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Identification of the Multifunctionality of Andalusian Autochthonous Pastoral Livestock Breeds at the Farm Level

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Abstract: The multifunctionality of agricultural and livestock systems is a pivotal attribute that should be considered when formulating rural policies, as it serves as a significant source of income for those managing these systems in their respective areas. The objective of this work was to quantify the farm-level multifunctionality of extensive livestock systems with local meat breeds (cattle, sheep and goats) in Andalusia (southern Spain). The study focused on three autochthonous breeds located in southern Spain: (i) the Pajuna cattle breed; (ii) the Negra Serrana goat breed; and (iii) the Lojeña sheep breed. To assess multifunctionality in Andalusian systems, four aggregated function scores based on farm characteristics and activities were identified and evaluated: (i) production function; (ii) residence function; (iii) habitat and biodiversity function; and (iv) recreational, cultural and educational function. The farm data supporting these indicators were derived from personal interviews conducted with a total of 40 farmers. The total multifunctionality index was significantly higher for Lojeña sheep compared with Pajuna cattle and Negra Serrana goats. Across each breed, scores varied significantly for individual functions and indicators, highlighting the complexity and diversity inherent in each system. Based on the results obtained, a series of specific changes are deemed necessary to enhance the multifunctionality of the farms that specialize in the three breeds studied: (i) ensuring food self-sufficiency by promoting local opportunities; (ii) advocating for equal participation and active involvement of spouses in farm work; (iii) establishing optimal pasture management practices; (iv) fostering the development of activities related to livestock farming that contribute to ecotourism or rural tourism; (v) aligning local livestock farming practices with tasks related to forest fire prevention; and (vi) encouraging the participation of livestock farmers in training future practitioners and disseminating the role of livestock farming in society.

Keywords: ecosystem services; protected natural areas; gender equality; survey

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1. Introduction

Pastoral livestock farming, based on autochthonous breeds, has been present in the Mediterranean basin for thousands of years. It serves as a tool for shaping and managing the landscape, providing employment for the local population and creating economic diversification in rural areas [1]. This model of livestock production generates high-quality food, but it is not always adequately acknowledged and remunerated. It is also closely tied to local culture, which consumers recognize and demand, although perhaps not to the extent that would be desirable. As a result, it fosters a balance between production and the maintenance of the ecosystem. Beyond marketable and tangible goods, this model of livestock production also yields other products, often referred to as positive externalities [2,3]. These generate numerous direct goods and services that are not yet fully recognized by society [4].

In the Mediterranean region, particularly in Andalusia (southern Spain), there are numerous autochthonous livestock breeds—primarily cattle, sheep, goats and pigs—that are well adapted to their environments. While these autochthonous breeds may be less productive, they possess valuable functional characteristics stemming from their resilience and ability to adapt to environmental conditions [5]. Hence, they constitute an essential element in the naturalization of Mediterranean woodlands [5,6]. In addition to producing food for human consumption, livestock grazing in these areas plays a crucial role in biodiversity conservation, carbon sink capacity, soil protection and water management, among other aspects [2,4–6]. The adoption of a multifunctionality approach in these farming systems improves the use of natural resources, promoting sustainable practices that aim to balance production needs with environmental conservation. This not only enhances the resilience of grasslands in the face of current environmental challenges such as climate change, but also fosters harmony between agricultural activities and the conservation of these ecosystems, contributing to a sustainable and balanced management model. As a result, farmers breeding these autochthonous livestock breeds play a crucial role in ecosystems and, consequently, in society. Their management practices can modulate the flow of services and act as mediators for the preservation and maintenance of provisioning services (such as food, feed and fiber), supporting services (including nutrient cycling and biodiversity conservation), regulating services (carbon sequestration, pollination and soil erosion control, among others) and cultural services (education, cultural heritage, tourism, etc.) [2,3]. The combination of these services, encompassing both private and public goods, is referred to as multifunctionality [7].

Nevertheless, the prevailing trend toward the intensification and specialization of livestock farming, coupled with economic crises and climate change, poses a threat to the ongoing viability of livestock farming if no action is taken. In this context, the conservation and enhancement of autochthonous breeds emerge as essential elements in addressing this challenge. The presence of extensive genetic biological diversity reinforces the resilience of livestock systems, which are in a better place to confront unforeseen changes [8]. However, the low profitability of pastoral livestock farming, which relies on indigenous breeds that are less productive but more environmentally and health-conscious, combined with challenges in accessing pastures, poses a significant threat to the survival of these livestock systems that is compounded by the issue of generational replacement [9,10].

There is no doubt that financial support from the Common Agricultural Policy (CAP), which is designed to compensate for income loss and to financially reward livestock farmers contributing to environmental improvement, could ameliorate the economic viability of farms. This holds true for meat-oriented livestock farms in Andalusia, where CAP support constitutes over 50% of their income [5], proving it to be essential in addressing the economic challenges associated with managing vast areas, maintaining extensive herds and promoting environmentally friendly farming and livestock management practices [11]. Furthermore, CAP support serves as an incentive for the adoption of innovative technologies and practices aimed at optimizing production and improving efficiencies. This, in turn, assists extensive livestock farms in addressing current economic and environmental challenges. However, it is crucial to be able to measure and quantify the broader contribution that this type of livestock farming makes to society, extending beyond the provision of meat, milk, fur or wool. This is essential for achieving a balance between economic, environmental and social aspects.

In this context, one of the primary challenges for pastoral livestock farming in Andalusia and other northern regions of the Mediterranean basin is to preserve or restore the multifunctionality of ecosystems [12–14] and to ensure compensation for these contributions. Multifunctionality is a crucial attribute of agricultural and livestock systems that must be considered when formulating rural policies and as a source of income for those managing these systems in their respective areas. Despite the increasing usage of the concept of "agroecosystem multifunctionality" [12,13,15], it is not yet prominently integrated into agroecosystem management. Management practices tend to be narrowly

focused on one or a few services, primarily provisioning services, prioritizing productivity and often neglecting potential synergies or trade-offs with the regulation of ecosystem services, which are vital from an environmental perspective [14].

