock configuration: (i) the replacement rate (V1, Replacement, in %), (ii) the percentage of animals artificially inseminated in the first attempt on the females of the flock (V2, PercOfAI, in %), and (iii) the use of artificial insemination (V3, UseOfAI). Two variables described culling practices: (i) the number (V4, NbCullCrit) and (ii) the type of culling criteria used (V5, CullCrit). Two variables described the current selection practices of farmers: (i) the type of criteria they used to select animals such as genetic (e.g. EBV values), phenotypic (e.g. actual milk performances) or socio-economic (e.g. purchase price, relationship with the seller) considerations (V6, CritForSelec) and (ii) the number of traits based on which farmers select breeding animals (V7, NbSelTraits). Three variables aimed to describe farmers' views on sustainability of their system, characterising the desirable future direction of breeding objectives: (i) the number of traits to select

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on to increase sustainability of their system (V8, NbTraitsForSust), (ii) the type of traits viewed as relevant to achieve it (V9, TraitsForSust), and (iii) farmers' views on changes to be made to the selection indexes (V10, ChangeIndex). Finally, two variables described the level of integration of the farmer in the socio-technical environment of the genetic improvement system: (i) the status of breeder/farmer (V11, BreederStatus) and (ii) the enrolment in a performance-recording organisation (V12, PerfControl).

Furthermore, a set of supplementary variables (SVi.j, i = 1–29, j = 1–13 for categorical variables) that described general characteristics of the farm or farmers' practices that were not directly related to the characterisation of genetic management was also considered (Supplementary Table S2). Supplementary variables were nevertheless relevant to illustrate the groups identified in further analyses: country, total agricultural area, crop rotation with relative percentages of each crop type, total livestock units (LSU), stocking rate, etc.

The dataset (available here) was composed of n = 272 individuals described by 51 variables, among which 31 were categorical ones and 20 were quantitative ones.

2.3. Data analysis

The objective was to characterise and analyse the diversity of strategies implemented by small ruminants' farmers regarding flock genetic management and improvement of farm sustainability. As developed by (Pagès, 2004) to analyse the pattern of relationships of individuals described by both categorical and quantitative variables, we performed Factorial Analysis of Mixed Data (FAMD) of a subset of the dataset (272 farms × 12 active variables, among which 10 were categorical ones and 2 quantitative ones).

Then, Hierarchical Clustering on Principle Components (HCPC) was performed, which used results of the FAMD to discriminate and characterise groups of farmers with different strategies of genetic management and improvement of farm sustainability. All statistical analyses were performed using RStudio software (version 4.0.4, RStudio Inc., Boston, MA, USA), with FactoMineR (Lê et al., 2008) and factoextra ((Kassambara & Mundt, 2017)) packages.

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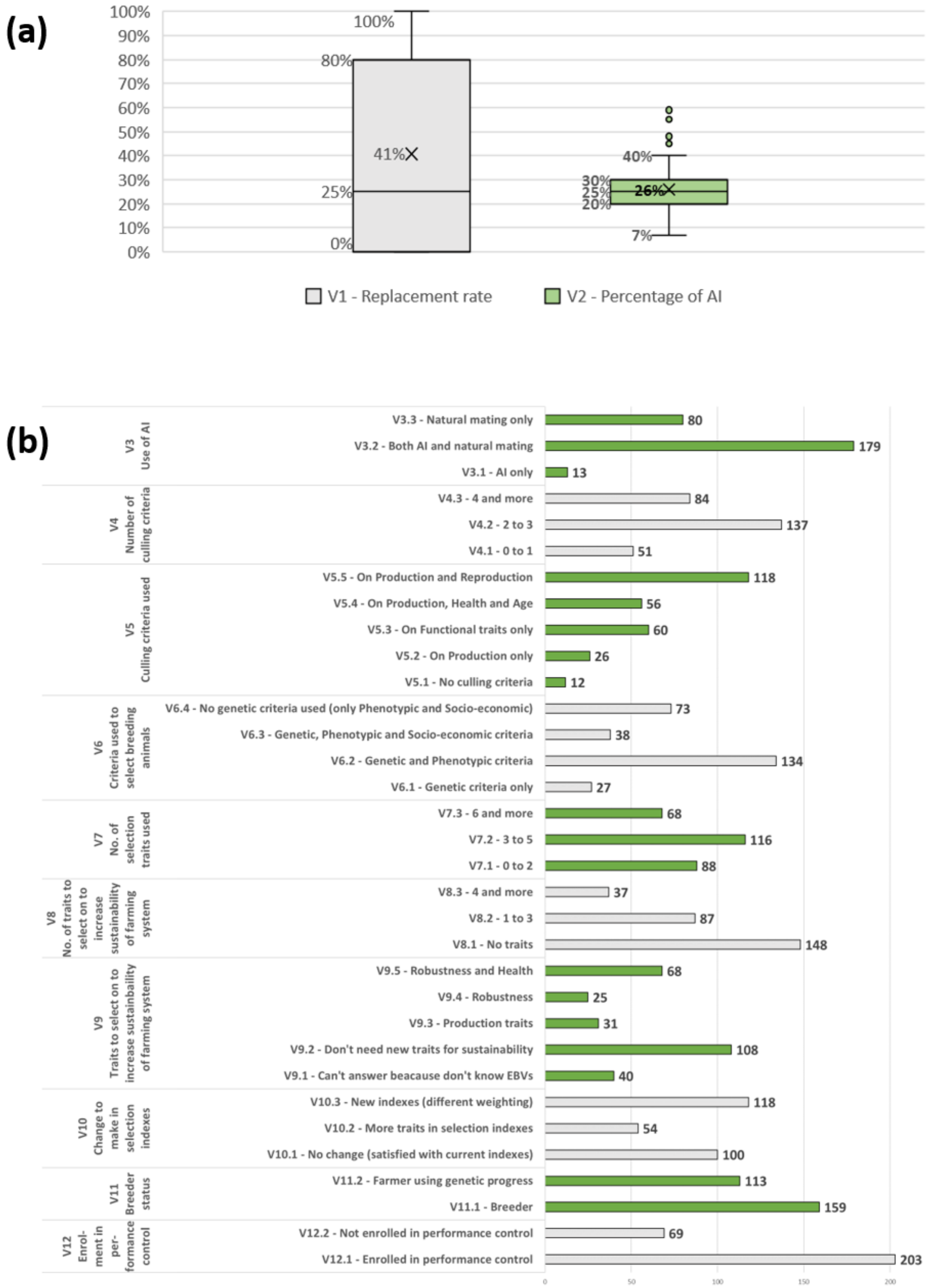

