Universidad Politécnica de Madrid

Escuela Técnica Superior de Ingenieros Agrónomos

INTEGRACIÓN DE ASPECTOS SOCIOECONÓMICOS Y GENÉTICOS INVOLUCRADOS EN LA CONSERVACIÓN DE RECURSOS GENÉTICOS ANIMALES

Integration of socioeconomic and genetic aspects involved in the conservation of animal genetic resources

TESIS DOCTORAL

PhD Thesis

Daniel Martín Collado

Ingeniero Agrónomo

2013

POLITÉCNICA

TESIS DOCTORAL

PhD thesis

Departamento de Mejora Genética Animal
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria

Departamento de Producción Animal
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Directores
Supervisors
Dra. Clara Díaz Martín
Dr. Miguel Ángel Toro Ibáñez

Daniel Martín Collado
Ingeniero Agrónomo

Febrero 2013

To Clara, Miguel, Asko and Katriina.

To the light and the darkness.

CONTENTS

Acknowledgements

I would like firstly to thank Clara and Miguel for all they have taught me during these five years of work. But mostly for the way they have guided me in the world of science, neither pulling me nor pushing me but going by my side, opening up their minds to me and showing me how to see the world always from a different perspective.

My special thanks go to Asko for his thoughtful revisions of the draft versions of this thesis; his suggestions and comments have improved it a lot. His sharp critiques and ironic comments have made me reconsider again and again the way to explain scientific studies and the opinion expressed in the papers. Thanks Asko.

I would like to thank Gustavo, Asko and Katriina for the opportunity they gave me to investigate with them in Milan and Jokioinen. And for the capacity they have to create warm and comfortable atmospheres in which working is a pleasure.

I wish to thank particularity to all the national and international scientific colleagues that have collaborated in the studies which are part of this PhD thesis. All of them have contributed their knowledge in different disciplines (environmental economics, genetics, sociology and computing) and wide experience in the field of FAnGRs conservation and development in enriching this thesis with their suggestions and inputs. This thesis is as much theirs as it is mine. My thanks to Joseph K Abraham, María Jesús Carabaño, Adam Drucker, Jesús Fernández, Gustavo Gandini, Sipke Joost Hiemstra, Asko Mäki-Tanila, Silvia Rodríguez, Katriina Soini, Kerstin Zander and all the people involved in the EURECA project.

I also want to thank the Federations of Breeders Associations of Spanish breeds (FEAGAS) for all the support they have given us to carry out all the studies included in this thesis. I am also very grateful to the Avileña-Negra Ibérica and Alistana-Sanabresa breeders Associations for providing the data and helpful comments for the interpretations of the results of the studies included in chapters 4 and 5 and 1 respectively.

I thank Morris, Mariví, Rocío and María Jesús for their language and spelling mistakes revision of the text. Their support has helped me to handle the stress under the last weeks of the thesis writing.

Finally, I also would like to acknowledge to all my INIA colleagues, for the good moments in these five years, for all those lively discussions and surreal stories we have shared, usually around a good meal. Thanks Natalia, Maite, Cris, María Jesús, Malena, Sofiene and Carmen for bearing with me.

Here you have the outcomes of my struggle against the despair. I hope you enjoy it.

This PhD thesis has been carried out within the European Action 012 AGRIGENRES 870/2004 (EURECA) and the Collaboration Agreement (CC09-009) between the Spanish National Institute of Agriculture Research (INIA) and the Spanish Federation of Associations of Livestock Breeds (FEAGAS). I am grateful to the European Commission, Directorate-General for Agriculture and Rural Development, for the financial support under Council Regulation (EC) No 870⁄2004, to the Spanish Ministry of Agriculture Food and Environment for the financial support to the collaboration agreement between INIA and FEAGAS and to the MTT Agrifood Research Finland and the research project NEWGAM (S2009/AGR 1704) funded by CAM for the financial support to attend international congresses and research stays.

RESUMEN

Resumen

El sector ganadero está siendo gradualmente dominado por sistemas intensivos y especializados en los que los factores de producción están controlados y en los que los caracteres productivos son los criterios principales para la selección de especies y razas. Entretanto, muchos de los bienes y servicios que tradicionalmente suministraba el ganado, tales como los fertilizantes, la tracción animal o materias primas para la elaboración vestimenta y calzado están siendo reemplazados por productos industriales. Como consecuencia de ambos cambios, las razas seleccionadas intensivamente, las cuales están estrechamente ligadas a sistemas agrícolas de alta producción y altos insumos, han desplazado a muchas razas autóctonas, en las que la selección prácticamente ha cesado o es muy poco intensa. Actualmente existe una mayor conciencia social sobre la situación de las razas autóctonas y muchas funciones del ganado que previamente habían sido ignoradas están siendo reconocidas. Desde hace algunas décadas, se ha aceptado internacionalmente que las razas de ganado cumplen funciones económicas, socio-culturales, medioambientales y de seguridad alimentaria. Por ello, diferentes organismos internacionales han reconocido que la disminución de los recursos genéticos de animales domésticos (RGADs) es un problema grave y han recomendado su conservación. Aun así, la conservación de RGADs es un tema controvertido por la dificultad de valorar las funciones del ganado. Esta valoración es compleja debido que los RGADs tiene una doble naturaleza privada - pública. Como algunos economistas han subrayado, el ganado es un bien privado, sin embargo debido a algunas de sus funciones, también es un bien público. De esta forma, el aumento del conocimiento sobre valor de cada una de sus funciones facilitaría la toma de decisiones en relación a su conservación y desarrollo. Sin embargo, esta valoración es controvertida puesto que la importancia relativa de las funciones del ganado varía en función del momento, del lugar, de las especies y de las razas.

El sector ganadero, debido a sus múltiples funciones, está influenciado por factores técnicos, medioambientales, sociales, culturales y políticos que están interrelacionados y que engloban a una enorme variedad de actores y procesos. Al igual que las funciones del ganado, los factores que afectan a su conservación y desarrollo están fuertemente condicionados por localización geográfica. Asimismo, estos factores pueden ser muy heterogéneos incluso dentro de una misma raza. Por otro lado, es razonable pensar que el ganadero es el actor principal de la conservación de razas locales. Actualmente, las razas locales están siendo

explotadas por ganaderos muy diversos bajo sistemas de producción también muy diferentes. Por todo ello, es de vital importancia comprender y evaluar el impacto que tienen las motivaciones, y el proceso de toma de decisiones de los ganaderos en la estructura genética de las razas.

En esta tesis doctoral exploramos diferentes aspectos sociales, económicos y genéticos involucrados en la conservación de razas locales de ganado vacuno en Europa, como ejemplo de RGADs, esperando contribuir al entendimiento científico de este complejo tema. Nuestro objetivo es conseguir una visión global de los procesos subyacentes en la conservación y desarrollo de estas razas. Pretendemos ilustrar como se pueden utilizar métodos cuantitativos en el diseño y establecimiento de estrategias de conservación y desarrollo de RGADs objetivas y adecuadas.

En primer lugar, exploramos el valor económico total (VET) del ganado analizando sus componentes públicos fuera de mercado usando como caso de estudio la raza vacuna Alistana-Sanabresa (AS). El VET de cualquier bien está formado por componentes de uso y de no-uso. Estos últimos incluyen el valor de opción, el valor de herencia y el valor de existencia. En el caso del ganado local, el valor de uso directo proviene de sus productos. Los valores de uso indirecto están relacionados con el papel que cumple las razas en el mantenimiento de los paisajes y cultura rural. El valor de opción se refiere a su futuro uso potencial y el valor de herencia al uso potencial de las generaciones venideras. Finalmente, el valor de existencia está relacionado con el bienestar que produce a la gente saber que existe un recurso específico. Nuestro objetivo fue determinar la importancia relativa que tienen los componentes fuera de mercado sobre el VET de la raza AS. Para ello evaluamos la voluntad de la gente a pagar por la conservación de la AS mediante experimentos de elección (EEs) a través de encuestas. Estos experimentos permiten valorar individualmente los distintos componentes del VET de cualquier bien. Los resultados los analizamos mediante de uso de modelos aleatorios logit. Encontramos que las funciones públicas de la raza AS tienen un valor significativo. Sus valores más importantes son el valor de uso indirecto como elemento cultural Zamorano y el valor de existencia (ambos representaron el 80% de VET). Además observamos que el valor que gente da a las funciones públicas de la razas de ganado dependen de sus características socioeconómicas. Los factores que condicionaron la voluntad a pagar para la conservación de la raza AS fueron el lugar de residencia (ciudad o pueblo), el haber visto animales de la raza o haber consumido sus productos y la actitud de los encuestados ante los conflictos entre el desarrollo económico y el medioambiente. Por otro lado, encontramos que no todo el mundo tiene una visión completa e integrada de todas las funciones públicas de la raza AS. Por este motivo, los programas o actividades de concienciación sobre su estado deberían hacer hincapié en este aspecto. La existencia de valores públicos de la raza AS implica que los ganaderos deberían recibir compensaciones económicas como pago por las funciones públicas que cumple su raza local. Las compensaciones asegurarían un tamaño de población que permitiría que la raza AS siga realizando estas funciones. Un mecanismo para ello podría ser el desarrollo del turismo rural relacionado con la raza. Esto aumentaría el valor de uso privado mientras que supondría un elemento añadido a las estrategias de conservación y desarrollo. No obstante, los ganaderos deben analizar cómo aprovechar los nichos de mercado existentes, así como mejorar la calidad de los productos de la raza prestando especial atención al etiquetado de los mismos.

Una vez evaluada la importancia de las funciones públicas de las razas locales de ganado, analizamos la diversidad de factores técnicos, económicos y sociales de la producción de razas locales de ganado vacuno existente en Europa. Con este fin analizamos el caso de quince razas locales de ocho países en el contexto de un proyecto de colaboración internacional. Investigamos las diferencias entre los países para determinar los factores comunes clave que afectan a la viabilidad de las razas locales. Para ello entrevistamos mediante cuestionarios a un total de 355 ganaderos en las quince razas. Como indicador de viabilidad usamos los planes de los ganaderos de variación del tamaño de las ganaderías. Los cuestionarios incluían diferentes aspectos económicos, técnicos y sociales con potencial influencia en las dinámicas demográficas de las razas locales. Los datos recogidos los analizamos mediante distintas técnicas estadísticas multivariantes como el análisis discriminante y la regresión logística. Encontramos que los factores que afectan a la viabilidad de las razas locales en Europa son muy heterogéneos. Un resultado reseñable fue que los ganaderos de algunos países no consideran que la explotación de su raza tenga un alto valor social. Este hecho vuelve a poner de manifiesto la importancia de desarrollar programas Europeos de concienciación sobre la importancia de las funciones que cumplen las razas locales. Además los países analizados presentaron una alta variabilidad en cuanto a la importancia de los mercados locales en la distribución de los productos y en cuanto al porcentaje en propiedad del total de los pastos usados en las explotaciones. Este estudio reflejó la variabilidad de los sistemas y medios de producción (en el sentido socioeconómico, técnico y ecológico) que existe en Europa. Por ello hay que ser cautos en la implementación de las políticas comunes en los diferentes países. También encontramos que la variabilidad dentro de los países puede ser elevada debido a las diferencias entre razas, lo que implica que las políticas nacionales deber ser suficientemente flexibles para adaptarse a las peculiaridades de cada una de las razas. Por otro lado, encontramos una serie de factores comunes a la viabilidad de las razas en los distintos países; la edad de los ganaderos, la colaboración entre ellos y la apreciación social de las funciones culturales, medioambientales y sociales del ganado local. El envejecimiento de los ganaderos de razas locales no es solo un problema de falta de transferencia generacional, sino que también puede suponer una actitud más negativa hacia la inversión en las actividades ganaderas y en una menor capacidad de adaptación a los cambios del sector. La capacidad de adaptación de los ganaderos es un factor crucial en la viabilidad de las razas locales. Las estrategias y políticas de conservación comunes deben incluir las variables comunes a la viabilidad de las razas manteniendo flexibilidad suficiente para adaptarse a las especificidades nacionales. Estas estrategias y políticas deberían ir más allá de compensación económica a los ganaderos de razas locales por la menor productividad de sus razas.

Las herramientas para la toma de decisiones ayudan a generar una visión amplia de la conservación y desarrollo de las razas locales. Estas herramientas abordan el diseño de estrategias de conservación y desarrollo de forma sistemática y estructurada. En la tercera parte de la tesis usamos una de estas herramientas, el análisis DAFO (Debilidades, Amenazas, Fortalezas y Oportunidades), con este propósito, reconociendo que la conservación de RGADs depende de los ganaderos. Desarrollamos un análisis DAFO cuantitativo y lo aplicamos a trece razas locales de ganado vacuno de seis países europeos en el contexto del proyecto de colaboración mencionado anteriormente. El método tiene cuatro pasos: 1) la definición del sistema; 2) la identificación y agrupación de los factores influyentes; 3) la cuantificación de la importancia de dichos factores y 4) la identificación y priorización de estrategias. Identificamos los factores utilizando multitud de agentes (*multi-stakeholder appproach*). Una vez determinados los factores se agruparon en una estructura de tres niveles. La importancia relativa de los cada uno de los factores para cada raza fue determinada por grupos de expertos en RGADs de los países integrados en el citado proyecto. Finalmente, desarrollamos un proceso de cuantificación para identificar y priorizar estrategias. La estructura de agrupación de factores permitió analizar el problema de la conservación desde el nivel general hasta el concreto. La unión de análisis específicos de cada una de las razas en un análisis DAFO común permitió evaluar la adecuación de las estrategias a cada caso concreto.

Identificamos un total de 99 factores. El análisis reveló que mientras los factores menos importantes son muy consistentes entre razas, los factores y estrategias más relevantes son muy heterogéneos. La idoneidad de las estrategias fue mayor a medida que estas se hacían más generales. A pesar de dicha heterogeneidad, los factores influyentes y estrategias más importantes estaban ligados a aspectos positivos (fortalezas y oportunidades) lo que implica que el futuro de estas razas es prometedor. Los resultados de nuestro análisis también confirmaron la gran relevancia del valor cultural de estas razas. Las factores internos (fortalezas y debilidades) más importantes estaban relacionadas con los sistemas de producción y los ganaderos. Las oportunidades más relevantes estaban relacionadas con el desarrollo y marketing de nuevos productos mientras que las amenazas más importantes se encontraron a la hora de vender los productos actuales. Este resultado implica que sería fructífero trabajar en la motivación y colaboración entre ganaderos así como, en la mejora de sus capacidades. Concluimos que las políticas comunes europeas deberían centrarse en aspectos generales y ser los suficientemente flexibles para adaptarse a las singularidades de los países y las razas.

Como ya se ha mencionado, los ganaderos juegan un papel esencial en la conservación y desarrollo de las razas autóctonas. Por ello es relevante entender que implicación puede tener la heterogeneidad de los mismos en la viabilidad de una raza. En la cuarta parte de la tesis hemos identificado tipos de ganaderos con el fin de entender cómo la relación entre la variabilidad de sus características socioeconómicas, los perfiles de las ganaderías y las dinámicas de las mismas. El análisis se ha realizado en un contexto sociológico, aplicando los conceptos de capital cultural y económico. Las tipologías se han determinado en función de factores socioeconómicos y culturales indicadores del capital cultural y capital económico de un individuo. Nuestro objetivo era estudiar si la tipología socioeconómica de los ganaderos afecta al perfil de su ganadería y a las decisiones que toman. Entrevistamos a 85 ganaderos de la raza Avileña-Negra Ibérica (ANI) y utilizamos los resultados de dichas entrevistas para ilustrar y testar el proceso. Definimos los tipos de ganaderos utilizando un análisis de clúster jerarquizado con un grupo de variables canónicas que se obtuvieron en función de cinco factores socioeconómicos: el nivel de educación del ganadero, el año en que empezó a ser ganadero de ANI, el porcentaje de los ingresos familiares que aporta la ganadería, el porcentaje de propiedad de la tierra de la explotación y la edad del ganadero. La tipología de los ganaderos de ANI resultó ser más compleja que en el pasado. Los resultados indicaron que los tipos de ganaderos variaban en muchos aspectos socioeconómicos y en los perfiles de sus ganaderías. Los tipos de ganaderos determinados toman diferentes decisiones en relación a la modificación del tamaño de su ganadería y a sus objetivos de selección. Por otro lado, reaccionaron de forma diferente ante un hipotético escenario de reducción de las compensaciones económicas que les planteamos. En este estudio hemos visto que el capital cultural y el económico interactúan y hemos explicado como lo hacen en los distintos tipos de ganaderos. Por ejemplo, los ganaderos que poseían un mayor capital económico, capital cultural formal y capital cultural adquirido sobre la raza, eran los ganaderos cuyos animales tenían una mayor demanda por parte de otros ganaderos, lo cual podría responder a su mayor prestigio social dentro de la raza. Uno de los elementos claves para el futuro de la raza es si este prestigio responde a una superioridad genética de las animales. Esto ocurriría si los ganaderos utilizaran las herramientas que tienen a su disposición a la hora de seleccionar animales. Los tipos de ganaderos identificados mostraron también claras diferencias en sus formas de colaboración y en su reacción a una hipotética variación de las compensaciones económicas. Aunque algunos tipos de ganaderos mostraron un bajo nivel de dependencia a estas compensaciones, la mayoría se manifestaron altamente dependientes. Por ello cualquier cambio drástico en la política de ayudas puede comprometer el desarrollo de las razas autóctonas. La adaptación las políticas de compensaciones económicas a la heterogeneidad de los ganaderos podría aumentar la eficacia de las mismas por lo que sería interesante explorar posibilidades a este respecto. Concluimos destacando la necesidad de desarrollar políticas que tengan en cuenta la heterogeneidad de los ganaderos.

