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Farmer Perception of Links between Grassland Diversity and Animal Health in Relation to Farm Structure

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Abstract: Grasslands cover a substantial share of land area in the world and in Europe, where they are used to feed herbivores and provide a range of ecosystem services. Grasslands also help in animal health maintenance by hosting a diversity of plant species with antioxidant components. This animal health benefit has been under-researched. The aim of this study is to capture how farmers perceive links between grassland diversity and animal health, and to examine whether their perceptions are related to their farm and its structure. For that purpose, we conducted 103 surveys in three regions of France to collect farmers' perceptions regarding animal health, grassland diversity, and the link between the two. We then used factorial analysis of mixed data to study the relationship between the farmers' perceived links between grassland and animal health and their type of farm structure and management. For 61 farmers, there was a strong link between grassland diversity and animal health. However, we found no statistical relationship between the type of farm and the type of farmer-perceived link between grassland diversity and animal health, and the farmers who perceived a strong link employed a wide range of feeding systems. Further research is needed to deeply analyze farmers' practices and perceptions of grassland–health links.

Keywords: livestock; grassland diversity; animal health

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1. Introduction

Grassland as a biome covers more than 40% of the Earth's land surface and is vital to the livelihoods of a billion people around the world [1]. In Europe, grassland is the dominant type of land use for agriculture, covering an area of about 56 million ha [2]. Grasslands are broadly categorized as permanent or semi-natural grasslands, which are composed of perennial or native species in an ecosystem that is managed long-term, typically for more than 5 years, and temporary grasslands, which are composed of species planted less than 6 years ago [3].

Grasslands are mainly used to feed ruminants bred for milk and meat production [4–6], which poses various challenges in terms of nutritional value and production. However, grasslands also provide many other ecosystem services through their permanent vegetation cover and botanical diversity [7,8]. They play a positive role in clean water retention, soil fertility maintenance, and soil structure protection [6]. Grasslands are also important for global carbon sequestration: it has been estimated that grasslands store about 343 billion tons of carbon, which is almost 50 percent more than the carbon stored by forests around the world [9]. Grasslands are equally important for a number of other ecosystem services,

from biodiversity conservation to resources for pollinators, while also providing goods for local economies and spaces and opportunities for recreation [2,8].

Beyond their environmental services, grasslands can also play a role in animal health [10,11]. In fact, diversified grasslands provide grazing livestock with balanced energy and protein nutrition [8]. They are also a good source of medicinal plants. Grassland vegetation can provide a wide number of special compounds called "secondary metabolites", such as carotenoids, phenolic compounds, and vitamins, which are produced by dicotyledons and other grassland plants. These secondary metabolites act as antioxidants, countering problems linked to oxidative stress in several animal species [12–14], while dietary vitamin E and selenium can help reduce the risk of mastitis [15]. Other secondary metabolites also have proven effects on animal health. Condensed tannins enhance antiparasitic activity [16,17]. Plant polyphenols, which include more than 8000 different compounds that all contain a phenol ring, play a role in scavenging capacity and reduce inflammation in farm animals [18]. The effects of grassland and forage species on animals, whether medicinal or toxic, are fairly well known [19,20].

The evidence thus suggests that grassland diversity can potentially play a role in animal health, at the grassland or forage-system level. However, the relevant literature available to date only reports theoretical compositions of plants of permanent and temporary grasslands in terms of secondary metabolites [15,21,22]. Articles in ethnoveterinary science [23] have reported veterinarian uses of several plant species, such as lupins or chamomile. However, to our knowledge, no study has been carried out to investigate the use of species-diverse grasslands for health purposes, and very little is known about existing practices, farmers' knowledge, or the profiles of farms affected by grassland diversity. Petit et al. [24] reviewed ten years of empirical research on farmers' representations of grassland services and found that animal health was not mentioned as a grassland benefit.

It is therefore important to better understand the links—whether positive or negative—that farmers make between their grasslands and the health of their animals, and to characterize the population of farmers that are sensitive or receptive to this issue, in order to better implement future innovations promoting the health benefits of diverse grasslands. Organic farmers may be receptive to such innovations due to the constraints imposed by organic farming standards [25], which encourage the use of alternative medicines and the implementation of practices that promote animal health.