Figure 3 Active variables used to characterise types of genetic management of sampled farmers: (a) boxplots for the two quantitative variables (V1 and V2), cross indicates mean value; (b) classes of the ten categorical variables (Vi.j, i = 3–10 and j = 1–5)

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3. Results

3.1. Breeders and farmers 'integration in the sociotechnical system and their views on sustainability

The two first axes of the MCA explained 15.7% and 11.2% of the total inertia, respectively (Figure 4). We considered these as guidelines structuring genetic management 's strategies by small ruminants' farmers and views on genetics and its development.

Axis 1 was determined mainly by the integration level of small ruminants' farmers in the sociotechnical breed selection system and performance recording. On the right side of axis 1 (Table 3), were the strategies of breeder farmers (V4.1) enrolled in performance recording organisations (V5.1) that consisted in a significantly higher use of artificial insemination (V2, V3.1, V3.2), relatively stricter flock configuration management, with higher replacement rate (V1), culling and selection of breeding animals on numerous criteria (V6.3 and V9.3, respectively). Selection strategies could include several criteria, but were always genetic-based (V8.2, V8.3) and production-driven (V7.3), including traits of interest to increase their farming system's sustainability (V10.3) such as milking speed and lifetime production. Such strategies were associated to an interest in genomics and its development (SV25.2), no-use of crossbreeding (SV23.1), and an unclear opinion on information sharing (SV27.3) with some fears but also expectations of benefits for breeding programmes, breed recognition and import/export of breeding animals (SV28.4). Conversely, on the left side of axis 1 (Table 3), were the farmers' strategies with little knowledge of genetic selection (V10.1). These farmers were not enrolled in performance recording organisations (V5.2), unknow their (or unfamiliar with) genetic progress (V4.2) and based their selection practices on non-genetic criteria (V8.4). Such strategies consisted in natural mating with no use of artificial insemination (V3.3) and relatively less strict management of flock configuration (V1, V2, V6.2), but with a focus on functional traits (V7.4). Increasing their system's sustainability were considering as requiring many new traits to select on (V11.3), none of them being related to production but to robustness and health (V10.5). Such views on strategies to increase sustainability were associated with a lack of interest in genomics, whose development was considered as of low priority (SV25.1). Moreover, these farmers were less reluctant to use crossbreeding (SV23.2) and to share information between countries and breeding organisations (SV27.1).

Axis 2 was determined mainly by small ruminants farmers' views on farm sustainability and the strategies, they intended to adopt to make it more efficient. On the top side of axis 2 (Table 4), there were farmers who did not believe genetics could contribute towards increasing their farm's sustainability, or who did not view sustainability as a relevant objective. They did not consider any traits to select on that could increase sustainability (V11.1), nor felt the need to (V10.2), as they were satisfied with the current indexes (V12.3) or considered themselves not qualified enough to express their opinion (V10.1). Many farmers managed culling with few criteria (V6.1, V7.5) and mostly production-driven (V7.1). Conversely, on the bottom side of axis 2 (Table 4), there were farmers with expectations of the possibilities offered by genetic selection tools to increase their farming system's sustainability. They were mostly not satisfied with the current indexes, in which they wanted to add numerous new traits (V11.2, V11.3, V12.1), especially some related to functional performances of animals: thus, they viewed that their system's sustainability through more robustness and animal condition improvement, as health (V10.4, V10.5).

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Table 3 Classes of the active (Vi.j, green rows) and supplementary variables (SVi.j) that are significantly represented on the first axis retained from the factorial analysis of mixed data performed to describe genetic management of small ruminants farmers. For quantitative variables (in italic), there are no v.test values.