Finalmente abordamos el estudio de la estructura genética de poblaciones ganaderas. Las decisiones de los ganaderos en relación a la selección de sementales y su número de descendientes configuran la estructura demográfica y genética de las razas. En la actualidad existe un interés renovado por estudiar las estructuras poblacionales debido a la influencia potencial de su estratificación sobre la predicción de valores genómicos y/o los análisis de asociación a genoma completo. Utilizamos dos métodos distintos, un algoritmo de clústeres basados en teoría de grafos (GCA) y un algoritmo de clustering bayesiano (STRUCTURE) para estudiar la estructura genética de la raza ANI. Prestamos especial atención al efecto de la presencia de parientes cercanos en la población y de la diferenciación genética entre subpoblaciones sobre el análisis de la estructura de la población. En primer lugar evaluamos el comportamiento de los dos algoritmos en poblaciones simuladas para posteriormente analizar los genotipos para 17 microsatélites de 13343 animales de 57 ganaderías distintas de raza ANI. La ANI es un ejemplo de raza con relaciones complejas. Por otro lado, utilizamos el archivo de pedigrí de la raza para estudiar el flujo de genes, calculando, entre otras cosas, la contribución de cada ganadería a la constitución genética de la raza. En el caso de las poblaciones simuladas, cuando el F_{ST} entre subpoblaciones fue suficientemente alto, ambos algoritmos, GCA y STRUCTURE, identificaron la misma estructura genética independientemente de que existieran o no relaciones familiares. Por el contrario, cuando el grado de diferenciación entre poblaciones fue bajo, el STRUCTURE identificó la estructura familiar mientras que GCA no permitió obtener ningún resultado concluyente. El GCA resultó ser un algoritmo más rápido y eficiente para de inferir la estructura genética en poblaciones con relaciones complejas. Este algoritmo también puede ser usado para reducir el número de clústeres a testar con el STRUTURE. En cuanto al análisis de la población de ANI, ambos algoritmos describieron la misma estructura, lo cual sugiere que los resultados son robustos. Se identificaron tres subpoblaciones diferenciadas que pudieran corresponderse con tres linajes distintos. Estos linajes estarían directamente relacionados con las ganaderías que han tenido una mayor contribución a la constitución genética de la raza. Por otro lado, hay un conjunto muy numeroso de individuos con una mezcla de orígenes. La información molecular describe una estructura estratificada de la población que se corresponde con la evolución demográfica de la raza. Es esencial analizar en mayor profundidad la composición de este último grupo de animales para determinar cómo afecta a la variabilidad genética de la población de ANI.

SUMMARY

Summary

Livestock sector is gradually dominated by intensive and specialized systems where the production environment is controlled and the production traits are the main criteria for the selection of species and breeds. In the meantime, the traditional use of domestic animals for draught work, clothes and manure has been replaced by industrial products. As a consequence of both these changes, the intensively selected breeds closely linked with high-input high-output production systems have displaced many native breeds where the selection has practically ceased or been very mild. People are now more aware of the state of endangerment among the native breeds and the previously ignored values of livestock are gaining recognition. For some decades now, the economic, socio-cultural, environmental and food security function of livestock breeds have been accepted worldwide and their loss has been recognized as a major problem. Therefore, the conservation of farm animal genetic resources (FAnGR) has been recommended.

The conservation of FAnGR is controversial due to the complexity of the evaluation of its functions. This evaluation is difficult due to the nature of FAnGR both as private and public good. As some economists have highlighted, livestock animals are private goods, however, they are also public goods by their functions. Therefore, there is a need to increase the knowledge about the value of all livestock functions since to support the decision-making for the sustainable conservation and breeding of livestock. This is not straightforward since the relative importance of livestock functions depends on time, place, species and breed.

Since livestock play a variety of roles, their production is driven by interrelated and ever-changing economic, technical, environmental, social, cultural and political elements involving an enormous range of stakeholders. Not only FAnGR functions but also the importance of factors affecting the development and conservation of FAnGR can be very different across geographical areas. Furthermore, heterogeneity can be found even within breeds. Local breeds are nowadays raised by highly diverse farmers in equally diverse farms. It is quite reasonable to think that farmer is the major actor in the *in situ* conservation of livestock breeds. Thus, there is a need to understand the farmers' motivations, decision making processes and the impact of their decisions on the genetic structure of breeds.

In this PhD thesis we explore different social, economic and genetic aspects involved in the conservation of local cattle breeds, i.e. FAnGR, in Europe seeking to contribute to the

scientific understanding of this complex issue. We aim to achieve a comprehensive view of the processes involved in the conservation and development of local cattle breeds and have made special efforts in discussing the implications of the research results in this respect. The final outcome of the thesis is to illustrate how quantitative methods can be exploited in designing and establishing sound strategies and programmes for the conservation and development of local livestock breeds.

Firstly we explored the public non-market attributes of the total economic value (TEV) of livestock, using the Spanish Alistana-Sanabresa (AS) cattle breed as a case study. Total economic value of any good comprises both use and non-use components, where the latter include option, bequest and existence values. For livestock, the direct use values are mainly stemming from production outputs. Indirect use values relate to the role of livestock as a maintainer of rural culture and landscape. The option value is related to the potential use of livestock, the bequest values relate to the value associated with the inheritance of the resources to future generation and the existence values relate to the utility perceived by people from knowing that specific resources exist. We aimed to determine the relative importance of the non-market components of the TEV of the AS breed, the socio-economic variables that influence how people value the different components of TEV and to assess the implications of the Spanish national conservation strategy for the AS breed. To do so, we used a choice experiment (CE) approach and applied the technique to assess people’s willingness to pay (WTP) for the conservation of AS breed. The use of CE allows the valuation of the individual components of TEV for a given good. We analysed the choice data using a random parameter logit (RPL) model. AS breed was found to have a significant public good value. Its most important values were related to the indirect use value due to the maintenance of Zamorian culture and the existence value (both represent over 80% of its TEV). There were several socioeconomic variables influencing people’s valuation of the public service of the breed. In the case of AS breed, the place of living (city or rural area), having seen animals of the breed, having eaten breed products and the respondents’ attitude towards economic development – environment conflicts do influence people’s WTP for AS conservation. We also found that people do not have a complete picture of all the functions and roles that AS breed as AnGR. Therefore, the actions for increasing awareness of AS should go to that direction. The farmers will need incentives to exploit some of the public goods values and maintain the breed population size at socially desirable levels. One such mechanism could be related to the development of agritourism, which would enhance the private good value and provide an important addition to the conservation and utilisation strategy. However, the farmers need a serious evaluation on how to invest in niche product development or how to improve product quality and brand recognition.

Using the understanding on the importance of the public function of local cattle we tried to depict the current diversity regarding technical, economic and social factors found in local cattle farming across Europe. To do so we focused in an international collaborative project on the case of fifteen local cattle breeds in eight European countries. We investigated the variation among the countries to detect the common key elements, which affect the viability of local breeds. We surveyed with interviews a total of 355 farms across the fifteen breeds. We used the planned herd size changes by the farmer as an indicator of breed viability. The questionnaire included several economic, technical and social aspects with potential influence on breeds' demographic trends. We analysed the data using multivariate statistical techniques, such as discriminat analysis and logistic regression. The factors affecting a local breed's viability were highly heterogeneous across Europe. In some countries, farmers did not recognise any high social value attached to keeping a local cattle breed. Hence there is a need to develop communication programmes across EU countries making people aware about the diversity and importance of values associated to raising local breeds. The countries were also very variable regarding the importance of local markets and the percentage of farm land owned by the farmers. Despite the country specificities, there were also common factors affecting the breed viability across Europe. The factors were from different grounds, from social, such as the age of the farmer and the social appreciation of their work, to technical-organizational, such as the farmers' attitude to collaborating with each other. The heterogeneity found reflects the variation in breeding systems and production environment (in the socioeconomic, technical and ecological sense) present in Europe. Therefore, caution should be taken in implementing common policies at the country level. Variability could also be rather high within countries due to breed specificities. Therefore, the national policies should be flexible to adapt to the specificities. The variables significantly associated with breed viability should be positively incorporated in the conservation strategies, and considered in developing common and/or national policies. The strategy preparation and policy planning should go beyond the provision of a general economic support to compensate farmers for the lower profitability of local breeds. Of particular interest is the observation that the opportunity for farmer collaboration and the appreciation by the society of the cultural, environmental and social role of local cattle farming were positively associated with the breed survival. In addition, farmer's high age is not only a problem of poor generation transfer but it is also a problem because it might lead to a lower attitude to investing in farming activities and to a lower ability to adapt to environment changes. The farmers' adaptation capability may be a key point for the viability of local breeds.

Decision making tools can help to get a comprehensive view on the conservation and development of local breeds. It allows us to use a systematic and structured approach for identifying and prioritizing conservation and development strategies. We used SWOT (Strengths, Weaknesses Opportunities and Threats) analysis for this purpose and recognized that many conservation and development projects rely on farmers. We developed a quantified SWOT method and applied it in the aforementioned collaborative research to a set of thirteen cattle breeds in six European countries. The method has four steps: definition of the system, identification and grouping of the driving factors, quantification of the importance of driving factors and identification and prioritization of the strategies. The factors were determined following a multi-stakeholder approach and grouped with a three level structure. FAnGR expert groups ranked the factors and a quantification process was implemented to identify and prioritize strategies. The structure of the SWOT analysis allowed analyzing the conservation problem from general down to specific perspectives. Joining breed specific analyses into a common SWOT analysis permitted comparison of breed cases across countries. We identified 99 driving factors across breeds. The across breed analysis revealed that irrelevant factors were consistent. There was high heterogeneity among the most relevant factors and strategies. The strategies increased eligibility as they lost specificity. Although the situation was very heterogeneous, the most promising factors and strategies were linked to the positive aspects (Strengths and Opportunities). Therefore, the future of the studied local breed is promising. The results of our analysis also confirmed the high relevance of the cultural value of the breeds. The most important internal factors (strengths and weaknesses) were related farmers and production systems. The most important opportunities were found in developing and marketing new products, while the most relevant threats were found in selling the current conventional products. In this regard, it should be fruitful to work on farmers' motivation, collaboration, and capacity building. We conclude that European policies should focus on general aspects and be flexible enough to be adapted to the country and breed specificities.

As mentioned, farmers have a key role in the conservation and development of a local cattle breed. Therefore, it is very relevant to understand the implications of farmer heterogeneity within a breed for its viability. In the fourth part of the thesis, we developed a general farmer typology to help analyzing the relations between farmer features and farm profiles, herd dynamics and farmers' decision making. In the analysis we applied and used the sociological framework of economic and cultural capital and studied how the determined farmer types were linked to farm profiles and breeding decisions, among others. The typology was based on measurable socioeconomic factors indicating the economic and cultural capital of farmers. A group of 85 farmers raising the Spanish Avileña-Negra Ibérica (ANI) local cattle breed was used to illustrate and test the procedure. The farmer types were defined by a hierarchical cluster analysis with a set of canonical variables derived from the following five the socioeconomic factors: the formal educational level of the farmer, the year the farmer started keeping the ANI breed, the percentage of the total family income covered by the farm, the percentage of the total farm land owned by the farmer and the farmer's age. The present ANI farmer types were much more complex than what they were in the past. We found that the farmer types differed in many socioeconomic aspects and in the farms profile. Furthermore, the types also differentiate farmers with respect to decisions about changing the farm size, breeding aims and stated reactions towards hypothetical subsidy variation. We have verified that economic and cultural capitals are not independent and further showed how they are interacting in the different farmer types. The farmers related to the types with high economic, institutionalized and embodied cultural capitals had a higher demand of breeding animals from others farmers of the breed, which may be related to the higher social prestige within the breed. One of the key implications of this finding for the future of the breed is whether or not the prestige of farmers is related to genetic superiority of their animals, what is to say, that it is related with a sound use of tools that farmers have available to make selection decisions. The farmer types differed in the form of collaboration and in the reactions to the hypothetical variation in subsidies. There were farmers with low dependency on subsidies, while most of them are highly dependent on subsidies. Therefore, any drastic change in the subsidy programme might have influence on the development of local breeds. The adaptation of these programme to the farmers' heterogeneity might increase its efficacy, thus it would be interesting to explore ways of doing it. We conclude highlighting the need to have a variety of policies, which take into account the heterogeneity among the farmers.

To finish we dealt with the genetic structure of livestock populations. Farmers' decisions on the breeding animals and their progeny numbers shape the demographic and genetic structure of the breeds. Nowadays there is a renovated interest in studying the population structure since it can bias the prediction of genomic breeding values and genome wide association studies. We determined the genetic structure of ANI breed using two different methods, a graphical clustering algorithm (GCA) and a Bayesian clustering algorithm (STRUCTURE) were used. We paid particular attention to the influence that the presence of closely related individuals and the genetic differentiation of subpopulations may have on the inferences about the population structure. We first evaluated the performance of the algorithms in simulated populations. Then we inferred the genetic structure of the Spanish cattle breed ANI analysing a data set of 13343 animals (genotyped for 17 microsatellites) from 57 herds. ANI breed is an example of a population with complex relationships. We used the herdbook to study the gene flow, estimation among other things, the contribution of different herds to the genetic composition of the ANI breed. For the simulated scenarios, when F_{ST} among subpopulations was sufficiently high, both algorithms consistently inferred the correct structure regardless of the presence of related individuals. However, when the genetic differentiation among subpopulations was low, STRUCTURE identified the family based structure while GCA did not provide any consistent picture. The GCA was a fast and efficient method to infer genetic structure to determine the hidden core structure of a population with complex history and relationships. GCA could also be used to narrow down the number of clusters to be tested by STRUCTURE. Both, STRUCTURE and GCA describe a similar structure for the ANI breed suggesting that the results are robust. ANI population was found to have three genetically differentiated clusters that could correspond to three genetic lineages. These are directly related to the herds with a major contribution to the breed. In addition, ANI breed has also a large pool made of individuals with an admixture of origins. The genetic structure of ANI, assessed by molecular information, shows a stratification that corresponds to the demographic evolution of the breed. It will be of great importance to learn more about the composition of the pool and study how it is related to the existing genetic variability of the breed.

INTRODUCTION

Introduction

Since the domestication process in the Neolithic Age, livestock have spread all over the world mainly as a result of human migration or exchanges among neighboring human populations (Diamond and Bellwood, 2003; Zeder, 2008). Domestic animals were multifunctional; they were used for draught work, clothes, manure, fuel and food (Food and Agriculture Organization -FAO-, 2007b). As they reached different places, they slowly adapted to the specific environmental conditions of the area and to the uses and cultural preferences of their new herdsmen, giving rise to the livestock's genetic diversity (Wollny, 2003; Mendelsohn, 2003). It was not until the eighteenth century in Europe when these differences between animals within the same species acquired a name, and were called 'breeds' (Taberlet *et al*., 2008). After the industrial revolution, the traditional use of domestic animals for draught work, clothes and manure was slowly but steadily replaced by industrial products. With the increasing demand for protein of animal origin, breeds were intensively selected for food purposes and the development of specialized breeds began. This process started at different periods depending on the country and region and it is still ongoing in many areas around the world (Domínguez Martín, 2001; FAO, 2009b). In recent decades, the livestock sector is moving even faster towards intensive and specialized systems, in which the production environment is controlled and production traits are the main criteria for the selection of species and breeds (FAO, 2007b). Intensively selected breeds and their high-input high-output production systems have displaced many native breeds where the selection has practically ceased or been very mild. Many of the native breeds have survived in areas where high-input high-output systems were not established for economic, cultural or environmental reasons (Mendelsohn, 2003). Therefore, somehow the disappearance of local breeds is related to economic development; at the European level, the higher the gross domestic product per capita the higher the proportion of breeds that have gone extinct (Hall and Ruane, 1993)

This process of breed displacement and substitution, i.e., a decline of farm animal genetic resources (FAnGRs), has not gone unnoticed; in the first United Nations Conference on Human Environment held in Stockholm in 1972, the problem was recognized and the conservation of genetic resources was recommended. Since then, other international bodies (among others, the 1982 International Union for the Conservation of Nature's World Conservation Strategy or the 1992 United Nations Conference on Environment and development of Rio de Janeiro) have recognized the importance of FAnGRs and the need to conserve them. Several studies have analyzed the state of breeds in different areas and points of time (Hall and Ruane, 1993; Rege, 1999; FAO, 2000). The last study of the global state of FAnGRs for food and agriculture launched by FAO (2007b) provided worrying figures. About 20% of all breeds or livestock populations are considered to be ‘at risk’ and 9% are already extinct. In the developed regions of the world the decline has been sharper, e.g. in Europe, 28% of mammalian breeds are at risk, while 22% have already gone extinct (FAO, 2007b). Cattle are not an exception; at least 130 of the previously known European cattle breeds are already ‘extinct’ (Hyperlink, http://www.fao.org/dad-is). In Spain the decline in census began in the 1950s to the 1990s (García Dory *et al*., 1990).

