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Agroecological engagement among beginning livestock farmers' farms in France: a marginal but emerging trend

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Introduction: Livestock production is undergoing major transformation as it confronts environmental, economic, and social challenges. This study uses statistical analysis of the 2020 French agricultural census to examine the extent to which beginning livestock farmers' farms contribute to the agroecological transition of livestock farming systems.
Methods: Utilizing data from the 2020 French Agricultural Census and the Mutualité Sociale Agricole database, we identified farms where at least one farmer obtaine official status as a farm manager between 2010 and 2020 (beginning farmers' farms [BFF]) and compared them with earlier farmers' farms (EFF). We characterized these farms based on structural, functional, and sociodemographic variables, emphasizing indicators of agroecological functioning. Through multiple factor analysis and hierarchical clustering, we developed a BFF typology across production orientations.
Results: Results indicated three to six clusters per production orientation, grouped into four transversal farm types: type A, large-scale farms with limited participation in quality schemes; type B, medium-scale farms with high participation in quality or origin certifications and strong reliance on permanent grassland; type C, small-scale farms with organic certification and short supply chains; and type D, crop-based farms with secondary livestock activities. BFF exhibited greater diversity and more significant engagement in agroecological practices than EFF, particularly through type C farms, which emphasize organic production and short-value chains. BFF comprised a slightly larger share of type C farms than EFF, suggesting a modest shift toward agroecology. However, the majority of beginning livestock farmers still start their careers on type A farms (except for goat farming), which are larger and less engaged in quality schemes, suggesting that the overall transition to agroecological systems is still in its early stages. Type B and C farms represent relatively larger clusters among beginning farmers' farms than among others, suggesting a possible shift toward more agroecological farming.
Discussion: These findings underscore both the persistence of structural trends in agricultural transformation and the challenges beginning farmers face in adopting agroecological practices. Facilitating access to production resources, promoting good working conditions, and ensuring fair incomes while preserving the environment should be priorities for agricultural extension services and public policies supporting these transitions.

KEYWORDS

beginning farmers, agroecology, France, statistical analysis, farm's structural change, agricultural census, sustainable agriculture, livestock farming systems

1 Introduction

The livestock farming sector in the Global North faces various environmental, economic, and social challenges (Lebacq et al., 2013). France is both a major agricultural power in Europe and a country that exemplifies these challenges, making it a particularly relevant case for analysis. Farmers must produce sufficient quantities of high-quality food (Zahoor et al., 2019; Prache et al., 2022) to feed the population (Wu et al., 2014) while addressing food waste and inequities in the production and supply system (Loon and Sarkar, 2021). In addition, they must adapt to climate change (Skuce et al., 2013; Godde et al., 2021; Intergovernmental Panel On Climate Change, 2021), reduce the environmental impact of agriculture (Van Der Werf et al., 2005; Steinfeld et al., 2006; Bellarby et al., 2013; Leip et al., 2015; Garnett et al., 2017), and improve animal welfare (Busch et al., 2018; Alonso et al., 2020; Stampa et al., 2020). Social challenges, such as improvement of the farmer's working conditions (Kolstrup, 2008; Duval et al., 2021) and renewal of the agricultural workforce (Zagata and Sutherland, 2015; Hostiou et al., 2020), also permeate this sector.

Agroecology is seen as a promising approach to these challenges. Recent researches focus on the analysis, design, and evaluation of practices or production systems that rely on the management of interactions within agroecosystems. These practices aim to mimic the ecological functions of natural ecosystems, reducing dependence on external inputs (Altieri, 2018). These approaches emerged during the 20th century and developed alongside agroecological practices and social movements (Wezel et al., 2009). In parallel, agroecology has been established as a goal by European and international authorities, particularly within the framework of the Green New Deal, the UN's Sustainable Development Goals (FAO, 2024a), or the FAO's principles (FAO, 2024b). Livestock farming has been seen as a potential driver of agroecological transition (Dumont et al., 2013; Altieri and Nicholls, 2020), as it enables, for example, to enhance nutrients cyclings and more largely resilience of systems. However, transforming a farming system and farmers' practices to make them more agroecological can be challenging. Several authors have used the concept of path dependency to explain that major changes in farming systems often occur in response to "trigger events" (Sutherland et al., 2012; Chantre and Cardona, 2014; Gosnell et al., 2019). In this framework, events such as farm succession or the arrival of a new farm manager can be considered as potential trigger events that may lead to significant transformations by disrupting existing trajectories (Sutherland et al., 2012; Revoyron et al., 2022). This is a critical moment when the farm's size, management, work organization, and economic strategy are (re) defined, potentially initiating new path dependencies that shape future decisions and practices. Several studies have analyzed the factors influencing generational renewal (Conway et al., 2021; Coopmans et al., 2021); barriers to the entry of new farmers, such as farmland acquisition (McKee et al., 2018); and strategies to enter the animal farming sector (Góngora Pérez et al., 2020). However, only a few studies have considered the arrival of beginning livestock farmers (recent entrants into livestock farming; see Methods for details) as a potential trigger point for the (re)design of farms, which may or may not foster the development of agroecological practices.

Building on these considerations, we decided to focus on beginning livestock farmers and the characteristics of their farms to understand how these farms align—or fail to align—with the requirements of an agroecological transition. We focused on livestock farms where at least one farm manager established as a livestock farmer between 2010 and 2020 (beginning farmers' farms [BFF]). We investigated the following question: To what extent do the characteristics of BFF reflect a transition toward agroecology? To address this question, we characterized the diversity of BFF based on structural and functional farm criteria. In this article, we first present the materials and methods, detailing the dataset construction, the identification of BFF, the selection of variables for statistical analysis, and the farm clustering based on multivariate analysis. In the results section, we provide: (1) clustering of BFF within four selected production orientations, (2) a transversal typology of BFF, and (3) a comparison of BFF and EFF distribution among clusters. The discussion interprets the characteristics of each farm type and examines whether BFF reflect a shift toward agroecology.

2 Materials and methods

The first two methodological steps—building datasets and identifying farms where livestock farming is a significant activity—are presented in Figure 1. To assess the agroecological characteristics of BFF, we focused on France. It represents an interesting case study because it was among the first countries to adopt strong political commitment to agroecological development, notably with the 2014 law supporting the agroecological transition. However, recent agricultural policies have tended to diverge from these initial objectives, raising concerns about the future direction of agroecology in the country. To help non-French readers better understand the national context, we produced a map showing the spatial distribution of livestock density (in livestock units per km^2) as well as the main mountain ranges, classified as such under the Areas facing Natural Constraints (ANC) scheme of the European Common Agricultural Policy. (Figure 2).

2.1 Building initial dataset

We constructed two comparable datasets of farms: one containing farms where at least one farm manager established between 2010 and 2020, referred to as BFF, and another consisting of farms where all farmers were established before 2010, referred to as earlier farmer's farms (EFF). These groups were not constructed as statistically matched samples, but rather to reflect actual diversity and provide a basis for comparison across generations of farmers. For this, we extracted farm data from the 2020 decennial Agricultural Census (AC20) database by matching the business identifiers with those in the database of nonsalaried farmers (called MSA COT-NS and provided