Extensive livestock production holds a strategic position in the Andalusian agricultural sector, not only from an economic standpoint but also environmentally and socially, as it serves multiple functions for society. Unlike other studies, this research endeavors to highlight the inherent complexities and multifaceted contributions of these systems, thereby providing a comprehensive understanding that surpasses the existing literature. Notably, by doing so, this study aims to offer an invaluable foundation for recognizing and economically valuing their diverse and often underappreciated roles in rural territories.

The organization of this paper is as follows: Section 2 covers the methodology, study species and data recovery; Section 3 presents the results; Section 4 discusses the findings; Section 5 addresses limitations and future research; and, finally, Section 6 concludes the paper.

2. Materials and Methods

2.1. Description of Species and Study Area

The study focused on three autochthonous breeds located in southern Spain: (i) the Pajuna cattle breed; (ii) the Negra Serrana goat breed; and (iii) the Lojeña sheep breed. The usage areas for each breed are shown in Figure 1, all of them closely linked to protected natural areas. The Pajuna cattle breed is distributed across various mountain areas of Andalusia (Spain), primarily Sierra Nevada, Serranía de Ronda, Sierra de Grazalema and Sierra de Cazorla. The Negra Serrana goat breed predominantly inhabits the rugged foothills of the Sierra Morena and Sierra de Alcaraz areas (in the provinces of Ciudad Real, Albacete and Jaén; Spain). Lastly, the Lojeña sheep breed is found in a very specific enclave in the province of Granada (Spain) and utilizes communal mountain pastures in the districts of Loja, Zafarraya and Alhama de Granada.

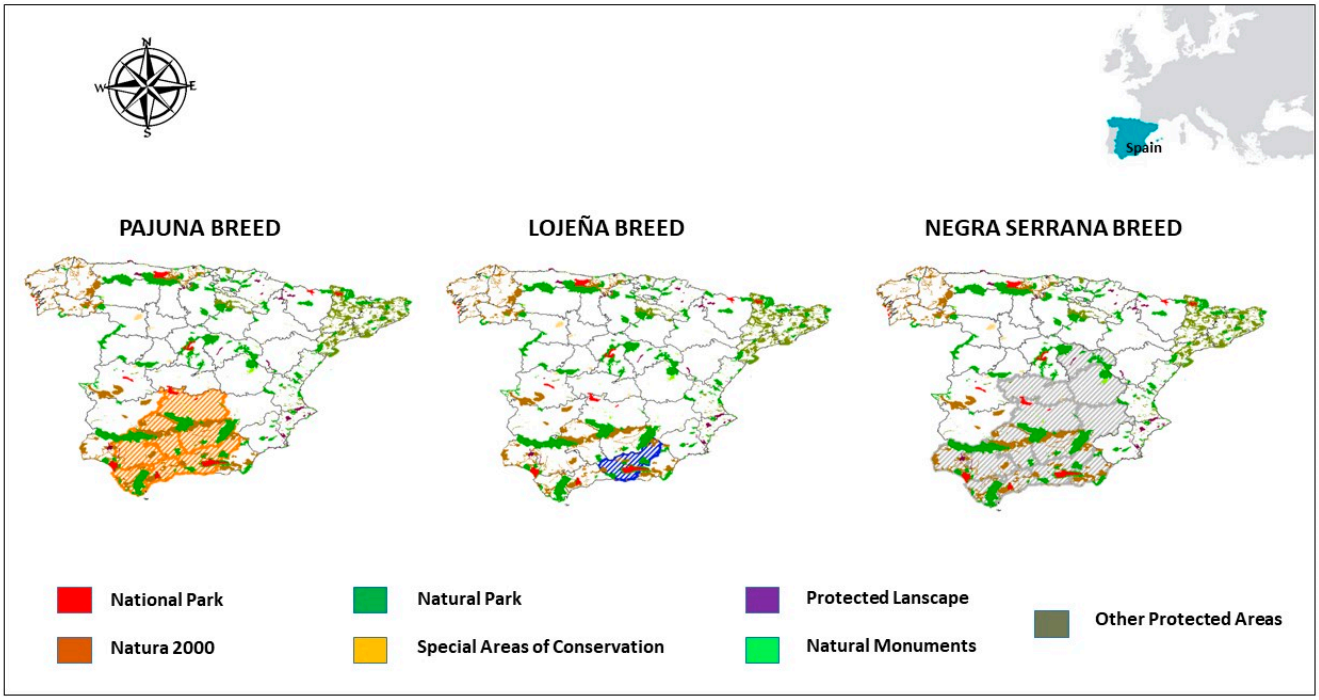

Figure 1. Main distribution areas of the studied species are represented, including protected areas in Spain. Orange = Pajuna cattle; blue = Negra Serrana goats; and grey = Lojeña sheep.

All of the above breeds are autochthonous breeds [16] specializing in meat production. The traditional farming system for these three species is extensive. The herds graze all year round on communal pastures in dehesas and mountain areas with low tree densities. The cultivation of crops to feed the animals, either for grazing or to supplement the herds' diets, is very limited [16].

The Pajuna breed farms under study have an average of 60 ± 15 female breeders older than two years. These farms encompass an average cattle rearing area of 1356 ± 182 ha, with an average stocking rate of 0.044 livestock units (LU) ha^{-1}. In 92% of the studied farms, the animals graze within protected natural areas, 80% of which are owned, while the remaining areas are leased to private or public tenants at no rental cost. Livestock feeding primarily relies on natural pastures, although most farmers use cereal hay supplements during pasture shortages and at specific times (such as adverse weather conditions like heavy snowfall, concentration of animals due to sanitation controls, etc.). One-third of the studied farms practice transhumance. They produce pastured calves, fed on the milk of the grazing mothers and the pasture itself, reaching a live weight of 150–170 kg at 5–7 months of age, considered the typical product of the mountain cow. Slightly more than half of the studied Pajuna farms (60%) are certified organic.

The Negra Serrana goat farms studied have an average of 446 ± 91 breeding females older than one year. These farms possess extensive common pasture areas in high mountain regions (the average area per farm is 1787 ± 132 ha), all without perimeter fencing. The utilization of large areas results in very low average stocking rates (0.036 LU ha^{-1}). Transhumance is not widely practiced, with only 17% of the studied farms adopting this method. Up to 44% of the farms use private land, while the rest are either rented or located on public forest land. Generally, concentrated feed is provided to goats only during the farrowing period, with no additional fodder used throughout the year. The production system is centered on suckling goats primarily fed on their mother's milk. These goats are typically slaughtered at 40–50 days old, with a live weight of 10–12 kg. A significant number of the Negra Serrana goat farms studied (78%) are certified organic.