A key point in the FAnGRs conservation discussion is to analyze why a society should conserve breeds that farmers have abandoned (Notter, 1999; Mendelsohn, 2003; Simianer, 2005; FAO, 2007a). The reasons invoked in the literature can be divided in the following three groups:

- *Economic reasons.* Despite the fact that many breeds have been displaced by mainstream breeds, and its associated high input-high output production system, many others still retain a remarkable economic value. The profitability of those breeds is mainly associated with three qualities.

    - *Production in low-input low-output production systems*. Mainstream breeds are usually raised in systems where their production potential can be maximized through the control of production conditions, what implies a high input use including feed, pharmaceuticals, infrastructure, veterinary care and labor (Oldenbroek, 2007). If appropriate production conditions exist, highly specialized mainstream breeds can be produced at levels which are difficult to beat. However, if those conditions do not exit, due to the technical difficulties or the lack of investment, mainstream breeds might not be the best option (Karugia *et al*., 2001; Ayalew *et al*., 2003). Usually local breeds are better adapted to low input-low output production systems which still have a huge importance in most regions (FAO 2009a, 2009b)

    - *Production in harsh environments*. Mankind have habited most world environments and raised livestock almost everywhere. Over time, animals have acquired the features needed to live and produce in each specific environment (Baker and Rege, 1994). Many breeds are able to thrive in harsh environments where other breeds cannot

(Bennewitz *et al*., 2007). This adaptation can be due to general fitness traits, such as the Yakutia cattle raised in Siberia (Ovaska and Soini, 2011) or the Retinta and the Avileña-Negra Ibérica cattle breeds in the dehesa forest of south and south-western Spain (Garcia-Medina *et al.*, 1987), or specific traits such as the ability to feed on seaweed by North Ronaldsay sheep (Ponzoni,1997).

- *Production of singular products*. Livestock production is more and more dependent on fewer breeds and production systems and food products are becoming more similar worldwide. At the same time as many unique products are disappearing, the value of remaining products is increasing and new niche markets are created (Woolliams *et al*., 2005; Oldenbroek, 2007). Many local breeds are associated with unique products due to unique features of the animals themselves or their production conditions. Products from local breeds have also been associated with food trends such as "functional food", "local food, and "slow food" (Soini and de Haas, 2010). Several breeds have succeeded in taking advantage of these market opportunities, counteracting their low production with an increase in product price. The production of singular products linked to livestock breeds is a very profitable economic activity in many cases and places. That is why the development of specific products is usually included in every conservation program of endangered breeds (Verrier *et al*., 2005; Mathias *et al*., 2010). However, the development of breed products is not always feasible since there may not be a specific product, marketing difficulties may exist or the farmers are not well organized.

- *Security reasons.* Breeds are carriers of genetic information that can be used to adapt to future uncertainties (Mendelsohn, 2003; Simianer, 2005; Woolliams *et al.*, 2005). It is risky to assume that we can foresee every future need related to livestock, especially in terms of future market predictions (Clark, 1995). Therefore, every society should maintain a minimum capacity to adapt to uncertainties. Those uncertainties could be related to three aspects.

    - *Future market demands*. Consumers' preferences and needs change with time and therefore market demand varies with time and place (Oldenbroek, 2007). A good example of the influence of consumer preferences on livestock breed dynamics is the Iberian pig. The numbers of Iberian pig were drastically reduced in the 1960s and

1970s due in part to the lower demand for animal fat. However, in the last decades, Iberian pig meat is considered top quality, demand has increased sharply and their population census has recovered (Fabuel *et al*., 2004)

- *Change of production conditions.* Now that climate change is a well-known process (IPCC, 2007), it is easy to think of a future where environmental conditions will be different (FAO, 2007c; Calvosa *et al*., 2010)

- *Disease outbreaks*. Loss of genetic variability will reduce the ability to find resistance to new diseases that might develop in the future (Horst *et al*., 1998; FAO, 2007b) as they have in the past (Carrillo *et al*., 1990, Baker and Rege, 1994). A classic example of breed resistance to disease is the Trypanosomosis tolerance of the African N'dama cattle (Leperre and Claxton, 1994)

- Another reason to conserve FAnGRs (Oldenbroek, 2007), which might sound a bit dramatic but cannot be forgotten, is their high strategic value in face of potential catastrophes such as wars.

- *Socio-cultural reasons*. As every other product developed by humans, livestock breeds can be considered cultural assets (Gandini and Villa, 2003). Some breeds have a role in social, political and religious ceremonies (Simianer, 2005). Therefore breeds are a cultural heritage that societies may want to conserve (Mendelsohn, 2003).

- *Environmental reasons.* Breeds are sometimes associated with specific landscapes that they have helped to create. These would then be, in a way, elements of a cultural (man-made) landscape (Gandini and Villa, 2003). It may be important to maintain that landscape as symbol of identity of a society (Mendelsohn, 2003) or it might generate revenues through rural or ecotourism (Soini and de Haas, 2010). Other times, some breeds can be used for functional features that conserve landscapes that otherwise cannot be maintained, such as mountain pastures or that would be more expensive to carry out without them, such as the clearing vegetation for fire control (FAO, 2007b)

- *Ethical reasons.* Finally, people might want to conserve breeds for their own sake (Mendelsohn, 2003), for the positive feelings they have from knowing that a breed is not going extinct.

The reasons invoked as justification for the conservation FAnGRs can be seen as an outline of the functions that livestock breeds have, this is, the various ways through which breeds generate human wellbeing. Summarizing, it is nowadays widely accepted that livestock have several functions. Other traditional livestock outputs, apart from food production, are the production of fibre, skins, hides and pelts. In addition to these outputs, livestock also holds other important functions as agriculture inputs, transport and fuel that, although decreasing in importance, are still very relevant in many developing areas of the world (FAO, 2007b). Last but not least, livestock can represent savings used for risk management and have important public functions through sociocultural functions (Gandini and Villa, 2003) and environmental services (FAO, 2009).

The conservation of FAnGRs becomes controversial when evaluating the importance of each of these functions (Mendelsohn, 2003; Blasco, 2008). The controversy stems from two tricky facts. The first one is the complexity of measuring the importance of some functions, added to the difficulty of expressing the value of the different functions in the same units. The complexity of the evaluation unleashes subjective evaluation. Subjectivity leads to conservation support policies that evenly spread resources across breeds due to political reasons instead of distributing support based on objective measures related to the importance and status of each specific breed. The second problem that fuels the controversy is that the relative importance of functions depending on time, place, species and breed. Furthermore, some breeds or species may lack one or some functions (Drucker *et al.*, 2001). Therefore, specific cases and examples can be found to support almost every position in the discussion over FAnGRs conservation.

The complexity of livestock evaluation stems from the nature of FAnGRs as private and public goods. Livestock animals are private goods, however, as we have seen, some of their functions are public. The objective valuation of FAGRs, which has been undertaken only recently (Drucker *et al.*, 2005), draws from the field of environmental economics, one of whose central concepts is market failure. As explained by Hanley *et al.* (2007), "*A market failure occurs when the market does not allocate scarce resources to generate the greatest social welfare. A wedge exists between what a private person does given market prices and what society might want him or her to do to protect the environment. Such a wedge implies wastefulness or economic inefficiency; resources can be reallocated to make at least one person better off without making anyone else worse off*". In the case of FAnGRs, decisions about which breed to keep have been based on commercial factors (e.g. increasing demand for meat and milk worldwide) and in the farmers' valuation of the direct outputs of the animals. However, there is an increasing awareness that the market has failed to fully account for the value of a wide range of livestock functions and services, particularly those which represent public goods (Drucker *et al*., 2005). Therefore, there is an urgent need to increase the knowledge of the value of all livestock functions. A key issue of this valuation would be the study of it variation across species, breeds, time and space. This knowledge can support decision-making in livestock conservation and sustainable use (Drucker *et al*., 2001).

According to the field of environmental economics, the value of any natural resource is evaluated according to the concept of total economic value (TEV). The TEV of any product is represented by its use, which is divided into direct and indirect use values, and non-use values. For livestock, direct use values include production outputs. Indirect use values relate to the role of livestock as maintainers of rural culture and landscapes. Option value is related to the potential future use of livestock. Bequest values relate to the value associated with the passing on of resources to future generations and existence values relate to the utility derived by people from knowing that a specific resource exists. Since several of the attributes of the TEV are non-marketed stated preferences, valuation methods are employed to determine such values for both plant and animal genetic resources (Drucker *et al*., 2001). One method that has increasingly been used is based on choice experiments (CEs), which allow the valuation of individual attributes of a given good or components of its TEV (Hanley *et al.*, 1998). Stated values are expressed by the respondent's willingness to pay (WTP) or willingness to accept compensation for the existence of or changes in environmental quality or, in the case of animal breeds, the different attributes than constitute its TEV.

There has been quite a lot of research about the TEV of environmental goods, such as forests (Pearce, 2002; Merlo and Croitory, 2005) or rivers (Loomis *et al*., 2000; Hanley *et al*., 2006). Others studies have focused on animal species, such as the valuation of wild animals using CE (Martín-Lopez *et al.*, 2007, 2008). Those researchers have made a great effort to understand which socioeconomic factors influence the willingness to pay for conserving wild animals. They found that people's WTP for species conservation depends on the degree of familiarity with the species and their understanding of the role that species plays in the ecosystem. Thus, they highlighted the importance of awareness of environmental benefits on its valuation. They also found that affective factors play a role. As opposed to wildlife, little is known about the TEV of livestock species or breeds. Improved understanding of the TEV of breeds and the relative weights of the different components of TEV can be used to help determine which kinds of interventions and incentive mechanisms might be most appropriate to ensure their long-term survival. Several authors have considered the costs of farm animal conservation programs (Smith, 1984; Cicia *et al*., 2003). However, to our knowledge only one publication has analysed the TEV of a livestock breed (Zander *et al*., forthcoming).

In the **first chapter of this thesis** we aim to introduce the TEV concept of livestock breeds and improve the understanding of the factors that influence it. To this end, we explore the TEV of livestock breeds and the relative importance of its different components using the local Spanish beef breed Alistana-Sanabresa (AS) as a case study. We implemented a choice experiment in Zamora city and different villages of Zamora Province where the AS breed is raised.

The disappearance of an important number of livestock breeds and the decrease in numbers of many others, together with the loss of their associated public values, have led governments to take action. In the Interlaken declaration adopted by 109 countries delegations in 2007, in the context of the International Technical Conference on Animal Genetic Resources organized by FAO, the governments of these countries "*confirmed their common and individual responsibilities for the conservation, sustainable use and development of animal genetic resources for food and agriculture; for world food security; for improving human nutritional status; and for rural development*" (FAO, 2007a). But good will alone is not enough to get things done, especially when dealing with such a complex task as the conservation of FAnGRs. Since livestock play a variety of different roles, their production is driven by interrelated and ever-changing economic, technical, environmental, social, cultural and political elements involving an enormous range of stakeholders (FAO, 2006, 2007a, 2007b, 2009). Farmers are obviously the key stakeholder and the analysis of their motivations has been the subject of great interest in recent years (Hiemstra *et al*., 2010). However, it can be said that the whole society is involved in livestock production, in one way or another since we are either a part of the agrifood sector (farmers, breeding associations and breeding companies, manufacturers and retail groups, or consumers) or carry out activities that influence that sector or are influenced by it. Stakeholders interact through their specific interest influenced by the time horizons they are concerned with (Woolliams *et al*., 2005). Finally there are the politicians whose final aim is to maximize public welfare and whose actions have an enormous influence in the development of any sector. However, governmental policies often undermine FAnGRs conservation (Mendelsohn, 2003; Wollny, 2003).

One last aspect should be mentioned regarding FAnGRs conservation. Although the causes of FAnGRs depletion and the factors affecting its conservation are, somehow, similar (Tisdell, 2003), its relative importance can be very different across geographical areas (e.g. Gandini *et al*., 2010a, 2010b). The differences across breeds, productions systems, agrifood sector features and social needs, demands and idiosyncrasy across regions, countries and world areas can influence the state and development of livestock breeds use. Regarding FAnGRs conservation programs and policies, these differences may require specific strategies adapted to each case. However, there are also similarities that may justify common strategies. Therefore, a key point is then to identify common and specific factors that might be taken into account when developing strategies and policies at different levels to promote livestock breed conservation.

In the **chapter two** we analyze similarities and differences regarding the factors influencing the viability of farms raising local breeds. We used as a case study a group of fifteen breeds from eight European countries to account for as much heterogeneity as possible. We investigated the aspects that differ among countries and the implications of such heterogeneity in the policies and programmes to be developed. Then we aimed to detect key elements common to countries, which may affect the viability of local breeds. Following Hiemstra *et al*. (2010), we considered that farmers are the key stakeholders in the conservation and development of local breeds. We took into account that they might not exclusively base their choices on profit maximizing motives (Norton *et al*., 1994) and therefore, apart from technical and economic factors, to a large extent, the focus was placed on farmers and their views and values.

Assuming that all the factors influencing a problem (in our case, FAnGRs conservation) are known, or even that our knowledge is incomplete, conservation strategies have to be generated. Decisions about what has to be done have to be taken. However, as we have seen, making decisions in such a complex system as the local breeds' production sector is not straightforward. The integration of all these factors is complex because the effect of many of them is difficult to measure, and the methods have been developed for specific purposes. However, the evaluation of the impact of factors on FAnGR in a comprehensive manner may help us to establish sound conservation strategies. In this regard, we can draw a parallel between FAnGR conservation and business. Entrepreneurs have to make decisions in an environment that usually is influenced by many factors and full of uncertainty. In addition, businesses involve many stakeholders who have to be taken into account when designing strategic plans. Entrepreneurs usually design strategies for the development of their business using decision making tools. Those tools may help to design and establish FAnGR conservation strategies.

Decision making tools usually tackle complex problems by dividing them into smaller parts to think about them one at a time (Saaty, 1986). The influence of each part of the overall problem is measured by different methods. The assessments are joined by rebuilding the structure in which the problem was split and used as criteria to make decisions concerning problem solving. Therefore, there are three key issues in problem solving; the principle of decomposition, the assessment of the element and the synthesis of priorities (Saaty, 1986). Among the several decision making tools that can be found in the literature (Saaty and Takizawa, 1986; Lahdelma *et al*., 1998; Terrados *et al*., 2005) one of the most used is SWOT (Strengths, Weaknesses, Opportunities and Threats). Its power arises from the simplicity of its use and from the adaptability to a wide range of situations (Impoinvil *et al*., 2007; Vonk *et al*., 2007; Lee *et al*., 2009).

SWOT analysis is an exercise of adjusting the internal behavior of an organization with its surrounding environment (Kangas *et al*., 2003). It begins by determining the driving factors of the organization and grouping them into internal and external. Internal factors refer to the organization features that can be exploited (Strengths) or have to be minimized (Weaknesses) to improve. External factors are features of the environment, and therefore cannot be controlled by the organization, whose performance they are fostering (Opportunities) or hampering (Threats) (Karppi *et al.,* 2001). Once factors are determined, they are presented in a SWOT matrix (Weihrich, 1989), to visualize the interactions between internal and external factors and determine the most suitable strategy to implement. There are two key issues to consider when applying a SWOT analysis: the identification of the driving factors and the measurement of their relative importance (Hill and Westbrook, 1997). The most popular approach to overcome the subjective recognition of factors is the use of a wide range of people in the identification process (Impoinvil *et al.*, 2007). Several studies had developed different methods to assess the importance of the driving factors, the main difference being the use of cardinal (Kurttila *et al.*, 2000) or ordinal scales (Kangas *et al*., 2003).

SWOT analysis has also been used widely in the context of conservation and sustainable use of livestock breeds. It is common to find it being used in the context of the development of conservation and development plans (e.g. FAO 2010, Marta-Costa and Costa, 2011; Martiniuk *et al*., 2011). However, although SWOT analysis is well developed in the literature, it is normally used in a descriptive way, more as a method of organizing the driving factors without going further in the analysis (e.g. Woolliams *et al*., 2005; Pizzi *et al*., 2010).

In the **third chapter** we illustrate how SWOT analysis can be used to find strategies for the conservation and development of FAnGR. We have adapted the analysis to a decision-making tool that allows us to analyze in a systematic and structured way the problem of identifying and prioritizing strategies, and applied it to analyzing the case of 13 European local cattle breeds kept in six countries. The proposed methodology allows comparing breed cases across countries and helps policy makers, authorities, breeders' associations and other stakeholders to define and choose strategies to further develop and/or conserve local breeds. It starts from research at the breed level and ends with an overall analysis.

In the above discussion about the heterogeneity of causes, factors and processes influencing livestock breed farming we have considered breeds and their famers as the smallest element of analysis. However, farmers are far from homogeneous. Moreover, local breeds are nowadays raised by highly diverse farmers in equally diverse farms (Diepen *et al*., 2007; Gandini *et al*., 2010a). It seems reasonable that this heterogeneity would lead to differences in management and decision-making related to farm animal breeds. Therefore, it does not seem that farmers of a breed will act as a whole and this has some implications on the impact of conservation and development policies and programs. For example, according to the results of our interviews (data not published) of breeders from six Spanish local cattle breeds, after the hypothetical removal of subsidies, 20-70% of the farmers, depending on the breed, will stop keeping animals. Therefore, the consideration of the socioeconomic features of the farmers is crucial to develop sound and optimal strategies and policies for developing local breeds (Emtage *et al.*, 2007).

