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Measuring farmers' attitude towards breeding tools: the Livestock Breeding Attitude Scale

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Under-use of genetic improvement tools and low participation in breeding programmes are key drivers of breeding programmes under-performance. Both aspects are heavily influenced by farmers attitudes which, to date, have not been analysed in an objective and systematic manner. A key factor constraining the implementation of attitudinal studies towards livestock breeding tools is the lack of a reference scale for measuring attitudes. In this research, we provide the livestock breeding sector with such a reference measure. We developed the scale following the standardized psychometric methodologies and statistical tools. Then, as a case study, we used the scale to explore the attitudes of beef and dairy sheep farmers in Australia, New Zealand and Spain and analysed farmer and farming system factors related to those attitudes. Fourteen sheep and beef breed associations facilitated the implementation of a survey of 547 farmers, generating data that was used for the scale evaluation. The relationship between attitudinal factors and farmer and farming system factors was analysed using generalized linear models across and within breeds. The results suggest that the 8-item definitive scale we have developed is appropriate to measure farmer attitudes. We found that attitudes towards genetic improvement tools have two components; i) traditional selection and ii) genetic and genomic selection combined. This means that positive attitudes towards traditional phenotypic selection do not necessarily imply a negative attitude towards genetic and genomic selection tools. Farmer attitudes varied greatly not only across the studied breeds, species and countries, but also within them. High-educated farmers of business-oriented farms tend to have the most negative attitude towards traditional selection. However, attitudes towards genetic and genomic selection tools could not be linked to these factors. Finally, we found that the breed raised had a large effect on farmer attitude. These findings may help in the evolution of breeding programmes by identifying both the farmers most inclined to uptake breeding innovations in the early stages of its establishment and the farmers who would be more reluctant to participate in such programmes, thus informing where to focus extension efforts.
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Implications

We provide the livestock breeding sector with a standard reference measure scale to assess farmers' attitudes towards livestock breeding tools. This will help inform where to focus extension efforts in the context of breeding programme development and implementation, by identifying both the farmers most inclined to participate in the initial phases of programme establishment and the farmers who would be more reluctant to do so. The scale will also allow benchmarking of the evolution of attitudes over space and time and serve as an indicator for the assessment of the impact of farmer training.

Introduction

The increase of livestock productive performance at the animal level that took place in the second half of the last century may be attributed to a large extent to livestock genetic improvement and breeding. Paradigmatic examples of this genetic gain are chicken broilers and Holstein-Frisian dairy cows (e.g. Havenstein et al., 2003; Brotherstone and Goddard, 2005). Despite the irrefutable impact that breeding can have on improving livestock performance, the uptake of breeding tools across farmers communities and their participation in breeding programmes

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has happened at a very variable pace across world regions, species and breeds (e.g. Sise et al., 2012; Miglior et al., 2017). A low turnout in breeding programmes and under-use of breeding tools have been suggested to be major drivers of breeding programme under-performance (Serradilla, 2008; Nielsen et al., 2011 and 2014). Yet, the study of the factors influencing farmer uptake of breeding tools and participation in breeding programmes has been overshadowed in the scientific literature by the development of methods for genetic evaluation, the construction of selection indices, as well as the development of computational algorithms to be able to incorporate genomic data into breeding programmes. This tendency has been apparently changing in recent years as social drivers of breeding programmes are gaining increasing attention in the scientific community. To date, the focus of these studies has been on analysing farmers' preferences for animal traits to inform the development or update of breeding objectives aiming to increase farmer participation in breeding programmes (Byrne et al., 2016; Paakala et al., 2018). However, to our knowledge, farmers' attitudes towards livestock breeding tools have not been analysed yet in an objective and systematic manner.

Human attitudes have been extensively proven to determine intention and influence human behaviour. For example, regarding consumer behaviour, attitudes are a key component when trying to explain and/or predict buyers' preferences and behaviours from a psychological perspective. The influence of farmers' attitudes on their decision-making is not an exception. Evidence shows that farmers' attitudes influence their behaviour and choice making in several areas, such as farm environmental management (e.g. Ahnström et al., 2009), welfare and health management (e.g. Jansen et al., 2009) or adoption of new technologies and policies (e.g. Edwards-Jones, 2006). In this sense, Munoz et al. (2019) showed how positive attitudes towards handling sheep influenced farm management behaviour, fostering positive ewe welfare outcomes. Therefore, farmers' attitudes towards breeding very likely influence how they approach breeding and how readily they uptake breeding tools, as noted by several authors (e.g. Kinghorn et al., 2002; Nielsen et al., 2014; Ragkos and Abas, 2015).