The aim of this article is to capture farmers' viewpoints on how grasslands and grassland diversity are linked to animal health, and to examine whether these perceived links are related to farm structure and management. This investigation was based on the hypothesis that organic farmers would see a strong link between grassland diversity and animal health due to the fact that organic farming standards restrict the use of chemically synthesized drugs.

In order to describe the grassland–animal health link, we proceeded in three steps. First, we studied how farmers defined 'good' animal health and a 'good' grassland. Second, we identified different categories of grassland diversity–animal health linkage as expressed in our sample. Finally, we performed an analysis to explore any relationships between the type of farm system and the type of link expressed.

2. Materials and Methods

2.1. Surveys

This study was part of the PRAIDIV project, a four-year (2020–2024) French national project funded by the French Ministry of Agriculture. The purpose of PRAIDIV is to explore the health benefits for animals provided by grasslands. This study encompassed three regions of France, i.e., Western France, Central France, and Eastern France, which are characterized by a high proportion of grasslands in the utilized agricultural area (UAA), a diverse range of production systems (dairy cows, beef cows, sheep, goats for milk or meat, and so on), and a range of climates (continental, oceanic, and continental to mountain). The technical partners of the PRAIDIV project provided a list of farms in each of these three

regions. All the farms eligible had to have a significant proportion of permanent and/or temporary grasslands in the UAA and include grass in their livestock diet. Moreover, the farmers were required to be interested in, or make a link between, grasslands and animal health. The objective was to produce a sample of at least 100 farms, distributed across the three regions.

The farmers volunteered to be interviewed so we could collect their definitions and perceptions of their grasslands, the health of their animals, and the links they made between grassland and animal health, as well as basic data on their farm structure and farm management. The interview consisted of four main parts: a presentation of the production system; a description of farm management along with the farmer's definition and perception of 'good' animal health; a description of the grassland management along with the farmer's definition and perception of 'good' grassland; and a focus on the farmer's perception of the grassland–animal link.

Closed-ended questions were used to gain information on the farm structure, such as stocking rate, use of the UAA, quality label standard(s), and feeding system. Open-ended questions were used to find out how farmers perceived their animals and grasslands, and the links between grassland and animal health.

The interviews were conducted between September 2021 and March 2022 by three groups of master's students (each group composed of five to eleven students) from three engineering schools in France. The students were coached in interview delivery by three researchers, and they all used the same questionnaire they were trained to deliver. Data were noted on the paper questionnaire and later transposed to an Excel spreadsheet. Relevant verbatim responses were recorded, especially in response to the open-ended questions, to support the analysis.

2.2. Data Analysis

A database was built from the data collected in the three different regions. Data from the open-ended questions on definitions and perceptions of good grassland or animal health were analyzed qualitatively using the principles of thematic analysis. The answers were categorized to consider the different emerging themes present in the farmers' discourses.

To capture and analyze the link between grasslands and animal health, we used three questions—'What links do you see between grassland and animal health?', 'Have you noticed any effect (positive or negative) of the grass produced by your grasslands on the health of your animals?', and 'If so, what effect?'—to build a synthetic variable. We then examined the relationship between this synthetic variable and the type of farm system by performing two types of statistical analysis. First, we tried to build a farm classification scheme based on 12 variables related to farm structure, type of feeding system, and strength of the link expressed between animal health and grassland diversity (Table 1). For that purpose, we performed a factor analysis of mixed data (FAMD) in R (version 4.1.1) using the FactoMineR (version 2.4) and factoextra (version 1.0.6) packages. Graphs and illustrations were generated using the ggplot2 (version 3.3.5) and dplyr (version 1.0.7) packages.

To complete the analysis, a focus was performed on the "strong" group to identify the profiles of breeders making a strong link between grassland and health. For that purpose, we carried out a hierarchical clustering of principal components (HCPC) using the same software packages, in order to better characterize the "strong" group with regard to the zone of origin, animal type, and the type of summer and winter feeding. For the second clustering, the same 12 variables were used as in the first step (Table 1).

Table 1. List of the 12 variables used for the multivariate analysis.