One way of approaching the study of farmer heterogeneity is the development of typologies. Typologies summarise the characteristics of archetypal persons and they usually aim to determine the factors influencing behaviour. Thus, the goal is to illustrate variation in behaviour, to provide an insight for the reasons behind the variation (Emtage *et al*., 2007). There is a long tradition of typology research in agriculture (Kostrowicki, 1977). However, to our knowledge, we have been involved in the only study developing local breeds' farmer types (Soini et al., 2012, -Annex 1-). We determined, using a qualitative content analysis (Hsieh and Shannon, 2005), the existence of seven types of local breed farmers types that could be recognized across thirteen local cattle breeds in six European countries. Then we grouped them according to the aim of their farms in three main categories: production oriented, product and service oriented and hobby oriented farmers.

In addition to qualitative approaches for the development of typologies (mainly used in anthropology, qualitative sociology and psychology) there are several statistical approaches for analysis and development of typologies. The main methodological and theoretical issues that need to be considered when developing typologies: the selection of criteria to classify farmers into a set of types (that depends on the aim on the study), the technique to define the types and the assessment of the validity and utility of the typology. This is done by comparing the typologies with reality (Emtage *et al*., 2007). The most used classification technique is the cluster analysis (Kobrich *et al*., 2003; Dossa *et al*., 2011) that consists of grouping observations in clusters so that those in the same cluster are more similar than ones in another cluster. There are several clustering techniques that differ in the method used to build the clusters.

In **chapter four** a general farmer typology is developed to help analyse herd dynamics and farmers' decision making in the context of designing strategies for the development of local breeds. We made use of the knowledge acquired in the development of typologies for the 13 European cattle breeds included in Annex 1 and applied them to the case of the Spanish cattle breed Avileña-Negra Ibérica. In this study, we use a quantitative approach to determine the types and in the assessment of the differences regarding farm profiles, management decisions and dependency on subsidy payments. In addition to statistics, we used sociological theories for the selection of the criteria to build the farmer types. We selected a few measurable socioeconomic factors that are often used as indicators of the economic and cultural capital of farmers (Siegmund-Schultze and Rischkowsky, 2001; Kristensen *et al*., 2004; Emtage *et al.*, 2006). Finally, we utilized the typology to recommend effective specific support measures for the local breed, keeping farms differing in socioeconomic and cultural features of its farmers.

Up to this part of the thesis, we have tried to understand why to preserve and use local breeds. We have illustrated how farmers play an essential role in the future of these breed. However, any aspect treated up to now deals with maintaining breed population numbers at socially desirable levels. In addition to socioeconomic aspects, the future of all these breeds will very much depend on their population structure. Livestock breeds do not constitute a panmictic population; they usually have a pyramidal demographic structure. In that type of structure herds are classified according to the origin of its sires: nucleus herds are those that never use reproductive males born in other herds, multipliers are herds that buy and sell reproductive males, and commercial herds are ones that only use reproductive males born in other herds (Vasallo and Díaz, 1986). The situation of herds on the pyramid could be due to several reasons such as the confidence of the farmers about their own breeding programme or the prestige of the sires of a specific herd, or the prestige of its farmer, which is usually related with traditional social relations among farmers. Since the status of a population of farm animals depends, at least in part, on farmers' decisions, one would expect that this status will be somehow related with the socioeconomic features of the farmers.

The demographic structure is correlated with the genetic structure of livestock populations. This genetic structure has important implications for the design of breeding and conservation programs since it affects the genetic status of the population which is a key issue for the future of low-census breeds. The structure of a breed influences two important parameters of conservation genetics: genetic variability and inbreeding. The first is defined by the expected heterozygosity and the second by the observed homozygosity. Maintaining high levels of genetic variability in a population is required to implement genetic improvement programmes and to adapt to environmental challenges. Restricting the observed homozygosity is required to avoid inbreeding depression (Toro *et al.*, 2011).

Livestock breeds are usually subdivided populations in which herds would be the subpopulations and would have different degrees and patterns of connections. Subdivided populations maintain more genetic diversity than non-subdivided but they usually have higher inbreeding rates. There are methodologies that help to design the genetic management of the populations maintaining a compromise between both aspects (Fernández *et al.*, 2011). Although optimal genetic management of populations can be achieved with these methodologies, it is often very difficult to apply to livestock breeds because the socioeconomic factors are dominant in the structuring of the populations. However some advice can be given, for example Gutierrez *et al.* (2003) analyzing Spanish breeds suggest that a slight exchange of animals between herds will lead to a much more favorable evolution of inbreeding. In any case, it is vital to know the genetic structure of the breed to be able to evaluate its genetic status, to predict the future prospective of the breed and to design genetic programs that, although not always implemented completely, would serve as a guide of what has to be done.

The best way to describe the genetic structure of the breed is a genealogical analysis while high density genotyping will be more common in the future. In such analysis the genetic diversity is 1 minus the expected homozygosity. The expected homozygosity of a cohort of animals is measured by the average coefficient of coancestry. The inbreeding (observed homozygosity) is measured by the inbreeding coefficient. The increasing rate of both parameters (coancestry and inbreeding) is inversely related to the effective size of the population therefore, this constitutes the parameter to maximize in a breeding programme (Fernández *et al*., 2011). There are several software programs that implement genealogical analysis such as the ENDOG or POPREP software (Toro *et al.*, 2011). This software also allow to study and analyze the pyramidal structure.

Pedigrees have allowed to monitor all these aspects and to design mating schemes to control the evolution of the genetic status of populations. However, the usefulness of the pedigrees is strongly determined by its depth, or the number of generations for which information is available. Unfortunately, the quality of pedigree records in local breeds is usually rather poor. Pedigrees are usually incomplete and go back a limited number of generations (Gutierrez *et al.*, 2003).

Molecular information has introduced important advances in the analysis of genetic population structure. Apart from not depending on the quality of pedigrees, it allows to estimate the realized, expected and observed homozygosity. Analogously to genealogical analysis, the expected homozygosity of a cohort corresponds to the average molecular coancestry of the cohort and the observed homozyigosity corresponds to the average molecular inbreeding. Their calculations give information on the departures of Hardy-Weinberg equilibrium and on the classical F_{ST} fixation index of Wright (Wright, 1969).

Several methodologies have been developed to study the genetic structure of a population. These methodologies have been developed in ecology to detect hidden structures of natural populations where demographic or pedigree records are not available or are incomplete or unreliable (Waples and Gaggiotti, 2006).The Bayesian methods and in particular the STRUCTURE software has become very popular. Loosely speaking, these unsupervised Bayesian clustering methods infer population structure by minimizing Hardy–Weinberg and linkage disequilibrium within subpopulations. This software has become incredibly popular although other approaches such as the distance methods *(*Rodríguez-Ramilo *et al*., 2009) also work reasonably well. Both approaches have proved to be useful tools to infer structures of simulated populations and real populations with relatively simple gene flow. But problems arise when populations show more complex relationships. Pritchard *et al.* (2009) warned that STRUCTURE could overestimate the number of clusters when closely related individuals are present in an evaluated data set. This was investigated by Rodríguez-Ramilo and Wang (2012) using simulated and real data to investigate the impact of close relatives in a sample on Bayesian population. They concluded that unsupervised Bayesian clustering algorithms cannot be used blindly to detect genetic structure in a sample with closely related individuals. They suggest that when closely related individuals are suspected to be frequent in a sample, these individuals should be first identified and removed before conducting a population structure analysis.

In **the last chapter** we analyze the genetic structure of the Avileña-Negra Ibérica breed making use of a set of molecular markers that has been used to verify paternity. The set has a reasonably high number of microsatellites (17). The genealogical structure of the ANI breed was studied some decades ago (Vasallo and Díaz, 1986). It was found to have a pyramidal structure in which nucleus herds where found to be related more with the traditional prestige of its farmers than with the genetic value of the animals (Vasallo *et al*., 1989). We wanted to analyze whether this structure has been modified or not. We also applied a new algorithm that uses molecular coancestry matrix to determine the most genetically isolated individuals and builds subpopulations on them. We compare this new method with STRUCTURE using simulated populations and analyze the case of the ANI breed as an example of populations with complex relationships. We end the chapter discussing the potential influence of the history of ANI breed and of the relationships between its farmers in the ANI demographic and genetic structure and the implication of this structure for the genetic management of the breed.

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OBJECTIVES

Objectives

Most cattle breeds can be categorized as local breeds. As a large number of breeds are endangered, the previously ignored values of livestock are gaining recognition. For some decades now, the important environmental, social, cultural, market and security values of local cattle breeds have been accepted worldwide. Therefore, awareness of the need for conserving Farm Animal Genetics Resources (FAnGR) has emerged. But the conservation of FAnGR is not an easy task since the causes for the erosion of the resources, the stakeholders involved in local animal production and the factors influencing the current status and future prospects of local breeds are multiple and interrelated. In addition, the relative importance of these factors varies among breeds and world regions.

In this PhD thesis we have explored different social, economic and genetic aspects involved in FAnGR conservation in Europe seeking to contribute to the scientific understanding of this complex issue. We have selected research topics of which relatively little is known and use several approaches aiming to achieve a comprehensive view of the processes involved in FAnGR conservation and development. In every chapter we discuss the implications of the research results for the conservation and development of FAnGR. The final outcome of the thesis is to illustrate how one can use quantitative methods to help in designing and establishing sound strategies and programmes for the conservation and development of local livestock breeds.

The thesis is structured in five chapters and one annex. Each of them corresponds to a scientific article published or being in process of becoming published in an international scientific journal. The article included in the **annex** is the research that motivated the study included in chapter 4. The aim of the article was to provide a preliminary typology for the local cattle farmers to promote future research on farmers involved in *in situ* conservation and to assist policy-making and implementation of FAnGr conservation programmes. We were involved as co-authors in this study and therefore, we have considered it pertinent to include it as an annex of the PhD thesis.

In **chapter one,** we explore the public non-marketed attributes of total economic value of livestock, using the Spanish Alistana-Sanabresa (AS) cattle breed as a case example. In particular we aim to,

- Analyze the relative importance of the non-market components of the total economic value of the AS breed.
- Determine the socio-economic variables that influence people's valuation of the different components of total economic value.
- Asses the implications of the Spanish national conservation strategy for the AS breed.

In **chapter two,** we analyze the current diversity regarding technical, economic and social factors found in local breed farming across Europe. To do so we focus on the case of fifteen local cattle breeds of eight European countries. The specific aims of this chapter are,

- Identify elements that are useful in designing common policies and programmes for conservation and development of animal genetic resources, using a group of European local cattle breeds as a case study.
- Investigate the variation among the countries and the implications of this heterogeneity for the policies and programmes to be developed.
- Detect the key elements common to countries, which may affect the viability of local breeds.

In **chapter three,** we adapted the SWOT analysis to a decision making tool that allows us to use a systematic and structured approach for identifying and prioritizing strategies. We then applied the analysis to the case of thirteen European local cattle breeds kept in six countries. The objectives of this chapter are twofold,

- Find a modification for the SWOT analysis to identify, assess and prioritize strategies for the conservation and development of local cattle breeds on the basis of breed-specific analyses.
- Use the proposed methodology to identify and compare potential strategies for a set of thirteen European local cattle breeds.

In **chapter four,** we develop a general farmer typology to help analyzing the herd dynamics and farmers' decision making and designing strategies for the development of local breeds. We used the Spanish Avileña-Negra Ibérica cattle breed as a study case. The chapter aims are,

- Analyze how cultural and economic variables are associated with the farmer types.
- Determine which farmer types could be based on economic and cultural factors.
- Study the possible links between the farmer types and farm profiles.

- Ascertain if the farmer types differ in management decisions.

Finally in **chapter five**, we study the current genetic structure of the Spanish Avileña-Negra Ibérica cattle breed using molecular markers. We relate it to farmers' decision in relation to the use of breeding animals. These decisions have shaped the demographic structure of the breed through the years. We discuss the implications of this structure for the genetic management of the breed. We use two different methods to determine the structure given its complexity. Specifically in this last chapter we aim to,

- Assess the utility of a graphical clustering algorithm to identify the genetic structure of a livestock population.
- Study the performance of such an algorithm compared to Bayesian clustering algorithms.
- Analyze the current genetic structure of Avileña-Negra Ibérica breed.
- Identify implications of the structure for the genetic management of the breed.

CHAPTER 1

This chapter entirely reproduces the following paper under revision in Animal.

Determination of non-market values to inform conservation strategies for the threatened Alistana-Sanabresa cattle breed

D. Martín-Collado[1], C. Díaz[1], A. G. Drucker[2], M. J. Carabaño[1] and K. K. Zander[3]

[1]*Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria (INIA), Madrid, Spain*

[2]*Bioversity International, Rome, Italy*

[3]*The Northern Institute, Charles Darwin University, Darwin, Australia*

Determination of non-market values to inform conservation strategies for the threatened Alistana-Sanabresa cattle breed

Abstract

Through the application of a choice experiment survey in Zamora province, Spain, the total economic value (TEV) of the threatened Alistana-Sanabresa (AS) cattle breed was investigated. An analysis of the relative importance of the non-market TEV components and an assessment of the socio-economic variables that influence people's valuation of such components is used to inform conservation strategy planning. High cultural and existence values (totalling over 80% of TEV) suggest that an *in situ* conservation strategy would be appropriate and that farmers will need incentives if they are to capture some of these public good values and maintain breed population numbers at socially desirable levels. One such mechanism could be related to the development of agritourism initiatives, which would enhance private good values and provide an important addition to a conservation and use strategy. However, farmers need to seriously evaluate how to invest in niche product development as well as the need of improving product quality and brand recognition. Finally we found that people do not have a complete picture of all the functions and roles that AS breed as a farm animal genetic resource. Therefore, future AS increasing-awareness actions should go in that direction.

Introduction

Worldwide, the number of livestock breeds is declining, mainly due to the expansion of intensive livestock production systems (Food and Agriculture Organization of the United Nations –FAO-, 2007a). These systems have partly substituted traditional holistic farming approaches and decisions about which breed to keep have been based on commercial factors (e.g. increasing demand for meat worldwide). The aim has been to maximize the direct benefits of animal production (Mendelsohn, 2003). It is estimated that 28% of European mammalian breeds are at risk, while 22% have already become extinct (FAO, 2007a). Spanish cattle breeds are no exception. Most of them experienced a severe decline between the 1950's and the 1980's (Garcia Dory *et al.*, 1990).

However, increasing awareness that the market has failed to fully account for the value of a wide range of livestock functions and services, particularly those which represent public goods (Drucker *et al.*, 2005) has led to conservation interventions with a view to maintaining these values for wider society. Such public good values include, *inter alia*, the maintenance of landscapes, cultural elements and the future option values for adapting to global change (Mendelsohn, 2003). In Spain, livestock conservation policies and programs began in the mid-1990s leading to a period of stabilization and a limited recovery of some population numbers. However, currently 29 out of the 37 recognized indigenous Spanish cattle breeds are endangered (Official Spanish Gazette -O.S.G.-, 15 February 2012).

Many local breeds are no longer commercially profitable and are hence increasingly unattractive to farmers whose livelihoods depend on income from livestock. In order to avoid the wholesale replacement of these local breeds by mainstream breeds, one of the main instruments of government conservation policy has often been the use of support payments to compensate farmers for the reduced profitability of maintaining such breeds. However, investment in the conservation of local livestock breeds competes with other socially-desirable agricultural investments and the need for long-term support raises issues related to the sustainability of such approaches. Furthermore, the distribution of agricultural subsidies may not always be efficient and equitable (Cong and Brady, 2012). This paper focuses on one of these breeds, the Alistana-Sanabresa (AS), as a good case study with which to illustrates the above dynamics and implications of its non-market public good values for conservation strategy planning.

It has been argued (Drucker *et al.*, 2001) that proper assessment of the full range of functions and services provided by livestock, as expressed in terms of their total economic value (TEV), can support decision-making in livestock conservation and sustainable use. Improved understanding of the TEV of threatened breeds and the relative weights of the different components of TEV can be used to, *inter alia,* help determine which kinds of interventions and incentive mechanisms might be most appropriate for ensuring their long-term survival.

The conceptual economic background to the loss of animal genetic resources (FAnGRs) has been described in detail elsewhere (Drucker and Rodriguez, 2009; Zander *et al.*, forthcoming). Breed loss is considered to result in less than socially desirable levels of FAnGRs being maintained, in particular as a result of the fact that significant non-market and/or public good values associated with conservation services have been ignored (Drucker *et al.*, 2005). As has been shown for plant genetic resources at the landscape level such goods and services relate to the public good role of genetic resources use in supporting agroecosystem resilience, maintaining socio-cultural traditions, local identities and traditional knowledge, as well as the maintenance of evolutionary processes, gene flow and global option values (Drucker *et al*., 2005). Public good characteristics, unrelated to direct use values associated with production outputs, but instead associated with the use of genetic resources to minimise exposure to external shocks are also frequently unaccounted for (Zander *et al*., forthcoming).