The average size of the studied flocks of Lojeña sheep was 915 ± 126 animals, including breeding ewes over one year old. The majority of the farms (92%) own their land and have an average surface area of 527 ± 15 ha, typically natural mountain pasture (with an average stocking rate of 0.26 LU ha^{-1}). The sheep's wool, which is of fine and loosely packed fleece, is utilized, making it suitable for the manufacturing of tapestries, carpets and for the artisan industry. Transhumance is not practiced for this breed on any of the farms. These systems specialize in the production of organic lambs weighing 15–20 kg. All the farms studied (100%) are certified organic.

2.2. Quantitative Analysis of Farm-Level Multifunctionality

The methodology developed by Andersen et al. [13] to study Danish farms was modified and adapted to assess multifunctionality in the systems analyzed in this work. The livestock farm served as the basic unit of analysis. This level is crucial as it reflects the operational scope where farmers can make decisions to promote multifunctionality. Additionally, it is the legal and economic unit through which payments for externalities financed by the CAP are to be received.

Firstly, a review of the four main functions of livestock systems proposed by Andersen et al. [13] and their indicators was carried out to assess multifunctionality. These authors describe multifunctionality in terms of those four functions: (i) production of food, fiber or energy (including the pre-treatment of fields, planting, harvesting and ploughing, as well as the breeding and feeding of livestock); (ii) provision of habitats for wildlife (supporting habitats for flora and fauna and maintaining natural processes); (iii) housing or residence (providing a place for the farming family to live); and (iv) recreation, understood as the development of leisure activities (tourism, outdoor sports, etc.) for the farming family and the general population. The adaptation and revision of the methodology were conducted by six experts from universities and research centers who possess knowledge of the mul-

tifunctionality of livestock systems, along with three veterinarians directly involved in the ruminant sector. As a result, it was decided to keep the four functions proposed by Andersen et al. [13], but the names of two of them were changed: the "habitat function" was renamed "habitat and biodiversity function" because of the importance of biodiversity (autochthonous breeds) in the case study, and the "recreation function" was renamed "recreational, cultural and educational function" to include the potential involvement of livestock farmers as teachers in training projects, such as the Andalusian shepherd school. The proposed changes to the indicators for each function aimed to adapt the methodology to the characteristics of extensive livestock farming, particularly focusing on meat aptitude in the Mediterranean area. The indicators that were removed or included for each function analyzed are provided in Table 1.

Table 1. Indicators removed from Anderson et al. [13] or included for each analyzed function.

	Deleted	**Added**	**Changes in the Score**
Production function	New drainages Irrigation on farm Plans for set-aside areas	New watering troughs, channeling systems or pylons Improvement of pastureland Another income-generating agricultural activity	Ownership reason Spouse working time on farm Crop area of total area Rented land
Residence function	Prod. buildings changed to residential	Time spent in housing	Number of farm residents Ownership reason Private garden improvements
Habitat and biodiversity function	Plans for set-aside change Change, rotation to uncultivated Hedgerows planted Dikes established Small nature areas established New ponds or lakes Uncultivated river borders Subsidies for nitrate reduction Subsidies for permanent grassland Subsidies for nature projects	Stone enclosures or traditional constructions Agri-environment payments Remuneration for maintaining autochthonous breeds Payment for ecosystem services (e.g., fire prevention) Other autochthonous livestock species	
Recreational, cultural and educational function	Angling activities Expressed amenity value	Hiking activities Farmers as trainers for other farmers	Riding activities New forest planted Accessibility improvements

The final step involved reviewing the scoring of each indicator, assigning a weighting based on its relative importance to the associated function. The validation procedure with the previously cited experts consisted of three sessions during which each expert contributed their modifications until a joint validation was achieved. The weighting and ranking of indicators were determined based on expert judgment regarding the multifunctionality of the studied system. The results reflect the strength of each indicator in relation to the corresponding function, leading to different maximum weights for various indicators. The final indicators for one of the functions are shown in Table 2.

Table 2. Indicators for each of the four functions assessed across the 40 Andalusian farms included in the survey. The score for each of the indicators is detailed.