One of the main problems of the study of farmers' attitudes towards livestock genetic improvement tools is the lack of standardized tools to measuring such attitudes. A solution to this problem would be the development of a reference scale of farmers' attitudes towards genetic improvement tools, similar to those widely used in other science fields (e.g. Dunlap et al., 2000; Hawcroft and Milfont, 2010). Such a scale would allow benchmarking of farmers' attitudes across time, a comparison among groups of farmers (e.g. raising different breeds or livestock species) and an analysis of the factors driving attitudinal difference. In addition, such a scale would be useful for improving the design of breeding programmes in general, to design tailored extension activities to increase farmer uptake of breeding tools and to assess the impact of extension, which in turn will demonstrate to stakeholders the impact of their extension activities.

The analysis and measurement of peoples' attitudes and the development of attitude scales are a scientific field, which psychologists have been researching and developing for a long time. Attitude scales have been used in the psychometry field since its first applications in the beginning of twentieth century; therefore, methods, tools and statistical models are well-developed and readily available (Fabrigar et al., 1995).

In livestock breeding, there have been three steps of evolution of approaches and tools: traditional selection (based on the external observation of animal appearance and/or raw phenotype or their progeny), genetic selection (based on the estimation of genetic values combining phenotypes and pedigree) and genomic selection (incorporating genomic information to the genetic evaluation procedures or combining phenotypes and genotypes). These three steps have likely led to three attitudinal paradigms in the livestock farmer community, all currently coexisting. The prevalence of each paradigm and its relative importance in a given farmer community will likely depend on a number of factors such as livestock species, breed, farming system, region and country and surely will be influenced by farmer profiles.

In this context, the purpose of this research is to provide the livestock breeding sector with a reference measure to assess farmers' attitude towards animal breeding tools. Then, as a case study, we used the scale to explore the attitudes of farmer raising several beef and sheep breeds in Australia, New Zealand, and Spain and analysed potential farmer profile and farming system factors related to those attitudes. Finally, we discuss the potential use of the developed scale for breeding programme design and implementation.

The Livestock Breeding Attitude Scale

Material and methods

In short, the development of attitude scales consists of three consecutive steps: i) item definition, ii) item analysis and reliability assessment and iii) validity evidence based on internal structure (Netemeyer et al., 2003).

Item definition

An attitude can be defined as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour" (Eagly and Chaiken, 1993). Attitude scales consist of a fixed set of attitudinal statements (i.e. "items" in the rest of the manuscript) across which agreement scores, derived from Likert scales, are used to determine respondents' total level of agreement with the issue under analysis. Items must be carefully designed to measure peoples' attitudes in all relevant aspects of the issues of interest. In order to get an adequate representation of the attitudinal content that we aim to evaluate (i.e., content validity or evidence based on test content; see Sireci and Faulkner-Bond, 2014), four elements have been considered: domain definition, domain representation, domain relevance and appropriateness of the test development process. The initial list of items of the scale was thoughtfully discussed and defined in an iterative process by a group of geneticists and two psychologists expert in attitude scales development and psychometry formed *ad hoc* for this task. The group of geneticists had wide experience in animal breeding and in the establishment and development of breeding programmes, and a long history of collaboration with farmers and breeders associations. The item definitions were made under the assumption that the three steps of evolution of breeding methods and tools (i.e. traditional selection, genetic selection and genomic selection) have led to three attitudinal components (i.e. paradigms). The initial list consisted of 14 items: 10 which covered the three hypothesized livestock breeding components, plus four across-paradigms items related to farmers attitudes towards the maintenance of breed features, crossbreeding, farmer collaboration in breeding programmes and the use of reproductive technologies in breeding (Table 1). Eleven items were worded such that the agreement reflects acceptance of the tools the statement refers to, while in the rest (items 6, 8, and 12 in Table 1), disagreement reflects acceptance. The position of items within the questionnaire did not follow any particular order. To assess respondents' agreement with items, we used a six-level Likert scale (1-Totally disagree, 2-Disagree, 3-Somewhat disagree, 4-Somewhat agree, 5-Agree, and 6-Totally agree) which avoids central tendency bias. In addition, we included an "*I do not know/I do not have an opinion on this*" option.

Item analysis and reliability coefficient

The quality of the attitude scale as a measurement instrument was assessed through the analysis of different psychometric properties, univariate and bivariate item analysis and reliability estimation. Mean and SD as well as sample skewness per item were used for item analysis. Reliability (or internal consistency) was assessed using Cronbach's α (and

Table 1
Initial 14-item list of attitudinal statements.