In this paper we apply a TEV framework (Bateman *et al*., 2003), classifying such values into use and non-use components, where the latter include option, bequest and existence values. For livestock, direct use values include production outputs. Indirect use values relate to the role of livestock as maintainers of rural culture and landscapes. Option value is related to the potential future use of livestock, bequest values relate to the value associated with the passing on of resources to future generations and existence values relate to the utility derived by people from knowing that a specific resource exists. It has been argued that the relevance of these values may depend on the type of stakeholder and their socio-economic status (Louviere *et al*., 2000)

The challenge in determining the TEV of a livestock breed arises from the private and public good characteristics of FAnGR. Stated preference valuation methods have consequently been employed to determine such values for both plant and animal genetic resources (Drucker *et al*., 2001). One method that has increasingly been used is based on the use of choice experiments (CEs), which allows the valuation of individual attributes of a given good or components of its TEV (Hanley *et al.*, 1998). Under such methods the stated values are expressed by the respondent's willingness to pay (WTP) or willingness to accept (WTA) compensation for the existence of or changes in environmental quality. A number of economic studies using CE in order to examine farmers' values for livestock breeds traits have been undertaken to date (Omondi *et al.*, 2008; Zander and Drucker, 2008). More recently, Zander *et al*. (forthcoming) use a CE to determine the TEV of two Italian livestock breeds and a similar approach is adopted here.

This paper consequently seeks to contribute further to such scientific understanding by: 1) analyzing the relative importance of the non-market TEV components of the AS breed; 2) determining the socio-economic variables that influence people's valuation of the different components of TEV; and 3) assessing the implications for AS conservation strategy in Spain.

Material and methods

Study breed and area

The AS breed found across Zamora province in northwest Spain originated in the mountainous regions of Aliste and Sanabria in the northwest of the province. By the mid-1920s the breed had spread beyond its original area and into neighbouring regions (Yanes García, 2000). The traditional farming system with which it had been associated is the family-based production system typical of Northern Spain. Animals were bred in small herds, stabled during the winter and allowed to range freely when weather conditions permitted. The AS was a multipurpose breed located within a diversified farming system oriented towards animal production, mountain agriculture and forestry. Such traditional farming systems were increasingly located in the culturally and geographically isolated regions of Aliste and Sanabria, where economic development was slower than in other areas of Zamora province. However, the farming system associated with the breed has evolved in recent decades, adapting to economic, technical and social changes (FAO, 2007a; Delgado *et al.*, 1999). Broadly speaking, the breed nowadays can be characterised as being reared under three different types of farming systems: a slightly modified traditional system, an evolved traditional system and an extensive system. The first system is formed by farms that introduced some technical progresses as compound feed but are still using traditional stone stables, which limit the growth of the herds, and traditional marketing channels, mainly cattle dealers and local cattle markets. Forestry has mostly disappeared from these farms but agriculture remains in most of them. The evolved traditional system have gone further in the transformation, farms are specialized in beef productions, have modern infrastructures and make use of a wider variety of marketing channels besides the traditional cattle dealers. Finally, in the last decades have appeared farms breeding AS cattle under extensive systems. They are mostly located in the traditionally agriculture oriented regions of the centre and south of the province. These farms are holding the growth of breed census.

The long coexistence of the AS breed and the inhabitants of the regions in which it is found has given rise to cultural elements, some of which still remain. For example, the origins of the AS breed market of Porto de Sanabria that is still held monthly during spring and summer can be traced back to the XIX century. Meat from the AS has traditionally been considered in the province as a high quality product. However, despite this reputation and demand for its meat, it is not always straightforward for consumers to find breed-related products as no breed-specific label has been developed, leading some breeders to argue that niche product market development could be a successful strategy for supporting conservation activities.

Starting in the 1950s, the AS population suffered a sharp decline from around 37.000 breeding females to less than 1.500 by the end of the 1990s (Yanes García, 2000). Awareness regarding the need for a conservation program began in the mid-1990s; provincial agricultural authorities created a breed herd book in 1998 and promoted the foundation of the Alistana-Sanabresa Breeders Association (AECAS). They also started a program of payments to farmers from rearing AS animals which quantity have been variable throughout the time. Nowadays farmers receive economic support from the provincial government and from EU that together sum around €200 per animal. AECAS started by focusing on herdbook fulfilment in order to foster the performance recording of animals and the development of a conservation program. The promotion and development of the breed and its products have formed another main focus of AECAS's work. Such interventions have contributed to some degree of recovery of the breed population, which now numbers over 3.000 breeding females (AECAS data). Nevertheless, despite this population increase, it remains an endangered breed according to the Spanish Ministry of Agriculture, Food and Environment (OSG, 15 February 2012).

The choice experiment

We used a CE to determine the non-market TEV components of AS breed. In this sort of experiments CE, respondents are presented with a series of choice tasks, known as choice sets, each containing a finite number of scenarios which describe the environmental good or policy outcome in question (Hensher *et al.*, 2005). The choice sets are described through attributes that change under each scenario. A monetary attribute is usually included which allows willingness to pay (WTP) or willingness to accept (WTA) estimates to be assigned to each of the attributes and represents an estimate of the utility or welfare that respondents derive from the attributes of a given scenario. The selection of the attributes and levels that would be used in the CE was made in consultation with Spanish cattle experts and the design was pre-tested before the main survey started. Table 1 contains a description of the attributes, the TEV components and the number of levels considered in the CE. We accounted for elements of direct use, indirect use, option and existence values. Cultural and landscape values of the AS breed were explicitly considered as these two indirect use value attributes are often given as a justification for breed conservation interventions (Mendelsohn, 2003; FAO, 2007a). The payment vehicle (the monetary attribute) used was a one-off contribution (ranging from €0 to €100) to a conservation programme for the AS.

We created choice sets with three scenarios, one of which was always a status-quo (SQ) scenario. The other two represented the outcomes of hypothetical conservation programmes relative to the SQ (Figure 1). Respondents were asked to select their preferred scenario, noting that they incurred no financial cost if selecting the SQ, while the other two scenarios would involve a once-off donation to an AS breed conservation programme.

Table 1 [+]*TEV component attributes and their levels as used in the choice experiment*

Attribute	TEV component	Nº of levels	Levels
Quality of the breed-related special food products ([+]FOOD)	Direct use value	2	[++]**Average**, Superior
Maintenance of local rural culture (CULTURE)	Indirect use value	3	**Declining**, Stable, Improving
Maintenance of rural landscape (LANDSCAPE)	Indirect use value	3	**Declining**, Stable, Improving
Ability to re-establish the breed should it turn out to be important in the future and no live animals remain (FUTURE)	Option value	2	**Low,** High
Certainty of the continued existence of live animals over the next 50 years (EXISTENCE)	Existence value	3	**10%**, 50%, 90%
One-off contribution to a conservation programme (in €) (DONATION)		5	**0**, 10, 25,50, 100

[+]Total Economic Value.
[++]Variables names (in brackets) are as used in the model with the status-quo levels indicated in bold.

Given the number of attributes and their levels, there were 540 potential choice sets, each made up of three scenarios, one of which is the SQ (2^2 x 3^3 x 5^1). As it would not have been practical to work with such a large number of choice sets, in order to optimise the design, Ngene software (Institute of Transport and Logistics Studies, 2007) was used to create a design that minimised the D_p-error and maximise the balance (Ferrini and Scarpa, 2007).

The final design revealed a D_p-error of 0.17 and was 94% balanced, i.e. the different attribute levels used in the design were broadly equally represented. The design yielded twelve choice sets, which were divided into two blocks. Each respondent was presented with one of the two blocks and was hence asked to make six choices.

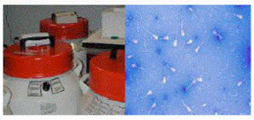
	Option 1	**Option 2**	**Current situation**
1. Maintenance of breed-related special food products 	No —	Yes ↑	No —
2. Maintenance of breed-related rural culture 	Declining —	Improving —	Declining ↓
3. Maintenance of breed-related rural landscape and environmental services 	Declining ↓	Improving ↑	Declining ↓
4. Possibility to re-establish the breed for the future if it becomes extinct 	Low ↓	High ↑	Low ↓
5. Certainty of continued existence of live animals over the next 50 years 	50%	10%	10%
One-off contribution to a conservation program 	**100 €**	**10 €**	**0 €**

Figure 1 *Example of choice set*

Survey; selection of respondents and interviewing procedure

203 households were interviewed, 102 in Zamora city and 101 in six villages of Zamora province. Villages selected were located in Sanabria and Aliste regions, where the

breed was originally found. This sampling approach permitted us to differentiate between areas with residents for whom the AS is local and areas whose residents are more distant from the places where the AS breed is found (but who are also potential visitors to the local area) in order to test for differences in the AS TEV between these different types of stakeholder.

Data related to several socio-economic variables were also collected in order to explore their effect on AS TEV. Respondents were selected in such a way as to ensure a balanced sample of the population with regard to gender, age and job status. Additional data related to respondent knowledge about the AS breed was also compiled. The full questionnaire can be found in Supplementary material S1. Potential adult respondents were approached in public places such as squares, markets, universities and schools. They were informed about the objectives of the research and, for those who agreed to take part, prior to undertaking the survey, were provided with additional introductory information regarding the importance of livestock breeds, the current status of animal genetic resources worldwide, as well as the specific status of local Spanish cattle breeds, including that of the AS. Such information included a set of photographs also shown to the respondents to help familiarise them further with the topic and the breed in question. Finally, the CE survey questions were presented.

Analysis

The theoretical framework of the CE draws on Lancaster (1966) as well as on random utility models (Luce, 1959; McFadden, 1974). Lancaster's theory (1966) states that consumers derive utility from the attributes of the good and not only from the good *per se*. This is important since many decisions related to environmental management are concerned with changing attribute levels, rather than losing or gaining the environmental good as a whole (Hanley *et al.*, 1998).

We analysed the choice data using random parameter logit (RPL) models. RPL models are flexible, allowing preference variation across respondents and the use of panel data (many choices made by one respondent) (Hensher *et al.*, 2005). Detailed RPL model specifications can be found in Hensher and Greene (2003) and Hensher *et al*. (2005). In general, choice models are based on modelling the level of utility that a decision maker obtains from an alternative. Utilities for each alternative are not directly observable but can be modelled by a set of known covariables (usually, the attributes of each alternative and, possibly, characteristics of the decision makers) and a random residual term that captures the variation in utility values unexplained by the covariables. In the random parameter choice models, the utility perceived from a decision maker of a given alternative is allowed to differ each occasion the alternative is evaluated by the same individual, and the explanatory covariables receive weights that are not fixed but vary among respondents to allow for different preferences. The general model can be written as,

$U_{njt} = \beta_n' x_{nj} + \varepsilon_{njt}$ [1],

where U_{njt} is the utility perceived by the decision maker n of alternative j in occasion t, $\boldsymbol{\beta}_n$ is a vector of random parameters defining the weight of each covariable on the value of the utility, $\mathbf{x}_{nj}$ is a vector containing the known values for the level of covariables associated with alternative j, and, ε_{njt} is a random residual term that is distributed iid extreme value, independent of $\boldsymbol{\beta}_n$ and $\mathbf{x}_{nj}$. Vector $\mathbf{x}_{nj}$ contains values for levels of the attributes of the public good that are being evaluated as well as the value of the monetary attribute. In the random parameter models, the random variables in $\boldsymbol{\beta}_n$ are assumed to have a distribution with mean **b** and (co)variance **W**, being these the target parameters to estimate.

In our study, covariables included values for the attributes of the breed (Table 1) as well as socio-economic variables (Tables 2 and 3). The monetary attribute, i.e. the level of donation, was coded using the actual values presented, while all other variables were dummy-coded. Apart from covariables for attributes and socioeconomic characteristics, alternative specific constants (ASC) were included. These constants capture the average effect on utility of all factors that are not included in the model. Two ASC were fitted, one associated to the corresponding alternative and a dummy variable associated to the SQ alternative. This dummy variable takes a value of 1 if the option is the status quo, and zero otherwise and it was fitted to determine whether there are impacts on utility which are associated with the SQ alternative as a whole, rather than the individual attribute levels which comprise this option. Interaction terms between the socioeconomic and the SQ were included to detect the source of preference heterogeneity among respondents by explaining which kind of respondents were more likely not to pay (to choose the SQ) for the conservation of AS breed. Estimation was done by maximising the log likelihood of the observed choices using simulation procedures to sample values of the marginal distributions of the parameters of interest. The levels of the SQ alternative were used as the reference levels for the attribute levels. Therefore, results for the estimated coefficients of the attributes and socioeconomic characteristics are referred to the SQ. Alternative distributions for the random variables in $\boldsymbol{\beta}_{nk}$ were tried. Selection of the best distribution for this data case was based on the likelihood ratio test. The willingness to pay (WTP) or welfare estimates of a marginal change in an attribute level was calculated as the (negative) ratio of the attribute parameter to the monetary attributes,

$$WTP_{nk} = -\frac{\beta_{nk}}{\beta_{price}}$$

This ratio represents the marginal rate of substitution between costs and attributes, *ceteris paribus*. If the calculated ratio is positive, it signifies that respondents are willing to pay. WTP was derived by simulating the ratio $\frac{\beta_{nk}}{\beta_{price}}$, from equation [1] where β_{nk} is the coefficient for attribute *k* for individual *n* and β_{price} is the monetary attribute. Using the mean and standard deviation of each distribution, we simulated the WTP of each individual *n* for each attribute *k* ten thousand times (as per Thiene and Scarpa, 2009). We report the mean, and the upper and lower quartiles (i.e. the amounts that individuals would be willing to pay at least 25% or 75% of the time, respectively) to account for randomness (Marsh, 2012).

Results

Respondents' characteristics

Job status, age and gender were evenly represented in villages and in Zamora city (Table 2).

Respondents covered the full range of educational levels (Table 3). A high proportion of respondents (43%) had jobs related to the agriculture sector. Mean family size was 2.3 persons with an average of 0.4 children. The vast majority of respondents stated that they had undertaken an outdoor activity in the countryside at least once in the last 2 years and/or that they enjoy seeing traditional agricultural landscapes when they are in the countryside. 45% of respondents stated that they give equal weight to economic development and nature conservation when conflicts arise, 30% favour economic development and 25% conservation. The mean stated level of knowledge related to the AS breed averaged 4.8 on a 10 point scale (*sd* = 2.3). Most respondents (84%) had heard of the AS breed, 87% had seen it before and 74% had eaten an AS breed-related product. Approximately half of the respondents refused to give information regarding their family income, while a majority of the remainder stated that they have low family income.

Table 2 *Distribution of interviews according to location, gender, job status and age*

			Age					
	Gender	Job status	18-30	31-45	46-60	61-75	>75	Total
Villages (n=101)	Men	Employed	6.9%	15.8%	17.8%	2.0%	-	42.6%
		Unemployed	2.0%	5.0%	5.9%	6.9%	-	19.8%
		Student	1.0%	-	-	-	-	1.0%
		Total	9.9%	20.8%	23.8%	8.9%	-	63.4%
	Women	Employed	7.9%	13.9%	5.9%	1.0%	-	28.7%
		Unemployed	2.0%	2.0%	1.0%	3.0%	-	7.9%
		Student	-	-	-	-	-	0.0%
		Total	9.9%	15.8%	6.9%	4.0%	-	36.6%
	Total		19.8%	36.6%	30.7%	12.9%	-	100%
Zamora city (n=102)	Men	Employed	6.9%	10.8%	9.8%	1.0%	-	28.4%
		Unemployed	3.9%	3.9%	3.9%	4.9%	2.0%	18.6%
		Student	6.9%	-	-	-	-	6.9%
		Total	17.6%	14.7%	13.7%	5.9%	2.0%	53.9%
	Women	Employed	4.9%	7.8%	12.7%	-	-	25.5%
		Unemployed	2.0%	4.9%	2.9%	6.9%	-	16.7%
		Student	3.9%	-	-	-	-	3.9%
		Total	10.8%	12.7%	15.7%	6.9%	-	46.1%
	Total		28.4%	27.5%	29.4%	12.7%	2.0%	100%

Results of the CE

The best model, according to the likelihood ratio tests, was found to be one in which the two ASC were non-random and all attributes entered the model as random and normally distributed, apart from the monetary attribute which was constrained to having a triangular distribution with a standard variation not larger than the mean. This constraint avoids the coefficient of the monetary attribute taking a negative sign (Hensher *et al.*, 2005). The model had a McFadden R^2 of 0.45 (McFadden, 1974).The SQ constant was found to be significant and positive (7.83), meaning that respondents were more likely to choose the SQ (and hence not to donate) than choosing one of the other two scenarios (Table 4). Approximately half of the respondents (105 or 51%) always chose the SQ option. The ASC for Alternative A was

***Table 3** Respondents´ socioeconomic characteristics and knowledge about the AS breed*

	Variable	Percentage of respondents ([+]n)
Education level	Elementary school	25% (50)
	Secondary school	13% (26)
	High school	18% (37)
	Technical school	15% (30)
	University	26% (52)
	Other	2% (5)
	No information	1% (3)
Percentage of respondents related with the farm sector		43% (87)
Family Income p.a	<6000 €	3% (6)
	6.000 - 14.999 €	24% (48)
	15.000 – 24.999 €	10% (21)
	25.000 – 49.999 €	11% (23)
	50.000 – 69.999 €	1% (3)
	70.000 - 99.000 €	0% (0)
	> 100.000 €	0% (1)
	No information	50% (101)
Number of adults per household ([++]NADULTS). Range: 1-6		2.3 ± 1.0
Number of children (<18 years) per household. Range: 0-3		0.4 ± 0.7
Percentage of respondents having participated in outdoor activities in the last 2 years		96% (195)
Percentage of respondents enjoying traditional agriculture landscape		94% (190)
Perception towards development	No information	0% (1)
	Favour preservation of the environment more frequently (FAV_ENV)	25% (51)
	Favour economic development more frequently (FAV_DEV)	30% (60)
	Favour both equally	45% (91)
Previous level of knowledge about the breed. Range: 1-10		4.8 ± 2.7
Percentage of respondents having heard about the breed.		82% (167)
Percentage of respondents having seen the breed (SEEN)		87% (176)
Percentage of respondents having eaten products of the breed (EATEN)		71% (144)

[+]Total sample size was 203; 101 from villages and 102 from Zamora city.
[++]The name used in the text is in brackets.

not significant, which is desirable as it means that ‘left-right’ bias (i.e. the order in which scenarios are presented on a choice card) was not present in respondents’ choices. The coefficient for DONATION was negative (-0.16), meaning that, as expected, the higher the costs for respondents, the less likely that the alternative would be chosen.