Active Variables Used in the FAMD	Description of the Variable
Nutrition_winter	Feeding during winter
Nutrition_summer	Feeding during summer
PP_use	Type of use of permanent grassland
PP	Quantity of permanent grassland(ha)
Proportion PP	Percentage of permanent grassland in the farm's land area
Animal_type_principal	Type of animal in the main activity
UAA	Utilized agricultural area (ha)
Forage area	Size of the forage area (ha)
N_LU	Number of animals (livestock units)
Organic_farm	Farm certified organic (or not)
area	Geographic localization of the farm
MWU	Number of workforce units

3. Results

3.1. Description of Surveyed Farms

The sample included 103 farmers from farms distributed across all three regions: 24 farms were in Central France, 28 were in Eastern France, and 51 farms were situated in Western France. Organic farms accounted for half of the sample, and 41% of the farms received agri-environmental subsidies (a compensatory allowance for natural handicaps and agri-environmental measures). The farms surveyed had one on-farm operation (n = 66 farms) or more than one (typically crops and livestock (dairy or meat production); n = 37 farms). Among the farms, 43 had dairy cattle, 46 had beef cattle, 13 had small ruminants, and one had field crops. The cattle herd size was 118.5 livestock units on average, but ranged from 3.6 to 375.7 livestock units (Table 2). The average UAA was 129.20 ha, ranging from 10 ha to 303 ha. The average forage area was 108.9 ha, ranging from 8 ha to 208 ha. The average proportion of grassland in the forage area was 93.2%. The average permanent grassland area was 80.7 ha, ranging from 0 ha to 270 ha. The average temporary grassland area was 23.9 ha, ranging from 0 ha to 100 ha. All the herds grazed during the summer, and some were supplemented with hay or haylage and concentrates. All the herds were fed hay during the winter, and some were also fed haylage or silage (grass, corn, etc.).

Table 2. Description of the structure of the surveyed farms.

	Average	Min	Max
Number of animals (livestock units)	118.55	3.6	375.67
Utilized agricultural area (UAA)	129.2	10	303
Forage area (ha)	108.9	8	208
Area of permanent grasslands (ha)	80.7	0	270
Area of temporary grassland (ha)	23.9	0	100
Proportion of grassland in main forage area	93.2	48.5	100

3.2. How Do Farmers Perceive a Healthy Animal?

The farmers described their perception of a healthy animal using eight different themes, in no particular order: (1) "normal general condition": farmers looked at the animal's normal activities, such as good movement, no problems in rest position, expressing natural behaviour; (2) "fine-looking": animals having a shiny coat and good feet or horns, where the farmers generally referred to the whole body; (3) "productive": this meant that the animal could produce and reproduce without any problems; (4) "normal feeding behaviour": the animal showed no problems during feeding, and ruminated well; (5) "lively behaviour": animals that appeared happy, with a lively temperament; (6) "autonomous": an animal that the farmer did not have to worry about, which did not stand out as different to the others in the herd; (7) "high longevity" on the farm; (8) "all-round perception": in some cases,

farmers stated that you can only describe an animal as healthy by holistically factoring in different aspects of an all-around perception, without singling out any specific aspects.

The most-recorded themes were "normal general condition" (cited by 55 out of 103 farmers; Figure 1), and "fine-looking" (44/103; Figure 1). The least-cited themes were "high longevity (3/103) and "all-round perception" (2/103).

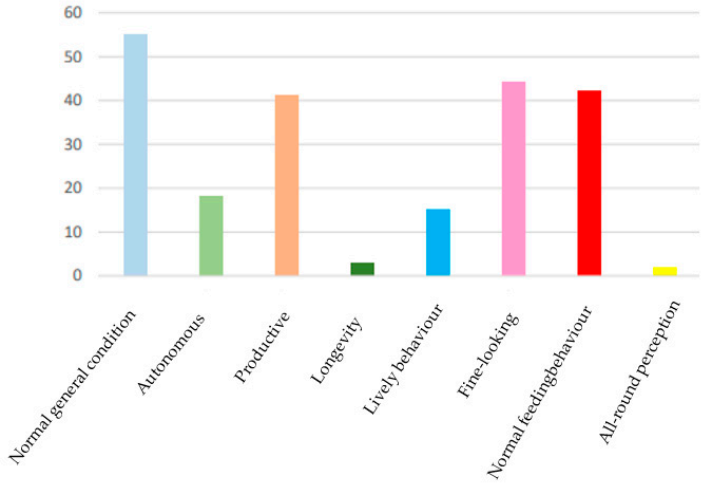

Figure 1. Diagram of the 8 themes recorded by livestock farmers to describe a healthy animal.