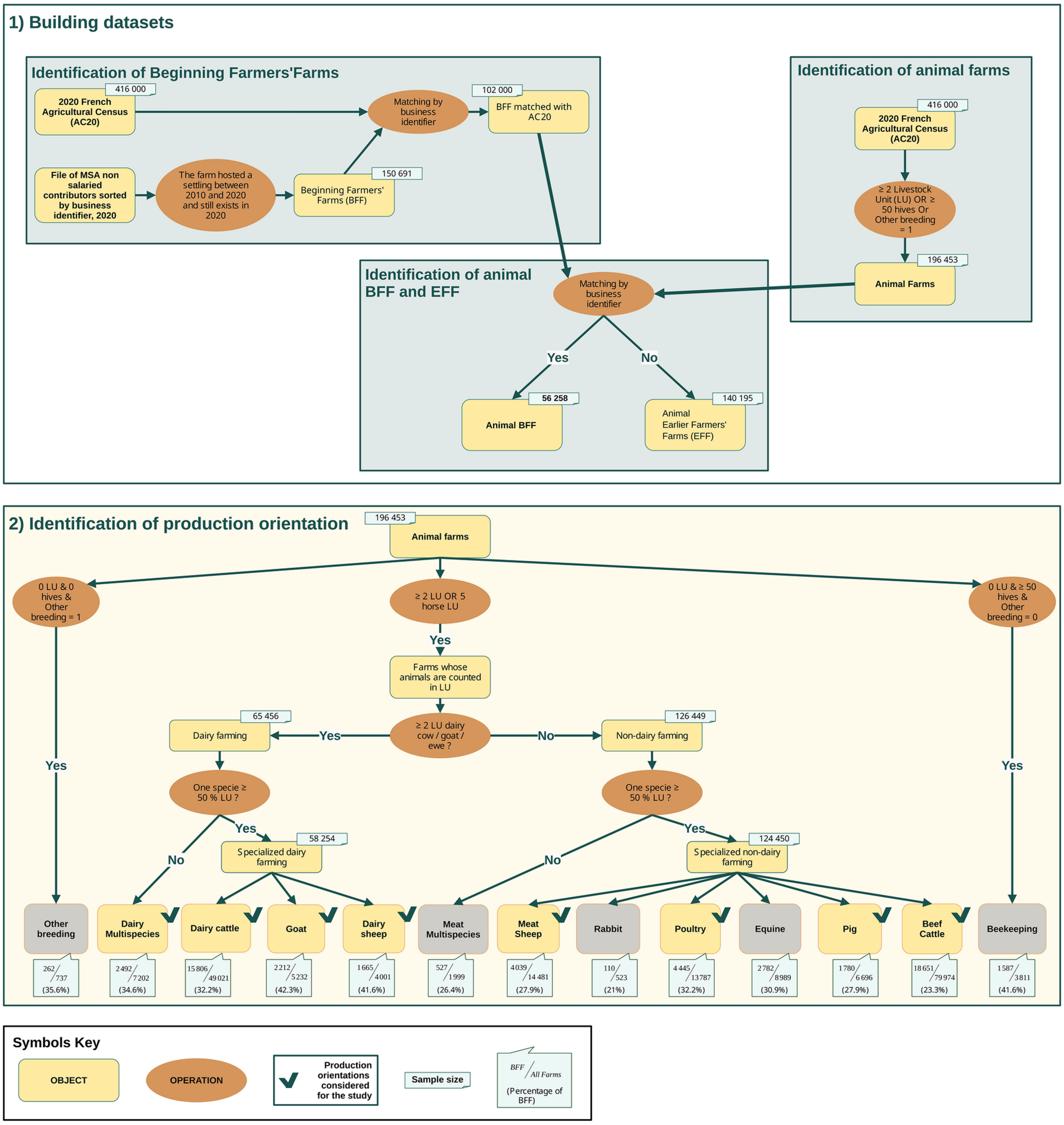

FIGURE 1
Building dataset: identification of beginning farmers' farms and main livestock production.

by the Mutualité Sociale Agricole). The AC20 is a database fed by a comprehensive survey, providing a wide range of information (over 3,000 variables) on the characteristics of all french farms (area, animals, workforce, production, marketting, etc.). It enumerated 416,478 farms in 2020 in France. The MSA COT-NS database includes all individuals who pay contributions as farmers (MFA, 2020), i.e., almost all French farmers. The establishment of a livestock farmer is defined as the act of obtaining the farm manager status, which allows us to identify beginning livestock farmers. The acquisition of this status can correspond to several situations: the creation of a new farm, the takeover of an existing farm (whether family-owned or not), or the arrival of a new comanager in an existing farm (expansion of the workforce or replacement of a member). However, the available data do not allow for a rigorous distinction between different forms of entry into livestock farming, particularly between newly created farms and those resulting from succession or transfer.

2.2 Selecting farms where livestock farming is a significant activity

Then, our goal was to capture all farms where animal farming activities represent a considerable portion of the working time. We chose to work with the livestock unit (LU), a common unit, frequently used to assess herd sizes. We tested several thresholds, from more than 0 LU up to 4 LU, and found little variation in the

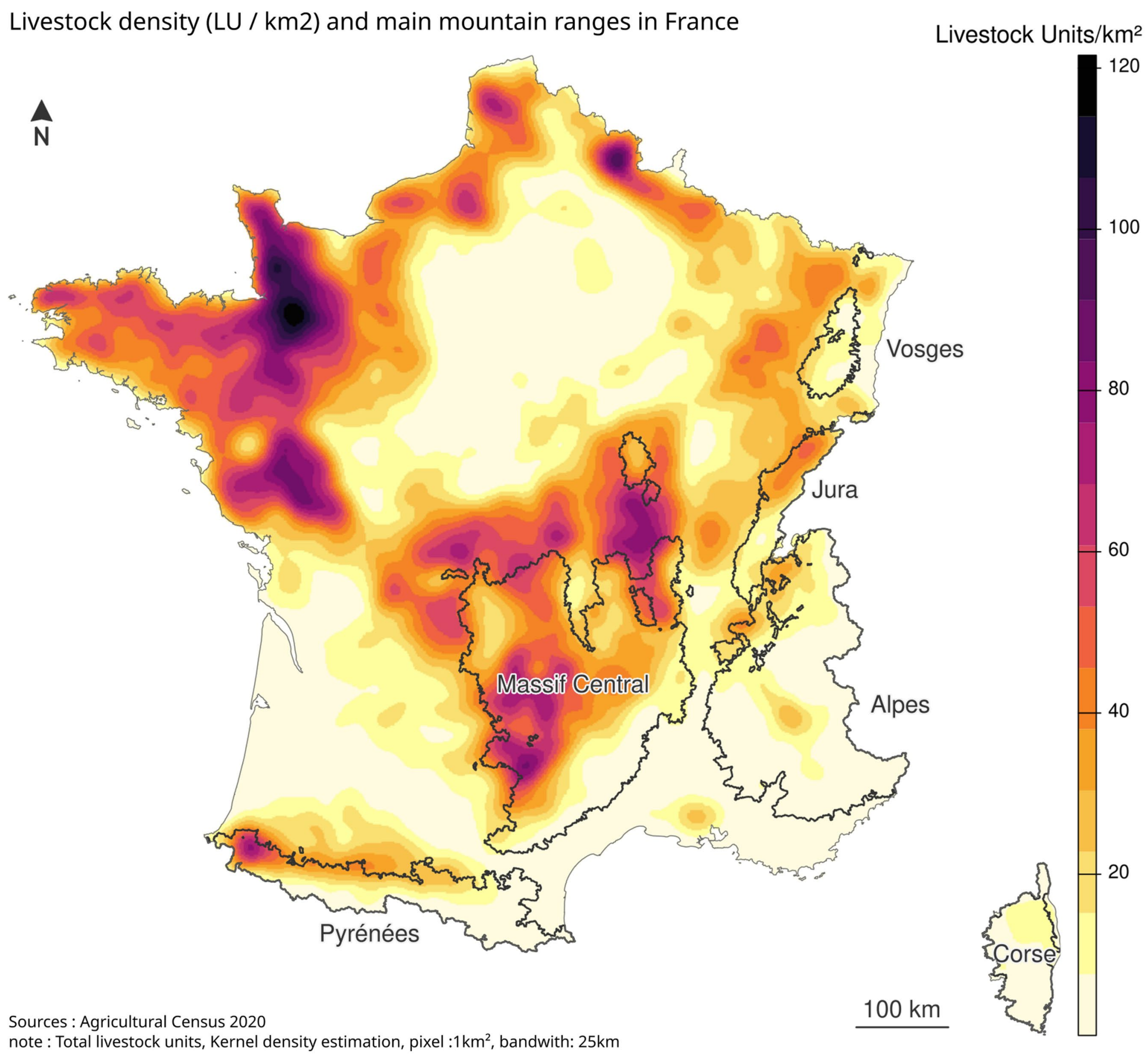

FIGURE 2
Map showing the main mountain ranges in France and livestock density (LU / km^2).

number of BFF identified (from 57,612 to 53,469), indicating that BFF with very small herds are relatively rare. Ultimately, we selected a threshold of 2 LU equivalent to 2 dairy cows, 3 beef cows, 7 goats, 12 nursing ewes, 10 dairy ewes, 10 breeding sows, 143 laying hens, or 182 broilers. This threshold captures farms with meaningful livestock activity, including those where beginning farmers start with small herds that they plan to expand or valorize through processing and short supply chains. We decided to exclude meat multispecies farms, beekeepers, horse breeders, rabbit farming, and farms in the "other" category, such as frogs and snails as their variables were irrelevant or insufficient to address our research question. These productions are shown in gray on Figure 1.

We determined the production orientation of the farms based on two criteria: (i) presence of dairy production (≥2 LU of dairy cows or ewes or goats) and (ii) degree of specialization (main species ≥ 50% LU). The resulting frequency table can be found in Figure 1 and Supplementary Table 1. In this article, only four production orientations are discussed in detail: dairy cattle, beef cattle, goats, and pigs. Among these, only the map for dairy cattle is presented in the main text. All other maps are available in the Supplementary materials or at the following https://www.data.gouv.fr/datasets/caracteristiques-des-fermes-delevage-ayant-accueilli-un-nouveau-chef-dexploitation-entre-2010-et-2020/. The Supplementary materials also contain the data, comments and maps for meat sheep, dairy sheep, poultry, and dairy multispecies farms.