All the coefficients of the significant attributes had positive signs meaning that respondents preferred improvements compared to the levels of the SQ (Table 4). Respondents were found to be indifferent towards the attribute FUTURE and to the level “improving” of the LANDSCAPE attribute. The standard deviations were significant for all attributes (Table 4), meaning that the preference parameter is not constant across the population. This is reflected in the large difference between the upper and lower quartiles in the welfare estimates of the significant attributes of the model (Table 5).

Table 4 *Estimates of the fixed regression coefficients (DONATION) and the standard error of the estimate as well as regression coefficients and the standard deviations of the random parameter logit model*

	Variable	Coefficient	Standard Deviation
	+ASC – Status Quo (SQ)	7.83**	
	ASC – Alternative A	0.21	
	DONATION	-0.16**	0.16**
Attributes of the components of the TEV	++FOOD – Superior	0.99**	4.74**
	CULTURE – Stable	3.91**	3.25**
	CULTURE – Improving	4.89**	4.61**
	LANDSCAPE – Stable	1.36*	2.63**
	LANDSCAPE – Improving	-0.1	5.53**
	Existence – 50%	5.43**	4.01**
	Existence – 90%	5.67**	2.55**
	FUTURE – High	0.71	3.96**
Interaction between socioeconomic variables and SQ	CITY* SQ	3.44**	
	FAV_ENV * SQ	-4.33**	
	FAV_DEV * SQ	3.78**	
	NADULTS * SQ	-1.35**	
	EATEN * SQ	-4.60**	
	SEEN * SQ	3.94**	
	Log-likelihood	-731.01	
	Halton draws	500	
	McFadden Pseudo R^2	0.45	
	Number of observation	1218	
	Number of respondents	203	

+Alternative-specific constant.

++Name of the attribute of the components of the TEV and its level as explained in Table 1.

*5% significance level.

**1% significance level.

In order to understand preference variation, interactions terms between socio-economic variables and the SQ were included in the model and those that were significant are reported in Table 4. Respondents who lived in Zamora city were more likely to choose the SQ (CITY*SQ coefficient equal to 3.44). Regarding respondents' general attitude towards economic development-environment conflicts, those who stated favouring environment (FAV_ENV*SQ) were less likely (-4.33) to choose the SQ, while those who favour economic development (FAV_DEV*SQ) were more likely to do so (3.78). Households with fewer adults (NADULTS*SQ) were less likely to prefer the SQ (-1.35), as were respondents who had previously eaten (EATEN*SQ) AS breed-related products (-4.60). Unexpectedly, respondents who had seen the breed before (SEEN*SQ) were more likely (3.94) to choose the SQ. The remaining socio-economic and AS knowledge variables analysed (Tables 2 and 3) had no significant influence on WTP for conserving the AS breed.

The total economic value

Overall, the welfare estimates of the significant attributes (Table 5) reveal that respondents would be willing to pay €7 for superior quality breed-related special food products, €25 for stable and €31 for improving maintenance of local rural culture, €9 for a stable landscape, €34 for a 50% certainty of the breed's continued existence and €36 for a 90% certainty.

Table 5 *Welfare estimates for significant attributes of the model*

Variable	Mean (€)	+Percentage contributions to TEV	25% / 75% quartiles
FOOD – Superior	7	8.4%	-14 − 26
CULTURE – Stable	25	-	11 − 38
CULTURE – Improving	31	37.3%	11 − 50
LANDSCAPE – Stable	9	10.84%	-2 − 20
EXISTENCE – 50%	34	-	17 − 51
EXISTENCE – 90%	36	43.4%	25 − 46

+The total economic value (TEV) of the Alistana-Sanabresa breed was calculated by summing the highest levels of the attributes.

The TEV of the AS breed was calculated by summing the highest levels of the attributes (see Table 5) and represents a one-off WTP. The TEV for the AS can therefore be seen to total €83 (€7 direct use value + €40 for indirect use values (€9 for landscape and €31 for cultural value) + €36 for non-use existence values). It can therefore be seen that over 91% (i.e., €76 =

€83 - €7) of TEV of the AS breed is associated with public good indirect use and non-use values, with existence values and the maintenance of traditional culture being particularly important.

Discussion

Socioeconomic variables influencing TEV valuation

Several socioeconomic variables influencing people's valuation of the AS breed were identified. As hypothesised, the location of the respondent had a significant influence on the WTP for AS conservation, with villagers having higher WTPs than town residents. Such a result may be expected as the villagers surveyed were in the region of origin of the AS breed and their inhabitants are closely linked to the breed, with it forming a recognizable element of their local culture. The support of villagers to AS conservation might be a symbol of conserving their culture and the way of life of the countryside. It has been shown in other studies (Zander and Drucker, 2008) that entire traditional lifestyles, such as pastoralism, may depend on particular breeds and that with the loss of these breeds the traditions will be lost as well.

With regard to family income, it was hypothesised that income status would influence WTP, as has been found in other studies (Zander *et al*, forthcoming). However, no such significant impact was found. Such a finding might have occurred as a result of the one-off contribution requested having been small enough to be affordable to everybody independently of their income level, although we are unable to test for this explicitly.

Awareness regarding endangered farm animal breeds is considered to be an important factor for the success of conservation programs (FAO, 2007b). In our study, none of the factors measuring respondent knowledge about the breed were found to influence the WTP for its conservation. However, we have to consider that many of the respondents did in fact already have some minimum knowledge regarding the current situation of the AS. Most of the respondents (82%) had heard about the breed and had some previous knowledge about the breed (with a rating of 4.8 out of 10). Furthermore, respondents were given a short explanation about the current situation of FAnGRs and the AS breed prior to the CE. Information about the status of local breeds can be relatively easily placed in the context of environmental degradation and biodiversity loss. In general, these are issues which are widely known these days. Therefore, even the provision of a minimal level of information about the state of FAnGRs may be considered sufficient for people to build an informed opinion.

Respondents' attitude towards economic development-environment conflicts influenced WTP for AS conservation in the expected direction. Those people who stated that they tend to favour *economic development* over *environment* in situations where a trade-off exists were shown to be less likely to be WTP to conserve the AS breed. This finding seems coherent with the high importance of the cultural and existence value on the TEV as we believe that is reasonable to think that people who favour environment over economic development give high value to culture and breeds conservation.

Those respondents who had eaten AS beef were more likely to be WTP for conservation of the breed. However, those who had previously seen it were unexpectedly less likely to do so. Such a result may arise as a result of the fact that aesthetically the AS breed is very similar to other breeds in the neighbouring regions of Northwest Spain (Yanes García, 2000). A similar finding related to the influence on WTP for conservation of having previously seen animals of the cattle breed in question has been also found in Italy (Zander *et al*., forthcoming). They showed that having seen the breed had a positive effect on the value of a breed that had specific morphological features, while a more aesthetically common one generated results similar to that of the AS.

So far we have seen how different types of stakeholders have also shown to place different values on the public good attributes of AS breed (including some who had zero values), a finding that may also hold for many other breeds of domesticated livestock.

Attribute values and policy orientations

The AS breed was shown to have significant public good values associated with it. Although people placed a value on direct use aspects they placed higher values on the indirect use cultural and landscape maintenance functions, as well as its existence value (Table 4).

The *direct use value* of AS beef was not highly valued overall (€7), with some respondents not placing any value at all on this attribute (Table 5). Since AS breed products do have a good reputation as a high quality traditional product, this may suggest that improved differentiation and marketing of its products may be necessary. However, the low overall value also suggests that the ability of such niche product market development investments to generate sufficient funding for attaining conservation strategy goals may in fact be limited.

The *indirect use cultural value* of the AS was found to be between three to four times higher than the direct use value. Respondents were willing to pay more (31€) for improving cultural aspects associated with the breed than for merely maintaining them (€25), a fact that might reflect that the current status of AS cultural traditions is perceived as poor. The increase in AS population numbers have largely arisen from an increase in farm sizes and as a result of the development of extensive farming systems, while the semi-stabled ones continue to disappear. This dynamic has been sharper in the slightly modified traditional farms, which may be particularly associated with the maintenance of cultural traditional practices; only tens of such farms now remain scattered across the Aliste and Sanabria regions. The relatively higher importance of AS cultural values over its special food products is also confirmed by the outcomes of a quantitative SWOT analysis (unpublished data) following a methodology developed by Martín-Collado *et al*. (2012, -Chapter 3-).

The findings related to the *indirect use value related to landscape maintenance* contrasts with the above. Although respondents would pay €9 for maintaining the landscape as it is, they are not willing to pay to improve it (Table 5). This finding may arise from the fact that the current landscape status might be considered to be satisfactory from the perspective of the respondents; the farming sector continues to remain important in Zamora and the agriculture landscape is still "well conserved". The corollary to this is that where such environmental quality decline, it might be expected that the related AS service values generated by the breed would be more highly valued.

The high *existence value* might highlight the importance of ethical aspects in the animal husbandry sector; respondents wanted to conserve AS breed regardless of their use values as it might be the case for other breeds or domesticated livestock. Respondents would pay €36 for a 90% level of chance of ensuring the existence of AS, which is the highest valued attribute of AS TEV.

Finally, and unexpectedly, respondents did not highly value the *option value* of the AS breed. It could be that respondents do not consider AS breed as having a role in helping to adapt to future needs, however, the high *existence value* figure may be due to the fact that respondents' perceive these values to largely overlap.

The general feeling of the Farm Animal Genetic Resources (FAnGRs) sector is that there is a lack of social awareness on the conservation these resources (Woolliams *et al*., 2005; FAO, 2007b). Consequently many conservation programs and project have tried to increase the awareness on the delicate state of FAnGRs. This has been the AS breed case, which Breeders Association work has been partly devoted to the promotion of the breed and its products. About half of the respondents were WTP for the conservation of AS breed. This finding suggests that the efforts made to increase social awareness on AS breed threatened state have succeeded, although as we have seen in the previous paragraph, people do not have a complete picture of all the functions and roles that AS breed as a FAnGR has (FAO, 2007a). Therefore, future AS increasing-awareness actions should go in that direction.

The results indicate that respondents were willing to pay around three to four times as much for the continued existence and for the cultural value of AS than for the landscape value and the direct use value analysed. In particular, the cultural value of the AS (37.3% of TEV) suggests that interventions may consider agritourism development, with funds being invested to help farmers to maintain/restore cultural aspects related to traditional farming practices (e.g. restoring traditional stable, holding fairs, etc.) and to attract tourists to farms. Similarly, anthropological museums would seem to be reasonable options to foster rural and ecotourism in the region with especial interest in Sanabria region where rural tourism sector is well developed. On the other hand, farmers need to seriously evaluate how to invest in niche product development as well as the necessity of improving product quality and brand recognition, particularly where linked with the cultural and traditional farming systems of the breed. This evaluation could even be more crucial for farmers who are out of the area with cultural unique attributes or exploiting the breed under the evolved management systems.

The evaluation of the non-market values of a breed may also be used as a criterion for orienting the type of conservation intervention to be undertaken. Provided that farmers cannot be expected to, or be able to afford to maintain the AS at socially desirable levels, the development of incentive mechanisms to allow farmers to capture some of those public good values when they are significant (as shown in this study, where they comprise 91% of TEV) may be justified. Such positive incentives are also in line with those called for in general by the CBD 2011-2020 Strategic Framework. Based on the figures presented above, the value the general public in Zamora province placed on the public good functions and services of AS breed may be estimated as being approximately €12.2m (€76 x 160,000 adult individuals).

This is equivalent to €608,000 on an annualised basis during 20 years, using a standard 5% discount rate. Thus, we may conclude that the loss of this breed (even where total meat/milk production remains unchanged by using an alternative breed) would imply the loss of significant public good values. Finally we note that although half of the respondents stated that they were not willing to pay for the conservation of AS breed, this may not necessarily reflect a lack of interest in conserving the breed rather than a perception of responsibilities. Martín-Lopez et al. (2007) in a wildlife conservation study found that many respondents stated that they considered that the conservation of wildlife species is the duty of governments and not of private individuals. The extent to which policies related to public spending and government interventionism actually influence people perception of responsibility and therefore private WTP for the conservation of local breeds is thus a future research topic of interest since it could have a significant influence in the validity of CEs.

Conclusions

We have shown how CE can be used to explore the value that people place on the non-market attributes of local breeds. The results of this sort of experiments may be used to inform both the design of conservation strategies and resources allocation between breeds which might also include a measure of their genetic distinctiveness, for example as part of their option value.

The TEV analysis carried out in this paper suggests that the most appropriate intervention strategies would be those that focus on those breed attributes that people value the most, considering the values more as a measure of their relative importance of the attributes than as an absolute value. The results indicate that most valuable attributes would be related to securing cultural traditions and the long-term continued existence of the breed, with the former only being achievable through *in situ* conservation strategies.

Acknowledgments

The authors wish to thank UE 012 AGRIGENRES 870/2004 (EURECA) and the Collaboration Agreement (CC09-009) between INIA and FEAGAS which is supported with funds from the Spanish Ministry of Agriculture Food and Environment. We also are very thankful to the the Alistana-Sanabresa Breeders Association for the collaboration and fieldwork assistance provided.

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Supplementary material S1 *Questionnaire on Total Economic value of Alistana-Sanabresa breed*

Questionnaire n. .... Date ....

Done by: ....

City of interview................................

Place of interview .... (station, supermarket, public garden, street, etc)

Introduction

I am carrying out, on behalf of the National Institute of Agriculture Research (INIA), a Europe-wide research survey related to the loss of an increasing number of local cattle breeds. The survey is only for adult residents of this town/village (Q1. Are you an adult resident of the area? If yes, continue). The questionnaire takes approximately 15 minutes.

Like dogs or cats, there are many different types of cattle breeds (*interviewer to show a picture with different cattle breeds on it*) and different breeds have different uses. Local cattle breeds are not only associated with meat and milk production but also with the maintenance of traditional landscapes (such as through grazing riverside areas or mountain pastures), cultural events and special breed-related food products. They also may be useful in helping to adapt animal food production to changing conditions in the future. However, despite the importance of such values, many of these breeds are facing increasing degrees of endangerment as agriculture becomes increasing industrialized and a relatively small number of standardized cattle breeds are being used.

In Spain 29 out of 36 local cattle breeds are threatened. Such is the case of the Alistana-Sanabresa breed, which is found mainly in Zamora Province and is particularly known for its singular meat and its ability to graze in the harsh Aliste and Sanabria regions.

We are interested in determining the public’s interest in recognizing the role of local breeds and supporting conservation programmes that will help ensure the continued existence of the breed and its associated services. Your answers will help to design and implement an appropriate conservation programme.

A. General questions

A1. Have you ever heard of the Alitana-Sanabresa breed? YES / NO

A2. Have you ever seen a live animal of the Alistana-Sanabresa breed? *(Interviewer to show pictures of Alistana-Sanabresa breed*) YES / NO

We will now provide you with some background information regarding the Alistana-Sanabresa breed:

Before the industrialization of agriculture,in the 1950's, there were many breeds in Spain, each suited to producing under different agricultural and environmental conditions. Today most of these breeds, 29 out of 36, are endangered.

The Alistana-Sanabresa breed is one of these. In 1950's it is calculated that there was 37.000 animals of the breed that were reduced to 10.000 in 198. Nowadays there is around 3000 breeding cows of the breed. If no action is taken and this trend continues, the Alistana-Sanabresa breed may become extinct.

Alistana-Sanabresa breed is still reared under semi-stabled traditional farming systems (animals freely graze in summer and are stabled during winter nights) in its origin regions of Aliste and Sanabria. The breed is also reared since the 1990's in other Zamora Province regions under extensive system.

A3. Have you ever eaten any food products directly associated with the Alistana-Sanabresa breed? Such food products include a distinct tasting meat that is used in a variety of local dishes. YES / NO

A4. (*For non-local area interviews only*). Have you ever been to the areas where the Alistana-Sanabresa breed is found? YES / NO

C. Follow-up questions

C1. Please rank the attributes in order of the importance in making your choices (with 1 being most important, don't rank those that were not important to you).

