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Sheep welfare assessment of meat farms from Spain in different breeds and production systems

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Sheep production systems are diverse in Europe, and welfare assessment should consider this diversity, including differences in breed type, climatic conditions, and time of the year. The aim of this study was to evaluate welfare in 100 commercial sheep farms in Spain, and therefore in Mediterranean conditions, using a list of 24 indicators, comprising three for good feeding, five for housing, 11 for health, and five for appropriate behavior. The list includes indicators from the AWIN protocol and other suggested indicators. Level of intensification was the main parameter that affected the welfare outcomes of feeding and health, but seasonality and flock size also affected some of the outcomes. Novel indicators included in the list (sternum evaluation, crowding behavior, subcutaneous abscesses, external parasitism, aggressive behaviors, wool pulling, ear posture, and reaction during restraint) were useful to evaluate welfare in Spanish farming conditions, but further studies should be performed to validate these indicators.

KEYWORDS

assessment, behavior, indicators, farm, sheep, welfare

Introduction

In recent years, the development of animal welfare assessment tools has received increasing attention because consumers, the distribution chain, retailers, and farmers demand a reliable welfare assessment as a key step before any decision-making. An EU-funded research project (Welfare Quality®) developed the first welfare assessment protocol based on animal-based measures for the species with the biggest populations in Europe, such as pigs, cattle, and poultry. That initiative facilitated the development of animal-based welfare assessment protocols in other species. Sheep are a notable livestock species in Europe, representing the third-largest livestock population (85.2 million animals, EUROSTAT, 2020) behind pigs (147.9 million animals, EUROSTAT, 2020) and cattle (86.6 million animals, EUROSTAT, 2020), especially in the UK and Mediterranean countries (Greece, Italy, and Spain). The European Animal Welfare Indicators Project

(AWIN) developed welfare assessment protocols for small ruminants, among other species, also using animal-based indicators, which seek to be feasible and reliable in commercial conditions (AWIN, 2015). That protocol provided the first ever list of validated indicators that can be used for assessing sheep welfare.

Sheep production systems in Europe are diverse according to management and farm size (EFSA, 2014; Ministerio de Agricultura, Pesca y Alimentación, 2019) and may also vary according to geographical region. Indeed, sheep production systems in the European Mediterranean context have their own particularities, which should be disaggregated in terms of the use of resources, degree of intensification, and cultural roles, among other factors, according to some authors (Bernués et al., 2011). Sheep breed morphology may vary considerably within and between countries. In Spain, wool type and color vary greatly between breeds (Sánchez Belda, 1979). Mediterranean breeds can exhibit some behavioral differences compared with other continental breeds. They graze in large and cohesive groups, whereas other breeds from middle and northern Europe tend to disperse and form small subgroups, which can vary in size depending on breed (Fisher and Matthews, 2001). Climatic conditions, including seasonal effects, also vary between countries and regions, and they affect the occurrence of diseases (Roger, 2008) such as foot rot. Animal welfare indicators may provide the necessary framework to effectively assess all aspects of welfare, including nutrition, health, comfort, and behavior. In order to evaluate sheep welfare on Spanish farms, a list of measures comprising some of the already validated measures and suggested novel measures that are relevant to the welfare of local breeds may prove to be useful. Therefore, the aim of this study was to evaluate animal welfare in 100 commercial sheep farms in Spain using a list of validated and suggested measures designed to provide information on the animals' welfare throughout the year in different production systems and breeds, addressing the welfare principles of good feeding, health, comfort, and normal behavior.

Materials and methods

One hundred sheep meat farms in Spain were visited for welfare assessment. Farmers were contacted through local sheep organizations and their participation was voluntary. Farms were located in different provinces of Spain, mainly in three provinces of Catalonia (Barcelona, Girona, and Lleida), but also in provinces of other regions (Zaragoza, Soria, Castellón, Valencia, Madrid, and Mallorca). The locations of the farms are shown in Figure 1. Farms were classified according to flock size, level of intensification, and breed. Flock size ranged from 100 to 2,800 animals. Level of intensification was categorized according to grazing restriction as intensive (I), semi-intensive (SI), or semi-extensive (SE). The most popular breed was Ripollesa, a local breed from the northeast of Spain, and the rest of the sheep were other local breeds, foreign breeds, or crossbreeds. In order to account for potential seasonal differences, the study was performed throughout the year, but each farm was visited only once. For this parameter, four periods were considered (winter, summer, autumn, and spring). An accurate description of the criteria used for farm classification is shown in Table 1.

Welfare assessment was performed using a list of measures. In order to obtain a suitable list adapted to Spanish farm conditions, different particular aspects of evaluation were considered, and suggestions for adapted or new indicators were developed by the authors, taking into account the contribution of other experts and scientific literature relevant to Spanish sheep conditions. Possible welfare aspects not included in previous welfare protocols, such as crowding behavior, external parasites, or signs of wool pulling, were subsequently considered, and all of them are summarized in Table 2. The definitive list included measures from the AWIN protocol, but also additional measures addressing welfare issues that are relevant to Spanish sheep farming conditions. It contained 24 indicators and included individual indicators, group indicators, and farm measures. The full list and scoring criteria are shown in Table 3.