2.3 Variables

Among the 3,000 variables of the AC20, we selected a set of 17 variables, presented in Table 1, based on a literature review on agroecology. These variables were chosen to both structurally and functionally characterize BFF and EFF and assess their level of agroecological performance. We began by using classic structural indicators to measure the BFF's size, workforce composition and legal status to assess whether beginning farmers enter farming on large farms. We then used variables related to farm size per worker to assess labor productivity. We also used indicators of farm specialization, feeding management and participation in quality schemes to evaluate the importance of agroecological practices. Economic indicators such

TABLE 1 Variables used to analyze the diversity of beginning farmers' farms and earlier farmer's farms.

Subject	Variable name	Indicator	Unit	Link to agroecological principles	References
Farm size	Herd per worker	Livestock units (LU)/number of Full-Time Equivalent (FTE)	LU/FTE	Proxy of labor productivity	Volken and Bottazzi, 2024; Bainville et al., 2025
	Farm size per worker	Hectares of Utilized Agricultural Area (UAA)/FTE	Hectares/FTE	Proxy of labor productivity	Volken and Bottazzi, 2024; Bainville et al., 2025
	Herd size	Livestock units	LU	NA	
	Farm size	Hectares of UAA	Hectares	NA	
Workforce	Workforce size, outside outsourcing	Number of FTEs outside outsourcing	FTE	NA	
	Share of wage labor	Nonfamilial salaried FTE/total FTE	Ratio	NA	
	Share of female farm managers (illustrative variable)	Number of female farm managers/number of farm managers	Ratio	Women tend to rule more agroecological farms	Gomori-Ruben and Reid, 2023
	Legal status (illustrative variable)	1 = individual farm 2 = GAEC[1] 3 = EARL[2] 9 = other forms	NA	Nature of farm and level of legal complexity	Purseigle et al., 2017
Level of farm specialization	Importance of crop production	Standard gross production from crops/total standard gross production	Ratio	Complementarity between productions is considered as a driver to agroecology	Dumont et al., 2023
	Diversity of animal species	1 − Simpson index over LU	0 = every LU belongs to a different species 1 = monospecific	Complementarity between productions is considered as a driver to agroecology	Dumont et al., 2023
Animal feeding management	Stocking rate	LU/ha of UAA	LU/ha	Proxy of feed autonomy – manure availability – risk of overgrazing	Stout et al., 2000; Pleasants et al., 2007, Bayram et al., 2023
	Share of maize fodder (specific for herbivore farming)	Hectares of maize fodder/(hectares of the main fodder area + hectares of the summer grazing unit) * 100	Ratio	Farms heavily relying on maize fodder are those that purchase the most concentrates	Paccard et al., 2003; Ineichen et al., 2014; Ghozlane et al., 2021
	Share of permanent grassland (specific for herbivore farming)	Hectares of permanent grassland/hectares of the main fodder area + hectares of the summer grazing unit	Ratio	Pastoral livestock systems are considered as among the most sustainable and autonomous livestock systems	Lebacq et al., 2015; Schils et al., 2022
Participation in quality schemes	Organic certification	Organic label on animals (LU)	0 = no 1 = yes	Favorable to agroecology for its prohibition of synthetic inputs and commitment to animal welfare, lower impact on biodiversity	Van Wagenberg et al., 2017
	Other official labels identifying the quality or origin (%)	Certification within one of the following: protected geographical indications (PGI), protected designation of origin (PDO), Label Rouge	0 = no 1 = yes	PGI and PDO are favorable to agroecology for increasingly integrating sustainability criteria into their standards. Label Rouge for its high-quality production	Vandecandelaere et al., 2021; Drevon et al., 2024
	Short-value chains	On-farm processing and/or short supply chain	0 = Neither 1 = On-farm processing OR short supply chain 2 = On-farm processing AND short supply chain	Preferred mode of selling agroecological products	Loconto et al., 2018

[1]GAEC: Groupement Agricole d'Exploitation en Commun (Joint Farming Group): from 2 to 10 farmers.
[2]EARL: Exploitation Agricole à Responsabilité Limitée (Limited Liability Agricultural Operation): from 1 to 10 farmers.

as yields, margins, or incomes could not be included due to the lack of relevant data in the 2020 Agricultural Census.

2.4 Farm clustering

Our objective is to characterize the diversity of involvement in the agroecological transition among BFF and to compare them with EFF. Our analysis was, first of all, conducted by production orientation. We used the RStudio software (version 2022.12.0 + 353.pro20). The analysis began with multiple factor analysis (MFA; MFA, 2020), which enables the analysis of mixed data (continuous, frequency-based, and categorical) and the identification of variables and groups of variables that most strongly differentiate the sample (Pagès, 2002). Then, hierarchical clustering was performed based on the MFA results (Husson et al., 2010) using the hierarchical clustering on principal component (HCPC) (Husson et al., 2023) function in the FactoMineR package. It partitions the sample into groups that maximize and minimize the distance between and within groups, respectively. An optimal number of clusters are suggested based on the hierarchical tree and confirmed using the k-means method. The characteristics of each cluster were then examined and compared with each other. We mapped the geographical distribution of farms belonging to the different clusters for each production orientation. We used the scale of the petite région agricole (PRA), a French territorial division based on agricultural activities and environmental conditions. Colors on the map represent the number of BFF in each cluster within each PRA. The color scale for the maps was defined using the Jenks method or "natural breaks," which minimize intraclass variance while maximizing interclass variance.

We then built a typology of BFF that brings together all production orientations by identifying similarities between the clusters. We compared the clusters obtained for the different production orientations by examining their mean, median, and quartile values across selected variables, as well as the combination of their characteristics. For clusters exhibiting intermediate positions between types, we prioritized classification based on farm and herd size—both in absolute terms and relative to the number of workers—to assign them to the most representative type.

Finally, we assigned clusters to EFF. This process involves placing a new sample (EFF) in the clusters created by HCPC via multinomial logistic regression. The explanatory variable was the cluster, and the explicative variables were those used for the MFA. This enabled us to compare the distribution of clusters between the BFF and EFF populations. We did not extensively focus on significance tests for the results as the studied population covers all French farms. However, p-values were used to highlight the most notable differences between the BFF and the EFF. p-values were not used as inferential statistics but rather as a descriptive tool to emphasize the magnitude of differences observed in the dataset.

3 Results

As shown in Supplementary Table 1, the production orientations with the largest numbers of BFF are beef cattle (18,651 farms) and dairy cattle (15,806), followed by poultry (4,445) and meat sheep (4,039). However, the orientations with the highest proportion of BFF are goat farming (42.3%), meat sheep (41.6%), and beekeeping (41.6%). The characteristics of BFF as a whole and across four production orientations compared to those of EFF are given, respectively, in Supplementary Tables 2, 3.

3.1 Diversity of BFF by production orientation

The BFF analysis resulted in the construction of three to six clusters per production orientation. The colors used to represent clusters on maps and figures are based on the analysis presented in the second part of the results. In the tables, continuous variables are expressed as median values, whereas categorical variables are expressed as percentages.

3.1.1 Dairy cattle

For dairy cattle farms, we obtained three clusters, which are presented in Table 2 and mapped in Figure 3. The first cluster (dairy cattle 1 [DC1]) gathers the largest proportion of dairy cattle BFF (57%). This cluster has the highest dimensions per worker, total dimensions, and stocking rate among the three clusters. It is the only cluster with a substantial proportion of maize fodder in the fodder area (39%). Participation in quality schemes, such as organic certification, quality labeling, origin labeling, or short-value chains, is extremely low. The mapping of this cluster shows a high concentration in France's historical (and today intensive) dairy production areas, particularly in Brittany, Normandy, and Pays de la Loire. The second cluster (dairy cattle 2 [DC2]) assembles smaller farms per worker and in total, with 59 livestock units (LU) per full-time equivalent (FTE), 141 LU in total, 45 hectares (ha) per FTE, and 105 ha in total. DC2 BFF have the highest proportion of permanent grassland in the fodder area (85%), with maize fodder being almost nonexistent. Moreover, 78% of these farms have an official sign of quality or origin. However, these farms engage very little in other quality initiatives. DC2 assembles 27% of dairy cattle BFF, mostly located in areas of famous protected designation of origin (PDO) cheese production, specifically in the three regions of Franche-Comté, Normandy, and Auvergne. The BFF in the third cluster (dairy cattle 3 [DC3]) have the smallest size per worker and total size (54 LU/FTE and 133 LU, 40 ha/FTE, and 98 ha). These BFF have the highest level of organic certification (74%) and engagement in short-value chains (56%). Just over half of the fodder area consists of permanent grassland, with maize fodder being almost nonexistent. This cluster is distinctive as 25% of its farms have a workforce composed of at least 20% wage labor (Supplementary Table 4). DC3 comprises the smallest proportion of dairy cattle BFF (16%), predominantly located in areas similar to those of DC1, which are historically specialized in intensive dairy production. However, DC3 farms are also found in other regions, such as the Grand Est, and sometimes in more challenging natural conditions, like the eastern part of the Massif Central. All three clusters consist of over 60% of farming partnership (GAEC), and the proportion of female farm managers is of a similar magnitude between clusters (30%).