- Maintenance of the breed-related special food products

- ☐ Maintenance of local culture and traditions
- ☐ Maintenance of rural landscapes and environmental services
- ☐ Possibility to re-establish the breed for future use if it becomes extinct
- ☐ Certainty of the breed existing in 50 years
- ☐ How much I would pay

C2. Thinking about the information presented earlier about the breed, please indicate your response to the following statements:

C2.1. I understood the information in the questionnaire.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

C2.2. I needed more information than was provided.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

C 2.3. I found the choice questions difficult.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

D. Socio-economic questions

In this final section we would like to ask a few questions about yourself, to make sure the people we are surveying come from a range of backgrounds

D1. Where do you live?

- Town/City ………………….(specify)
- Village………………………(specify)
- Countryside ....(specify)

D2. How long have you been living here? Years = ……………………………

D3. In which age category are you?

i. 18-30
ii. 31-45
iii. 46-60
iv. 61-75
v. 75+

D4. Gender (*by observation*)

- Male
- Female

D5. How many people live in your household?

- Number of Adults
- Number of children (<18)

D6. Are you, or a member of your close family, associated with the farming sector (livestock or crop farming)?

- Yes
- No

D7. Into which professional category do you fall?

- Employed. Please specify type of job……………………….

- Unemployed
- Student

D8. How would you rate your knowledge of the issues addressed in this survey on a scale of 1 to 10 (1 having no previous knowledge and 10 having extensive knowledge)?

D9. Do you participate in outdoor activities in the countryside (e.g. walking, hiking, cycling, birding, camping, etc.) in the last 2 years? YES / NO

D10. Does the existence of traditional agricultural landscapes and activities enhance your enjoyment of the country-side? YES / NO

D11. When there has been a conflict between economic development and the environment in your region, have you tended to:

- Favour preservation of the environment more frequently?
- Favour economic development more frequently?
- Favour economic development and environmental preservation equally?
- Don't know

D12. What is the highest level of education you have obtained or are obtaining?

- Primary school
- Secondary school
- High school
- Diploma or trade certificate
- University
- Other (please specify)

D11. To the best of your knowledge, please indicate the total annual income, after taxes, that your household earned last year:

- Under Euro 6,000
- Euro 6,000 – 14,999
- Euro 15,000 – 24,999

- Euro 25,000 – 49,999
- Euro 50,000 – 69,999
- Euro 70,000 – 99,999
- More than €100,000
- Don’t know

CHAPTER 2

This chapter entirely reproduces the following paper published in the Journal of Animal Breeding and Genetics (2012), 129, 427-435.

Farmer's views and values to focus on cattle conservation policies: the case of eight European countries

G. Gandini[1], D. Martín-Collado[2,] , F. Colinet[3], D. Duclos[4], S.J. Hiemstra[5], K. Soini[6], EURECA consortium[7] and C. Díaz[2]

[1]*Department VSA, Faculty of Veterinary Medicine, University of Milan, Milan, Italy*

[2]*Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria (INIA), Madrid, Spain*

[3]*Animal Science Unit, Gembloux Agro-Bio Tech, University of Liège, Gembloux, Belgium*

[4]*Institut de l'Elevage, Cryobanque Nationale, Paris, France*

[5] *Centre for Genetic Resources, the Netherlands (CGN), Wageningen University and Research Centre, Lelystad, The Netherlands*

[6] *Economic Research, MTT Agrifood Research Finland, Jokioinen, Finland*

[7] *Hyperlink, http:// www.regionalcattlebreeds.eu*

Farmer’s views and values to focus on cattle conservation policies: the case of eight European countries

Summary

Our aim was to identify elements useful in designing policies and programmes for conservation of farm animal genetic resources, taking as case study a group of European local cattle breeds. We first investigated the implications of differences among countries in the policies and programmes to be developed. Secondly, we analysed key elements common to countries, which may affect local breed viability. We used the herd size trend expected by the farmer in the near future as an indicator of breed viability. Fifteen breeds, for a total of 355 farms, were surveyed. To take into account the multiple factors influencing breeds’ demographic trends, the questionnaire included economical, technical and social aspects. Among the major differences across countries was the perception of the farmer on the value attributed to the local breed by society. Concerning the elements common to countries and their association to breed viability, the greater the collaboration among farmers and the stakeholders’ appreciation as perceived by the farmer, the greater the viability of the farm. An opposite trend was observed for the age of the farmer. Older farmers generally planned to soon cease farming or decrease herd size, whereas young farmers planned to increase the size of their herds. Implications of including these elements in conservation polices are discussed.

Introduction

In 1992, FAO launched a global program for the management of farm animal genetic resources (AnGR) (Food and Agriculture Organization of the United Nations -FAO-, 1998). In the same year, the European Union started a policy of economic support to farmers keeping endangered local breeds. Today, the European Union (Regulation EC 1698/2005) provides incentive payments to compensate farmers for the lower output of local endangered breeds relative to mainstream breeds. However, the gap in profitability with mainstream breeds varies substantially among local breeds; incentive payments are not breed specific and therefore rearing local breeds remains unprofitable for many farmers (Signorello and Pappalardo, 2003). Furthermore, incentives are subject to political decisions and are therefore unlikely to be sustainable in the long term (FAO, 1998). For these reasons, there exists a pressing need to study the characteristics of successful conservation policies, on both regional and national levels, to identify key factors for effective promotion and development of local breeds, and approaches capable of accelerating the process toward self-sustainability. Such approaches are likely to be more sustainable than providing general economic support (e.g. Gandini and Oldenbroek, 2007).

In designing conservation policies for a large region, such as Europe, differences across the production systems of local breeds may require policies and strategies adapted to their characteristics. However, there are also similarities across countries and farming systems that may justify common conservation policies. The key point is then to identify factors that might be taken into account when developing common policies to booster viable local breeds.

Conservation of local breeds is a complex issue influenced by factors from multiple grounds. It is also characterized by the presence of many different stakeholders (Martín-Collado *et al*., 2010), among which farmers play a major role for local breed development and conservation. However, to what extent farmer's values and motives are considered in the process of developing policies is not clear.

The general aim of this work was to identify elements that might be useful in designing common policies and programmes for conservation and development of AnGR, using as a case study a group of European local cattle breeds. We first investigated the aspects that differ among countries and the implications of this heterogeneity in the policies and programs to be developed. Secondly, we aimed to detect key elements common to countries that may affect viability of local breeds. To a large extent the focus was placed on farmers and their views and values, considering that they are the key stakeholders in the conservation and development of local breeds.

Materials and Methods

The farmer survey

A total of 371 farms, in eight European countries, across fifteen local cattle breeds, were surveyed. Interviews for farmers were mostly conducted face-to-face during a farm visit, or alternatively on the telephone or by email. Additional information on survey and questionnaire methodology can be found elsewhere (Gandini *et al.*, 2010a). The set of the fifteen breeds surveyed across the eight countries was selected among local cattle including breeds that were declining (27%), stable (33%) or increasing (40%) in population size. All but two breeds were classified as endangered according to EU criteria (<7,500 cows; EC

Regulations 1257/99 and 445/02). These two had population sizes above the EU endangerment threshold but had experienced severe declines in recent decades. Table 1 reports, by country, the names of the fifteen breeds surveyed, number of herds analysed per breed, breed populations sizes and trends. Farms with mixed herds with less than 5% of cows belonging to the corresponding local breed were excluded from the analysis. In total, 355 farms were used in the study.

Breed viability is taken in our investigation as the objective of conservation and development policies. We define breed viability as the capacity of the breed to persist and evolve without significant external supports. We used the expected herd-size trend in the near future as indicator of breed viability. Thus, farmers were asked how they were planning to changes the size of their herds in the next five years, according to the following categories: increase, no-change, decrease/stop farming. Frequencies, after data editing, were: increase (134), no-change (145), and decrease/stop (41). The relatively short period of five years (approximately one generation interval) was used because a preliminary investigation showed that farmers have difficulties to predict herd-size changes over longer periods. Nevertheless, thirty-five farmers (10%) were not able to forecast changes in herd size.

Table 1 *Breeds surveyed by country, their population size and trend, and number of herds analysed*

			Breed population	
Country	Breed name	No. herds	Nº of cows	+Trend
Belgium	Dual Purpose Belgian Blue	23	4,400	s
	Dual Purpose Red and White	18	3,000	d
Estonia	Estonian Native	26	1,500	d
Finland	Eastern Finn Cattle	30	790	i
	Western Finn Cattle	31	2,950	d
France	Ferrandaise	19	730	i
	Villard de Lans	14	340	s
Ireland	Kerry	20	1,200	i
Italy	Modenese	18	650	s
	Reggiana	29	1,500	i
The Netherlands	Deep Red	21	454	i
	Groningen White Headed	22	1,500	s
	Meuse-Rhine-Yssel	22	14,400	d
Spain	Avileña-Negra Ibérica	31	100,000	s
	Alistana-Sanabresa	31	2,000	i

+Breed population trend: i =increasing; s = stable; d = decreasing.

Local breed viability is a component of sustainable agriculture, and since the 1992 Rio Earth Summit, a wide body of literature on indicators for sustainable agriculture practices has become available (e.g. Rigby *et al.*, 2001; Nahed-Toral *et al*., 2008). However, no reports are available in the literature on factors affecting local cattle breed viability. We identified a total of fifteen variables with a potential influence on herd-size, according to experts and direct or indirect indications from the literature. Nine variables originated directly from the questionnaire, six (indexes) were built on farmers answers. To take into account the multiple grounds influencing local breeds, the questionnaire included economic, technical, and social aspects:

1. Farm area: size of the farm (hectares);
2. Herd size: number of cows, considering all cows of the herd, independently of their breed;
3. Herd size deviation: deviation of herd size from average breed herd size ((herd size - mean herd size)/mean herd size);
4. Local cows: % of local cows in the herd;
5. Income cattle: % of the total family income covered by cattle farming activities;
6. Income local: % of the local cattle share of the total farm income;
7. Owned area: % of the farm area owned by the farmer;
8. Market local: % of the total cattle production sold on farm and/or on the local market;
9. Farmer age: age of the farmer (years);
10. Breed comparison index: farmers compared their local breed to a well-known mainstream breed they knew better for productivity and for five functional traits (fertility, longevity, demanding, robustness and docility). They evaluated each of the six characteristics as poor (value: -1), same (value: 0) and good (value: +1). The index was built by summing the values over the six comparisons;
11. Collaboration index: farmers were asked how much they collaborate with other farmers (values: 0, +3), in terms of exchange of animals, marketing of products and services, and

any other form of collaboration. The index was built by summing the results over the three collaboration options;

12. Entrepreneurship index: farmers were asked about the entrepreneurship activities in relation to their breed in the past and planned for the future. The index was built as: 0 = no activities in the past and in the future; 1 = activities done in the past or planned for the future; 2 = activities in the past and future;

13. Stakeholder appreciation index: farmer's perception of the opinion of stakeholders about their local breed and its products. Five stakeholders were considered: agricultural authorities, research institutes, farmers of mainstream breeds, consumers and media. Farmers were asked to give a value to how they felt their local breed was valued by the stakeholders: positive (value: +1), neutral (value: 0), negative (value: -1). The index was built by summing the results over the five stakeholders;

14. Tradition index: farmers were asked to quantify (values: 0-3) the importance of tradition as reason to keep their local breed;

15. Society value index: farmers were asked to give their opinion on how (positive (value: +1), neutral (value: 0), negative (value: -1)) important they thought the following five breed attributes are for society in general: quality of products, specific traits, cultural heritage, landscape conservation, source of genetic variation. The index was built by summing the results over the five attributes.

In Europe, changes in number of cattle farms from 2005 to 2007 (EUROSTAT, 2011) were correlated with their size (variables 1-4), with smaller holdings showing larger decreases. Lower profitability (variables 5-6) compared to mainstream breeds has been often advocated as major cause of breed decline (Tisdell, 2003; Oldenbroek, 2007). Ownership of the farm (variable 7) was included for its possible relation to attitude regarding investment. Development of niche and local markets (variable 8) has been often suggested to increase local breed profitability (e.g. FAO, 2010; Lauvie *et al.*, 2011). Farmer age (variable 9) has been reported to be associated to farm management strategies (e.g. Burton, 2006) including size of farming operation. The six indexes (variables 10-15) were built in order to include in the analysis the variation of values and attitudes among farmers observed in a previous analysis (Gandini *et al*., 2010a).

Table 2 reports some basic statistics for the fifteen independent variables analysed across the 355 farmers. All variables, except farmer age, were not normally distributed; therefore, a non-parametric approach was used.

Table 2 *Statistics of the fifteen variables analysed in the fifteen local cattle breed*

	Farmer age (years)	Farm area (ha.)	Owned area (%)	Herd size (n cows)	Herd size deviation	Local cows (%)	Income cattle (%)	Income local (%)	Market local (%)
n	355	355	355	355	355	355	355	355	355
Range	25-83	1.3-2740	0-100	1-500	-1-4.9	6-100	0-100	0-100	0-100
Mean	48.84	145.09	47.70	56.90	-0.07	68.97	80.79	59.32	42.67
sd	11.11	290.05	34.90	66.52	0.74	33.75	29.08	37.21	46.04
Median	48.00	59.00	47.25	39.00	-0.21	85.0	95.00	60.00	10.00
Mode	47.00	80.00	100.00	40.00	-0.66	100.00	100.00	100.00	0.00
Skewness	0.11	5.04	0.10	3.14	1.96	-0.51	-1.53	-0.20	0.31
Kurtosis	-0.37	32.39	-1.36	13.76	7.19	-1.36	1.03	-1.57	-1.79

	Breed comparison index	Stakeholder appreciation index	Society value index	Collaboration index	Tradition index	Entrepreneurship index
n	355	355	355	355	294	355
Range	-2-5	-3-5	0-5	0-3	0-3	0-3
Mean	2.38	1.48	3.28	0.52	1.90	0.20
sd	1.33	1.79	1.75	0.52	10.11	0.42
Median	3.00	2.00	4.00	1.00	1.00	0.00
Mode	3.00	2.00	5.00	1.00	0.00	0.00
Skewness	-0.77	0.00	-0.7	0.21	16.68	2.04
Kurtosis	0.96	-0.54	-0.87	-0.61	283.22	5.00

Statistical analysis

Presence of differences among countries and breeds was our initial assumption. Therefore, we aimed to separate the fifteen variables investigated into two groups; variables that explained differences among countries, and those that did not. The first group of variables would include aspects to be considered in developing regional policies. The second group should be considered in setting common policies.

Differences among countries

We used non-parametric discriminant analysis (DA) (e.g. Dillon and Goldstein, 1984; Johnson and Wichern, 1998) setting the country as classification variable and the fifteen variables as explanatory ones. We first used a stepwise selection procedure to identify the set of variables that best distinguish among countries. Then, the ability of the set of selected variables to discriminate among countries was evaluated using the k-nearest neighbourhood method (k=5). Mahalanobis distances where used to avoid problems derived from the different scales. The performance of the discriminant criteria was evaluated by cross-validation, by estimating probabilities of misclassification of farms among countries. Misclassification rates were also estimated in order to explore the behaviour of each variable; several discriminating models were run, beginning with a simple model with only the first selected variable in the stepwise DA and adding one by one the eleven variables in the order they were selected in the stepwise procedure. To treat missing values, three scenarios were studied. Missing values were substituted with the breed mean (for continuous variables) and with the breed mode (for categorical variables). Alternatively, continuous variables were replaced by median values. In addition, farms with missing values were removed from the analysis.

Breed viability across countries

We used logistic regression (LR) (e.g. Hosmer and Lemeshow, 2000) to study how variables that did not respond to differences among countries may be related to breed viability. We first identified the variables to include in the LR model by a stepwise selection procedure. Then, the relationship between variables and herd-size trend categories was analysed building a LR model. We used the logit function as linking function. Logit coefficients were estimated by maximum likelihood via the Fisher-scoring algorithm. We tested the consistency of the results using alternatively the probit function as linking function. A total of 35 missing observations (i.e. farmers who did not forecast herd size changes in the next five years), which were rather homogenously distributed among countries, were removed from the data set. Therefore 320 farms were included in this analysis. Statistical analyses were implemented by using SAS 9.0 (SAS Institute, 2004).

Results and Discussion

Differences among countries

Table 3 reports a summary of the results of the stepwise selection procedure for the DA. Variables shown are those that have some discriminatory power among countries. The table shows the entry order in the discriminant function from the most to the least significant variable, the F-value, and its significance, associated to the entry of each variable, the Wilks’ λ statistics and the associated significance that measures the discriminatory power of the variables in each step. Twelve out of the fifteen variables studied were identified. Three variables, *Farmer-age*, *Tradition index* and *Entrepreneurship index* were not selected by the stepwise procedure and therefore are not included in Table 3. The variables with the greatest discriminatory power were *Society value index*, *Market*-l*ocal* and *Owned-area*. As previously mentioned, *Society value index* evaluates how relevant is the local breed for the society from the farmers' point of view. This variable was analysed on the assumption that the feeling of playing a relevant role for the society could raise farmers´ motivation to drive their activities towards the conservation of the local breed. The second and the third variables reveal differences among countries on some technical aspects of farming: distribution channels of products and land ownership.