Attitudinal dimension[1]	Order[2]	Items[3]
Traditional selection	4	The appearance of a bull/cow[4] is sufficient for telling its performance.
	10	The appearance of progeny fully indicates how good the bull/cow is.
	8	I do not need written recorded performance data on a bull/cow to fully know how good the animal is.
Genetic selection	2	Using genetic merit (breeding value) to select bull/cows improves the performance of beef better and faster than other ways of selecting.
	6	The genetic merit (breeding value) of bulls/cows does not help in the performance of their offspring.
	3	Combining information from several traits into selection indices is the best way to summarise genetic merit information (breeding values).
Genomic selection	5	The use of genomic and DNA/gene information to select bull/cows will improve the performance of sheep better and faster than any other method.
	7	It is important that opportunities for selection of beef with genomic and DNA/gene information are fully utilized.
	9	Genomic and DNA/gene information will be the only information used to select bull/cows in the future.
	11	It is important that opportunities for selection of beef cattle with new genetic developments (transcriptomics, epigenetics, gene regulation networks and metagenomic) are fully utilized.
Across dimensions	1	It is very important to maintain the breed features of bull/cows.
	14	Crossing animals of different breeds is a bad method of improving beef performance.
	13	In order to improve the performance of my herd collaboration in animal comparison with other farmers is crucial.
	12	Reproductive technologies (artificial insemination, embryo transfer) are not useful ways of improving beef performance.

[1] Hypothesized attitudinal dimension.
[2] Order in which items are presented in the survey.
[3] Question wording: "Below you will find some statements about selection of bulls and cows. Please, indicate how much do you agree/disagree with each of them".
[4] "Bull/cow" was replaced by "Ram/ewe" in the questionnaires for sheep farmers.

the 95% confidence interval (**CI**) obtained by calculating the intra-class correlation), which is the most usual estimate of reliability of psychometric tests such as attitude scales (Netemeyer et al., 2003). Because we hypothesized that farmers' attitudes towards genetic improvement tools have three attitudinal components (see above), the estimation of reliability has been calculated based on the results of a Principal Component Analysis (**PCA**, see below). As thumbnail rule, Cronbach's α value of 0.6 is usually considered the limit value above which an attitude scale can be used for research purposes, values below 0.5 would indicate a scale with low reliability (Kerlinger and Lee, 2002).

Validity evidence based on internal structure

This kind of construct validity refers to the degree to which the relationships among scale items and scale components contribute to the construct on which the proposed test score interpretations are based (e.g. Rios and Wells, 2014). As noted above, the scale was designed considering three *a priori* components, which would cover the three (hypothesized) existing attitudinal breeding paradigms. Following the usual protocols (e.g., Hair et al., 2010), two statistical tests were used to evaluate the suitability of our data to structure detection: the Kaiser–Meyer–Olkin (**KMO**) test of sampling adequacy and the Bartlett's test of sphericity. Following Dunlap et al. (2000), the internal structure of the data was evaluated by PCA with Varimax rotation for orthogonal components using the "Psych" package of R software (Revelle, 2019). In addition, we applied Oblimin rotation to evaluate the correlation between components and ensure that the use of Varimax rotation was adequate (Fabrigar et al., 1999). The number of components to consider was determined by Parallel Analysis (PA) (Thompson, 2004).

Survey and sample

The list of items of the scale was the core section of a questionnaire which also included a wide range of questions related to farming system, farmer profile and farmer breeding strategies and use of breeding tools (Supplementary Material S1). This additional information was used to explore the relationship between farmer attitudes, farmer profiles and farming system characteristics. The survey was implemented both face-to-face and online in Spain, New Zealand and Australia, from September 2017 to July 2018 (Table 2). Fourteen sheep and beef breed associations were involved in the study by facilitating the implementation of the survey with their associated farmers (either commercial or breeder), both by advertising the online survey and by carrying out face-to-face surveys. All farmers in the associations were invited to voluntarily complete the survey. Initially, 617 surveys were received. Surveys with more than 3 missing values in the attitude scale questions were removed from the analysis. The definitive data set consisted of 547 surveys (Table 2). Specifically, for the evaluation of the scale, only surveys without any missing values in the scale questions were used ($n = 348$).

Results

Scale evaluation

Parallel analysis results suggest the existence of four components in the attitude scale. The results of the KMO (0.7) and the Bartlett's test of sphericity ($\chi^2 = 984.6$; $P < 0.001$) showed enough sampling adequacy for the implementation of a data reduction technique. The results of the PCA on the 14-item initial list suggest the removal of four items. Items

Table 2
Number of surveys implemented across countries, species and breeds.

Country	Species and breeds	Total number of surveys[1]	Number of surveys used in the construction of the scale[2]	Number of surveys used in the case study[3]
Spain	Beef	328	213	232
	Asturiana de Valles	55	41	43
	Avileña-Negra Ibérica	26	18	24
	Morucha	6	2	
	Parda de Montaña	30	9	23
	Pirenaica	68	41	50
	Retinta	4	3	
	Rubia Gallega	136	98	92
	Otros	3	1	
	Sheep	116	63	84
	Assaf	29	18	21
	Churra	11	7	
	Latxa	33	9	29
	Manchega	41	28	34
	Otros	2	1	
Australia	Beef (Angus)	57	41	43
New Zealand	Beef (Hereford)	23	14	20
	Beef (Simmental)	23	17	20
	Total	547	348	399

[1] The data set includes surveys with up to 3 missing values in attitude scale questions.
[2] Surveys with no missing values in the attitude scale questions.
[3] Surveys of breeds with more than 20 farmers surveyed.