To describe a healthy animal, farmers cited one or several themes. Only 26 farmers used just one theme, which in eight cases was "normal general condition". In contrast, 44 farmers used two themes (mainly "normal general condition" and "productive", n = 10) and 22 farmers used three themes (mainly "normal feeding behaviour", "fine-looking", and "normal general condition"). Finally, ten farmers combined four themes (of which five farmers combined "normal general condition", "normal feeding behaviour", "fine-looking", and "productive").

3.3. How Do Farmers Perceive a Good Grassland?

The farmers described their perception of a good grassland (n = 98 responses to this item) using five themes: (1) "diverse", meaning that the grassland was composed of different kinds of forage species (forbs and legumes) and flowers (cited by 71 out of 98 farmers; Figure 2); (2) "productive", i.e., providing ample forage (44/98); (3) "resilient", a grassland that had the capacity to regrow after a cycle, i.e., one that could self-renew (29/98); (4) "qualitative", associated with good-nutritional-quality forage and healthy soil (18/98); and (5) a final category grouping several types of descriptive factors, such as the colour of the field, the presence of water, the absence of inedible plant species, and animals that did well when on the grassland.

To describe a good grassland, farmers cited one or several themes. We found that 25 farmers cited one theme ("diverse" was the most cited), 44 cited two themes ("diverse" and "productive" was the most cited combination), and 24 cited three themes. Only four livestock farmers used a combination of four themes to describe a good grassland, and one used five themes.

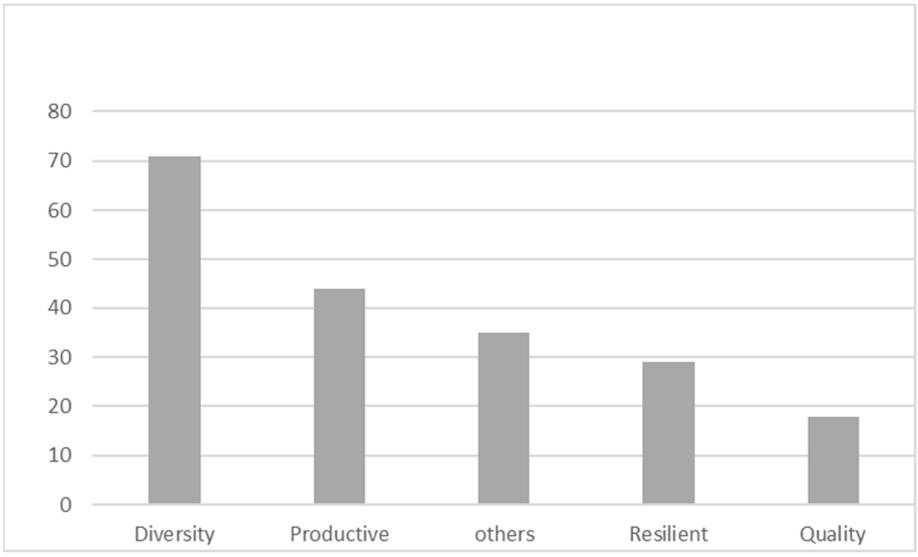

Figure 2. Diagram of the 5 themes recorded by livestock farmers to describe a good grassland.

3.4. What Type of Link Do Farmers Perceive between Grassland Diversity and Animal Health?

We divided the farmer-perceived link between grassland diversity and animal health (n = 100 responses) into four categories: 'strong link', 'medium link', 'weak link', and 'no link'. The "strong link" modality gathered farmers who saw a strong link between a diversified grassland and the health of their animals (61/100): these farmers were able to explain the theory behind the link and also to precisely detail the effects observed in their daily livestock farming practice. The "medium link" modality gathered farmers who saw a link in theory and recognized it in practice but were unable to describe that link precisely (14/100). The "weak link" modality was composed of farmers who could not explain the link in theory and did not recognize a link in practice (23/100). The last group ("no link") was composed of farmers who firmly stated that there was no link between diversified grassland and animal health (4/100).