Axis and side	Selected classes	Coord.	Cos²	v.test
Axis 1 Left side	*V2 – Percentage of AI for first mating*	*-0.774*	*0.599*	/
	V1 – Replacement	*-0.319*	*0.102*	/
	SV16 – Total livestock units	*0.238*	*0.056*	/
	SV14 – Percentage of areas on which pesticides are used	*0.197*	*0.039*	/
	SV21 – Stocking rate	*0.137*	*0.019*	/
	V4.1 – Breeder	-1.357	0.888	-13.086
	V5.1 – Enrolled in performance recording organisations	-0.872	0.871	-12.164
	V3.2 – Use both AI and natural mating	-1.034	0.805	-11.660
	SV1.4 – Spain	2.158	0.796	9.841
	V10.2 – No need new traits for sustainability	1.344	0.508	9.058
	SV26.1 – Don't buy males	1.122	0.925	7.734
	V8.2 – Selection on genetic and phenotypic criteria	0.828	0.407	6.775
	V6.3 – Culling on 4 criteria and more	1.176	0.351	6.528
	V7.3 – Culling on production and reproduction	0.862	0.316	6.265
	SV24.5 – Zootechnical problems only	0.958	0.799	5.640
	V9.3 – Selection on 6 traits and more	1.130	0.266	5.416
	SV27.3 – No clear-cut opinion on information sharing	1.152	0.651	5.145
	SV25.2 – Want to be part of its development	0.287	0.679	4.536
	SV23.1 – Don't use crossbreeding	0.102	0.675	4.110
	SV28.4 – Benefits for breed program, recognition and economic benefits	1.029	0.810	3.650
	SV15.1 – Conventional farming	0.122	0.589	3.609
	SV1.5 – Uruguay	1.361	0.610	2.826
	SV2.4 – Wool meat sheep	1.386	0.539	2.782
	V10.3 – Production traits for sustainability	0.908	0.076	2.704
	V8.3 – Selection on genetic, phenotypic and socio-economic criteria	0.773	0.070	2.587
	V3.1 – AI only	1.337	0.070	2.488
	V11.1 – 0 traits for sustainability	0.247	0.031	2.245
	SV29.8 – Various expectations	0.568	0.471	2.101
	SV2.2 – Dairy sheep	0.196	0.079	1.974
Axis 1 Right side	*SV12 – Percentage of meadows/grassland in UAA*	*-0.355*	*0.126*	/
	SV22 – No. of breeds in the flock	*-0.254*	*0.064*	/
	V3.3 – Natural mating only	-2.460	0.885	-13.187
	V4.2 – Farmer	-1.836	0.852	-12.852
	V5.2 – Not enrolled in performance recording organisations	-2.511	0.853	-12.155
	V8.4 – Selection on phenotypic and socio-economic criteria	-1.932	0.686	-9.720
	V10.1 – Don't know EBVs meaning	-2.646	0.534	-9.123
	SV26.2 – Don't know EBVs meaning	-2.436	0.568	-8.399
	SV1.2 – Greece	-1.686	0.411	-7.448
	V7.4 – Culling on functional traits only	-1.408	0.369	-6.219
	V6.2 – Culling on 2-3 criteria	-0.599	0.220	-5.008
	V10.5 – Robustness and health for sustainability	-1.035	0.188	-4.963
	SV2.3 – Meat sheep	-1.387	0.352	-4.853
	SV1.1 – France	-0.874	0.270	-4.809
	SV25.1 – Genomics is not a priority	-1.038	0.679	-4.536
	SV24.7 – Various problems	-1.527	0.580	-4.380
	SV27.1 – Agree with information sharing	-0.352	0.531	-4.371
	SV23.2 – Use crossbreeding	-2.411	0.675	-4.110
	SV15.2 – Organic farming	-1.542	0.589	-3.609
	V9.1 – Selection on 0-2 traits	-0.577	0.108	-3.314
	SV26.3 – EBVs are not relevant or not provided	-1.261	0.595	-3.108
	SV3.2 – Meat sheep	-0.644	0.196	-2.724
	V11.3 – 4 traits and more for sustainability	-0.788	0.065	-2.598
	SV29.6 – Increase import-export	-0.696	0.298	-2.329
	SV28.7 – Economic benefits	-0.624	0.327	-2.119
	SV26.5 – Trust judgment fo the seller	-1.084	0.191	-2.097
	SV29.1 – Don't know/not interested	-1.758	0.515	-1.998

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Table 4 Classes of the active (Vi.j, green rows) and supplementary variables (SVi.j, italic) that are significantly represented on the second axis retained from the factorial analysis of mixed data performed to describe genetic management of small ruminants farmers. For quantitative variables (in italic), there are no v.test values.

Axis and side	Selected classes	Coord.	Cos²	v.test
Axis 2 Top	V11.1 – 0 traits for sustainability	1.263	0.797	13.553
	SV1.2 – Greece	1.894	0.519	9.900
	V6.1 – Culling on 0-1 criteria	1.840	0.403	8.683
	V10.2 – No need new traits for sustainability	1.046	0.308	8.339
	V7.1 – Culling on production only	2.456	0.386	7.844
	V10.1 – Don't know EBVs meaning	1.868	0.266	7.619
	SV26.2 – Don't know EBVs meaning	1.668	0.266	6.804
	V12.3 – No change of indexes	0.836	0.276	6.263
	SV2.2 – Dairy sheep	0.525	0.566	6.257
	V8.3 – Selection on genetic. phenotypic and socio-economic criteria	1.371	0.221	5.427
	V4.2 – Farmer	0.541	0.074	4.480
	V7.5 – No culling criteria	2.121	0.160	4.476
	SV13.3 – No fertilisation	0.938	0.647	4.158
	V9.3 – Selection on 6 traits and more	0.705	0.104	4.002
	V3.1 – AI only	1.761	0.122	3.876
	V5.2 – Not enrolled	0.621	0.052	3.559
	SV19.1 – No other species	0.205	0.595	3.486
	SV13.2 – Mineral fertilisation only	1.255	0.278	2.978
	V3.3 – Natural mating only	0.440	0.028	2.789
	SV29.3 – Increase breed population and import-export	0.819	0.258	2.503
	SV29.6 – Increase import-export	0.609	0.228	2.410
	SV25.2 – Want to be part of genomics development	0.126	0.131	2.361
	SV24.1 – No specific problems	0.575	0.163	2.309
	SV28.5 – Benefits for breed recognition and economic benefits	0.689	0.202	2.104
	V8.4 – Selection on phenotypic and socio-economic criteria	0.342	0.021	2.034
Axis 2 Bottom	*SV12 – Percentage of meadows/grassland in UAA*	*-0.197*	*0.039*	/
	SV22 – Other land area (moorland, woodland, heathland)	*-0.182*	*0.033*	/
	V11.2 – 1-3 traits for sustainability	-1.438	0.542	-9.687
	V10.5 – Robustness and health for sustainability	-1.667	0.488	-9.455
	SV1.1 – France	-1.224	0.531	-7.968
	V11.3 – 4 traits and more for sustainability	-1.670	0.294	-6.510
	V6.2 – Culling on 2-3 criteria	-0.623	0.239	-6.170
	SV3.2 – Meat sheep	-1.390	0.353	-5.755
	V12.1 – Adding new traits in current indexes	-1.098	0.238	-5.369
	V7.2 – Culling on production. health and age	-0.943	0.181	-4.715
	V9.1 – Selection on 0-2 traits	-0.691	0.155	-4.693
	V7.1 – Culling on production only	-1.313	0.159	-4.625
	V4.1 – Breeder	-0.384	0.074	-4.480
	V3.2 – Both AI and natural mating	-0.324	0.081	-4.422
	V10.4 – Robustness for sustainability	-1.346	0.155	-4.206
	V8.1 – Selection on genetic criteria	-1.263	0.142	-4.119
	SV1.3 – Italy	-0.838	0.261	-3.906
	V7.4 – Culling on functional traits only	-0.701	0.092	-3.666
	SV26.5 – Trust judgment of the seller	-1.590	0.411	-3.638
	V5.1 – Enrolled	-0.211	0.052	-3.559
	SV19.2 – Presence of other species	-0.615	0.595	-3.486
	SV20.1 – Both selling to industry and transformation at the farm	-1.285	0.574	-3.461
	SV2.1 – Dairy goat	-0.685	0.215	-3.350
	SV13.1 – Both mineral and organic fertilisation	-0.358	0.428	-3.317
	SV28.6 – Don't know what is to expect from international evaluation	-0.873	0.527	-3.132
	V8.2 – Selection on genetic and phenotypic criteria	-0.321	0.061	-3.103
	SV24.4 – Organisation and zootechnical problems	-0.745	0.496	-3.085
	SV20.3 – Transformation at the farm	-0.710	0.344	-3.021
	SV26.4 – Request EBVs	-0.449	0.424	-2.971
	SV29.1 – Don't know/not interested	-0.717	0.473	-2.708
	SV25.1 – Genomics is not a priority	-0.457	0.131	-2.361