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12 and 13 (Table 1) were removed due to their low communality level (below 0.3; Brown, 2015) in the initial analysis. Items 6 and 8 were removed because they made it difficult to obtain a simple structure (i.e. items with relevant factor loadings on only one component).

Then, PCA was implemented again on the resulting 10-item provisional list, and its results again suggested the existence of four components. Table 3 shows the factor loadings on the 10-item list (KMO = 0.68; Bartlett's tests: $\chi^2 = 690.5$; $P < 0.001$). The Oblimin rotation-determined correlation values between factors were very close to zero (0.14 was the highest correlation obtained), confirming the adequacy of using Varimax rotation. The four components detected were the following two multi-item components (A and B), and two components comprising one individual item each (Table 3):

- Traditional Selection Component (Component A). This component corresponds to an attitudinal dimension that relates to the traditional selection paradigm. It consists of two items that focuses on the appearance of breeding animals (i.e. phenotypic features) as an indicator of animal genetic merit.
- Genetic and Genomic Selection Component (Component B). This component corresponds to an attitudinal dimension that relates to both the genetic and genomic breeding paradigms. It consists of six items related to the use of both genetic and genomic breeding values as indicators of animal genetic merit and the use of technological DNA and gene-related tools to assist in animal selection.

Cronbach α was 0.67 (95% CI: 0.59–0.73) for Component A and 0.72 (95% CI: 0.67–0.77) for Component B. Factor loadings were moderately high and communality levels of items ranged between 0.49 and 0.78. With these communality levels, the recommendation is to use a sample size of at least 200 observations (Fabrigar et al., 1999) which is well below the sample size of our study.

Therefore, we finally considered that the definitive attitude scale is formed by the eight items that conform Traditional selection Component (i.e. Component A) and Genetic and Genomic Selection Component (i.e. Component B). We call this scale the Livestock Breeding Attitude Scale (**LBA** scale hereinafter).

The case study

Material and methods

After the development of the LBA scale, we used it to explore the attitudes of the sheep and beef farmers (both commercial and breeders) in Australia, New Zealand and Spain. Then, we analysed the relationship between such attitudes and farmer profiles, and farming systems characteristics. For this case study, missing values of LBA scale questions in the data set were substituted using an Expected Maximization algorithm. These types of algorithms have shown to perform properly for multiple imputations in complex multivariate settings (Schafer and Olsen, 1998; Malan et al., 2020). In addition, observations with any missing values in farm and farming system variables explored (see below) were removed. Finally, we did not consider those breeds with <20 farmer questionnaires delivered. The data set analysed consisted of 399 observations (Table 2), including three Spanish dairy sheep breeds, and eight beef breeds, five from Spain, two from New Zealand and one from Australia (Angus). The relationship between LBA attitudinal components and the farmer and farming system variables was analysed by generalized linear models (*glm*) using the "lme4" package of R software (Bates et al., 2015). Specifically, we ran two groups of *glm* models, one for each LBA component.

We tested 13 independent variables which described farmer profiles and farming system: farmer age (continuous), farmer formal education level (discrete; basic, intermediate or university), farmer dedication (discrete; full-time or part-time), depth of farming heritage (discrete; from a multi-generational farming family or newcomers), country (discrete; Australia, New Zealand or Spain), species (discrete; beef or sheep), breeds (discrete; eleven above mentioned), production system (discrete; extensive/pasture-based, semi-intensive or intensive), farm property regime (discrete; family farm, family business or company-owned business), type of farm (discrete; pure livestock system or mixed agriculture and livestock system), farm size (continuous; relative number of cows/ewes over breed average), source of males (discrete; artificial insemination (**AI**), livestock markets and fairs, directly to breeders, own herd/flock or several sources) and whether farmer sell reproductive animals (discrete; yes or no). Country, species and breeds

Table 3
Descriptive item information and Principal Components Analysis factor loadings of definitive list of attitudinal statements.