3.1.2 Dairy goat

For dairy goat farms, we obtained three clusters, which are presented in Table 3 and Supplementary Table 5. They are also mapped in Supplementary Figure 2. Similar to that in dairy cattle farms, the

TABLE 2 Characteristics of dairy cattle BFF's clusters.

Dairy cattle					
Variables	DC1 *N* = 8,993[1] = 57%	DC2 *N* = 4,293[1] = 27%	DC3 *N* = 2,520[1] = 16%	Overall, *N* = 15,806[1]	*p*-value[2]
Workforce size, outside outsourcing	2.38	2.18	2.50	2.37	<0.001
Share of wage labor	0	0	0	0	<0.001
Herd per worker	89	59	54	75	<0.001
Farm size per worker	54	45	40	49	<0.001
Importance of crop production	0.12	0.02	0.05	0.07	<0.001
Diversity of animal species	0.78	0.79	0.79	0.78	<0.001
Stocking rate	1.69	1.32	1.34	1.50	<0.001
Share of permanent grassland	0.40	0.85	0.57	0.53	<0.001
Share of maize fodder	0.39	0.00	0.01	0.24	<0.001
Organic certification (%)	0.1	1.6	74	12	<0.001
Other official labels identifying quality or origin (%)	7	78	8.8	27	<0.001
Short-value chains					<0.001
None (%)	94	78	44	82	
On-farm processing OR short supply chain (%)	3.5	12	6.9	6.3	
On-farm processing AND short supply chain (%)	2.1	10	49	12	
Herd size (LU)	210	141	133	177	<0.001
UAA (ha)	125	105	98	115	<0.001
Legal status					
1 = Individual farm	12	20	17	15	
2 = GAEC	61	68	62	63	
3 = EARL	24	11	18	19	
9 = Other legal entity	3.9	1.5	2.7	3.1	
Share of female farm managers	0.33	0.33	0.33	0.33	<0.001

[1]Median; n (%).
[2]Kruskal–Wallis rank sum test; Pearson's Chi-squared test.

BFF from the first goat cluster (dairy goat 1 [DG1]) are characterized by an extremely large size per worker and total size. The certification level is quite low for organic certification and quality labels, and only 10% of the farms are involved in short-value chains. Furthermore, only 32% of DG1 BFF are individuals, and they have the lowest share of female farm managers. This cluster represents 29% of the goat BFF, which are mainly located in the historical dairy goat production areas, i.e., in the western part of France (Pays de la Loire and Center Val de Loire Regions) and in Ardèche Department. The second cluster (dairy goat 2 [DG2]) assembles much smaller BFF than DG1 (approximately four times less LU/FTE and three times less LU than DG1). It has the largest workforce (2.5 FTE) and is the only goat cluster where 25% of the farms' workforce consists of at least 33% waged labor. Permanent grassland constitutes a considerable proportion of the fodder area with a median of 42%. DG2 is the only cluster with a substantial crop activity, with a median plant SGP of 39% of the total SGP. Approximately 50% of DG2 farms have official quality or origin labels, and over 50% process their production and sell through short-value chains. This cluster represents 17% of the goat BFF, notably concentrated in three major regions of PDO goat cheese production, as the Drôme and Ardèche Departments, the Lot Departments and the Center Val de Loire Region. Dairy goat 3 (DG3) BFF have similar size per worker to those from DG2 but a much smaller workforce (1.5 FTE), making them the smallest in terms of total size (40 LU and 21 ha). These farms are strongly associated with on-farm processing and short-value chains as only 7% of DG3 BFF are not at all engaged in such activities. Permanent grassland dominates and accounts for the entire fodder area for half of the farms. DG3 BFF are the most labeled in organic farming (34%), whereas few farms have other labels (9%). DG3 comprises 67% individual farms, which is approximately twice as much as DG1 and DG2. Moreover, they have the highest percentage of female farm managers. This cluster represents the majority of goat BFF, accounting for nearly 60% of them, mainly located in mountainous areas with less favorable natural conditions, such as Alps, Pyrenees, Massif Central areas and Corsica.

3.1.3 Beef cattle

For beef cattle farms, we obtained three clusters, which are presented in Table 4 and Supplementary Table 6 and mapped in Supplementary Figure 3. The BFF in the first beef cattle cluster (beef cattle 1 [BF1]) have the largest herd per worker (70 LU/FTE), the highest stocking rate (1.13 LU/ha), and the largest proportion of permanent grassland in the fodder area (91%). It corresponds to 55% of beef cattle BFF, 59% of which are under individual status. In

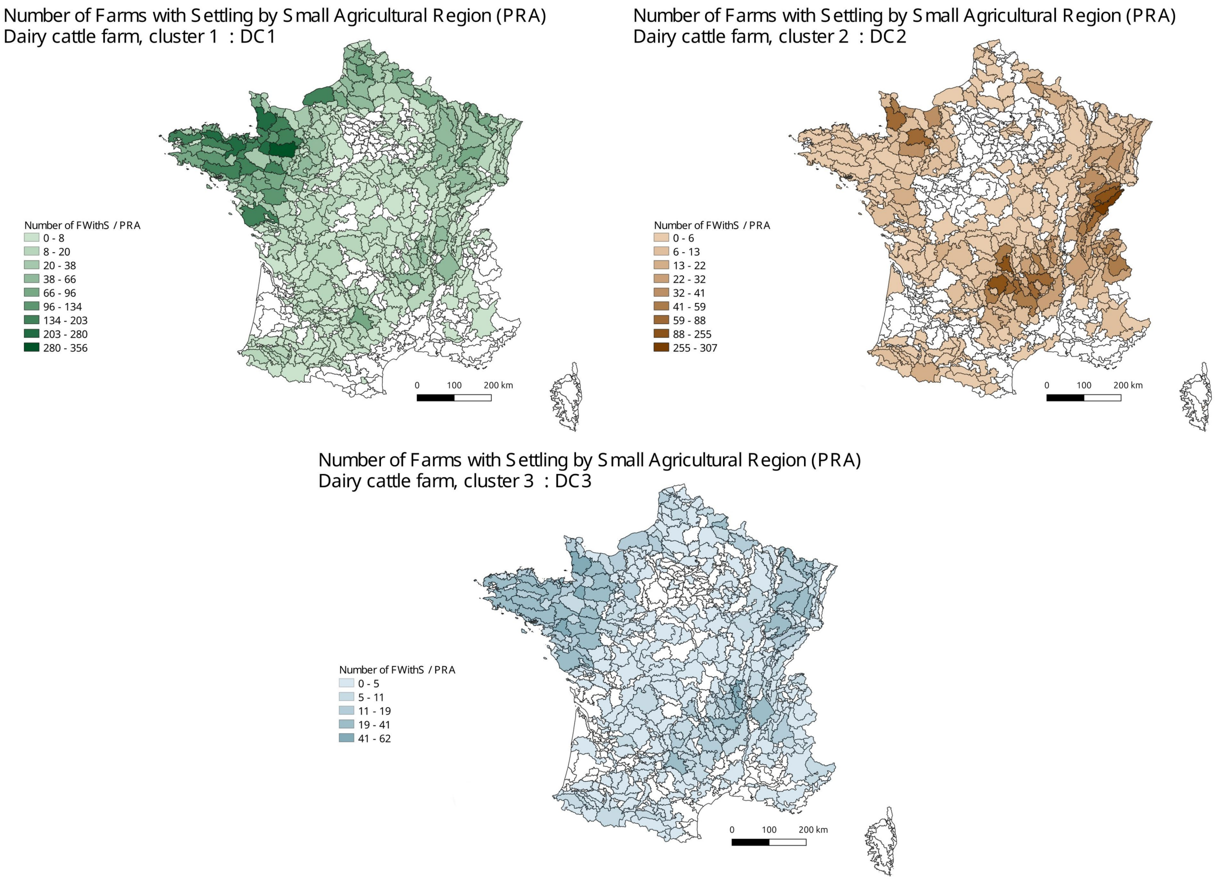

FIGURE 3
Location of dairy cattle BFF. The different maps present the different clusters.

addition, 25% of farms have nonorganic labels, but none are labeled as organic, and only 12% are engaged in short-value chains. These farms are mainly situated in the historical beef cattle production areas such as Massif Central and Limousin regions. Beef cattle 2 [BF2] BFF have a comparable overall herd size (85 LU) with BF1; however, the size per worker is smaller (53 LU/FTE), reflecting a higher number of FTEs. Its UAA is considerably larger (98 ha) than that of BF1, whereas the UAA per worker remains similar. Half of the BF2 farms have an organic label, and 80% are involved in short-value chains. This cluster gathers 17.8% of beef cattle BFF and does not appear to be concentrated in any specific region. The BFF in the third beef cattle cluster (BF3) are notable for the substantial contribution of plant-based SGP to their total SGP (71%) and for having the largest farm areas (total and per worker). This farm category is mainly engaged in crop farming, with animal activities as a secondary occupation and are found throughout France. They account for 27% of beef cattle BFF.