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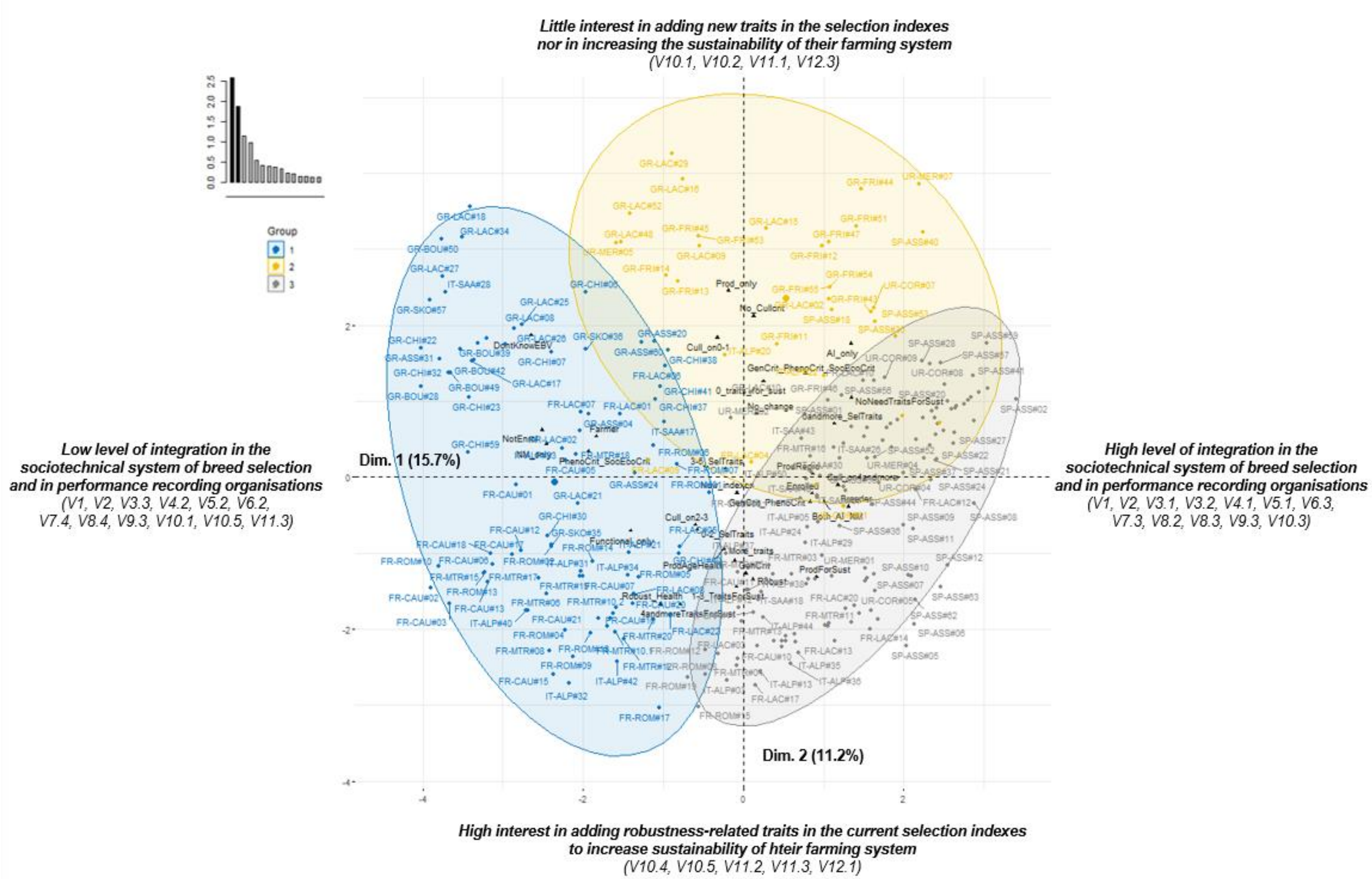

Figure 4 Three groups of small ruminants' farmers differing in their strategies of genetic management, views on, according to their level of integration in the sociotechnical system of breed selection and performance recording (Dim. 1) and to their views on sustainability and the strategies to increase it on their farm (Dim. 2). Classes of the active variables (Vi.j) determining each dimension are defined in Table 3 and Table 4. Ellipses of the groups are plotted according to a confidence interval of 90 %.