Welfare assessment in each farm was performed in a single visit in which all measures included in the list were evaluated. For individual measures, 30 post-partum ewes per farm (up to 1 month after lambing) were randomly selected and evaluated. Ewes were restrained by the farmer while all individual data were recorded. For group measures (crowding behavior, respiratory symptoms, and aggressive behavior), a 15-minute observation of the entire flock was conducted from outside the pen. An approach test was performed with the animals that were kept indoors during the visit, and a group of animals proportional to flock size (with a minimum of 10 animals) and from the same pen was randomly selected to perform the test (adapted from AWIN, 2015). Data concerning density and access to feeders and drinkers were directly measured by the observer. In addition to the parameters included in the assessment, other individual data from the evaluated ewes were recorded. Age was recorded according to number and type of teeth (1 year, 2 years, 3 years, or ≥ 4 years; Sotillo and Serrano, 1985). The presence of horns and urination or defecation during restraint were also recorded. Farm characteristics (number of animals, level of intensification, and breed) were obtained by interviewing the farmer. Bed condition on the farm was recorded using a four-point scale: dry and without organic remains (1), dry with presence of organic remains (2), wet (3), or wet and dirty (4). Shade availability was considered as sufficient when it could include all animals simultaneously and insufficient if it could not. Environmental temperature during the visit and total time for the welfare evaluation were recorded. Data collection and the approach test were recorded and performed by the main author on all farms.

Statistical analysis was performed using SAS version 9.1.3. (SAS Institute Inc., Cary, NC), with a significance level set at $p < 0.05$. Indicators of the protocol evaluated with non-continuous variables were analyzed using frequencies, and the chi-squared test was used to compare frequencies between types of farms. Indicators of the protocol evaluated with a numeric variable (level of intensification, farm size, breed, and season) were analyzed with mixed models, including farm as a random effect and using the mean value per farm. Spearman's correlations were used to analyze the effects of bed condition and environmental temperature. For behavior measures, the mean value of observed behaviors per farm was

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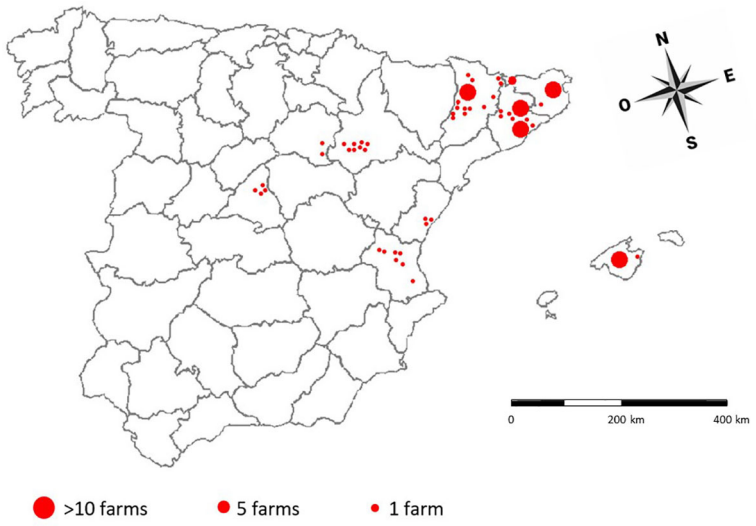

FIGURE 1
Location by provinces of farms included in the welfare assessment study.

recorded and correlations between behavior measures were also analyzed.

Results

Good feeding

The average BCS per farm was 2.40 and the BCS was significantly higher in intensive farms on average (BCS = 2.60 ± 0.08, $p = 0.03$). In four farms, the average BCS was lower than 2.0 (two SE and two SI farms). The average proportion of sheep with a low BCS (< 2.0) on each farm was 12%. BCS was significantly lower in animals older than 10 years of age (> 10 years BCS = 2.07 ± 0.04, < 10 years BCS = 2.45, $p < 0.01$). No effect from farm size, breed, or season on BCS was observed.

Observed drinkers were automatic (47%), containers (24%), water troughs (23%), and absent entirely (5%). Water provision was judged to be insufficient in 41% of farms. The hygiene of the drinkers was considered clean in 39%, partly dirty in 45%, and dirty in 16% of farms.

TABLE 1 Description of the criteria used for the classification of assessed farms and the number of farms included in each classification.

Characteristic	Classification	Description	Number of Farms
Flock size	Small	100 to 400 animals (244 ± 120)*	37
	Medium	401 to 800 animals (556 ± 114)*	35
	Large	More than 800 animals (1,212 ± 510)*	28
Level of intensification	Intensive	Animals have no access to pasture	9
	Semi-intensive	Animals have access to pasture only for specific periods, such as early gestation or mating	57
	Semi-extensive	The wholes flock goes out every day throughout the year	34
Breed	Ripollesa	Ripollesa breed	34
	Local breeds	Rasa Aragonesa (7)†, Ojinegra (1)†, Guirra (1)†, Roya Bilbilitana (3)†, Xisqueta (7)†, Mallorquina (7)†, Roja Mallorquina (1)†, Colmenareña (2)† cross-breed (17)†	46
	Foreign breeds	Assaf (1)†, Awassi (1)†, INRA (3)†, cross-breed (2)†, Lacaune (12)†, Suffolk (1)†	20
Season	Winter	December, January, February	22
	Spring	March, April, May	29
	Summer	June, July, August	20
	Autumn	September, October, November	29

*Values within brackets refer to mean ± standard deviation. †Values in brackets refer to the number of farms included in the study with a majority of sheep of this breed.

TABLE 2 Alternative indicators or suggested modifications to existing measures of sheep welfare under Spanish farm conditions.