Production Function	Indicator Scores (Score Possibilities in Brackets)	Top Score
Farm units owned	1 farm (0), >1 farm (10)	10
Ownership reason	Yes (10), no (0)	10
Spouse working time on farm	0% (0), >10% (1), >20% (2), >30% (3), >40% (4), >50% (5)	5
New farm building	0 m^2 (0), >20 m^2 (1), >40 m^2 (2), >60 m^2 (3), . . ., >200 m^2 (10)	10
Crop area of total area	0% (0), 10% (1), 20% (3), 30% (5), 40% (7), >50% (10)	10
Rented land	0% (0), 10% (1), 20% (3), 30% (5), 40% (7), >50% (10)	10
Change, pasture to rotation	Yes (5), no (0)	5
Change, uncultivated to cultivated for livestock feed	Yes (10), no (0)	10
Number of livestock (LU)	0 LU (0), >10 LU (1), >20 LU (2), . . ., >100 LU (10)	10
New watering troughs, channeling systems or pylons	More than one occurrence (10), one (5), none (0)	10
Improvement of pastureland	Yes (5), no (0)	5
Another income-generating agricultural activity	Yes (5), no (0)	5
	Total Score for Function	100
Residence Function		
Time spent in housing	All year (10), seasonally (6), occasionally (3), never (1)	10
Number of farm residents	0 (0), 1 (2), 2 (3), 3 (5), 4 (7), . . ., >4 (10)	10
Ownership reason	Yes (10), no (0)	10
New residential farm buildings	New housing (10), extension (6), patio (3), garage (1)	10
Rented out land	Yes (10), no (0)	10
Own orchard	Yes (5), no (0)	5
	Total Score for Function	55
Habitat and Biodiversity Function		
Pasture area (dehesa/shrubland)	0 ha (0), 1 ha (1), 2 ha (2), . . ., ≥10 ha (10)	10
Forest area	0 ha (0), 1 ha (1), 2 ha (2), . . ., ≥10 ha (10)	10
Uncultivated area	0 ha (0), 1 ha (1), 2 ha (2), . . ., ≥10 ha (10)	10
Age of nature areas	>20 years (10), >10 years (5), <10 years (0)	10
Organic farming status	Yes (5), no (0)	5
Increased number of wildlife observed	Yes (5), no (0)	5
Change, rotation to pasture	Yes (5), no (0)	5
Stone enclosures or traditional constructions	0 m (0), 100 m (1), 200 m (2), . . ., ≥1000 m (10)	10
Agri-environment payments	Yes (5), no (0)	5
Remuneration for maintaining autochthonous breeds	Yes (5), no (0)	5
Payment for ecosystem services (e.g., fire prevention)	Yes (5), no (0)	5
Other autochthonous livestock species	Yes (7), no (0)	7
	Total Score for Function	87
Recreational, Cultural and Educational Function		
Hunting activities	Owner (4), friends and family (6), rented (8), no hunting (0)	8
Wildlife interest (no hunting)	Ecoturism (8), wildlife watching (4), no interest (0)	8
Hunting ground improvement	Yes (2), no (0)	2
Hiking activities	Yes (7), no (0)	7
Riding activities	Yes (5), no (0)	5
New forest planted	Yes (10), no (0)	10
Accessibility improvements	Yes (10), no (0)	10
Other people's recreation	Daily (10), weekly (7), monthly (4), yearly (1), never (0)	10
Recreational activities of farm family	0 (0), 1 (1), 2 (2), . . ., ≥10 (10)	10
Farmers as trainers for other farmers	Yes (5), no (0)	5
	Total Score for Function	75
	Total Multifunctionality Index	317

The maximum score that a farm can achieve in each function is as follows: production function (100); residence function (55); habitat and biodiversity function (87); recreational, cultural and educational function (75). Finally, an additional aggregation can be achieved by combining the indices of each function within a farm into a single multifunctional index, with a maximum theoretical value of 317. Although this aggregation may obscure detailed information about individual functions, it provides an overview of the overall functional richness of the farm.

To gather information on each function based on farm characteristics and related activities, a survey was designed and organized into five sections: (i) general characteristics of the farm; (ii) production function; (iii) residence function; (iv) habitat and biodiversity function; and (v) recreational, cultural and educational function. All characteristics, activities and related indicators were identified through the data collected during the interviews, obviating the necessity for additional data. As previously mentioned, the specific objective of this study was to utilize farm-level data; each function acquires a unique value for each farm [13].

A total of 40 farmers were interviewed in the year 2023 (14 for sheep, 11 for goats, 15 for cattle). All the farms are members of the national association of breeders of the corresponding breed [17], and their animals are registered in the breed's herd book, recognized by the Ministry of Agriculture, Fisheries and Food of the Spanish Government. The surveyed farms are representative of the current composition of each association: 67% for the Lojeña sheep breed, 80% for the Negra Serrana goat breed and 60% for the Pajuna cattle breed.

2.3. Statistical Analysis

Given the non-normal distribution and heteroscedasticity of the data, a non-parametric analysis was conducted using the Kruskal–Wallis test to identify potentially significant differences among the results of the three studied breeds. Subsequently, pairwise comparisons were performed using the Mann–Whitney U test to evaluate significant differences between groups ($p \leq 0.05$). The analyses were carried out using IBM SPSS v29.0 software.

3. Results

The scores achieved by each of the study breeds on the variables comprising each of the functions are provided in Table 3. The total multifunctionality index was significantly different among the three study breeds (H = 9.07, $p \leq 0.05$). The Lojeña sheep presented significantly higher values (177 $\pm$ 6) than Pajuna cattle (150 $\pm$ 7) and Negra Serrana goats (146 $\pm$ 6); no significant differences were found between these latter two ($p \geq 0.05$, Figure 2).

Across each breed, scores varied significantly for individual functions and indicators, highlighting the complexity and diversity inherent in each system. The mean values obtained for the production function were notably low for the three studied breeds (36–48) relative to the maximum achievable value (100). The Lojeña sheep and Negra Serrana goats recorded significantly higher scores (48 $\pm$ 2 and 44 $\pm$ 3, respectability) than the Pajuna cattle (36 $\pm$ 3) (H = 14.19, $p \leq 0.05$; Figure 2). The variables associated with ownership, land renting, number of livestock and other income-generating agricultural activities exhibited the highest values. For the three study breeds, these low values were primarily attributed to: (i) the absence of crop and pasture improvements, (ii) the lack of grazing management, (iii) the introduction of new farm buildings in recent years and (iv) the limited participation of spouses in livestock activities (Table 3).

Table 3. Distribution of the average scores for each of the variables constituting the four functions of the overall multifunctionality index. The results are shown for each of the breeds studied (Pajuna cattle, Negra Serrana goats and Lojeña sheep). Means ± standard errors.