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3.2. Three patterns for managing selection and genetic

The clustering process using the coordinates from these two FAMD axes resulted in three groups of farmers that differed in their level of integration in the sociotechnical breed selection system and performance recording and to their views on sustainability and the strategies to increase it on their farm (Figure 4). Groups can be described with the main modalities present in the group and the characterising (noted M/C) or by identifying that a particular modality of the whole sample is essentially present in this group (noted C/M).

Group 1 'Non genetic farmers seeking robustness and multifunctionality'.

This group of 93 individuals (Table 5) was mainly composed of farmers (93% M/C) not enrolled (63% M/C) in performance control organisations. The majority of these farmers did not use artificial insemination (6% of using), but they bought rams for natural mating (80% M/C and 93% C/M). They selected their own animals based on for non-genetic traits (57% M/C and 73% C/M) and culled them for various traits, including functional ones (63% C/M). The replacement rate was lower in this group (23%), hence, resulting in relatively older-animal flocks. In fact, they had relatively less knowledge of genetics, with the majority (88% C/M) not knowing the meaning of EBVs, and therefore, did not use the tools of genetic progress (e.g. indexes, artificial insemination).

Their views on sustainability varied, but a significant proportion of farmers (42% M/C and 57% C/M) chose robustness and health traits as options to improve sustainability.

These farmers had relatively small multi-breed flocks (47 vs. 74 LSU) and used a high percentage of grassland and pasture in the UAA (59%). Farmers using crossbreeding are predominant in this group (91% C/M), as were two out of three organic farmers (65% C/M) and a large proportion (66% C/M) of meat producers. These were mainly Greek (41% M/C) and French (49% M/C) breeders. Specifically, all farmers rearing Chios and Boutsko sheep, and Skopelos goats and a large proportion of Romane (68% C/M) and Causse du Lot (67% C/M) sheep breeders were in this group.

Group 2: 'Genetic farmers seeking production efficiency'.

This smaller group of 34 individuals (Table 5) was mainly composed of dairy sheep farmers (79% M/C). In this group, flock configuration management practices were based on artificial insemination, with a higher level of use (65%) than in group 1, and productivity was the main criterion for culling animals (65% M/C and 85% C/M).

These farmers were not interested in specific traits to improve sustainability (71% M/C). Their farms had a relatively low proportion of grassland and pasture in the UAA (28% vs. 43% in the group and the whole sample) and used few pesticides (9% vs 23% in average). Half of these farmers were Greek (56% M/C); farmers rearing Frizarta sheep were mainly part of this group (92% C/M).

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Group 3: 'Breeders seeking production efficiency and sustainability'.

This large group of 145 individuals (Table 5) consisted mainly of breeders (97% M/C). They had demanding flock/herd configuration practices, such as greater use of artificial insemination (59%) combined with natural mating (96% M/C) and a higher replacement rate (27%). These were enrolled in performance recording organisations (99% M/C), had a sound knowledge of the genetics criteria used to select animals (66% M/C), and wanted to be involved in the development of genomic tools (86% M/C). Production was the main criterion for selecting animals (72% M/C). For culling purposes, production traits were also associated with reproductive traits (59% M/C, 72% C/M) or with the animal's age and health (27% M/C, 70% C/M).

Some of these breeders were satisfied with the current indices to ensure their system's sustainability (51% M/C) or believed that production traits are important to increase sustainability (77% C/M). Other breeders in this group (20% M/C) would like to include new robustness and health traits to increase the sustainability of the farm.

Most Spanish breeders were in this group (90% C/M), with the majority rearing Assaf sheep (83% C/M). Many goat farmers (70% C/M) were in this group, rearing mainly two breeds: Saaneen (87% C/M) and Alpin (71% C/M). These larger herds (96 vs. 74 LSU average for the group and the whole sample) were reared in relatively intensive farming systems, with a low percentage of meadows and pastures (36%), and high pesticide use (30%).

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Table 5 Characteristics of small ruminant farms in three groups of strategies of genetic management. Classes of the active variables (Vi.j) and supplementary variables (SVi.j) are defined in Figure 3 and Table S2, respectively. Active (Vi) and supplementary (SVi) quantitative variables are defined in Figure 3 and Table S2, respectively.

Characteristic	Group 1 (n = 93)	Group 2 (n = 34)	Group 3 (n = 145)
Classes of variables significantly represented in the group	Natural mating only (**V3.3**) Farmer using genetic progress (**V11.2**) Not enrolled in performance control recording (**V12.2**) Don't know EBVs meaning (**V9.1**) Selection on non-genetic criteria (**V6.4**) Culling on functional traits only (**V5.3**) Robustness and health for sustainability (**V9.5**) France (**SV1.1**), Greece (**SV1.2**) Meat sheep (**SV2.3**)	Culling on 0 to 1 criteria (**V4.1**) Culling on production traits only (**V5.2**) Greece (**SV1.2**) No need traits for sustainability (**V9.2**) 0 traits for sustainability (**V8.1**) Dairy sheep (**SV2.2**)	Breeder (**V11.1**) Both artificial insemination and natural mating (**V3.2**) Enrolled in performance control recording (**V12.1**) No need traits (**V9.2**) or production traits for sustainability (**V9.3**) Spain (**SV1.4**)
Group mean value of quantitative variables that are significantly <u>higher</u> than the overall sample mean	Percentage of meadows/grassland in UAA (**SV12**) No. breeds (**SV22**)	Percentage of artificial insemination (**V2**)	Percentage of artificial insemination (**V2**) Total LSU (**SV18**) Percentage of areas on which pesticides are used (**SV14**) Replacement rate (**V1**)
Classes of variables significantly underrepresented in the group	Breeder (**V11.1**) Both artificial insemination and natural mating (**V3.2**) Enrolled in performance control recording (**V12.1**) Spain (**SV1.4**) Selection on genetic and phenotypic criteria (**V6.2**) Don't need new traits for sustainability (**V9.2**)	Culling on 2 to 3 criteria (**V4.2**), on 4 and more (**V4.3**) Culling on production and reproduction traits (**V5.5**) or on Production, age and health (**V5.4**) 1 to 3 traits (**V8.2**), 4 and more traits for sustainability (**V8.3**) Robustness and health for sustainability (**V9.5**) France (**SV1.1**) Meat sheep (**SV2.3**)	Farmer using genetic progress (**V11.2**) Natural mating only (**V3.3**) Not enrolled in performance control (**V12.2**) Greece (**SV1.2**) Don't know EBVs meaning (**V9.1**) Culling on 0 to 1 criteria (**V4.1**) Robustness and health for sustainability (**V9.5**)
Group mean value of quantitative variables that are significantly <u>lower</u> than the overall sample mean	Total LSU (**SV18**) Replacement rate (**V1**) Percentage of artificial insemination (**V1**)	Percentage of meadows and grassland in UAA (**SV12**) Percentage of areas on which pesticides are used (**SV14**)	Percentage of meadows/grassland in UAA (**SV12**) No. breeds (**SV22**)
Position of the group on the FAMD factorial plan	Axis 1 Left side Axis 2 both top and bottom side	Axis 1 Right side Axis 2 Top side	Axis 1 Right side Axis 2 Bottom side