3.1.4 Pig farming

For pig farms, we obtained four clusters, which are presented in Table 5, Supplementary Table 7 and mapped in Supplementary Figure 4. The first pig BFF cluster (PIG1) contains the largest pig BFF in terms of LU per worker, with 242 LU/FTE. Furthermore, it has the highest total LU (440), and its UAA is comparable with those of other clusters. The median workforce size is 2 FTE, with one-fourth of PIG1 BFF having about a third or more of their workforce consisting of wage workers (Supplementary Table 7). These farms have extremely little commitment to quality schemes, with less than 1% for each type of initiative. Most of these farms are EARL (44%), but 19% have complex legal forms. They account for 43% of pig BFF and are predominantly located in Brittany, the region that concentrates more than half of the French's pig population as of 2020. Meanwhile, the second pig cluster (PIG2) corresponds to large farms in terms of total and per worker LU (146 LU/FTE and 358 LU), even though LU/FTE is approximately half that of PIG1. The work collective is quite large, consisting of 2.11 FTE, with the same share of wage labor as PIG1 (Supplementary Table 7). Moreover, 97% of these farms have at least one official quality or certification. However, only 1.1% of PIG2 farms are organic, and only 35% participate in short-value chains. PIG2 corresponds to 20.5% of pig BFF, which are mostly found in the same areas as PIG1 but also in Corsica where there are some famous PGI for cured pork products. The third cluster (PIG3) assembles BFF with the smallest herds (26 LU/FTE, which is 10 times less than PIG1) and land areas per worker. These farms are the most committed to the organic label (40%) and to short-value chains (85%). They are mostly individual farms. They constitute 27% of the sample and are primarily concentrated in mountainous areas, such as the Corsica and Ardèche Departments, with a long-standing tradition of outdoor pig farming. Finally, the last pig cluster (PIG4) also consists of farms with a small total size (39 LU). The number of LU/FTE is twice that of PIG3. All farms in this cluster are involved in either on-farm processing or short supply chains, but only a small percentage of farms have organic or other labels (17 and 19%, respectively). Furthermore, 57% of these farms are under individual status. This cluster represents

TABLE 3 Characteristics of dairy goat BFF's clusters.

	Goat				
Variables	DG1 N = 506[1] = 23%	DG2 N = 385[1] = 17%	DG3 N = 1,321[1] = 60%	Overall, N = 2,212[1]	p-value[2]
Workforce size, outside outsourcing	2.00	2.50	1.50	2.00	<0.001
Share of wage labor	0	0	0	0	<0.001
Herd per worker	61	15	13	17	<0.001
Farm size per worker	38	19	14	20	<0.001
Importance of crop production	0.06	0.39	0	0	<0.001
Diversity of animal species	1	1	1	1	0.002
Stocking rate	1.7	0.9	1	1.1	<0.001
Share of permanent grassland	0.41	0.42	1	0.8	<0.001
Share of maize fodder	0	0	0	0	<0.001
Organic certification (%)	7.5	14	34	24	<0.001
Other official labels identifying quality or origin (%)	18	46	9.1	18	<0.001
Short-value chains					<0.001
None (%)	90	29	7.1	30	
On-farm processing OR short supply chain (%)	3.8	18	7.9	8.7	
On-farm processing AND short supply chain (%)	6.1	53	85	61	
Herd size (LU)	113	40	20	29	<0.001
UAA (ha)	74	55	21	36	<0.001
Legal status					<0.001
1 = Individual farm	32	36	67	53	
2 = GAEC	40	34	23	29	
3 = EARL	26	25	8.9	16	
9 = Other legal entity	2.6	5.7	1.6	2.5	
Share of female farm managers	0.33	0.5	0.5	0.5	<0.001

[1]Median; n (%).
[2]Kruskal–Wallis rank sum test; Pearson's Chi-squared test.

only 9% of pig BFF. Due to the small number of farms, no conclusion can be drawn regarding the geographical distribution of PIG4.

3.2 Transversal typology across production orientations

We compared the clusters across production orientations and observed common characteristics, mainly in terms of size and engagement in quality schemes. We grouped these similar clusters into transversal types, which are presented below. Although these types show notable trends, variations exist within each type that correspond to different production orientations. Notably, some clusters were specific to certain production orientations, such as meat sheep 3 (MS3; Supplementary Table 8), Dairy Sheep 5 (DS5) and DS6 (Supplementary Table 9), and PIG4 (Table 5).

3.2.1 Type A: large-scale farms mostly conventional

Type A, represented in green on maps and graphs, is composed of BFF characterized by large herds and areas (total and per worker) and a high number of FTEs (two or more). Excluding dairy goat farming, a majority of new entries into livestock farming between 2010 and 2020 took place on large farms (type A), which represented between 43% of BFF in pig farming and 58% in poultry farming. These farms are large both in absolute terms (LU, UAA) and relative to the workforce. These type A farms have practically no commitment to organic labels or short-value chains. This type is identified across all production orientations. Among ruminant systems, type A farms are generally characterized by the highest stocking rates (LU/UAA) and the largest share of maize fodder in the fodder area. However, in beef cattle and meat sheep farming, maize fodder remains marginal, and permanent grassland predominates—a pattern consistently observed across all clusters within these two production orientations. Type A BFF are primarily located in their historical production areas, which have often undergone a process of specialization since the 1950s or later. Examples include dairy cattle, goat, pig and dairy multispecies (Supplementary Figure 7; Supplementary Table 10) farms in the western regions of France, beef cattle farming in the Massif Central area, meat sheep farming in the south and central-west of France (Supplementary Figure 5), dairy sheep in the mid-mountains areas of Aveyron and Pays Basque (Supplementary Figure 6), poultry in western France (Supplementary Figure 8; Supplementary Table 11). However, within this structurally large type A category, three production

TABLE 4 Characteristics of beef cattle BFF's clusters.

Beef cattle					
Variables	BF1 N = 10,277[1] = 55%	BF2 N = 3,313[1] = 18%	BF3 N = 5,061[1] = 27%	Overall, N = 18,651[1]	p-value[2]
Workforce size, outside outsourcing	1	1.63	1.38	1.13	<0.001
Share of wage labor	0	0	0	0	<0.001
Herd per worker	70	53	32	56	<0.001
Farm size per worker	62	64	72	65	<0.001
Importance of crop production	0.04	0.1	0.71	0.12	<0.001
Diversity of animal species	1	1	1	1	<0.001
Stocking rate	1.13	0.89	0.54	0.96	<0.001
Share of permanent grassland	0.91	0.84	0.74	0.86	<0.001
Share of maize fodder	0	0	0	0	<0.001
Organic certification (%)	0	50	2	9.5	<0.001
Other official labels identifying quality or origin (%)	25	19	19	22	<0.001
Short-value chains					<0.001
None (%)	88	20	74	72	
On-farm processing OR short supply chain (%)	12	9.4	22	14	
On-farm processing AND short supply chain (%)	<0.1	71	4.2	14	
Herd size (LU)	83	85	43	70	<0.001
UAA (ha)	73	98	102	86	<0.001
Legal status					<0.001
1 = Individual farm	59	43	44	52	
2 = GAEC	28	35	18	27	
3 = EARL	9.2	16	27	15	
9 = Other legal entity	4	6.2	11.3	6.5	
Share of female farm managers	0	0	0	0	<0.001

[1]Median; n (%).
[2]Kruskal–Wallis rank sum test; Pearson's Chi-squared test.

orientations stand out: beef cattle, meat sheep, and poultry. In these cases, a significant share of type A BFF are certified with official quality or origin labels, particularly Label Rouge. For instance, 25% of type A beef cattle BFF, 46% of type A poultry BFF, and up to 67% of type A meat sheep BFF are certified with an official quality or origin label.