Production Function	Lojeña	Pajuna	Negra Serrana
Farm units owned	9 ± 1	8 ± 1	7 ± 1
Ownership reason	9 ± 1	6 ± 1	5 ± 2
Spouse working time on farm	0	1 ± 0	1 ± 0
New farm building	1 ± 1	1 ± 1	1 ± 1
Crop area of total area	0	0	0
Rented land	10 ± 0	5 ± 1	7 ± 1
Change, pasture to rotation	0	2 ± 1	0
Change, uncultivated to cultivated for livestock feed	0	0	0
Number of livestock	10 ± 0	5 ± 1	9 ± 1
New watering troughs, channeling systems or pylons	5 ± 0	2 ± 1	3 ± 1
Improvement of pastureland	0	1 ± 1	1 ± 1
Another income-generating agricultural activity	3 ± 1	4 ± 1	3 ± 1
Residence function			
Time spent in housing	5 ± 1	6 ± 1	8 ± 1
Number of farm residents	5 ± 1	4 ± 1	4 ± 1
Ownership reason	9 ± 1	6 ± 1	9 ± 1
New residential farm buildings	1 ± 1	0	0
Rented out land	0	0	0
Own orchard	1 ± 1	5 ± 0	1 ± 1
Habitat and biodiversity function			
Pasture area (dehesa/shrubland)	10 ± 0	9 ± 1	9 ± 1
Forest area	0	7 ± 1	5 ± 2
Uncultivated area	0	2 ± 1	5 ± 2
Age of nature areas	10 ± 0	10 ± 0	10 ± 0
Organic farming status	5 ± 0	3 ± 1	4 ± 1
Increased number of wildlife observed	5 ± 0	5 ± 0	4 ± 1
Change, rotation to pasture	0	1 ± 0	0
Stone enclosures or traditional constructions	10 ± 0	0	0
Agri-environment payments	5 ± 0	4 ± 1	4 ± 1
Remuneration for maintaining autochthonous breeds	5 ± 0	5 ± 0	3 ± 1
Payment for ecosystem services (e.g., fire prevention)	5 ± 0	1 ± 1	1 ± 1
Other autochthonous livestock species	1 ± 1	2 ± 1	3 ± 1
Recreational, cultural and educational function			
Hunting activities	7 ± 1	6 ± 1	7 ± 0
Wildlife interest (no hunting)	8 ± 0	8 ± 0	8 ± 0
Hunting ground improvement	2 ± 0	0	0
Hiking activities	7 ± 0	7 ± 0	7 ± 0
Riding activities	5 ± 0	5 ± 0	5 ± 0
New forest planted	4 ± 1	6 ± 1	1 ± 1
Accessibility improvements	4 ± 1	4 ± 1	1 ± 1
Other people's recreation	7 ± 0	7 ± 0	7 ± 0
Recreational activities of farm family	7 ± 1	1 ± 0	3 ± 1
Farmers as trainers for other farmers	1 ± 1	1 ± 0	0

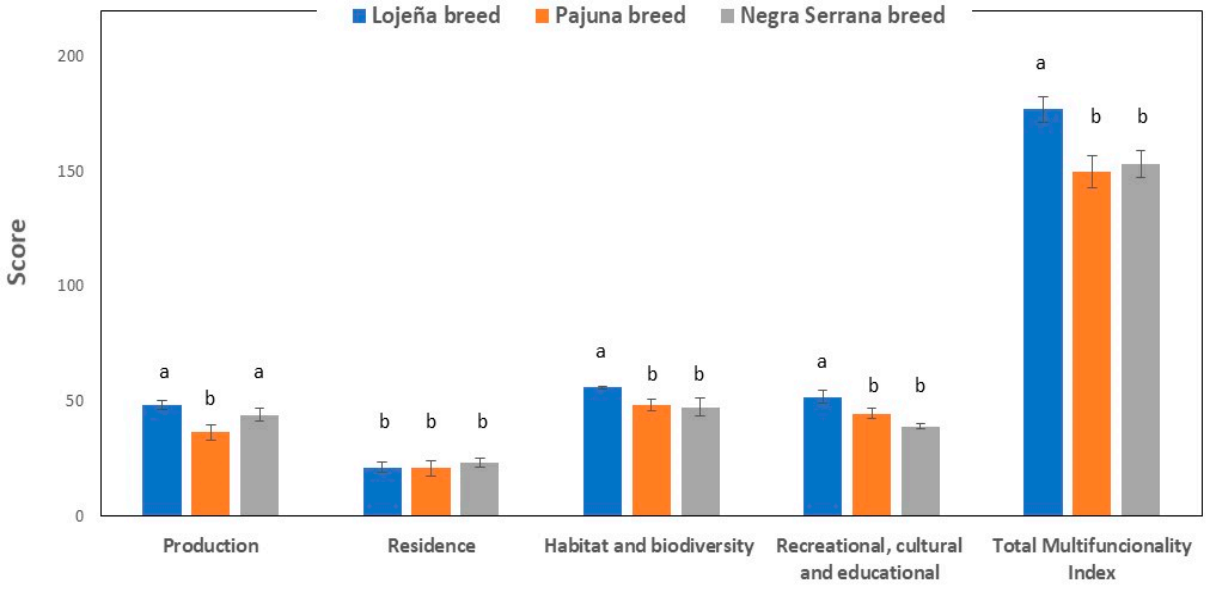

Figure 2. Mean values for the multifunctionality index and for each individual function in the studied farms (Pajuna cattle, Negra Serrana goats and Lojeña sheep). Means ± standard errors. ^{a,b} = Values with different letters in the same row mean significant differences ($p \leq 0.05$).

Regarding the residence function, very low values (21–22) were observed in comparison with the maximum achievable value (55). No significant differences were found among the values of each of the studied breeds ($p \geq 0.05$, Figure 2). The low scores were primarily due to the use of the residence on the farm as a regular dwelling place, modifications to the residence or the existence of orchards. For all other variables, the values were either high or very high (Table 3).

In terms of habitat and biodiversity, the values obtained for the three breeds surpassed the mean (47–56) of the maximum achievable value (87), with the Lojeña sheep breed scoring significantly higher (56 ± 1) compared to the other two study breeds (H = 7.01, $p \leq 0.05$). No significant differences were found between the Pajuna and Negra Serrana breeds (48 ± 3 and 47 ± 4 respectively; $p \geq 0.05$) (Figure 2). The variables concerning the utilization of protected natural areas (pasture area, age of nature area and increased number of wildlife observed), organic farming status and obtaining support (agri-environment payments and remuneration for maintaining autochthonous breeds) displayed significantly high values across all three study breeds. It is worth noting that the grazing areas on Lojeña sheep breed farms are characterized by the absence of forested areas. Additionally, these farms are the only ones that scored points for the variable "stone enclosures or traditional constructions". In most cases, the scarcity of wasteland and wooded areas (for the Lojeña sheep), the absence of other complementary indigenous livestock and the lack of traditional infrastructures providing environmental services were the indicators with the lowest scores (Table 3).