FAMD = factorial analysis of mixed data

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4. Discussion

4.1. How could the results have been improved by better sampling of farms?

The first point to note is the lack of homogeneity in the sample surveyed. Upstream of the project, each partner chose to include specific breeds in the research work, based on their own questions and local issues. This has led, on one hand, to not have the same number of farms in each of the different partner countries, and on the other hand to have chosen only a few systems/breeds. As a result, some less-represented systems are less identified in the results, as the analysis gives greater weight to the most common types of systems (in this case, dairy ewe farms). This point is not fundamentally problematic, as the study was not based on the representativeness of small ruminant farming systems (which would have been impossible to achieve). This is why we chose to analyse the data using exploratory statistics (MCA, CAH), an approach that consists in identifying operating patterns through a typology. A typology is formed by grouping observations into different types on the basis of their common characteristics, taking into account how each unique individual represents a particular pattern of characteristics ((Stapley et al., 2022)). This kind of approach has been used for many years in agricultural research to represent diversity as both an instantaneous and dynamic phenomenon ((Girard et al., 2001)).

The second point concerning the sample is the choice of farmers surveyed. Each of the partners carried out surveys with farmers who were available to participate. The survey process begun at the time of the Covid crisis. As a result, some partners had to adapt their sample to the survey possibilities in each country and the availability of breeders. In Spain, for example, only one ASSAF breeder could be surveyed. This is the main reason why most of the Spanish breeders are in the same group at the end of the analysis. An alternative to expert sampling would have been to use part of the snowball method, a non-probabilistic method for selecting a sample of farms. This method for selecting a survey sample is based on references of first breeders initially sampled and surveyed, who provide the names of others they believe possess the characteristics of interest ((Johnson, 2014)).

4.2. Culling and replacement practices at the heart of breeding patterns

Our survey has enabled us to identify the key determinants used by breeders to improve their flocks/herds. We can distinguish, the choices for culling practices and the practices enabling genetic progress. As shown by Perucho, Ligda, et al.(2019), different selection strategies can be distinguished based on culling practices for females and males and the replacement of animals. Our study shows how culling criteria distinguish and structure the three selection and genetic management strategies we have identified. These include productivity, functional and reproductive criteria combined with the use of AI or the purchase of males. The selection of animals is based on different criteria for each group of breeders, but relies heavily on productivity and functional aptitude. These criteria are the main levers for managing flock performance ((Perucho et al., 2020)). It should be noted that we based part of the questionnaire on the breeders' evaluation of EBVs as an indicator and selection tool available to them. However, a number of breeders stated during the surveys that they did not know what EBVs were, and consequently did not use them. The attitude of breeders to genetic tools is a complex

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phenomenon, due to the lack of tools for measuring their attitude ((Martin-Collado et al., 2014)). However, the use of EBVs could be very promising to help breeders to select their animals ((Perucho et al., 2020)). According to our study, breeders less inclined to use genetic tools (such as EBV, AI, synthetic indexes) rely instead on purchasing males from other trusted breeders in their vicinity, with similar systems and based on the animals' phenotypic criteria. This is in line with the observations made by (Perucho, Ligda, et al. (2019) in Corsica and Greece.

4.3. The involvement of farmers in the collective genetic program as a prerequisite for disseminating genetic progress

The MCA results showed that our sample was structured on a first factorial axis around two different poles. On the one hand, farmers with a strong commitment to the local (and/or national) socio-technical system linked to the raised breed. They take part in performance recording and are breeders or farmers with a strong knowledge of genetic tools. In view of the advances being made in genetics, they are determined to take part in genomic evaluations, and say they "want to be part of its development". In contrast, farmers less familiar with genetic tools focus their selection practices on functional criteria and animal phenotypes. This group includes farmers of less intensive local breeds (Chios, Boutsko and Skopelos, Causse du Lot) that make greater use of grassland or pastoral areas. As described by Perucho, Hadjigeorgiou, et al. (2019), local breeds are recognized as an important element in maintaining biodiversity and variation of farming systems. These systems, which are more focused on the diversity of local resources, are favourable to the agroecological transition (Thenard et al., 2021). Initiating an agro-ecological transition based on the contribution of genetics implies changing the relationship between breeders and breeding organizations. Targeted policy measures should be considered in order to foster interactions between the different stakeholders of a region by increasing active participation and cooperation on common goals (Perucho, Ligda, et al., 2019)).

4.4. Expectations for new traits still limited and unstated: the challenge of genomics?

Another point to be drawn from our research work is to identify breeders' expectations for new selection traits useful for strengthening the resilience of livestock farms. The SMARTER project aimed to identify genetic traits that could be used to select more robust and efficient animals. Our sample was structured around two poles around a gradient of interest in adding new traits to selection indexes.