Welfare principle	Welfare criteria	Particular aspects of evaluation in Spanish farm conditions	Score in previous protocols or recommendations according literature	Suggestions for adaptations or novel indicators
Feeding	Water provision	Hot conditions are usual. Ensure that all animals have correct access to water, especially when they return from pasture.	In previous protocols there is no specific requirement regarding the number of drinkers per number of animals or water trough length per number of animals, but some authors (Caja and Rivas, 1988; Dwyer, 2008) have recommended minimum requirements of water accessibility.	Accessibility to water should be evaluated according to Caja et al. (1999) and Dwyer's (2008) recommendations.
Housing	Comfort around resting	In arid climates the fleece should remain clean even if bedding is dirty or wet. In addition, wool cover is poor in some Spanish breeds, and wool color could be dark. An indicator based on palpation instead of visual inspection is advisable.	The Welfare Quality® protocol for cattle assesses the cleanliness of certain body parts. The AWIN protocol considers that assessment of fleece condition can provide information on whether or not sheep have been able to lie in comfort. No indicators based on palpation have been proposed.	Considering that the sheep sternum is the part of the body that is usually in contact with the ground when animals are lying down, and it gets dirty according to bed conditions, sternum evaluation by palpation could be a possible indicator to evaluate the dryness and hygiene condition of beds.
	Thermal comfort	Spanish breeds are adapted to high temperatures, but recent climate change makes it necessary to include climate-resilient farm indicators. Crowding behavior in the flock (ewes crowding with heads low) is usually observed in hot seasons.	The AWIN protocol includes panting as an indicator of thermal comfort, which is only observed in extreme temperatures (Moyano et al., 1992; Silanikove, 2000). It is a common opinion among Spanish experts that heat is primarily the cause of crowding behavior in the flock, although other factors could also affect it (Moyano et al., 1992).	Climate change reinforces the need for thermal comfort indicators, and Spanish experts consider crowding behavior as a crucial indicator. Crowding behavior should be included in the protocol.
	Ease of movement	In semi-intensive and intensive farms, animals are managed in subgroups whose size varies over time, due to the physiological state of each animal, and thus changes in stocking density are usual. On the other hand, feeders should allow all animals to feed together.	The AWIN protocol classifies ease of movement as "good" (minimum of 1.5 m^2/ewe or 2 m^2/ewe with lamb), "adequate" (1–1.5 m^2/ewe or 1.5–2 m^2/ewe with lamb), or "poor" (< 1 m^2/ewe or < 1.5 m^2/ewe with lamb). Other authors (Caja and Rivas, 1988; Dwyer, 2008) recommend a minimum of 1 m^2/ewe or 1.2 m^2/ewe with lamb.	Spanish experts' recommendations should be taken into account. Stocking density should be evaluated in all pens and it must be ensured that all ewes have access to feeders simultaneously in all pens.
Health	Injuries	When animals graze in stubble, ocular lesions can appear (keratitis and ocular trauma). When there is high sun exposure, dermatitis in the auricular pavilion can appear.	Keratitis, ocular trauma, and dermatitis are not specified in previous protocols.	Dermatitis on the auricular pavilion and ocular lesions should be included in a unique index of lesions.
	Disease	External parasites often appear (ticks and scabies), especially in extensive systems (Basco et al., 2008). Subcutaneous abscesses often appear depending on hygiene and housing conditions (Paton et al., 2003). Nipple lesions may appear (Díaz et al., 2014). Diarrhea usually appears in spring.	External parasites, subcutaneous abscesses, and nipple lesions are not specified as signs of disease in previous protocols. In the AWIN protocol diarrhea is assessed through fecal soiling, but direct observation of the anal sphincter is not included.	Abscesses and nipple lesions should be included. Ticks should be observed in the inner pinna, because it is one of the preferred locations for adult ticks and it is practical to observe under farms conditions. Scabies can be assessed by wool inspection. Diarrhea should be evaluated by direct observation of the anal sphincter.
Behavior	Social behavior	Aggressive behaviors can be observed on farms, even if low in proportion (Gougolis et al., 2010).	Aggressive behaviors are not included in previous protocols.	Aggressive behaviors should be included in the protocol. The main aggressive behaviors are head butting, head tossing, and displacing (Lauber et al., 2012).
	Other behaviors	Grazing restrictions can cause wool pulling as a redirected behavior (Vasseu et al., 2006). However other factors could affect this behavior, such as feeding particle size (Reinhardt, 2005).	Wool pulling is difficult to observe visually on the farm. No indicators of wool pulling are proposed in previous protocols.	Wool pulling could be evaluated through the presence of bald patches in wool because they can be clearly distinguishable from those caused by other factors, such as parasites or systemic processes (Chiezey, 2010).
	H–A relationship	Spanish breeds are very diverse in terms of the human–animal relationship. The reaction of the animal during restraint, such ear posture or attempts to escape, can contribute to a better evaluation of the H–A relationship.	No indicators of animal reaction during restraint are proposed in previous protocols. Ear posture has been used in experimental conditions (Reefmann et al., 2009; Boissy et al., 2011). Response during restraint has been used in previous studies (Stubsjoen et al., 2011).	Ear posture could be adapted as an indicator (Reefmann et al., 2009; Boissy et al., 2011). Response during restraint could be adapted from previous studies in which ewe reaction was evaluated during the farmer's approach (Stubsjoen et al., 2011).