Similarly to the previous function, the exhibited values for the recreational, cultural and educational function are above the mean (39–52) of the maximum achievable value (75) for the three breeds. The pattern was similar, with the Lojeña sheep breed scoring significantly higher (52 ± 3) compared to the other two study breeds (H = 10.82, $p \leq 0.05$). No significant differences were found between the Pajuna and Negra Serrana breeds (45 ± 3 and 39 ± 3 respectively; $p \geq 0.05$) (Figure 2). Recreational activities, such as hunting, hiking, horseback riding and others, are very common on the study farms, leading to high or very high values for their associated variables across all three study breeds. For this function, the indicators with the lowest scores were the lack of improvement in hunting grounds and the absence of participation in training activities (Table 3).

4. Discussion

The conducted sensitivity analysis, as anticipated, reveals varying degrees of relevance among indicators. Given the concentration of the analysis on average results, differences in rankings primarily stem from the fact that the most influential indicators of multifunctionality (with higher scores) are integral to the management of a significant number of farms. In contrast, indicators with lower impacts on the results (with lower scores) require enhancement in the analyzed farms.

Comparing the results of our study with those conducted by Andersen et al. [13] on farms of similar size (>100 hectares), several significant findings emerge. Firstly, concerning the production function, our study showed that the values for the Loñeja sheep breed were comparable (48) to those obtained for Danish farms (49), whereas they were considerably lower for the other two breeds (36–38). Furthermore, a generalized trend across all three breeds in our study revealed lower values for the residence function (21–22) compared to the original methodology results (32). Conversely, higher values for the habitat and biodiversity function were observed for all three breeds in our study (47–56) compared to the results from Danish farms (43). Finally, regarding the values for recreational, cultural and educational functions, this study found slightly higher values for the Lojeña sheep and Pajuna cattle breeds (45–52), while the value for the Negra Serrana goat breed was slightly lower than those reported by these authors from Danish farms (44). In terms of the total multifunctionality index, only the Lojeña sheep breed achieved higher values (177) compared to the Danish farms studied (168), while the values for the goat and cattle breeds were lower (146 and 150, respectively) [13].

This comparison highlights nuanced differences in multifunctionality across different livestock breeds and underscores the importance of considering various factors when assessing farm sustainability and productivity. The following section outlines the results for each of the functions analyzed, emphasizing the most crucial aspects for enhancing multifunctionality in each of the studied breeds.

4.1. Production Function

As previously mentioned, the majority of the studied livestock species heavily depend on extensive use of natural pasture, much of which falls within the list of Sites of Community Importance (SCIs) and Special Protection Areas for Birds (SPAs). These areas typically consist of steep terrain with shallow soils, rendering them unsuitable for cultivation [18,19]. In Spain, where over 30% of the territory possesses the necessary characteristics to be designated a protected natural area, in accordance with the requirements outlined by the Natura 2000 network, nature conservation policies in recent decades have not adequately addressed the integration of agriculture, including organic farming, into nature conservation efforts [20]. The restrictions on crop cultivation stem from the intention to avoid soil disturbance, prevent the introduction of non-native species or mitigate disruption of sensitive habitats [21]. The limited instances of crop integration observed in the studied farms have predominantly been driven by the farmers themselves, who lack sufficient support for the implementation of policies that encourage such integration and receive minimal assistance from administrative bodies. This situation significantly hinders the implementation of pasture management and improvement initiatives in the studied areas. While maintaining a degree of food self-sufficiency is crucial, the current context of climate change underscores the resilience and sustainability of extensive livestock farming as a production system, even without the supply of additional crops [22,23]. The capacity of these livestock systems to endure and prosper without direct reliance on agricultural practices is a distinctive and positive attribute. This characteristic contributes to the efficient utilization of local resources while simultaneously mitigating the environmental impacts commonly associated with conventional agriculture.

In a general sense and focusing on the three breeds under examination, a limited number of farms have improved their approach to grazing management in recent years. Certainly, efficient pasture management is crucial. The traditional method of continuous or uncontrolled grazing, allowing livestock unrestricted access to pasture for a set period, can lead to substantial pasture wastage or suboptimal utilization. Such practices can contribute to reduced livestock yields and have significant environmental consequences [24,25]. Rotational grazing stands out as one of the most commonly employed pasture management strategies; it entails the systematic rotation of livestock among distinct grazing areas at periodic intervals [26,27]. The objective of this approach is to maximize the use of natural resources, enhance the health of grass and foster a sustainable equilibrium within the ecosystem. Additionally, the adoption of Global Positioning System (GPS) technology and virtual paddocks for grazing management has become progressively prevalent, facilitating the monitoring of animals across expansive land areas in these livestock systems [24,26,27]. This technological approach marks a substantial advancement in the efficiency and accuracy of the diverse livestock operations. Beyond offering precise tracking of livestock locations, it furnishes valuable insights into movement patterns, grass preferences and incidents such as cattle theft or predator attacks, among other crucial data points. This information plays a pivotal role in the successful execution of rotational grazing strategies, leading to a reduction in the workload and costs associated with routine activities for livestock farmers [27–29].

In contrast to family-oriented dairy systems, where the active involvement of spouses in daily tasks is evident, the participation of women in the studied livestock rearing enterprises is not as prominent. The animals have access to large areas of natural pasture, resulting in less daily intervention by farmers compared with dairy systems, which require more direct management, such as daily milking and the need for specific infrastructures. Extensive livestock farming, not relying on intensive structures like barns, mechanical milking systems and supplementary feeding, can reduce the necessity for specialized constructions and facilities [5], as observed in the studied farms. Despite the reduced need for daily intervention, extensive livestock farming still demands vigilant monitoring and management of livestock, particularly in terms of health, reproduction and pasture quality. Historically, this type of work has been viewed as a male occupation; however, in the last decade, the increasing involvement of women as managers has become more evident [30]. Their growing presence signifies a noteworthy stride towards gender equity in the agricultural sector, offering valuable prospects for sustainable management, enhancing animal welfare and fortifying the economic resilience of rural communities [31]. Initiatives that promote equal participation, coupled with regulations like those on shared ownership [32], could incentivize a larger number of efforts to engage spouses in farm work and underscore the participation of those who are already involved.

4.2. Residence Function

In many cases, the characteristics of the areas of use make it impossible to have a dwelling on the farm with the minimum services (electricity, running water, telephone signal, etc.). The proximity of the farmers' residences to population centers indicates that they prefer not to live on their farms in order to have access to these and other essential services (food shops, schools, health centers, etc.). Those who have large dwellings on the farms and do not usually live in them could rent them for ecotourism or rural tourism.