Items[1]	Mean (SD)	Ss[2]	Factor loadings on attitudinal components			
			A[3]	B[4]	C	D
4. The appearance of a bull/cow[5] is sufficient for telling its performance.	3.0 (1.5)	0.3	0.84	0.07	−0.14	−0.12
10. The appearance of progeny fully indicates how good the bull/cow is.	3.1 (1.5)	0.3	0.79	0.09	−0.32	−0.22
2. Using genetic merit (breeding value) to select bull/cows improves the performance of beef better and faster than other ways of selecting.	5.0 (1.1)	−1.6	0.07	0.5	−0.14	−0.12
3. Combining information from several traits into selection indices is the best way to summarise genetic merit information (breeding values).	4.8 (1.0)	−1.0	−0.04	0.57	0.39	−0.09
5. The use of genomic and DNA/gene information to select bull/cows will improve the performance of sheep better and faster than any other method.	4.5 (1.2)	−0.9	−0.15	0.74	−0.34	−0.07
7. It is important that opportunities for selection of beef with genomic and DNA/gene information are fully utilized.	4.9 (1.2)	−1.4	−0.10	0.71	−0.16	−0.41
9. Genomic and DNA/gene information will be the only information used to select bull/cows in the future.	3.6 (1.4)	−0.1	0.06	0.61	−0.30	−0.53
11. It is important that opportunities for selection of beef cattle with new genetic developments (transcriptomics, epigenetics, gene regulation networks and metagenomic) are fully utilized.	4.9 (1.0)	−1.2	−0.20	0.73	−0.24	0.12
1. It is very important to maintain the breed features of bull/cows.	5.3 (1.1)	−2.3	−0.23	−0.30	0.68	0.01
14. Crossing animals of different breeds is a bad method of improving beef performance.	4.4 (1.7)	−0.7	0.32	0.27	0.30	0.72

[1] Number of the item represent the order in which items are presented in the survey.
[2] Sample skewness.
[3] Traditional Selection Component.
[4] Genetic and Genomic Selection Component.
[5] "Bull/cow" was replaced by "Ram/ewe" in the questionnaires for sheep farmers.

are cofounded variables, where breed explains the other variables. Therefore, for each dependent variable, we ran a complete "across-breeds" model considering the 10 variables describing farmer profile and farm system plus a breed variable. In addition, we ran specific models for each breed to explore if the effect of farmer and farming system variables on farmer attitude depends on the breed considered. Models were built following a backward elimination procedure and evaluated using the Akaike Information Criterion.

Results

We found high variability in farmers' attitude towards both Traditional Selection and Genetic and Genomic Selection Components within countries, species and breeds (Fig. 1 and Supplementary Tables S1 and S2). Overall, Australian and New Zealand farmers (i.e. Angus, Hereford and Simmental) had lower values (more negative) in both components than Spanish farmers (ANOVA $P < 0.001$; Supplementary Table S1). Dairy sheep farmers had on average lower values in the Traditional Selection Component and higher values in the Genetic and Genomic Breeding Component than beef farmers (ANOVA $P < 0.001$; Supplementary Table S1). Finally, comparing breeds, Assaf farmers had the highest value in the Genetic and Genomic Selection Component and the lowest value in the Traditional Selection Component of the breeds considered (pairwise *t*-test $P < 0.001$; Supplementary Table S2). On the contrary, the highest values in the Traditional Selection Component were found in farmers raising Parda de Montaña, Rubia Gallega, Pirenaica and