Some breeders, unfamiliar with genetic tools, would like to orient their animal selection on the basis of new, phenotypic criteria. Buying rams is a way of staying in touch with selection schemes while emphasizing the role of the breed in animal selection practices (J. Labatut & Hooge, 2016; Perucho, Hadjigeorgiou, et al., 2019)and even for some breeders to rely on conformity to the breed standard as a means of choosing their animals (Labatut, J., 2009).

Although interested in improving the characteristics of their animals, these breeders, especially in Greece, also resort to crossbreeding, which is also a way of for improving animal performance. According to Perucho, Hadjigeorgiou, et al. (2019) crossbreeding could help to increase milk production or to work out compromises between adaptive and productive traits. This is also in line with recent studies in dairy cows ((M. A. Magne et al., 2016; Quénon & Magne, 2021)).

Another group of surveyed breeders expressed their satisfaction with the current selection traits used in synthetic selection indexes. They justified this by pointing out that improving animal productivity

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would mean improving the sustainability of their farms. This confirms the simulation work of (Ramón et al., 2021), which shows the role of maintaining productivity in these drought-prone regions.

On the other hand, other breeders would like to see new traits integrated into selection schemes, in particular traits relating to animal health and robustness. These breeders are interested in selecting animals for resistance to parasitism, or for reduced susceptibility to mastitis. Other available studies also point to such prospects in the medium term (Aguerre et al., 2018; Oget et al., 2019; Rupp et al., 2019).

As for most of the breeders surveyed, they consider the current selection indices to be satisfactory for ensuring the sustainability of their system, and in particular see the arrival of genomics as a way of accelerating genetic progress, and developing more advantageous selection strategies than through conventional quantitative genetic selection ((Shumbusho et al., 2015)). According to Astruc et al. (2016), this is not only an economic advantage, but also a way of giving more flexibility to selection schemes. However, J. Labatut et al. (2013), warned of the importance of maintaining consistency between selection schemes and breeders. Genomic selection could reconfigure property rights over genetic information.

Finally, for the implementation of new selection programs, the economic interest and the gain from the introduction of new selection traits should be taken into account (Byrne et al., 2010; Theodoridis et al., 2023). Similarly, prioritization between criteria and the construction of trade-offs is complex, and although it can be modelled using choice-experiment surveys (Byrne et al., 2012), selection choices and the creation of new genetic schemes will have to be made in conjunction with breeders and their expectations. Based on our study, such expectations remain rather vague and above all very disparate depending on many factors such as the breeder, the country and the breed

Conclusion

Finally, this study has explored a large diversity of situation combining farmers and breeders. We focused on farmers and breeders' practices and preferences for breeding and genetics. Diversity of breed, country and production systems give elements to analyse the different responds of farmers and breeders, mainly with the socio-technical context. These results are elements that can be used by selection organizations and companies to support their reflection on the evolution of selection objectives to increase the resilience of small ruminant breeding systems to develop and use new selection traits and new genetics tools.

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Deviation and Delays

Initially, we planned to carry out this survey with breeders of 15 breeds, as specified in the DOA. However, in Spain, due to the Covid crisis, it was not possible to survey breeders of the Churra and Castellana. But more ASSAF farmers and breeders were surveyed, enabling the total number of surveys required at the start of the project to be carried out.

The Covid crisis severely disrupted the organization of surveys in several countries, making it impossible to carry them out in 2020 and early 2021. The surveys, which we had hoped to maintain the face to face format, were carried out later than planned. The extension period of 8 months also enabled us to analyze the data collected late. However, the planned number of surveys was reached (except among farmers and breeders of two breeds, as previously mentioned).

Drafting and formatting of the results was therefore delayed, leading to this deliverable, in the form of a scientific article, which will be submitted to the journal "Animal" in the coming weeks and before the end of September 2023.

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Supplementary material

Data:

Data is available here and will be made open access when the manuscript is published:

https://zenodo.org/record/8279981

Table S1: Structure and content of the interview guide on strategies implemented by small ruminants' farmers regarding genetic management of the flock and search for sustainability on their farm.

Topic of the interview guide	Collected data (for each section)	Selected encoded active variable (Vi. i = 1-12)
I. About crops and forages (Farm structure and general management)	Agricultural area. crop rotation. use of fertilisation and pesticides	Only supplementary variables (Table S2)
II. About livestock (General management of the flock)	Species. breeds. replacement practices. reproduction management	V1 *Replacement* V2 *PerfOfAI* V3 *UseOfAI* + supplementary variables (Table S2)
III. About genetic traits and selection indexes (Genetic management practices)	Use of and views on estimated breeding values and selection indexes. criteria to select breeding animals. traits to select breeding animals. views on change of indexes to make. traits to select on in order to increase sustainability	V4 *NbCullCrit* V5 *CullCrit* V6 *CritForSelec* V7 *NbSelTraits* V8 *NbTraitsForSust* V9 *TraitsForSust* V10 *ChangeIndex* + supplementary variables (Table S2)
IV. About genetic and breeding organisation (Socio-economic information)	Farmer's status and involvement in the breeding organisations. resources for genetic news and information. views on genomics and crossbreeding. views on information share between countries and organisation	V11 *BreederStatus* V12 *PerfControl* + supplementary variables (Table S2)

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Table S2 Summary of the 29 supplementary variables (SVi. i = 1-29) used to describe general characteristics of the farm. farmers' practices and views on genetic topics. For the categorical variables (n = 15). Classes and number of farms are indicated. For the quantitative variables (n = 14), minimal (min), maximal (max), median and mean values are indicated.