The COVID-19 pandemic has created opportunities for the development of rural tourism as people seek more authentic experiences, less crowded environments and a connection with nature [33,34]. Due to the characteristics of the areas where extensive Andalusian livestock farming is practiced, unique accommodation options could be promoted, such as rural cabins, agrotourism farms or local home-stay experiences that allow for income diversity. Recent studies have shown that this type of accommodation is highly appreciated and often selected for its privacy, security and authenticity compared with more crowded urban environments [35,36].

Having your own orchard goes beyond simply producing food; it offers a range of benefits, from ensuring food security and promoting health to fostering a connection with nature and contributing to sustainability [37]. This has a positive impact both on a personal level and in the broader context of the community and the environment. Vegetable gardens are common, and unlike what is seen in other case studies, they are well-established features in farms of the Pajuna cattle breed. As mentioned earlier, local laws and regulations restrict and prohibit agricultural activities in protected areas, making it impossible for most sheep and goat farmers to engage in such activities.

4.3. Habitat and Biodiversity Function

The management and revitalization of brownfield land can be of interest in terms of sustainable development, landscape restoration and environmental protection. These areas often provide opportunities to implement sustainable agricultural practices or restoration projects that enhance soil health and promote local biodiversity [38]. Due to the characteristics and age of the pastures in the study area (>20 years), fallow land is typically non-existent. Similarly, traditional walls, historically used to mark property boundaries or divide pastures into smaller plots, are increasingly falling into disuse. These structures can offer various services and benefits for both landscape management and livestock production, including soil and water control, promotion of biodiversity and the preservation of cultural and aesthetic identities [39]. In the areas where Lojeña sheep farming is prevalent, this type of infrastructure, along with other elements, such as drinking troughs, ponds and water holes, is well established. Despite the widely recognized advantages of such infrastructures over wire fencing, economic costs associated with construction or constraints imposed by local legislation and regulations sometimes hinder their implementation in protected areas. For the other breeds studied, these limitations make it impossible to introduce such infrastructures.

The conservation and promotion of autochthonous breeds not only fosters genetic diversity but also contributes to environmental sustainability, providing rural communities with a culturally rooted and economically valuable foundation for livestock production [40]. The complementarity of different indigenous breeds, including sheep, goats and cattle, allows for the exploitation of various types of forage. These breeds, having adapted over generations to the specific conditions of their areas of origin, enable a more holistic management of resources. This approach capitalizes on the specific strengths of each breed, diversifying economic opportunities and enhancing the resilience of the livestock sector [40]. Despite its potential benefits, success lies in careful management tailored to the specific conditions of each region. The plant–herbivore interactions are mutually beneficial: grasslands are fundamental to these livestock systems, and, in turn, pastoral livestock farming plays a crucial role in seed dispersal, organic fertilization and fire prevention, as well as in the preservation of the rich cultural and economic heritage of the Andalusian region [2]. As a result, this interaction contributes significantly to the goods and services that these natural ecosystems provide.

4.4. Recreational, Cultural and Educational Function

Most of the surveyed farms engage in big and/or small game hunting. The diversity of habitats, species hunted and hunting methods contributes to a rich hunting tradition in the Andalusian region [19]. In fact, for the majority of cases studied, hunting represents a significant additional source of income. Many of these areas are managed by others, generating revenue without requiring major improvements or investments. It is noteworthy that the areas grazed by the livestock studied can diversify the habitats available for wildlife. Well-managed grasslands can provide forage, shelter and breeding areas for a variety of animal species, including those of hunting interest [41]. However, it is essential that these activities are carried out in a planned and sustainable manner to ensure the long-term health of the ecosystem.

Finally, the involvement of farmers as trainers for other farmers and future technicians facilitates the dissemination of sustainable agricultural and livestock practices. This approach involves sharing knowledge, experience and effective practices not only with other farmers or future farmers but also with the wider community. It plays a crucial role in strengthening the livestock rearing community by fostering the exchange of information on common challenges, innovative solutions and successful management strategies [42]. An exemplary instance of this is the Andalusian Shepherd School, where a significant number of livestock farmers act as trainers. They play a pivotal role in imparting practical knowledge and technical skills, instilling sustainable values and promoting the farming identity of future livestock breeding professionals. This preparation equips future farmers to face the challenges and seize the opportunities existing in the livestock sector in their region [43].

5. Limitations and Future Research for the Improvement of Multifunctionality in the Livestock Systems under Study

Pastoral livestock farming is facing a landscape of transformations, requiring preparedness among livestock farmers. This readiness is crucial to meet the evolving demands of a society increasingly focused on environmental conservation, public health and animal welfare. In this context, the traditional knowledge, extensiveness and multifunctionality inherent in the studied livestock systems, far from being vulnerabilities, emerge as strengths and sources of opportunities that need to be recognized and enhanced. To achieve this objective, several improvements and lines of research are necessary to enhance the multifunctionality at the farm level for the three breeds under study.

1. *Ensuring herd food autonomy through the promotion of local production (production function).* The studied livestock farms operate in extensive environments and are characterized by low dependence on external raw materials for animal feed, including both concentrates and fodder [16]. However, these farms are typically situated in high mountain areas where land available for crops is limited due to wooded landscapes, steep slopes, challenging climatic conditions and legal restrictions associated with environmental protection [19,20]. A crucial strategy to ensure proper livestock feeding through the use of local and nearby resources involves establishing agreements and arrangements with local farmers for the supply of raw materials during the growing season and/or utilizing the remains of established crops after harvest, promoting a circular bioeconomy [44]. This collaboration would not only ensure the continuity of livestock farms but also help maintain price stability and improve the quality of the products obtained. By establishing partnerships with local farmers, it would be possible to optimize the use of the limited arable land in high mountain areas, leveraging the expertise and resources available in agriculture and ensuring a regular and adequate supply of raw materials. Moreover, this synergy between farmers and stockbreeders could be beneficial not only for sustainable animal food production, but also for strengthening local economies and promoting environmentally friendly farming and stockbreeding practices.
2. *Promoting equal participation and active involvement of both spouses in farm work (production function and residence function).* Inclusive policies and regulations, such as Royal Decree 297/2009 [32], have the potential to substantially contribute to gender equality in the agricultural and livestock sector. These policies promote the active participation of both spouses and create an enabling environment to ensure the continuity of family farms, which are also their places of residence. Gender equality is not merely a moral and social imperative to highlight the participation of those already involved; it also yields tangible and measurable benefits for the efficiency, resilience and sustainability of pastoralism and the agricultural sector at large. Implementing shared ownership rules would legally acknowledge the active participation of both spouses in farm management, establishing a framework that fosters equal roles and responsibilities. This would also enable both parties to equally access government support for the sector.