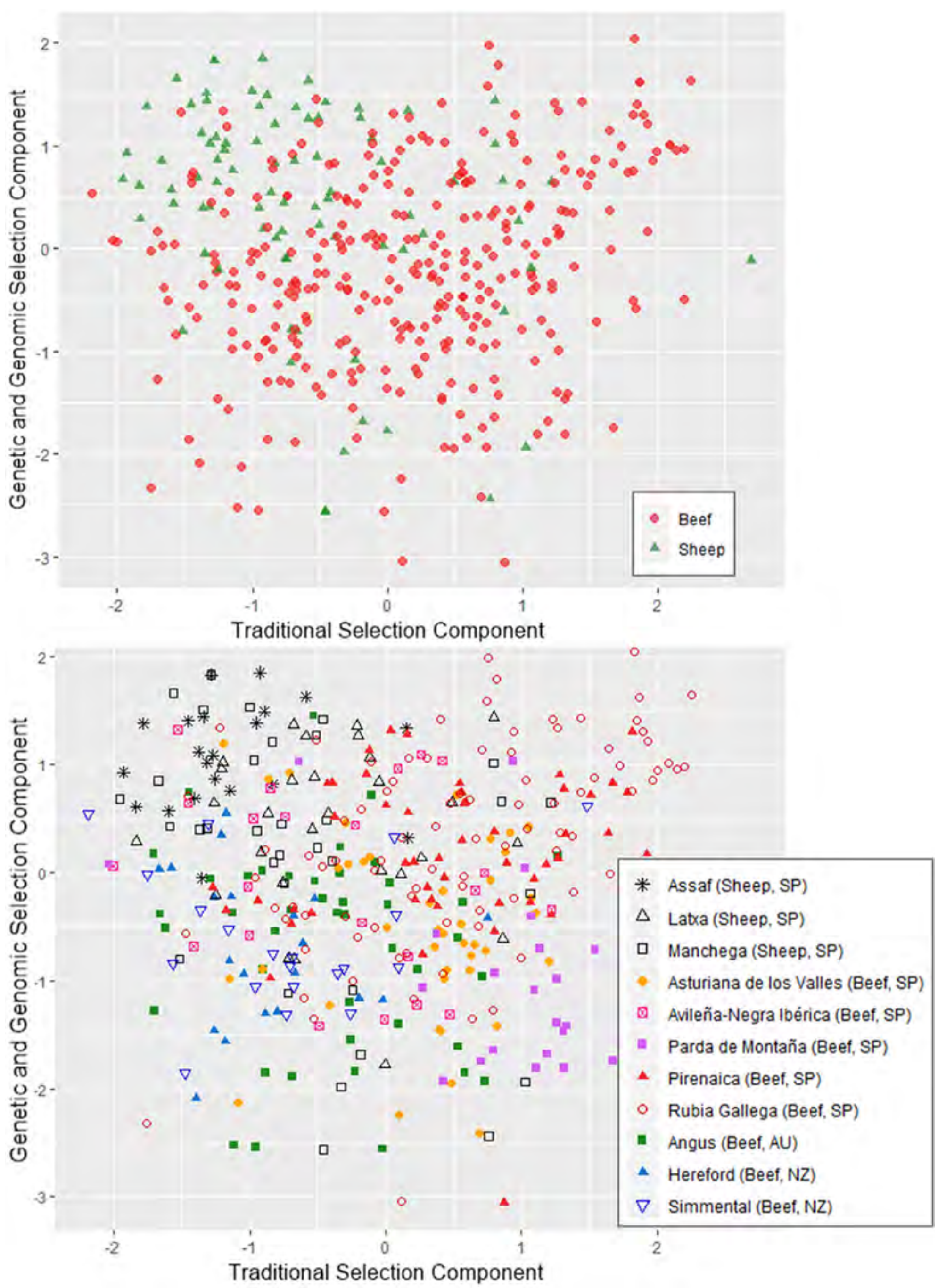

Fig. 1. Scatter plot of farmers' attitudinal components values across species and breeds.

Asturiana de los Valles breeds, while the lowest values in the Genetic and Genomic Selection Component were found in farmers raising Parda de Montaña, Angus, Hereford, Simmental and Asturiana de los Valles beef breeds (pairwise *t*-test $P < 0.001$; Supplementary Table S2).

The across-breeds *glm* models developed showed that the breed farmed had a large effect on farmers' attitudes both towards traditional selection and towards genetic and genomic selection (Table 4). In addition to the breed effect, five farmer and farming system variables had significant effects on farmers' attitudes towards breeding. Regarding farmer profile, the higher the formal education level, the more negative attitudes towards Traditional Selection Component ($P < 0.05$). Surprisingly, farmers with intermediate education level had more negative attitude towards genomic and genomic genetic improvement tools than farmers with both basic ($P < 0.001$) or university education ($P < 0.05$). In addition, farmers from families without farming tradition present a more negative attitude towards traditional selection tools than farmers with farming heritage ($P < 0.05$). Comparing farming system characteristics, farmers with farms under a business property regime had a more negative attitude towards traditional selection than farmers from family farms or family business farms ($P < 0.05$). Also, farmers with larger herds/flocks tended to have a more positive attitude towards genetic and genomic selection ($P < 0.1$). Finally, considering the source of males, we found that farmers using AI also tended to have ($P < 0.1$) a more negative attitude towards traditional selection than farmers getting males from other sources. Farmer age, farmer dedication, production system, being a pure livestock farm or not, or being a breeder or not were found to have no effect in the across-breed models.

Table 4
Generalized linear models results for the association of farmer profile and farming system variables with farmer attitude towards genetic selection tools.

[1]Variables and categories ("*Reference category*")	Genetic and Genomic Selection Component	Traditional Selection Component
Farmer formal education level ("*Intermediate*")		
Basic	0.359***	0.249*
University	0.312*	−0.284*
Family farming tradition ("*No*")		
Yes	ns	0.256*
Breed ("*Angus*")		
Hereford	ns	−0.549*
Simmental	ns	−0.476*
Asturiana de los Valles	ns	0.357†
Avileña-Negra Ibérica	0.647**	ns
Parda de Montaña	ns	0.994***
Pirenaica	0.980***	0.637***
Rubia Gallega	1.092***	0.709***
Assaf	1.824***	−0.706**
Latxa	1.244***	ns
Manchega	0.832***	−0.351†
Farm property regime ("*Family business*")		
Business	ns	−0.411*
[2]Herd/Flock size (*Continuous variable*)	0.098†	ns
Males source ("*Directly to breeders*")		
Artificial insemination	ns	−0.316†
Markets and fairs	ns	ns
Own herd/flock	ns	ns
Several sources	ns	ns
Null deviance	403.7	401.3
Residual deviance	283.4	235.2
Proportion of variance explained	0.30	0.41
Df	16	19
Akaike Information Criterion (AIC)	1027.8	963.5

† $P < 0.1$.
[1] The following variables did not show any significant effect on the models: Farmer age, farmer dedication, production system, pure livestock farms, and breeders.
[2] Number of reproductive females relative to breed average.