3.5. How Are Farm Structure and Management Related to Farmers' Perceptions of the Grassland Diversity–Animal Health Link?

To analyze the variable "link between grassland diversity and animal health" and the farm structure and management variables, a multivariate analysis was performed with farm structure and management as the active variable. This showed a strong contribution of the type of animal feed during the year (*y*-axis) and farm area (*x*-axis; Figure 3), with a percentage of inertia of 22%. Despite strong contributions of animal feed and farm area, and weaker contributions of stocking rate, type of system, and use of grassland in each individual FAMD (Figure 4), the variable "link between grassland diversity and animal health" was not discriminated on the three axes.

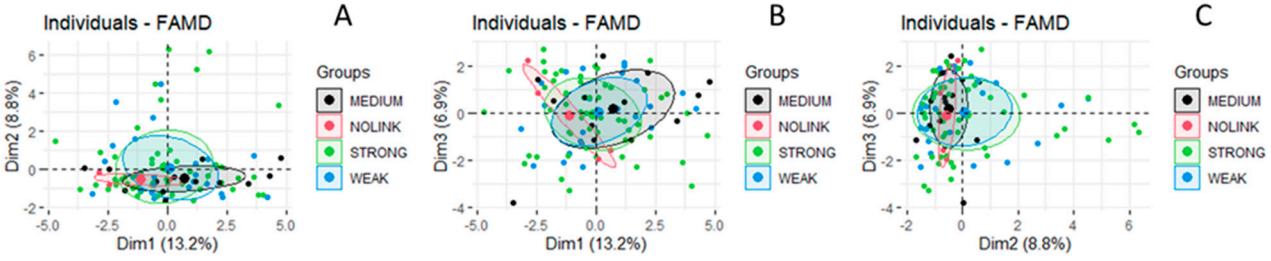

Figure 3. FAMD of farmers according to the type of link between grassland diversity and animal health. Representation in 3 dimensions to visualize group discrimination from 12 variables: (**A**) FAMD of farmers represented in dimensions 1 and 2, (**B**) FAMD of farmers represented in dimensions 1 and 3, (**C**) FAMD of farmers represented in dimensions 2 and 3.