(Continued)

TABLE 2 Continued

Welfare principle	Welfare criteria	Particular aspects of evaluation in Spanish farm conditions	Score in previous protocols or recommendations according literature	Suggestions for adaptations or novel indicators
	Approach test	Flock reaction in response to human approach is difficult to standardize due to the diversity of facilities.	Approach tests have been used in other species, such as cattle, but it has not been included in previous protocols for sheep.	Approach tests should be adapted to for a diverse range of housing systems.

TABLE 3 List of measures for welfare assessment used in the study.

Welfare principle	Welfare criteria	Welfare indicator	References	Individual/ group indicator, or farm measure	Scoring criteria	Score
Good feeding	**Prolonged hunger**	Body condition score (BCS)	Russell et al., 1968	Individual indicator	Individual: 1–5-point scale according to Russell et al., (1968). Group level: BCS average and number of animals with low BCS (< 2.0).	1: Emaciated 2: Thin 3: Average 4: Fat 5: Obese Group level: number of animals with BCS of 1
	Prolonged thirst	Water provision	Caja and Rivas, 1988; Dwyer, 2008	Farm measure	Access to drinkers on facilities is assessed. A minimum of 1 drinker/50 animals or 1 m of drinking trough/100 animals is required.	0: Correct 1: Incorrect
		Cleanliness of water points	AWIN, 2015	Farm measure	Each drinker on the farm is evaluated as dirty (water point and water dirty, or water source stagnant or polluted), partly dirty (water point is dirty, but water appears clean, or water with rubbish but appears clean), or clean (water point and water appear clean and unpolluted). The prevalent condition in the farm is considered.	0: Clean 1: Partly dirty 2: Dirty
Good housing	**Comfort around resting**	Sternum evaluation	Suggested indicator*	Individual indicator	Sternal region is evaluated by palpation, measuring hair quality according to its hardness and cleanliness.	0: Clean: hair appears soft at palpation and no dirt is detected 1: Partly dirty: hair appears hard at palpation but no dirt is detected 2: Dirty: remains of dirt or mud are palpated
		Shade availability	AWIN, 2015	Farm measure	Shade availability in facilities and outdoor areas is measured. Shade availability is required for the entire flock, with a minimum of 1 m^2/ewe or 1.2 m^2/ewe with lamb.	0: Correct 1: Incorrect
	Thermal comfort	Crowding behavior	Suggested indicator*	Group indicator	A period of 15 minutes is established for flock observation. The percentage of ewes that crowd with heads down is recorded at the beginning, middle, and end of the period.	Average percentage of animals that crowd with heads down (adapted from Moyano et al., 1992)
	Ease of movement	Density	Caja and Rivas, 1988; Dwyer, 2008	Farm measure	Space allowance per ewe is calculated in all pens. A minimum is required of 1 m^2/ewe or 1.2 m^2/ewe with lamb.	0: Correct 1: Incorrect
		Access to feeders	Caja and Rivas, 1988; Dwyer, 2008	Farm measure	Access to feeders is evaluated at the farm level. A minimum of 0.35 m of feeder/ewe or 1 headlock/ewe is required (Caja and Rivas, 1988).	0: Correct 1: Incorrect

(Continued)

TABLE 3 Continued

Welfare principle	Welfare criteria	Welfare indicator	References	Individual/ group indicator, or farm measure	Scoring criteria	Score
Good health	**Absence of injuries**	Lesions	Adapted from AWIN, 2015	Individual indicator	The animal is checked on both sides of the body, all four limbs, and the head, and the presence of the following lesions is recorded: lesions on skin with blood or crust, linear lesions, dermatitis in the auricular pavilion, keratitis, and ocular trauma.	0: Absence (no lesions observed) 1: Minor injuries (linear lesions <2 cm, dermatitis or keratitis) 2: Major injuries (lesions with blood or crust, linear lesions <2 cm or ocular trauma)
		Lameness	Adapted from AWIN, 2015	Individual indicator	The whole flock is observed when going out to pasture. If it is no possible, they are observed in the pens, making them walk. Animals with an abnormal gait are recorded and classified as mild lameness (the animal is able to keep up with the rest of the flock =1) or severe lameness (the animal is not able to keep up =2).	(Σ mild lameness + Σ severe lameness)/total number of animals.
	Absence of disease	Subcutaneous abscesses	Suggested indicator *	Individual indicator	The presence of subcutaneous abscesses in body, limbs, head and udder is recorded.	0: Absence of subcutaneous abscesses 1: Presence of at least one subcutaneous abscess
		Udder health	Adapted from AWIN, 2015	Individual indicator	The udder is palpated and visualized, and the following alterations are evaluated: presence of fibrous tissue, lesions in the udder skin, lesions on nipples and signs of mastitis.	0: Healthy udder 1: Altered udder (lesions on skin, lesions on nipples or presence of fibrous tissue) 2: Mastitic udder (pain or heat)
		Ocular discharges	AWIN, 2015	Individual indicator	Presence of ocular discharge or epiphora in both eyes is evaluated.	0: Absence of discharge or epiphora 1: Presence
		Nasal discharges	AWIN, 2015	Individual indicator	Presence of liquid or serous discharge is evaluated, unilateral or bilateral.	0: Absence of discharge 1: Presence
		Respiratory symptoms	Adapted from AWIN, 2015	Group indicator	During the 15-minute observation period, coughing is recorded.	Total number of coughs
		External parasitization	Suggested indicator*	Individual indicator	The inner part of the auricular pavilion on both sides is inspected; the presence of external parasites is recorded. Wool is inspected to observe wool patches with hardened skin caused by scabies; body and head skin is inspected to observe lesions caused by scabies.	0: Negative 1: Positive
		Diarrhea	Adapted from AWIN, 2015	Individual indicator	While the ewe is restrained, its tail is lifted back and only the anal sphincter is observed. The presence of mucus, including purulent or bloody mucus, is evaluated.	0: Absence 1: Presence
	Management procedures	Ear tag lesions	Stubsjoen et al., 2011.	Individual indicator	Both auricular pavilions are inspected; lesions caused by ear tags are recorded. Lesions include tissue tears and bloody or purulent lesions.	0: Absence 1: Presence
		Tail docking	Adapted from AWIN, 2015	Individual indicator	It is noted if the tail is docked or not.	0: Docked. 1: Non-docked