3. *Establishing optimal grazing management (habitat and biodiversity function)*. The introduction of rotational grazing, supported by advanced technology such as GPS and virtual fencing, has revolutionized livestock management [45]. This strategic approach entails the deliberate subdivision of grazing areas, allowing for the regular movement of animals from one area to another with minimal effort. This practice is particularly useful for the studied breeds, given the nature and characteristics of their extensive grazing areas, many of which are challenging to access. The integration of technologies like GPS enables precise monitoring of livestock location and behavior, offering valuable data for adjusting rotations and optimizing the utilization of natural resources, thus contributing to the maintenance of habitats, insect pollination, prevention of erosion processes, carbon storage and the maintenance of the water cycle. Virtual fencing, controlled by GPS technology, provides unprecedented flexibility in establishing mobile boundaries that can swiftly adapt to the specific needs of pasture and livestock [27–29]. The integration of rotational management with innovative technology not only enhances pasture health and resource use efficiency, but also contributes to the environmental sustainability and economic productivity of extensive livestock production.
4. *Engaging autochthonous livestock in environmental management tasks, such as forest fire prevention, land management and the conservation of plant and animal species (habitat and biodiversity function)*. The synergistic collaboration among various breeds of cattle, sheep, goats and horses, for example, alongside the development of fire prevention strategies, plays a central role in the sustainable management of rural areas, encompassing both natural landscapes and the livestock populations involved [46]. The diversification of livestock functions contributes to building resilience. Moreover, the combination of various livestock breeds and species serves as an integrated grazing management mechanism, exerting a positive influence on vegetation structure and mitigating the accumulation of flammable biomass [47]. Offering incentives or payments to local livestock farmers for their role in fire prevention plays a crucial role in promoting these sustainable practices [48]. Such compensation would not only acknowledge the indispensable role of local livestock farming in preserving rural landscapes, but also enhance cooperation between farming communities and authorities, fostering a collective and sustainable approach to environmental risk management. This strategic alliance would solidify an integrated and sustainable approach to livestock farming in rural areas.
5. *Promoting the development of pastoral activities to encourage ecotourism or rural tourism (recreational, cultural and educational function)*. The incorporation of recreational activities on livestock farms has the potential to augment and diversify the income of farmers. Moreover, it can yield significant economic, environmental and social benefits for the local environment by fostering a distinct and sustainable production model in harmony with the surroundings. The option for visitors to pay for farm visits not only serves as a financial source for the farm owner, aiding in the promotion and sale of their products, but also generates additional employment opportunities within the local community [35,36]. On the flip side, it serves as a means of informing and raising awareness about the importance of maintaining the activity of these farms and the employment opportunities they offer. This becomes crucial for the rejuvenation of the rural economy associated with the breeds under study. As part of the diversification, promoting tourism-related activities can encourage the public to engage more closely with these production systems. This, in turn, facilitates the establishment of networks and collaboration among various stakeholders, including farmers, local entrepreneurs, educational institutions and government organizations, thereby fortifying the social and economic fabric in rural areas. Nevertheless, for the successful promotion of diversified entrepreneurial activities on livestock farms, it is imperative to address challenges related to infrastructure, ensuring adequate access and providing staff training. The implementation of policies supporting such initiatives through rural

development programs and strategic plans for extensive livestock farming would be highly advantageous.

6. *Promoting farmer involvement in training future generations in agriculture and disseminating the crucial role of livestock farming in society (recreational, cultural and educational function)*. The role of livestock farmers as disseminators is crucial in raising awareness about the importance and multitude of services that agriculture and livestock farming provide to society. Encouraging farmers to share their experiences and knowledge not only fosters a closer connection between consumers and food producers, but also establishes robust bridges of understanding between agricultural production and public appreciation [42]. This active collaboration between producers and consumers serves to strengthen the relationship between rural and urban communities and to cultivate an informed consciousness, contributing to the overall well-being and long-term sustainability of the food system.

6. Conclusions

For the first time, the multifunctionality of Andalusian autochthonous pastoral meat breeds (Pajuna cattle, Negra Serrana goats and Lojeña sheep) has been evaluated. While the three studied breeds exhibited comparable diversification values, the overall multifunctionality index was slightly higher for the Lojeña sheep breed. However, significant variations were observed among the breeds in the results obtained for each function and their associated indicators, highlighting the complexity and variability of the existing management models.

The *residence function* showed very low values in all species. Families prefer to live in nearby population centers, which offer them more and better services. However, since these are meat-oriented livestock farms where animals do not require daily supervision, this fact usually does not pose a problem for the continuity of these farms, unlike the lack of profitability. Increasing and recognizing the other functions analyzed can present an opportunity to improve profitability. The *habitat and biodiversity function*, which obtained the best results, demonstrates the significant role of the livestock studied in providing ecosystem regulation services, which should be translated into direct payments to the farmer. While it is a characteristic of extensive livestock systems not to present high levels of productivity (which explains why the production function reached a low level), there are management actions that can improve this situation, as long as they do not imply a loss of food self-sufficiency for the farms. Finally, the increasing interest of society in getting closer to rural areas and demanding products from more natural systems can contribute to improving the *recreational, cultural and educational function*, which undoubtedly represents an opportunity to diversify the income sources of these farms, thus enhancing their economic viability.

Multifunctionality has an impact not only on the economy, the environment and nature, but also on societal and cultural development. Therefore, its quantification can be very useful for decision making both at the farm management level and for the formulation of specific policies for the management and conservation of pastoral ecosystems where they are developed.

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