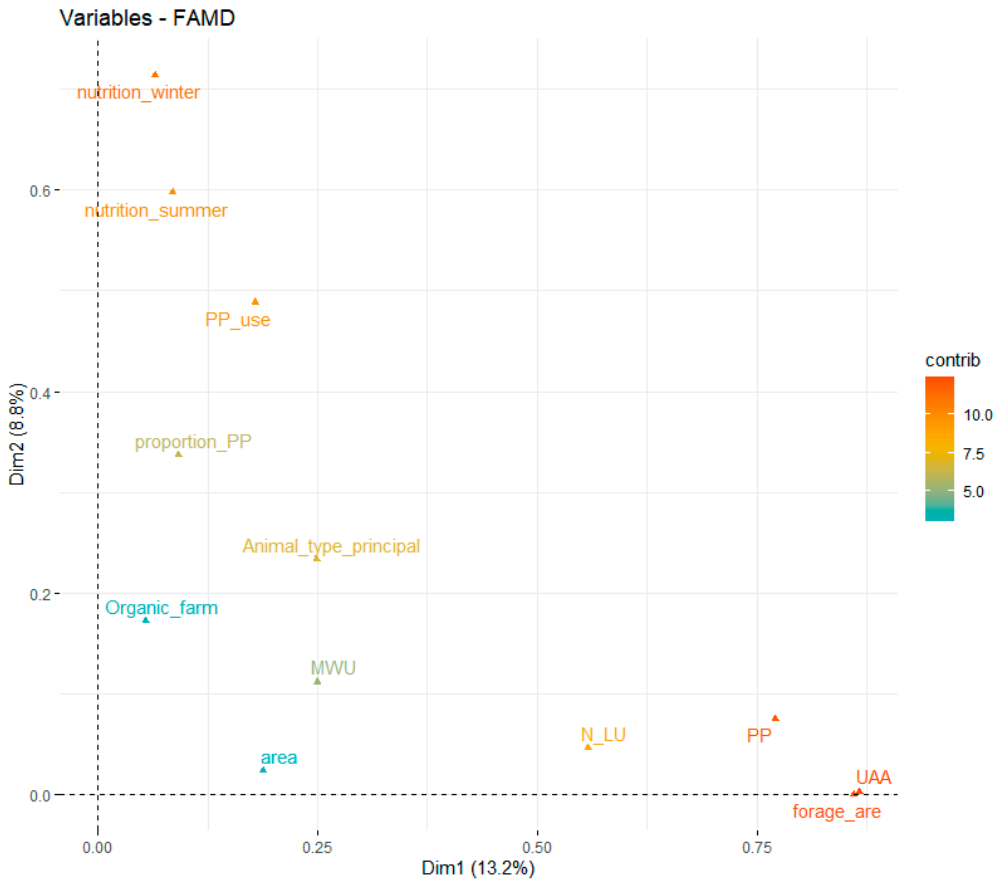

Figure 4. Plot of the individuals in the three dimensions of the factor analysis of mixed data (FAMD): nutrition_winter (feeding during winter), nutrition_summer (feeding during summer), PP_use (type of use of permanent grassland), PP (quantity of permanent grassland (ha)), proportion_ PP (percentage of permanent grassland in the farm's land area), animal_type_principal (type of animal in the main activity), UAA (utilized agricultural area (ha)), forage area (size of the forage area (ha)), N_LU (number of animals (livestock units)), organic farm (farm certified organic (or not)), area (geographic localization of the farm), and MWU (number of workforce units).

Hierarchical clustering of the "strong" group to better understand its explanatory variables identified three clusters of farms in this group (Figures 5 and 6). The first group, consisting of 33 farmers, was characterized by farms from all three regions (although predominantly the Eastern France region), with all types of production systems (dairy sheep, meat sheep, dairy goats, dairy cattle, and beef cattle), varied feeding systems with great quantities of grass and little supplementation in summer and mixed rations in winter, and never sole use of silage throughout the year. The second group, consisting of 15 farmers from all three regions but mainly Western France, was represented by beef and dairy systems. Feeding was again varied, with a large quantity of grass in the summer ration, supplemented to varying degrees (hay, etc.). The winter ration was also relatively diversified, mostly with a mix of hay and silage but sometimes with hay only. No group two farms used only silage in winter. Finally, the third group, comprising six farmers, mainly from Western France but partly from Central France, consisted entirely of dairy cattle farms. Annual feed in this group was more heavily based on silage, with pasture grazing and silage in summer and only silage in winter. Organic farms were not statistically over-represented in the "strong" group.

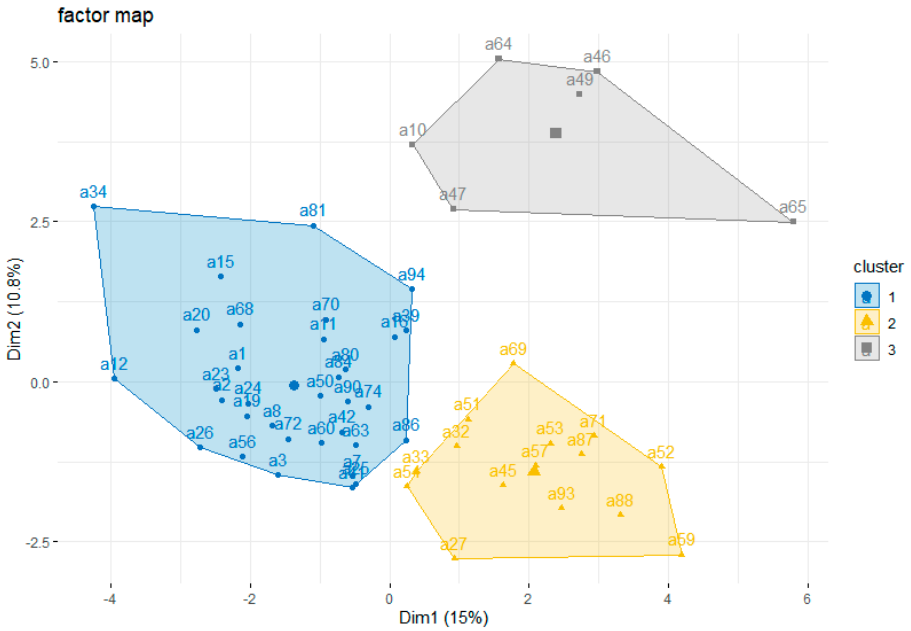

Figure 5. Graphical plot of the 3 different clusters obtained through hierarchical clustering of farmers asserting a "strong" link between grassland diversity and animal health.