(Continued)

TABLE 3 Continued

Welfare principle	Welfare criteria	Welfare indicator	References	Individual/ group indicator, or farm measure	Scoring criteria	Score
Appropriate behavior	**Social behaviors**	Aggressive behaviors	Suggested indicator*	Group indicator	During the 15-minute observation period, the following behaviors are recorded: head butting, head tossing, and displacing.	Total number of observed behaviors
	Other behaviors	Wool pulling	Suggested indicator*	Individual indicator	Wool is inspected; bald patches with no hardened skin or reddened skin, and their extent, are recorded.	0: Absence 1: Low (path area < 5 cm) 2: Medium (path areas clearly visible) 3: High (path areas greater than 50% of the total wool area)
	H–A relationship	Ear posture during restraint	Suggested indicator*	Individual indicator	It is observed if a backward ear posture is maintained for a minimum of 5 seconds during restraint.	0: No backward position observed 1: Backward position
		Reaction during restraint	Suggested indicator*	Individual indicator	The reaction of the animal during restraint (after being immobilized) is observed.	0: No reaction 1: Moves 2: Clearly attempts to escape
		Approach test	Adapted from AWIN, 2015	Group indicator	The reaction of flock in the pen when the observer touches one of the animals is observed.	0: No reaction (ewes can be touched) 1: Animals move 2: Adverse reaction

*Suggested indicators are included based on welfare issues detected in the scientific literature on Spanish sheep flocks that as of yet have no validated indicators to assess them. The relevant welfare issue and the suggested indicator are described in Table 2.

Good housing

The average sternum evaluation value per farm was 0.72, and 73% of farms scored below 1. Bed condition had a significant effect on average sternum evaluation ($p < 0.01$, Table 4); the average sternum evaluation value was higher with poorer bed conditions. No effect from level of intensification, farm size, breed, or season on sternum evaluation value was observed.

Crowding behavior was exhibited when the temperature was above 17°C and the percentage of animals crowding increased as the temperature became higher. When crowding behavior was compared with environmental temperature, a positive correlation was found ($p < 0.01$, $r = 0.65$), regardless of sun exposure. When environmental temperature was between 17°C and 24°C, the average percentage of crowding ewes was 34%, and above 25°C it rose to 62%. Shade availability was judged to be insufficient in 6% of the farms. Density was too high in 14% of the farms and access to feeders was inadequate in 35%. No correlation was observed between access to feeders and BCS ($p = 0.3$).

Good health

The average proportion of animals per farm showing lesions was lower than 5%. On 53 farms, no lesions were reported. No effect from intensification, farm size, breed, or season on lesions was

TABLE 4 Sternum evaluation mean in farms according to bed conditions.

Bed condition	Sternum evaluation (mean)	Number of farms
1. Dry without organic remains	0.41 ± 0.083^{d}	24
2. Dry with presence of organic remains	0.61 ± 0.071^{c}	34
3. Wet	0.86 ± 0.088^{b}	22
4. Wet and dirty	1.19 ± 0.097^{a}	20

Individual sternal evaluation was scored dirty (0), partly dirty (1) and dirty (2).
Values with differents letters mean statistically different.

observed. Lameness was not observed in most farms (66%). When it was observed, the percentage of affected animals per farm was very low (< 1%). The results for disease indicators are shown in Table 5. The level of intensification affected some of the disease indicators. Nasal discharge was higher on SE than on SI and I farms ($p = 0.02$). Ocular discharge and respiratory symptoms tended to be higher on SE farms than on SI and I farms ($p = 0.08$ and 0.10, respectively). In contrast, subcutaneous abscesses exhibited a higher prevalence on intensive farms ($p = 0.015$) than on SI or SE farms. Seasonality also affected some of the disease indicators. The presence of parasites was higher ($p < 0.01$) in spring than in the rest of the seasons. The presence of ocular discharges was higher ($p = 0.03$) in winter and spring than in autumn and summer. Abscesses were less frequent ($p = 0.05$) in winter than in spring. Flock size also had an effect on health status, as smaller farms showed a higher prevalence of diarrhea (small 0.03 ± 0.01 vs. medium and large 0.01 ± 0.01, $p = 0.02$), and large farms showed a higher prevalence of abscesses (small 0.09 ± 0.01, medium 0.11 ± 0.01, large 0.13 ± 0.01, $p < 0.01$). No association was observed between subcutaneous abscesses and bed condition. At an individual level, the presence of abscesses had no correlation with sternum evaluation, BCS, or age. Regarding management procedures, ear tag lesions were observed in 4% of the animals per farm on average, with a maximum of 20% on one farm. Tail docking was performed on 94% of the farms, with no routine anesthesia and analgesia during the procedure, as reported by farmers.