3.2.2 Type B: medium-scale farms with quality or origin certifications and emphasis on permanent grassland

Type B farms, shown in brown, are characterized by medium size (total and per worker) and a strong association with the official quality or origin certifications: between 44% (dairy multispecies) and 97% (pig BFF) have at least one nonorganic label. This type is particularly prominent in dairy productions, representing 23% of goat BFF and 38% of dairy multispecies BFF. Type B is found in all production orientations except beef cattle, meat sheep, and poultry. In these three sectors, although quality labels are widespread, the large size of the farms led to their classification as type A. Among ruminant livestock farms, type B is characterized by over 80% of the fodder area being permanent grassland. These farms are almost always located in mountainous areas, with numerous Geographical Indications. Within each production orientation, type B farms use the same number of FTEs as type A farms. Type B farms are clearly identified for dairy cattle, which are closely associated with permanent grassland and pig farming. Type B dairy sheep BFF are also numerous, mainly located in the Aveyron Department, due to Roquefort PDO, and in the Pyrénées Atlantiques Department, linked to Ossau-Iraty PDO. The share of permanent grassland in the fodder area is higher in Ossau-Iraty production than in Roquefort. For goat and dairy multispecies BFF, the commitment to quality or origin certifications is lower but still significant (over 40%). These farms also tend to have significantly smaller herds than type A farms and are located in cheese-producing regions.

3.2.3 Type C: small-scale farms with organic labels and short supply chains

Type C farms, shown in blue, are characterized by short-value chains and organic certification (between 32% for dairy multispecies and 74% for dairy cattle of type C farms are labeled organic). This type includes the smallest farms (total and per worker) and has the highest level of feminization among farmers. It is found in all production orientations, except for meat sheep farming. Moreover, it is more or less important depending on the production orientation and accounts for 60% of goat BFF but only 16% of dairy cattle BFF. Analysis of the location of these type C BFF shows greater dispersion compared with

TABLE 5 Characteristics of pig BFF's clusters.

Pig						
Variables	PIG1 *N* = 761[1] = 43%	PIG2 *N* = 365[1] = 21	PIG3 *N* = 488[1] = 27%	PIG4 *N* = 166[1] = 9%	Overall, *N* = 1,780[1]	*p*-value[2]
Workforce size, outside outsourcing	2	2.11	1.50	1.08	2	<0.001
Share of wage labor	0	0	0	0	0	<0.001
Herd per worker	242	146	26	53	133	<0.001
Farm size per worker	36	38	21	24	31	<0.001
Importance of crop production	0.14	0.14	0.11	0.19	0.14	0.3
Diversity of animal species	1	1	1	1	1	<0.001
Organic certification (%)	0.3	1.1	40	17	13	<0.001
Other official labels identifying quality or origin (%)	0.8	97	2.7	19	23	<0.001
Short-value chains						<0.001
None (%)	99	65	15	0	60	
On-farm processing OR short supply chain (%)	0.3	0	0	100	9.4	
On-farm processing AND short supply chain (%)	0.4	35	85	0	31	
Herd size (LU)	440	358	34	39	249	<0.001
UAA (ha)	65	87	36	31	57	<0.001
Legal status						
1 = Individual farm	22	26	55	57	35	
2 = GAEC	15	29	15	14	18	
3 = EARL	44	35	22	20	34	
9 = Other legal entity	19	10	8	9	14	
Share of female farm managers	0	0	0	0	0	0.6

[1]Median; n (%).
[2]Kruskal–Wallis rank sum test; Pearson's Chi-squared test.

type A and B farms. Most types C farms are located in mountainous areas or the south of France—and it is particularly true for goat farming—characterized by more environmental constraints and, consequently, more pastoral systems. However, several hundred type C BFF for dairy cattle, goats, and pigs are located in more fertile regions historically known for intensive agricultural livestock practices.

3.2.4 Type D: crop-based farms with secondary animal farming activities

Finally, type D farms, shown in purple, are mainly focused on crop production, with livestock being a secondary activity. These farms have the smallest herds (total size and per worker). This type was not identified for dairy farms but is present in meat sheep BFF (with a significant level of organic certification) and poultry, associated with a large workforce. This type is also present in beef cattle and dairy multispecies BFF. It does not seem to be particularly associated with specific regions or ecosystems.

3.2.5 Distribution of earlier farmer's farms between BFF clusters

The cluster assignment conducted on EFF allows us to observe the similarities and differences in the distribution of farms within the previously defined types. The Figure 4 presents the proportion of BFF and EFF out of the total number of farms. We have distinguished between BFF (dark color) and EFF (light color). The figures for other production orientations are presented in Supplementary Figures 9–12. As shown in Figure 4, the BFF and EFF distributions are generally similar, regardless of the production orientation. In almost all situations, except for dairy goat, meat sheep (Supplementary Figure 9), dairy sheep (Supplementary Figure 10) and dairy multispecies (Supplementary Figure 11), type A is the predominant type. However, it represents a higher percentage of EFF than of BFF. Conversely, type C is more prevalent among BFF than among EFF. Types B and D have the most similar distribution among BFF and EFF. EFF characteristics are detailed from Supplementary Tables 12–19.

Comparison of the characteristics of BFF and EFF type A farms indicates that BFF are slightly larger in absolute terms. For example, +5% for pigs and +38% for dairy cattle (LU) and +5% for goats and +37% for beef cattle (ha of UAA). However, the number of animals per worker (LU per FTE) is only slightly higher or even smaller among BFF, ranging from −4.7% for pigs to +14.8% for beef cattle. Similarly, the surface area managed per worker (UAA per FTE) is smaller or moderately higher, with values ranging from −9.5% for goats to +16.1% for pigs.

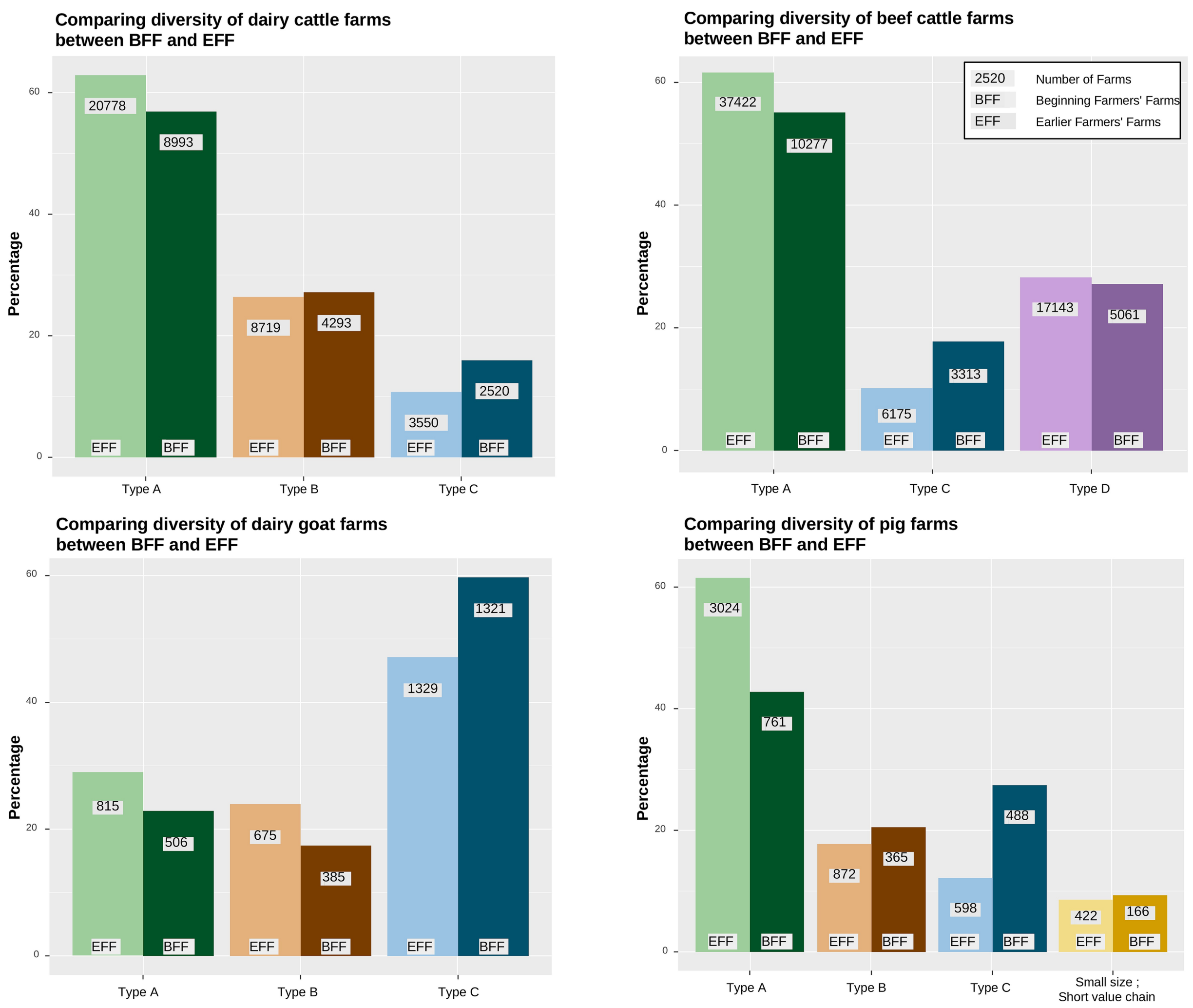

FIGURE 4
Diagrams comparing the distribution of BFF (strong color) and EFF (light color) among the clusters defined by statistical analysis by production orientation. The color shades vary depending on the farm types.