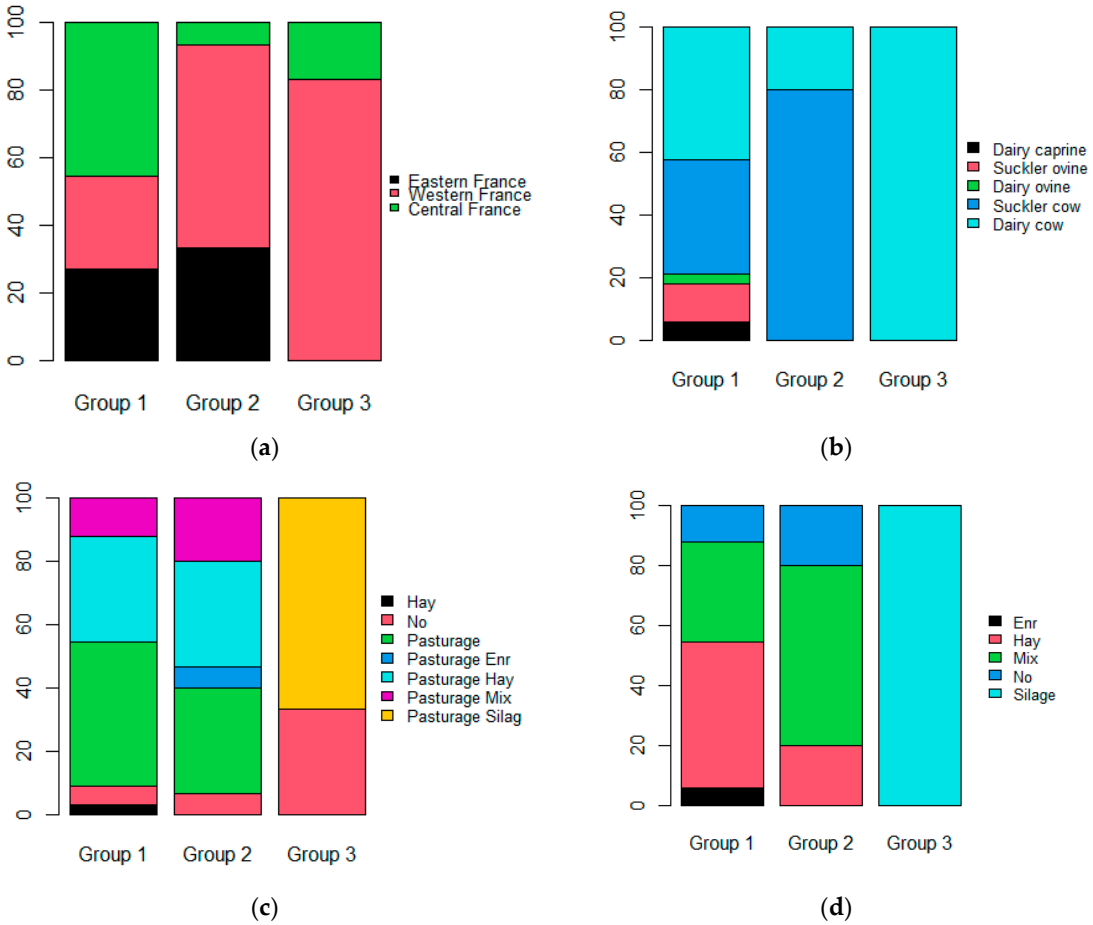

Figure 6. Diagrams representing the frequency of "strong" group farmers in the 3 clusters, for 5 variables: geographic zone, type of animal, permanent grassland use, winter feed system, and summer feed system. (**a**) Clusters stratified by region (Eastern France, Western France, Central France); numbers on the left indicate the frequency of farms in each group. (**b**) Clusters stratified by