The results of the within-breeds models showed that the farming system and farmer profile factors described above had also a significant effect within many breeds (Supplementary Tables S3 and S4). On the other hand, the results of the within-breed analyses showed that some factors (i.e. farmer age, farmer dedication, the production system, being a pure livestock farm or not, or being a breeder or not) that did not show any general effect across breeds had a significant effect on farmers attitude within some breeds. For example, farmer age on the Genetic and Genomic Selection Component in Hereford ($P < 0.05$) and on the Traditional Selection in Rubia Gallega ($P < 0.05$). Being a full-time farmer or not had an impact on the Genetic and Genomic Selection Component in Angus ($P < 0.01$) and on the Traditional Selection in Rubia Gallega ($P < 0.01$). The direction of the effect of some other factors (i.e. farmer dedication, production system, or being a breeder or not) depended on the breed considered. For example, Hereford ($P < 0.05$) and Simmental ($P < 0.05$) farmers of grassland systems had lower values on the Genetic and Genomic Selection Component than semi-intensive farmers, but the opposite was found in Asturiana de los Valles and Rubia Gallega farmers ($P < 0.01$). Pure livestock systems had a negative effect on the Traditional Selection Component in Hereford ($P < 0.01$). Finally, being a breeder also influenced farmers' attitudes, but the direction of the effect also varied depending on the breed; in Hereford farmers, it had positive effect on the Genetic and Genomic Selection Component ($P < 0.05$) and a negative effect on the Traditional Selection Component ($P < 0.01$), but the opposite happens in Simmental breed.

Discussion

In this study, we aimed to provide the livestock breeding industry with a measure scale to assess farmers' attitudes towards livestock breeding tools. The results reported suggest that the 8-item LBA scale we have developed is appropriate to measure farmer endorsement of both traditional selection methods and genetic and genomic selection tools. Our results - confirmed our initial hypothesis that farmers' attitudes towards breeding tools is a multidimensional concept. However, while the scale items were selected to represent three discernible components of farmers' attitude (covering traditional selection, genetic selection and genomic selection paradigms), results suggest that farmers' attitudes towards breeding tools have two components: traditional selection on the one hand, and, on the other hand, genetic and genomic selection combined. This finding has two key implications. First that, contrary to what one might think, farmers' positive attitudes towards traditional selection do not necessarily imply a negative attitude towards genetic and genomic tools, and vice versa. Second, that farmer's attitudes towards genetic and genomic tools are actually components on the same dimension, meaning that farmers do not differentiate between these two breeding approaches even though they have their specific uses, strengths and limitations.

Despite the fact that we have accomplished our goal of developing an instrument to measure farmers' attitude towards genetic improvement tools, we must highlight the need for further study of the LBA scale. First, it is important to assess if the scale is valid and reliable for other farmer communities beyond those studied here, farmers raising dairy sheep and beef breeds mainly from Spain (79.3% of the data used for the assessment of the scale) and to a smaller extent from Australia (11.8%) and New Zealand (8.9%). In a similar vein, an international group of geneticist carefully defined the 14 statements of the initial list of items to comprise all the attitudinal positions existing in the animal breeding discourse. However, their work and experience within the breeding industry is mainly in developed countries; therefore, the views might be biased towards these realities. Second, future research is needed to revise the issues of the scale dimensionality and corroborate that the two-dimensional pattern we found also applies in other farmer communities. In this sense, the study of the dimensionality of the scale in farmer communities where genomic breeding programmes are in place or in communities without well-established genetic breeding programmes might lead to different results. Such a study might give us some insight into the influence of the state of breeding programmes development in shaping farmer attitudes. Third, it would be important to replicate the results obtained regarding the dimensionality of the data with new samples from the same farmer communities considered in this study, to evaluate the temporal stability of the two identified components. Finally note that the scale has been developed for farmers in the broader sense (either commercial or breeders), but it will likely be applicable to other livestock industry stakeholder (e.g. veterinarians, breed association technicians, etc.); however, further research is needed to confirm this.