Behavior

Aggressive behavior was observed on 47 out of 100 farms, with an average of 2.2 aggressive events per farm. The main observed behaviors were head butting (53%), displacements (25%), and head tossing (22%). Aggressive behaviors were observed less frequently during warm seasons. Indeed, there was a negative correlation between the total number of aggressive behaviors per farm and environmental temperature ($p < 0.01$, $r = -0.30$). The frequency of aggressive behaviors was significantly higher in winter and spring than in summer (Figure 2, $p < 0.01$). No effect from the level of intensification, farm size, or breed on the frequency of aggressive behaviors was observed.

Wool pulling was observed on 23 farms, and the mean score per farm was significantly higher on I farms (See Table 5). Animals affected by wool pulling had a lower BCS than unaffected animals. Regarding the human–animal relationship, ear posture and reaction during restraint varied greatly between farms, but no effect from intensification, farm size, or breed on these behaviors was observed. At the individual level, urination showed a positive correlation with reaction during restraint ($p < 0.01$) and tended to have a positive correlation with backward ear posture ($p = 0.058$). At the farm level, the human approach test showed a positive correlation with the prevalence of reaction during restraint ($p < 0.01$). The average time to perform the full assessment for each farm was 2 hours and 10 minutes.

Discussion

The aim of this study was to evaluate sheep welfare in Spain throughout the year in different production systems and breeds, using a list of measures. Assessment was performed across 100 farms. Our results provide relevant information about welfare conditions on Spanish farms. Some of the measures required restraint of the animals; this meant that the assessment performed in the present study was not feasible in extensive systems in which animals remain outside of the pen at all times.

Good feeding

BCS may vary according to physiological state. In our study, all evaluated sheep were in the post-partum period and thus a score of 2.25 would be acceptable (Purroy, 1997). Most flocks exhibited an acceptable average BCS. However, in addition to flock average, it would be interesting to consider the number of animals with a low BCS. Ewes are adapted to low levels of nutrition (Caldeira and Portugal, 1991; Waterhouse, 1996), but food restriction may negatively alter the affective state of the animal (Verbeek et al., 2014).

TABLE 5 Results of disease indicators and wool pulling according to production system and season.

Welfare indicator	Level of intensification				Season				
	I	SI	SE	*p*-value	Summer	Autumn	Winter	Spring	p-value
Subcutaneous abscesses	0.15 ± 0.02^{a}	0.10 ± 0.01^{b}	0.07 ± 0.01^{b}	0.015	0.11 ± 0.02^{a,b}	0.11 ± 0.02^{a,b}	0.08 ± 0.02^{b}	0.14 ± 0.02^{a}	0.05
Udder health	0.06 ± 0.04	0.07 ± 0.02	0.07 ± 0.02	0.90	0.07 ± 0.03	0.07 ± 0.02	0.07 ± 0.02	0.07 ± 0.02	0.90
Ocular discharge	0.04 ± 0.03^{a,b}	0.04 ± 0.01^{b}	0.08 ± 0.01^{a}	0.08	0.02 ± 0.02^{b}	0.04 ± 0.02^{b}	0.08 ± 0.02^{a}	0.09 ± 0.02^{a}	0.03
Nasal discharge	0.04 ± 0.05^{b}	0.08 ± 0.02^{b}	0.16 ± 0.03^{a}	0.02	0.13 ± 0.04	0.07 ± 0.03	0.10 ± 0.03	0.08 ± 0.03	0.40
External parasitization	0.06 ± 0.09	0.02 ± 0.01	0.03 ± 0.01	0.53	0.11 ± 0.05^{a}	0.01 ± 0.04^{a}	0.05 ± 0.10^{a}	0.41 ± 0.04^{b}	<0.01
Diarrhea	0.01 ± 0.02	0.02 ± 0.02	0.03 ± 0.02	0.20	0.03 ± 0.02	0.01 ± 0.012	0.02 ± 0.01	0.01 ± 0.01	0.21
Respiratory symptoms	2.30 ± 2.16^{a,b}	2.60 ± 0.84^{b}	5.48 ± 1.09^{a}	0.10	5.25 ± 1.60	3.07 ± 1.25	1.35 ± 1.45	4.17 ± 1.31	0.21
Wool pulling	0.33 ± 0.06^{a}	0.05 ± 0.02^{b}	0.05 ± 0.03^{b}	<0.01	0.16 ± 0.04	0.08 ± 0.03	0.15 ± 0.04	0.17 ± 0.03	0.16

Mean values are calculated according to scoring criteria.
Values with different letters in each row mean statistically different.

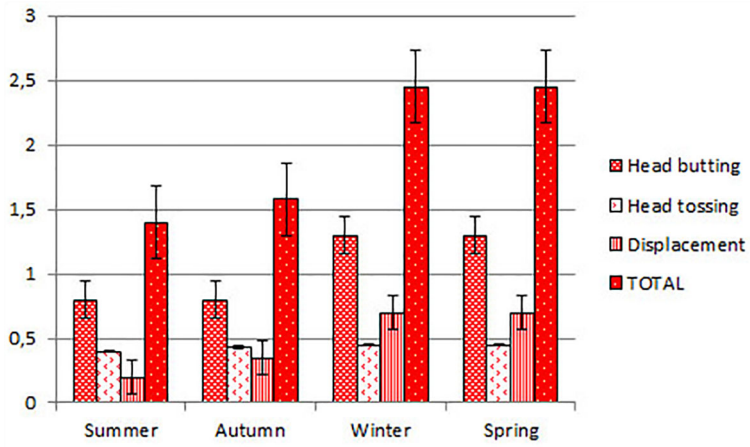

FIGURE 2
Mean of aggressive behavior according to season during the 15-minute observation period.