type of livestock (dairy goats, meat sheep farms, dairy sheep farm, suckler cow, dairy cow); numbers on the left indicate the frequency of farms in each group. (**c**) Clusters stratified by type of summer feeding (Hay: summer feeding is composed of hay; No = information on summer feeding is not available; Pasturage = summer feeding is composed of pasturage only; Pasturage Enr = summer feeding is composed of pasturage and grass silage; Pasturage Mix = summer feeding is composed of pasturage and a mix of other fodder; Pasturage Silage = summer feeding is composed of pasturage and maize silage); numbers on the left indicate the frequency of farms in each group. (**d**) Type of winter feeding per cluster stratified by type of winter-season feed (Enr = winter feeding is composed of grass silage; Hay = winter feeding is composed of hay; Mix = winter feeding is composed of a mix of several types of fodder; No = information on winter feeding is not available; Silage = winter feeding is composed of maize silage); numbers on the left indicate the number of farms in each group.

4. Discussion

The results of this research highlight the complexity of farmers' perceptions of animal health and good grassland. The themes used by the farmers to define a healthy animal reveal a broad range of perceptions. The animal can be considered in a general way, such as in the categories "normal general condition" and "all-round perception", through its production, such as in the categories "productive", "normal feeding behaviour", and "longevity", through its autonomy, or in a more visual way, as in the categories "fine-looking" and "lively behaviour". The literature on animal health has already identified this diversity of farmers' representations of what constitutes an animal in good health, especially on organic farms [26,27]. In organic systems, studies find a vision of animal health that is focused on respect for naturalness and limited interventions, whereas other, more productiveness-oriented representations are directed towards maintaining productive performance through more regular interventions. Our work has highlighted the complexity of farmers' perceptions, since many farmers expressed several perceptions of a healthy animal that associated respect for naturalness with productivity.

Regarding fodder, farmers' perceptions of a good grassland were mainly focused on floristic diversity and productivity at the plot scale. These perceptions are relatively narrow compared to other studies, which have found perceptions spanning a broad diversity of benefits at the plot scale, forage-system scale, farm scale, and regional scale (forage production, animal performance, environmental and agronomic impacts, economic performance, and wellbeing; [24]). The way the questionnaire was presented to the interviewees probably oriented them to answer on diversity and productivity and at the farm scale.

Our analysis of the links between grassland and animal health was unable to identify specific types of systems that would be more geared to using a diversity of plants for health management, as our "strong" category was not characterized by any particular type of system. A multivariate analysis revealed a strong weighting of feed compared with the other variables of grazing-system farms. The high proportion of grass on these farms (93.2%) may also explain these results. In France, the proportion of grass in rations ranges from 10% to 90% [28]. However, our results show that this "strong" category featured two different types of feeding systems: one directed more to silage and the other to grass and hay. In France, these two types of feeding systems correspond to two very distinct systems of production, the first directed more to animal productivity, and the second to valorizing natural resources. Explanations for this absence of a link between a type of system and farmers' perceptions of animal health can be found in the literature on animal health, and especially on farmers' strategies for reducing antibiotic use. A number of studies have described a diverse range of trajectories towards reducing antibiotic use [29], but Poizat et al. [30] showed that some pro-health animal-centred strategies (such as the use of alternative medicine) did not correlate to any one type of system. Our results here confirm that it is hard to find any link between a given type of system and strategies for reducing the use of chemical inputs for animal health. This is an interesting finding, as it

suggests that all types of farming systems are potentially concerned with moves to use a diversity of plants to manage animal health.

In this study, the "strong" category was the most largely represented category in our sample, which confirms the benefit of diverse grasslands to farmers. One limitation of our study is the fact that we did not perform a finer breakdown of the practices that use grassland for animal health. The survey was underequipped to identify these practices and to capture the livestock farmers' knowledge of floristic diversity, but the high number of farmers in our "strong" category can be considered as an indicator of a general understanding among farmers of a benefit of grassland diversity to farm animal health. Further studies are needed to better characterize these practices and to determine the level of diverse grassland use to benefit animal health.

5. Conclusions

This exploratory study analyzing the links between grassland diversity and animal health has highlighted farmers' definitions of good grassland and a healthy animal. We have demonstrated that the majority of farmers perceive a strong link between grassland and animal health. However, we have been unable to establish a statistical relationship between farm structure and management system and farmer-perceived links between grassland and animal health. Thus, further research needs to be conducted in this area to better characterize the animal health benefits provided by grasslands.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

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