4 Discussion

The purpose of this discussion is to gain a deeper understanding of the realities represented by these types and how they align—or fail to align—with the requirements of an agroecological transition. The literature is here invited to precise the signs observed with our analysis of the BFF in the Agricultural Census.

4.1 Three pathways into livestock farming with uneven engagement in the agroecological transition

4.1.1 Beginning livestock farmers on small-scale organic farms with short-value chains: a shift toward agroecology?

Type C farms are particularly noteworthy as they represent a larger proportion of BFF than EFF. Indeed, according to the literature (Alonso, 2011; Wezel and Peeters, 2014; Malak-Rawlikowska et al., 2019), these strategies relying on organic certification, on-farm processing, and short supply chains, are often employed to enhance product value and profitability, particularly in contexts where access to land is constrained (Lécole and Thoyer, 2021). As regards environmental issues, the high rate of organic certification is advantageous in terms of reducing the use of synthetic inputs, such as fertilizers, pesticides, herbicides, and antibiotics. Associated with the lower stocking rate (LU/ha) in our results, the farms of type C could have greater feed autonomy, fewer purchases of feed produced outside the farm, and lower nutrient concentrations resulting from manure spreading, as showed for example by Mondière et al. (2024) or Genest-Richard et al. (2025). Nevertheless, type C farms are not those with the highest share of permanent grassland within their fodder areas, particularly for dairy and beef cattle. In this regard, they are less aligned with agroecological principles.

The location of these type C farms in mountainous regions or in the south of France but also in more fertile regions is consistent with the findings of Horvath et al. (2023) who identified similar farms—both in size and marketing strategies—in mountainous and highly urbanized areas as a result of either biophysical or urban constraints. In addition, studies by Chevallier et al. (2014) and Nozières-Petit (2019) reported that population density and proximity to urban areas could influence the involvement of farms in short-value chains, potentially explaining the spatial distribution of type C farms. These farms could also play a pivotal role in renewing the agricultural population in France. With lower LU/FTE and ha/FTE, type C farms could become an important source of employment in rural areas facing agricultural decline, particularly in mountainous regions.

The greater share of type C farms among BFF compared to EFF supports previous studies that have identified the emergence of new forms of farms in Europe, characterized by organic production (Nozières-Petit, 2023), short-value chains (Kneafsey et al., 2013; Augère-Granier, 2016), or a combination of these attributes (Nozières-Petit, accepted). The growing prominence of these small farms could indicate the beginning of an agroecological shift. Van Der Ploeg et al. (2019) reported that agroecological farms—characterized by smaller size, pasture-based systems, and minimal soil tillage—can achieve better economic performance than conventional or industrial farms. However, type C farms remain considerably underrepresented, even among BFF, except in goat farming. In addition, these farms are, on average, much smaller in terms of livestock numbers and total hectares than type A and B farms. It can be inferred that they currently contribute only an extremely small share to the production of animal products.

4.1.2 Entering livestock farming through certified grassland-based systems

A considerable proportion of beginning farmers establish their operations on type B farms, particularly dairy farms with strong adherence to quality labels and and rely heavily on permanent grassland for ruminants. Quality labels, linked to the origin or not, define rules related to animal welfare, feeding, breed, production seasonality, product processing methods, etc. Although the associations between quality approaches and agroecology are debated (Hirczak, 2011; Aubron et al., 2014; Vandecandelaere et al., 2021; García-Hernández et al., 2022) and depend on each label andproduction orientation, it can be argued that most of the time, these rules improve the environmental sustainability of animal farming. Moreover, these labels are often integrating environmental criteria in their specification (Husson et al., 2019), which would enhance this contribution. Through the highest proportion of permanent grassland in their fodder area, these type B farms could provide various ecosystem services related to biodiversity, regulation of water flows and erosion, carbon storage, etc. (Dumont et al., 2019; Pédèches et al., 2023), which seem particularly interesting from an agroecological perspective. In addition, PDO and PGI labels can contribute to the preservation of local rustic breeds by maintaining their populations (Zjalic et al., 2012). These type B BFF are situated in traditional French PDO cheese production zones, typically in mountainous and remote areas where rural development is a key concern. When well-implemented, geographical indications (GIs) can significantly foster such development by supporting local value chains, tourism, and related sectors (Campagne and Pecqueur, 2014; Crescenzi et al., 2022). However, the literature highlights that these benefits are not uniform and may be limited by market dynamics—particularly the emphasis on exports—which can conflict with the agroecological aim of reinforcing local food systems (Husson et al., 2019). Despite these tensions, the stability ensured by origin- and quality-based labels remains essential for sustaining agricultural activity in these vulnerable regions. This contributes not only to combating rural depopulation but also to securing better incomes for farmers and supporting the production of high-quality food, aligning with the goals of agroecological transition in its extended meaning (Gliessman, 2016). Moreover, certain requirements within these specifications encourage the adoption of agroecological principles (as defined, for example, by Dumont et al., 2013) at both the farm and territorial levels. However, the ability of such schemes to engage production systems in sustainable development across multiple scales still needs to be strengthened (Vandecandelaere et al., 2021).

4.1.3 Large-scale farms remain the dominant entry model into livestock farming, raising questions about the agroecological transition

We showed that between 2010 and 2020, most entries in the French animal farming sector occurred on large farms, i.e., in type A. The highest stocking rates (LU/UAA) for this type A farms, especially for ruminants, may indicate low self-sufficiency levels in animal feed and a significant pressure for manure spreading. We observed a geographical concentration of this most intensive livestock farming (particularly dairy and monogastric farming) which is consistent with Domingues et al. (2018) who highlighted such concentration primarily in the most fertile regions, especially in Western France. Authors such as Gerber et al. (2008); Gaigné (2012) showed that this high geographical concentration of large farms could pose considerable pollution risks related to the management of livestock effluents.

The higher proportion of maize fodder in these type A farms may increase animal feed availability; however, it often requires the purchase of concentrates to meet protein needs which is not considered very agroecological. Several studies underline that while protein can be produced on farms, it appears that farms heavily relying on maize fodder are those that purchase the most concentrates (Paccard et al., 2003; Ineichen et al., 2014; Ghozlane et al., 2021). Moreover, the low proportion of permanent grassland within fodder areas seen in type A farms probably limits the biodiversity potential on farm plots (as highlighted by Lebacq et al., 2013; Schils et al., 2022). Finally, except for type A farms in beef cattle, sheep meat, and poultry production—which are heavily certified under quality and origin schemes (mainly Label Rouge)—the remaining farms exhibit extremely low levels of certification in quality initiatives or involvement in short supply chains. All these aspects call into question the capacity of these large farms to undertake an agroecological transition, not only at the farm level but also at broader spatial and systemic scales, as described by Gliessman (2016).

The predominance of type A farms among BFF question their capacity to enter the agroecological transition. In the literature, there are debates regarding the ability of large farms to address the challenges posed by agroecology. Indeed, some studies reported that large farms can be more efficient, particularly in terms of input use efficiency (Ren et al., 2019). But it is often small farms which are highlighted as more sustainable in terms of biodiversity (Belfrage et al., 2005). In the same way, Rudel et al. (2016) demonstrated that small diversified farms tend to adopt more sustainable practices on average but that farm size does not determine the level of sustainability. Ebel (2020) emphasized that there is no "natural" link between farm size and agroecology, arguing that practices are more decisive factors in determining the sustainability of farms than their size. Nevertheless, large farms often use more digital tools (Norton et al., 2019). These tools are part of precision agriculture, an option that is commonly proposed to reduce the environmental impact of large livestock farms (Ingrand, 2018). This approach aims to increase production per worker while minimizing environmental impacts. However, current research tends to temper the perceived benefits and effectiveness of precision agriculture, highlighting the need for further studies to elucidate its impacts (Tullo et al., 2019; Lovarelli et al., 2020; Papakonstantinou et al., 2024).