Regarding water provision, results indicate that most of the farms had an insufficient number of drinkers due to their malfunction or simply due to a lack of a sufficient number of water points. Poor access could lead to poor water consumption and this could affect not only welfare but also productivity, as water demand is particularly high in some productive states. For instance, 5–6 liters/ewe/day during gestation and 6–7 liters/ewe/day during lactation are recommended for sheep farms (Garces et al., 1995).

Good housing

Bed condition had a significant effect on average sternum evaluation, which suggests that this indicator may be valid for measuring comfort when resting, but specific research should be carried out to confirm its validity. Most of the farms showed good levels of sternum evaluation, and we suggest the sheep on these farms had a comfortable resting place. Bed quality has an effect on ewe comfort (Goddard, 2011), and sternum evaluation could be a precise and simple animal-based indicator to assess this because it can be used regardless of wool cover and color and, thus, in any breed type, even after shearing. Sternum evaluation could be an alternative to previously used indicators, such as the bed condition score (Napolitano et al., 2009; Lavín et al., 2012). According to our results, there is a close association between crowding behavior and environmental temperature. Crowding behavior allows for the reduction of heat gain from radiation and increases heat loss via convection and conduction (reviewed by Silanikove, 2000). Some authors consider this behavior to be affected by temperature and the presence of flies in a complex interaction (Moyano et al., 1992) but, according to our results, the association with temperature is strong, even when some breeds from hot climates are adapted to high temperatures. Our results suggest that crowding behavior could be complementary to environmental temperature measures when evaluating the perception of heat and, thus, thermal stress, but more research should be performed to confirm this as a reliable indicator.

Good health

The prevalence of lesions was high on some farms and this could be an indicator of handling quality because the type and quality of the equipment used during handling or housing can produce lesions (AWIN, 2015). In most cases, lesions were on the skin, but dermatitis and ocular lesions were observed as well. In some cases, lesions were attributed to recent shearing, which can be a cause of wounds and infections (Al Rawashdeh and Alqudahk, 2000), although this procedure must be performed at least once per year for health and welfare reasons (FAWC, 1994). We suggest that the date of the last shearing is taken into account when a welfare assessment is performed on a farm. Dermatitis was observed on some farms, but always in the ears, during the spring period and in white breeds, and it has been attributed to photosensitization (Ferrer et al., 2007). Ocular lesions were mainly observed in flocks with access to pasture (SE and SI systems). In Mediterranean pastures, the presence of the ovate goat grass (*Aegilops geniculata*) can produce ocular lesions on sheep while they are grazing, causing keratitis that can develop into ocular trauma, and is hypothesized to be the main cause of ocular trauma in this study.

Lameness was observed in very low proportions. No cases of foot rot were observed and lameness was always attributed to mechanical problems, which is in accordance with other studies carried out in Spain (Ferrer and Ramos, 2008). In central Europe, lameness is clearly associated with foot rot (Kaler et al., 2011) and is present in more than 90% of the flocks (FAWC, 2011).

Subcutaneous abscesses were more prevalent on intensive and large farms. Abscess prevalence increases due to poor hygiene and housing conditions in intensive systems (Guarde, 1986; Paton et al., 2003). However, we did not find a higher prevalence in farms with poor bedding, so abscesses could indicate infection pressure rather than bedding quality. Indeed, subcutaneous abscesses can be considered as an indicator of bad housing conditions if they facilitate the presence of bacteria in the animals' surroundings (Baird and Fontaine, 2007). Subcutaneous abscesses are usually caused by *Corynebacterium pseudotuberculosis* (i.e., caseous

lymphadenitis) and are related to general welfare conditions (Baird and Fontaine, 2007; Fontaine and Baird, 2008). In poor housing conditions, the presence of wounds is high and the prevalence of subcutaneous abscesses increases, because wounds facilitate bacterial infections (Nairn and Robertson, 1974; Fontaine and Baird, 2008), particularly if shearing is performed under poor hygienic conditions (Serikawa et al., 1993; Al Rawashdeh and Alqudahk, 2000). The prevalence of subcutaneous abscesses was in line with other studies in Spain (Sánchez et al., 1979; Vizcaíno et al., 2002). Nevertheless, the proportion of affected animals (8.45%) was lower than in other studies conducted in France (51%, Vizcaíno et al., 2002) and in Australia (26%, Paton et al., 2003).

On some of the farms, a very high percentage of external parasites was observed, and in some of them all sampled animals were infected by ticks. After considering the most convenient means of assessing external parasites, we chose to observe ticks exclusively in the auricular pavilion, because it is one of their preferred body regions. The prevalence of ectoparasites has been underestimated in hot climates (Basco et al., 2008). Ectoparasites are themselves an important welfare issue, but also spread several diseases. In southern European countries, ticks can be found on wild animals and plants in hot periods, which can be sources of infestation in sheep, especially in SE or SI systems (Basco et al., 2008). In Spain, different tick species have been identified in extensive conditions and each one requires different control methods (González et al., 2018). The geographical distribution of ticks is associated with climate conditions, and the Spanish climate favors their presence, but in recent years tick distribution has tended to increase across European countries (Estrada-Peña, 2017).