Supplementary variable	Description	Class	No. of farms
SV1 - Country	Country where the respondent's farm is located	SV1.1 France	83
		SV1.2 Greece	60
		SV1.3 Italy	50
		SV1.4 Spain	63
		SV1.5 Uruguay	16
SV2 - LS	Type of livestock farming system	SV2.1 Dairy goat	54
		SV2.2 Dairy sheep	62
		SV2.3 Meat sheep	41
		SV2.4 Wool-meat sheep	15
SV3 - Prod	Main production	SV3.1 Milk	216
		SV3.2 Meat sheep	56
SV4 - Breed	Main breed on the farm (for which the farm was sampled)	SV4.1 Alpine	35
		SV4.2 Assaf	69
		SV4.3 Boutsko	5
		SV4.4 Causses du Lot	21
		SV4.5 Chios	11
		SV4.6 Corriedale	9
		SV4.7 Frizarta	13
		SV4.8 Lacaune	43
		SV4.9 Merino	7
		SV4.10 Manech tête rousse	21
		SV4.11 Romane	19
		SV4.12 Saanen	15
		SV4.13 Skopelos	4
SV5 - UAA	Utilised Agricultural Area (ha) according to Eurostat definition	Min = 0; Max = 2 308; Median = 30; Mean = 108	
SV6 - Crops	Crops area (ha)	Min = 0; Max = 197; Median = 0; Mean = 16	
SV7 - ForageCrops	Forage crops are (ha)	Min = 0; Max = 810; Median = 0; Mean = 19	
SV8 - Meadows	Meadows are (ha)	Min = 0; Max = 975; Median = 0; Mean = 21	

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SV9 - PermGrassland	Permanent grassland area (ha)	Min = 0; Max = 7 300; Median = 7; Mean = 121	
SV10 - PermCrops	Permanent crops area (ha)	Min = 0; Max = 350; Median = 0; Mean = 6	
SV11 - OtherLand	Other land area (ha)	Min = 0; Max = 600; Median = 0; Mean = 24	
SV12 - PercMeadGrass	Share of meadows and grassland areas in the total utilised agricultural are (%)	Min = 0; Max = 1; Median = 0.4; Mean = 0.43	
SV13 - FertiPractices	Type of fertilization practices	SV13.1 Both mineral and organic fertilisation	128
		SV13.2 Mineral fertilisation only	15
		SV13.3 No fertilisation	46
		SV13.4 Organic fertilisation only	83
SV14 - PercSurfPesti	Share of agricultural area on which pesticides are used (%)	Min = 0; Max = 1; Median = 0; Mean = 0.24	
SV15 - ProductionLabel	Conventional or organic farming	SV15.1 Conventional farming	252
		SV15.2 Organic farming	20
SV16 - LSUSheep	Number of sheep. expressed as LiveStock Units (according to Eurostat definition)	Min = 0; Max = 12 000; Median = 50; Mean = 121	
SV17 - LSUGoat	Number of goat. expressed as LiveStock Units (according to Eurostat definition)	Min = 0; Max = 51; Median = 0; Mean = 3	
SV18 - LSUSmallRum	Total number of small ruminants. expressed as LiveStock Units (according to Eurostat definition)	Min = 0; Max = 1; Median = 0; Mean = 0.24	
SV19 - OtherSpec	Presence of animals on the farm that are no sheep or goats	SV19.1 No other species	204
		SV19.2 Presence of other species	68
SV20 - ProdDestination	Destination of agricultural production of the farm	SV20.1 Both selling to industry and transformation at the farm	19
		SV20.2 Selling to the industry	210
		SV20.3 Transformation at the farm	43
SV21 - StockingRate	Number of small ruminants (LSU) per hectare of UAA	Min = 0; Max = 44; Median = 0.9; Mean = 1.7	
SV22 - NbBreeds	Number of breeds of small ruminants on the farm	Min =1; Max = 5; Median = 1; Mean = 1.2	
SV23 - Crossbreeding	Use of crossbreeding on the farm	SV23.1 Don't use crossbreeding	261
		SV23.2 Use crossbreeding	11
SV24 - LimitGenProgress		SV24.1 No specific problems	39
		SV24.2 Organisational problems only	43

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	Farmer's views on what is limiting genetical progress or adoption of selection practices in the industry	SV24.3 Organisation and individual problems	29
		SV24.4 Organisation and zootechnical problems	41
		SV24.5 Zootechnical problems only	91
		SV24.6 Zootechnical and individual problems	16
		SV24.7 Various problems	13
SV25 - GenomicsDev	Farmer's views regarding the development of genomics	SV25.1 Genomics is not a priority	59
		SV25.2 Want to be part of its development	213
SV26 - BuyMales	Use of Estimated Breeding Values (EBVs) to buy males	SV26.1 Don't buy males	111
		SV26.2 Don't know EBVs meaning	40
		SV26.3 EBVs are not relevant or not provided	22
		SV26.4 Request EBVs	85
		SV26.5 Trust jugment fo the seller	14
SV27 - ShareInfo	Farmer's views regarding information sharing between countries and organisations	SV27.1 Agree with information sharing	188
		SV27.2 Disagree with information sharing	23
		SV27.3 No clear-cut opinion on information sharing	61
SV28 - ExpectInterEval	Farmers' views on the general benefits to be expected from the establishment of international evaluations	SV28.1 Benefits for breed program only	79
		SV28.2 Benefits for breed program and breed recognition	16
		SV28.3 Benefits for breed program and economic benefits	21
		SV28.4 Benefits for breed program. breed recognition and economic benefits	42
		SV28.5 Benefits for breed recognition and economic benefits	24
		SV28.6 Don't know what is to expect from international evaluation	32
		SV28.7 Economic benefits	39
		SV28.8 Other expectations	19
SV29 - ExpectForBreedProg	Farmers' views on the benefits for the breed to be expected from the establishment of international evaluations	SV29.1 Don't know/not interested	5
		SV29.2 Increase breed population	37
		SV29.3 Increase breed population and import-export	24
		SV29.4 Increase EBV accuracy	45
		SV29.5 Increase EBV accuracy and breed population	43
		SV29.6 Increase import-export	38
		SV29.7 No expectations	35
		SV29.8 Various expectations	45

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