If we observed that BFF type A farms are larger than EFF in absolute terms, our results showed a smaller increase, even a decrease in the number of animals per worker, especially in pigs and beef cattle. Three hypotheses can be proposed to explain the discrepancy between absolute farm enlargement and enlargement per worker, with contrasted implications in terms of agroecology. The first hypothesis is that the increase in surface area or livestock may not have occurred yet, as the beginning farmer start with a smaller herd than they eventually aim to manage later. Expansion is expected to occur later. Gale (1994) and Katchova and Ahearn (2016) reported that in the United States, post-settlement enlargement is a common phenomenon, particularly among young beginning farmers (below 35 years old). The second hypothesis is that we may have reached a limit in terms of the number of hectares and animals that can be managed per worker, as also suggested by Dubrulle et al. (2023), linked to a limit of possible gain obtained by equipment. Farm expansion is still possible, but it would likely require the addition of more workers to manage these larger operations. The third is that a part of the workforce may be shifting toward the implementation of more agroecological practices, which is likely to demand greater labor input (Durham and Mizik, 2021; Volken and Bottazzi, 2024; Bainville et al., 2025), particularly during transition from conventional to agroecological practices (Stratton et al., 2021).

4.1.4 Conclusion

Regarding the distinction between types A, B, and C farms, we find that types A and C align well with well-documented trends in the literature. Numerous studies have shown the ongoing enlargement of farms (type A; Bokusheva and Kimura, 2016) as well as the emergence of smaller-scale farms engaged in organic production and short supply chains (type C). However, the identification of type B farms—characterized by their strong association with official quality and origin certifications—highlights an intermediate pathway that has received comparatively little attention. These farms may represent a "middle way" currently chosen by a significant share of beginning livestock farmers, combining moderate to large farm size with a commitment to quality labels. This nuance enriches the usual dichotomy between large conventional and small organic farms, and points to the importance of considering certification schemes as a key factor in the agroecological transition in livestock farming.

4.2 Relevance of our method and limits of the study

One of the key strengths of our approach lies in its cross-sectoral and integrative perspective, enabling a comprehensive exploration of the shared dimensions underpinning the agroecological transition and, more broadly, the sustainable development of French livestock farming. While the analysis primarily focused on environmental aspects, it also incorporated social and economic considerations. In particular, examining the prevalence of specific value chains or quality labels among BFF provides insights not only into the emergence of fairer and more rewarding commercial opportunities for producers, but also into the promotion of more qualitative and differentiated food choices accessible to a broader range of consumers (Therond et al., 2017; Chiffoleau and Dourian, 2020). However, identifying relevant variables across all production orientations available in the agricultural census presents some challenges. We had to rely on fairly general variables, which restricts the depth of information. For example, we were unable to use indicators such as Treatment Frequency Indexes to assess the use of pesticides, or levels of farms' equipment, as these were only collected for a small sample of farms. Other dimensions are missing in these data, such as the origin and previous experience of beginning farmers. Assessing the level of agroecological engagement based solely on our set of variables remains challenging, as these indicators may reflect different realities depending on the farming system and local context. Further research is needed to understand the changes really at work when a trigger event—such as the arrival of a beginning livestock farmer—takes place (Sutherland et al., 2012), particularly in terms of their potential to initiate an agroecological transition. Such research could investigate the path dependency mechanisms affecting farms and how these mechanisms influence their capacity to undergo an agroecological transition. Our analysis does not allow us to distinguish between the various forms of entry into livestock farming, especially farm creation versus the transfer of existing operations, which represent contrasting types of trigger events.

An analysis of the trajectories [as proposed by Moulin et al. (2008) or Vega-Martinez et al. (2024)] of the farms with recent entries would help consolidate this notion of trigger event. Indeed, by comparing the types of BFF and EFF, we show that there is an association between farm entry and the characteristics of the farms involved. However, we cannot determine whether these characteristics were already present prior to the entry. Moreover, we compared farms at different stages in their trajectories, so the observed trends may simply reflect these temporal differences rather than a structural transformation in the French livestock sector. Additionally, assessing the capacity of livestock farming systems to engage in the agroecological transition and achieve greater sustainability requires a multiscale approach—from the farm to territorial and even international levels—utilizing concepts such as restricted and extended sustainability (Terrier et al., 2010) and holistic frameworks like those proposed by Zahm et al. (2024).

As emphasized by the FAO (2024a), agroecology is essential for building food systems that are both productive and capable of providing high-quality food while ensuring the preservation of natural resources and decent working conditions for farmers. Therefore, many countries or regions may be interested in conducting a similar study. Using agricultural census data, our method allows us to work on a complete population of farms and can be easily reproduced in other areas. Indeed, most European Union countries and the European Union itself, conduct regular agricultural censuses. Thus, access to similar structural and functional data could facilitate the development of a farm typology based on their alignment with agroecological principles. These data may also be available in non-european countries, collected either by national governments or by other organizations (NGOs, etc.). However, identifying BFF may be more challenging if the necessary data is missing or unreliable in the agricultural census. In our case, this identification was made possible thanks to the MSA COT-NS databases, but in other contexts, a specific method would be needed to address this limitation. Moreover, applying this approach in multiple countries could enable comparative analyses to assess whether different regions are progressing similarly—or unevenly—along the path toward agroecological transition.

5 Conclusion

The cross-cutting approach across production orientations adopted in this study enables a comparative perspective between farms with and without beginning farmer's entry in recent years. This approach provides valuable insights into the sector's dynamics and its connections to agroecology. Indeed, compared to earlier farm's farmers, a larger part of beginning livestock farmers' farms are certified organic or under quality label and/or are involved in short supply chains, which could indicate a shift toward agroecology. As highlighted by Dumont et al. (2021) or Rauw et al. (2023), promoting these models to drive an agroecological transition requires changes in public policies, land allocation rules, support for activities, market regulation and distribution of public subsidies. This study also shows that the majority of beginning farmers establish on farms that do not demonstrate a strong commitment to agroecology. Beginning farmers mainly establish on large farms, which are rarely certified with quality labels and are concentrated in areas specialized in livestock farming, with potential mineral surpluses. For ruminants, particularly dairy cattle, there is a significant reliance on maize (and likely soybean imports). These farms do not appear to be the most capable of addressing the challenges posed by the agroecological transition, even though adaptation pathways, as precision agriculture for example, are currently being investigated. Tittonell et al. (2020) argued that the agroecological transition of large farms requires restructuring of tax systems and public subsidies along with the commitment of public authorities and all relevant stakeholders to promote the adoption of agroecological practices.

To further advance this study, it would be valuable to overcome the limitations of the Agricultural Census indicators regarding agroecology. This could involve examination of feeding practices, such as grazing or the use of external inputs, by beginning livestock farmers. Despite their limitations, Supplementary databases (2015 livestock practice surveys, BDNI and RICA databases for ruminants, Common Agricultural Policy data) could offer additional insights. In addition, conducting field surveys with beginning farmers could shed light on how they select the farms on which they establish, adopt production practices and marketing strategies. It could also reveal to what extent these decisions align—or not—with agroecological principles, whether by personal choice or due to external constraints. With the aging of the European farming population, thousands of hectares and farms will soon be going through this trigger point of transmission. Accordingly, fostering and supporting the agroecological transition in livestock farming systems at this key moment of farm transmission represents a new challenge for research, extension services, and public policies.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: request to access 2020 French Agricultural Census and COTNS MSA datasets should be directed to service@casd.eu, https://www.casd.eu/mettre-a-disposition-ses-donnees-via-le-casd/.

Author contributions

LV: Investigation, Writing – review & editing, Conceptualization, Software, Funding acquisition, Supervision, Writing – original draft, Methodology, Formal analysis, Visualization. CA: Conceptualization, Writing – review & editing, Funding acquisition, Software, Investigation, Writing – original draft, Resources, Validation, Project administration, Supervision, Methodology. JD: Visualization, Writing – review & editing, Methodology, Validation, Software, Data curation, Conceptualization, Supervision. PL: Supervision, Validation, Methodology, Writing – review & editing, Conceptualization, Investigation. MN-P: Project administration, Funding acquisition, Validation, Writing – review & editing, Conceptualization, Methodology, Writing – original draft, Supervision, Resources, Investigation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that Gen AI was used in the creation of this manuscript. We used ChatGPT (OpenAI, GPT-4) to improve the fluency and clarity of the English language during the writing process. All scientific content, analyses, and interpretations were produced by the authors without the use of generative AI.

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The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1624405/full#supplementary-material

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