As a case study, we explored farmer attitudes across breeds, species and countries and analysed farmer and farming system factors as drivers of the identified attitudes. We found that farmer attitudes towards both traditional selection and genetic and genomic selection are very variable not only across the studied breeds, species and countries but also within them. Part of this variation can be explained by some of the captured farmer profile (i.e. education level and family farming tradition), and farming system characteristics (i.e. farm property regime, herd/flock size and source of males). Education level has been shown to shape attitudes towards multiple issues, and especially towards farm innovation (e.g. Knight et al., 2003). We expected that the higher the education level, the more positive attitude towards genetic and genomic selection and the more negative towards traditional selection. We found a clear signal that the higher the formal education level, the more negative the attitude towards traditional selection but no relationship with attitude towards genetic and genomic selection. One interesting result is related to the influence of family farming tradition on farmer attitudes towards breeding. Farmers with farming heritage showed higher positive attitude towards traditional selection compared to "newcomer" farmers. Traditional selection may be embedded in tradition and taught across generations, while genetic and genomic selection is taught to date mainly through extension services and professional learning programmes. As expected, business-oriented farmers using AI (which are in general large farms run by full-time farmers) had a more negative attitude towards traditional selection. This is so because business-oriented farms usually have breeding protocols based on the use of genetic breeding values rather than on phenotypic selection and use AI to disseminate high genetic merit males and therefore increase the genetic level of the population.

In addition to the above-mentioned variables, we found that the breed raised had a large effect on farmer attitude towards breeding. When looking at each breed in detail, our models showed that some variables that did not show any direct effect across breeds influenced farmers' attitudes within breeds. This was the case of age and whether the farmer was a full-time farmer or not. The effect of some other factors such as farmer dedication, production system, or being a breeder or not, was confusing in the sense that the direction depended on the breed considered. This could be due to the presence of latent variables that confuse or cancel the direct effect of these factors on the farmer's attitudes, and whose mediating effect has not been identified to date. For example, some of these variables might be influencing farmer innovation ability that might be actually the driver of farmer attitude. In such a case, it could happen that in some communities, younger farmers are more innovative, while in other communities, elder farmers have more economic capacity and are therefore more prone to take risks associated with innovation. We hope future studies help clarifying this issue.

Shrigley (1983) determined that attitudes are not innate, but learned, suggesting some experience with an object/activity shapes attitudes and future relationships with that given object/activity. In this sense, we must note that we failed to consider this aspect in our study, by not analysing any variable that somehow measures farmer experience with traditional selection methods and/or genetic and genomic genetic improvement tools. Part of the "breed" effect on farmers' attitudes that could not be explained by the breed-specific factors, or the relationship between farming family tradition and attitudes outlined above could be linked to this level of farmer experience. Indeed, farmer experience is likely to be breed-specific because usually breeding programmes and their associated extension activities are designed, managed and implemented at breed level. Specifically, the success of the actual application of genetic or genomic breeding programmes (or even traditional selection) in a given breed case might very likely influence the attitude of the farmers raising the breed. In a similar vein, the real and perceived gain of genomic or genetic breeding vs traditional selection might also be a factor to consider when exploring farmers attitudes in future studies. Again, further research is needed to disentangle this aspect.

We developed the LBA scale to serve several functions. As a standard reference measure, it allows for the comparison of farmer attitudes across communities (e.g. across and within breeds, species, regions and countries), which is one of the main applications for attitude scales (e.g. Hawcroft and Milfont, 2010; Grunert et al., 2018). The LBA scale opens the possibility of analysing the variables affecting farmer attitudes such as farmer background, farming systems, farm practices or any other variable of interest. We have analysed these two aspects in our case study. In addition, the development of the LBA scale should of course have practical uses in breeding programme design and implementation. The scale might help in evolution of breeding programmes by identifying both the farmers most inclined to uptake breeding innovations in the early stage of its establishment, and the farmers that would be more reluctant to participate in such programmes, thus informing where to focus extension efforts. In this sense, we must acknowledge there are other socio-psychological variables, besides attitudes, influencing people behaviour such us norms, values, beliefs and interests among others, which are considered in different analysis frameworks such us the Theory of Planned Behaviour (e.g. Borges et al., 2014) to explain farmer behaviour. The consideration of these factors in future studies will help to get a wider picture of driving forces of farmers breeding decision-making. We hope our study stimulates new research in this direction. Finally, the scale will also allow benchmarking the evolution of attitudes over space and time and, in this sense, might serve as an indicator for the assessment of the impact of farmer training programmes and the breeding programme at large.

To our knowledge, this study is the first attempt at measuring farmers' attitudes towards breeding methods and tools using standardized psychometric methodologies and statistical tools. We believe that it has produced relevant results, especially the finding that farmers' attitudes towards breeding are linked to two separate and independent components. However, the case study presented has also posed some questions regarding the variable influencing farmers' attitudes. We hope to see additional longitudinal research using the LBA scale to confirm the findings of our study and to provide further insight into the usefulness of the measurement scale in identifying elements of farmers' attitudes.

Supplementary materials

Supplementary data to this article can be found online at https://doi.org/10.1016/j.animal.2020.100062.

Ethics approval

Not applicable.

Data and model availability statement

None of the data were deposited in an official repository.

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Declaration of interest

None.

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