Diarrhea was observed at very low prevalence, which means that a very precise indicator to correctly assess the presence of diarrhea in animals is needed. Direct observation of the perineal zone, as described in the list of measures for welfare assessment (Table 3), allowed for the detection of animals with an incipient diarrhea. There were significant differences between farms in udder health, probably due to management procedures. Nipple lesions affect the welfare of lambs because this prevents them from suckling and leads to malnutrition. Clinical mastitis causes pain (Gregory, 2004) and can cause chronic stress, with loss of milk production and alteration of milk composition in the long term (Sevi et al., 1999; Sevi et al., 2001). The overall results of disease indicators show that there is a clear seasonal effect on disease and, thus, for a correct welfare assessment, it is necessary to evaluate the same farm at different periods.

In some farms, a high proportion of ear tag lesions was observed; hence it is important to include them in a welfare assessment. The presence of lesions depends more upon the shape of the tag than the type of material, and correct positioning and application is important to minimize damage; as a result, the effective training of the operator is important (Edwards and Johnston, 1999; Edwards et al., 2001).

Ruminal boluses are a less invasive method of identification than ear tags and remain in the reticulorumen without affecting productivity or welfare (Garín et al., 2005; Ghirardi et al., 2007). They could be an alternative to ear tags and are widely used in some countries. Indeed, European legislation makes an electronic identifier such as a ruminal bolus mandatory, but together with another visible, readable mark (Council Regulation 21/2004).

Behavior

Aggressive behavior increases with competition for resources such as feed, water, and space. Competition for space has been confirmed in sheep (Erhard et al., 2004; Jorgensen et al., 2009) and mainly depends on lying surface (Boe et al., 2006). The main negative interactions are blocking, threatening, head butting, nudging, and displacing. However, no studies have been performed at a farm level; in fact, some authors consider the issue of behavioral assessment at the farm level unresolved (Gougolis et al., 2010). Given the seasonal effect on aggression and the seasonality of breeding stages, observations should be carried out throughout the year to obtain a precise estimation of mean annual values.

Even if stereotypies are less frequent in ruminants than in other species (Dwyer and Bornett, 2004; Nowak et al., 2008), they should be included in a welfare assessment. When sheep are taken from pasture and kept indoors, their behavior is affected and this can lead to stereotypic patterns (Done-Curie et al., 1984). In sheep, one of the main stereotypies is wool pulling, which involves animals pulling the wool of their conspecifics and producing bald patches (Fraser and Broom, 1997). Fleece condition and wool cover has been proposed as animal-based indicators in sheep welfare assessment (Phytian et al., 2011; Llonch et al., 2015), but no specific assessment for wool pulling has been proposed. Bald patches produced by wool pulling should be distinguished from those caused by other factors, such as parasites, toxic agents, metabolic disorders, and nutritional insufficiencies (Chiezey, 2010). Wool pulling score proposed in this study allows this distinction. In our study, during farm visits, wool inspection and the observation of bald patches, hardness, and the redness of the skin allowed for a proper wool-pulling assessment, and other causes of bald patches could be accurately distinguished. Thus, wool cover may be a reliable indicator of wool-pulling, despite this measure requiring validation. Some authors consider wool pulling to be a consequence of a restrictive environment (Cooper and Jackson, 1996) or husbandry deficiencies (Reinhardt, 2005). According to our results, it appeared mainly in intensive farms, which supports the theory that wool pulling is a redirected behavior when sheep are subject to grazing restrictions and deprived of adequate levels of activity or oral stimulus (Vasseu et al., 2006).

Conclusions

In Spain there are some particularities in farming that should be considered in order to correctly evaluate sheep welfare. A hot and arid climate makes a focus on hygiene and health factors, such as bed condition, external parasites, and crowding behavior, particularly crucial. The particularities of Spanish sheep breeds also make the evaluation of some aspects that are seemingly

underestimated in existing protocols, such as aggressive behavior, reaction during restraint and wool pulling, essential. The list of measures used in this study to assess sheep welfare, based on the AWIN protocol but also including other suggested indicators, was useful in correctly evaluating sheep welfare in farms in accordance with Welfare Quality® principles, even if some of the suggested indicators still need validation. Sheep farms should be assessed during the four different seasons. Seasonality, breed, and flock size affected some welfare indicators but, according to our results, the production system is the main parameter that affects the welfare outcomes. Ewes in intensive systems exhibit a better body condition and better health indexes, but at the same time show a higher incidence of subcutaneous abscesses and stereotypies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval were not required for the animal study because the animals were handled as normal by the farmers and no wool, hair, blood, or saliva samples were taken. Written informed consent was obtained from the owners for the participation of their animals in this study.

Author contributions

RP conceived and designed the study and performed all work on the farms. PL and XM collaborated on the protocol development. PL contributed to the writing and structure of the manuscript. XS helped with farmer involvement and the statistical analysis. All authors contributed to the article and approved the submitted version.

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.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fanim.2023.1218495/full#supplementary-material

SUPPLEMENTARY FIGURE 1
Visual examples of the proposed sternum evaluation score.

SUPPLEMENTARY FIGURE 2
Visual examples of the proposed wool pulling score.

SUPPLEMENTARY FIGURE 3
Score examples for external parasitization, udder health and diarrhea.

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