The three least discriminating variables refer to how famers value their local cattle compared to mainstream breeds (*Breed comparison index*), to the percentage of cows of the local breed in the surveyed herds (*Local cows*), and to the local cattle share of the total farm income (*Income local).*

Table 3 [+]*Summary of results of discriminant analysis stepwise selection for countries of the fifteen variables surveyed*

Step	Variables	F-value	p > F	Wilk's λ	Pr < λ
1	Society value index.	54.08	<0.0001	0.46479	<0.0001
2	Market-local (%)	42.67	<0.0001	0.24524	<0.0001
3	Owned-area (%)	19.16	<0.0001	0.17476	<0.0001
4	Stakeholder Appreciation index	18.94	<0.0001	0.12481	<0.0001
5	Farm-area	18.76	<0.0001	0.08930	<0.0001
6	Collaboration index	14.65	<0.0001	0.06808	<0.0001
7	Income-cattle (%)	9.52	<0.0001	0.05658	<0.0001
8	Herd-size	7.31	<0.0001	0.04892	<0.0001
9	Herd-size-deviation	11.32	<0.0001	0.03934	<0.0001
10	Income-local (%)	6.29	<0.0001	0.03464	<0.0001
11	Local cows (%)	5.13	<0.0001	0.03118	<0.0001
12	Breed comparison index	3.77	0.0013	0.02882	<0.0001

[+]Three variables not selected by the procedure are not included in the Table.

Results were similar regardless how missing values were treated. We report here those obtained following the first scenario. The discrimination power of each of twelve discriminating models analysed is given in Figure 1 that illustrates the error rate of classification of observations in their respective countries by using the twelve models. The first model, including only the variable *Society value index* has an error rate of 69.9%. By including the second -*Market-local* - and the third variable - *Owned-area*- error rate decreases to 50.4 and 39.7% respectively, and finally, it drops to 23.7% when all twelve discriminating variables are included in the model. In Figure 1, an inflection point is observed between the third and the fourth models, from where the impact of introducing new variables becomes small as compared to the first three. By adding the last five variables, error reduction is negligible. A model including the last nine variables (non-reported in Figure 1) holds a misclassification rate of 73.9%, almost twice than the model including the first three variables (39.7%).

Examining in more detail the differences among countries for the three most discriminative variables, we observed that *Owned-area*, ranges from 1.5% ± 1.2 in Ireland to 76.0% ± 25.1 in Finland, with five countries above 40%. *Market-local* shows lower variation across countries and ranges from 53.6 ± 34.3 in Finland to 83.8 ± 28.8 in Ireland. We observe a large variation also in the way the social value of keeping local cattle is perceived by farmers (*Social value index*). While French and Belgian farmers do not give high social value to their activity (1 and 1.3 respectively, in a 0-5 scale), Estonians think their activity has high social importance (4.9). Ireland and Spain have also rather high values, above 4. These differences reflect the variation of breeding systems present in Europe; however, it must be also underlined that variability can be rather high within countries (Gandini *et al*., 2010a).

What inferences can be drawn from DA in terms of constructing conservation and development policies? The high heterogeneity observed in Europe should be attentively taken into account. Whenever the three most discriminating variables among countries will be somehow included in regional policies, caution should be taken in order to adjust common policies to countries situations, both avoiding negative effects on some countries and creating conditions for widening positive effects to a larger set of countries. Both FAO and European Union recognise there are important functions in local cattle farming, beside meat and milk production (e.g. FAO, 2007). We observed that in some countries, farmers do not recognise high social value to their local cattle farming activities. These findings would suggest to develop communication programmes across EU countries on the diversity and importance of values associated to farming local breeds, from landscape and heritage conservation, to quality of products and traits, to reservoir of genetic variation for future use. In addition, the high variability observed within country (Gandini et al., 2010a) suggests that national policies should be capable to adapt to the heterogeneity of farms and of farmers views and attitudes within breed and country.

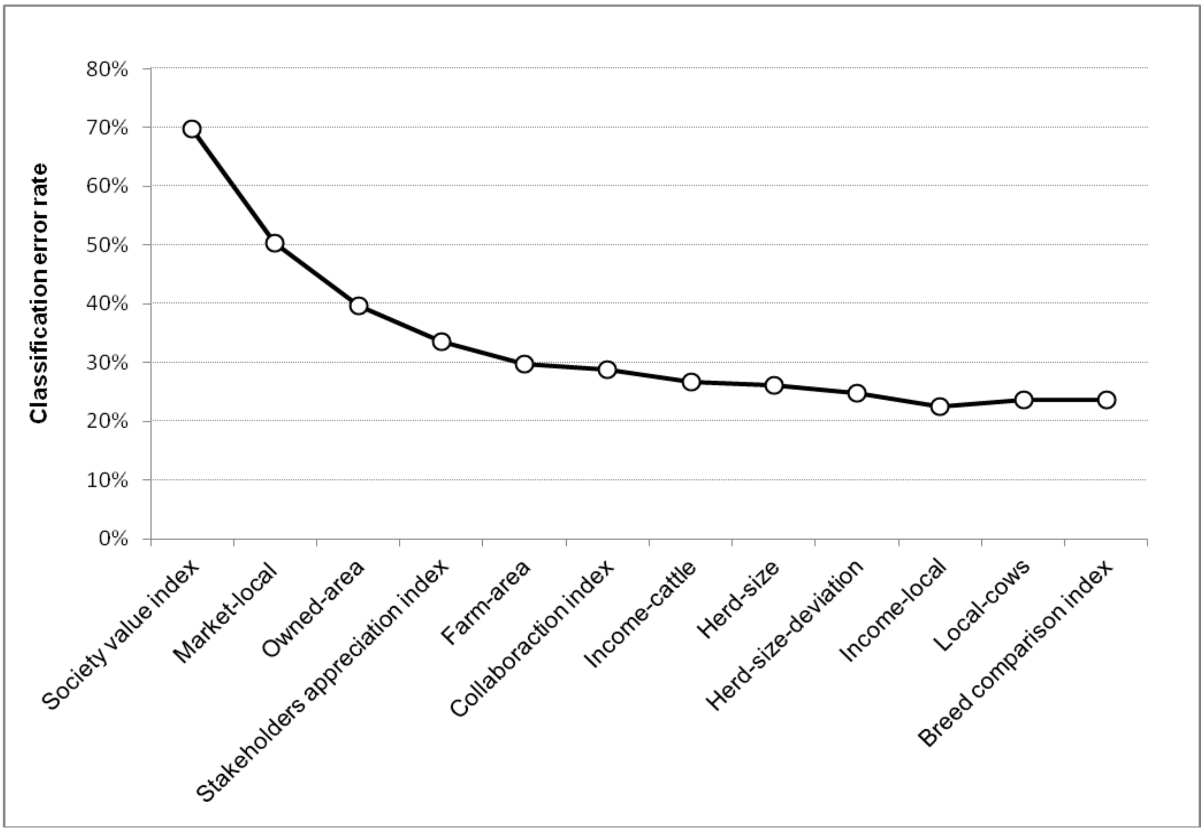

Figure 1 *Classification error rate of herds to countries with twelve discrimination models. Starting from the left, the first model includes the variable "Society value index" only. The second model (Market-local) includes the first and the second variable (Market-local) ,the last model (Breed comparison index) includes all 12 variables*

Breed viability across countries

A major aim of this investigation was to study how breed viability could be predicted across countries, and how conservation common policies could be oriented to influence this parameter. As above mentioned, herd size trend expected by the farmer in the near future was taken as indicator of breed viability. This parameter reflects the attitude of the farmer to invest in local cattle farming and his interest to keep his breed, thus providing a proper measure of breed viability.

The set of twelve variables analysed by LR for their relation with herd size trend included the three variables with no discriminatory effect for countries and the nine variables with the least discriminatory power among countries, that is the variables of Table 1 with the exclusion of the following three: *Social value index*, *Market local,* and *Owned area*.

Results of the LR were similar regardless of the link function used. This result is consistent with Gill (2001) who suggested that different linking functions generally provide identical conclusions. Table 4 reports the results of a logistic regression model using the logit function as the linking function.

Among the twelve variables, the stepwise procedure for building the logistic regression model selected the following three, in the order: *Collaboration index*, *Farmer age*, and *Stakeholder appreciation index*. The association of the three variables with the dependent variable showed consistent trends. In general, the greater the level of collaboration among farmers and the appreciation of the stakeholders, the higher the viability of the farm. An opposite trend was observed for the age of the farmer. Older farmers tend to stop or decrease herd size while young farmers tend to increase (Table 4). By increasing farmer age by one year, the odds ratio (OR) of planning to increase herd size, with respect of keeping it as it is now, decreases by 0.97, while the OR of planning to decrease herd size, always with respect to no changes, increases by 1.03. High farmer age has been suggested as a possible factor of breed endangerment, being an indication of poor generation transfer and risk of abandoning farming activities. Our results suggest that high farmer's age is not only a problem of poor generation transfer but it is also a problem of a lower investment attitude in farming activities and lower ability to adapt to environment (e.g. market, society, technology) changes. The livestock sector is in a transitional period (Delgado *et al.*, 1999) trying to adapt to the consistent social and market changes occurring worldwide; therefore, farmers' capability of adaptation might be a key point in local breeds viability.

Data show a positive trend between collaboration among farmers and breed viability. Farmers with better attitude and experiences to collaborate with other farmers have a tendency to increase herd size, with respect to no change (OR = 1.6). Collaboration among farmers includes exchange of animals, common marketing of products, participation in breeders associations and others.

Farmers who feel that their local cattle are appreciated by stakeholders are more prone to increase herd size versus no change (OR = 1.2). Conversely, farmers who feel that their local cattle have not a relevant value for stakeholders have tendency to decrease or stop farming compare to no change.

Table 4 *Parameter estimates for the three effects in the logistic model (above) and (below) estimated odds ratios (OR) and their confidence intervals (CI). Results are given in relation to the intermediate class "no change"*

Variable	Class	Estimate ± SE	p-value
Farmer age (unit=1 year)	Increase	-0.035 ± 0.012	0.003
	Decrease/stop	0.025 ± 0.017	0.134
Collaboration index (1 versus 0)	Increase	0.237 ± 0.125	0.058
	Decrease/stop	-0.317 ± 0.119	0.087
Stakeholder appreciation index (unit=1)	Increase	0.191 ± 0.070	0.006
	Decrease/stop	-0.168 ± 0.107	0.117
Variable	**Class**	**OR**	**95% Wald CI**
Farmer age (unit=1 year)	Increase	0.966	0.944-0.988
	Decrease/stop	1.026	0.922-1.060
Collaboration index (1 versus. 0)	Increase	1.606	0.984-2.619
	Decrease/stop	0.503	0.256-1.096
Stakeholder appreciation index (unit=1)	Increase	1.210	1.055-1.388
	Decrease/stop	0.845	0.685-1.043

The observed association between breed viability and collaboration among farmers can be interpreted in different ways. Collaboration leads to conditions facilitating the increase of herd size. Alternatively, intention to increase herd size leads to collaboration activities. In both cases, it seems reasonable to have EU policies favouring collaboration among farmers. Collaboration also leads to more efficient use of the limited resources. The Avileña-Negra Ibérica cattle is a successful case where farmers collaborate in fattening and marketing the products in order to have a better control of market prices and to minimise costs of production. This is considered by breed experts as a major reason for its demographic stability (Table 1). Collaboration among farmers is also needed in activities addressed to add value to local breeds, including the development of local products and identification and promotion of environmental and cultural services.

The fact that the famers who perceive in a variety of stakeholders a positive attitude toward their breeds are those planning to maintain and increase their herds suggest to increase in

Europe a social awareness on the values associated to local breeds conservation. The idea is similar to what occurs for conservation of natural habitats and wild species. Importance of local breed conservation includes (Gandini and Oldenbroek, 2007), among others, insurance against changes in market or environmental conditions, opportunities for development of rural communities, opportunities for maintenance of agro-ecosystems and rural cultural diversity. These values are well known among experts and should be shared with a larger audience of the society.

Conclusions

Within a region as large as Europe, hosting a high diversity of historical and cultural experiences, of economic development and agro-ecosystems, we expected a certain diversity in local breed farming systems created through centuries. Moreover, both the processes of erosion of local breeds observed during the last decades and the more recent conservation activities have most probably increased the original diversity of attitudes and values of farmers concerned with local cattle breeding, from operations oriented to general production, to niche products, to those more hobby oriented (Gandini *et al*., 2010b). This diversity was analysed in this study because it might pose problems in developing common conservation policies, but also because it might offer at the national level new opportunities in local cattle farming development.

We analysed a number of factors that were relatively easy to collect in a field survey, and we make no claim that a definitive analysis is provided. However, we think that this work offers a first understanding of the complex dynamics of local cattle farming in Europe, and it can promote the search for conservation policies taking into account farmers' motives and values. Further research should be addressed to understand the sources of the differences and similarities observed across countries, and to explore how they might impact viability of local cattle breeds.

Conservation of local cattle farming is a multi-dimension problem. This study used a total of fifteen variables related to technical, economic and social factors expected to affect breed future herd-size trends. In some cases, it was not possible to detect significant associations between the fifteen variables and herd-size dynamics, but the observed trends provides indications that variables affecting breed viability are from different grounds, from social, such as the age of the farmer and the social appreciation of their work, to technical-organizational, such as the attitude of farmers to collaborate among each other. Future studies on larger numbers of breeds might be able to confirm factors affecting breed viability, but costs associated to data collection might increase substantially.

The three variables significantly associated to breed viability could be positively affected by conservation strategies, and should therefore be taken into consideration in developing common and/or national policies going beyond the provision of a general economic support to compensate farmers for the lower profitability of local breeds. Of particular interest, the fact that opportunity of collaboration among farmers and the appreciation of the society for the cultural, environmental and social roles of local cattle farming are positively associated to breed survival.

The absence of economic factors among those affecting breed viability could be related to the high variability of the economic variables investigated, but it requires additional surveys to be understood. For example, Norton *et al.* (1994) have shown that farmers might not exclusively base their choices on profit-maximizing motives. They observed that if farmers value positively conservation activities, then compensatory payments can be lower than the income loss incurred from contributing to conservation.

Finally, the analysis revealed the presence of a diversity of attitude and values among farmers. The farmer approach has been rarely used in conservation studies, although it is used in economic studies (e.g. Scarpa *et al.*, 2003). This investigation suggests that farmers can provide elements to be taken into account in designing both common and local conservation policies and strategies.

Acknowledgements

This work was carried out within Action EURECA 012 AGRI GEN RES 870⁄2004. We are grateful to the European Commission, Directorate-General for Agriculture and Rural Development, for the financial support under Council Regulation (EC) No 870⁄2004.

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CHAPTER 3

This chapter entirely reproduced the following paper published in Animal (2012), doi:10-1017/S175173111200242X.

The use of SWOT analysis to explore and prioritize conservation and development strategies for local cattle breeds

D. Martín-Collado[1], C. Díaz[1], A. Mäki-Tanila[2], F. Colinet[3], D. Duclos[4], S. J. Hiemstra[5], EURECA consortium[6] and G. Gandini[7]

[1]*Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria (INIA), Madrid, Spain*

[2]*MTT Agrifood Research Finland, Jokioinen, Finland*

[3]*Animal Science Unit, Gembloux Agro-Bio Tech, University of Liège, Glembloux, Belgium.*

[4]*Institut de l'Elevage, Cryobanque Nationale, Paris, France.*

[5]*Centre for Genetic Resources, Wageningen University and Research Centre, Lelystad, The Netherlands*

[6]*Hyperlink, http:// www.regionalcattlebreeds.eu*

[7]*Department VSA, Faculty of Veterinary, University of Milan, Milan, Italy*

The use of SWOT analysis to explore and prioritize conservation and development strategies for local cattle breeds

Abstract

SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis is a tool widely used to help in decision making in complex systems. It suits to exploring the issues and measures related to the conservation and development of local breeds, as it allows the integration of many driving factors influencing a breed dynamics. We developed a quantified SWOT method as a decision-making tool for identification and ranking of conservation and development strategies of local breeds and applied it to a set of thirteen cattle breeds of six European countries. The method has four steps: definition of the system, identification and grouping of the driving factors, quantification of the importance of driving factors and identification and prioritization of the strategies. The factors were determined following a multi-stakeholder approach and grouped with a three level structure. Animal genetic resources expert groups ranked the factors and a quantification process was implemented to identify and prioritize strategies. The proposed SWOT methodology allows analyzing the dynamics of local cattle breeds in a structured and systematic way. It is a flexible tool developed to assist different stakeholders in defining the strategies and actions. The quantification process allows the comparison of the driving factors and the prioritization of the strategies for the conservation and development of local cattle breeds. We identified 99 factors across the breeds. Although the situation is very heterogeneous, the future of these breeds may be promising. The most important strengths and weaknesses were related to production systems and farmers. The most important opportunities were found in marketing new products, while the most relevant threats were found in selling the current products. The across breed strategies utility decreased as they gained specificity. Therefore, the strategies at European level should focus on general aspects and be flexible enough to be adapted to the country and breed specificities.

Implications

The proposed SWOT analysis methodology is suitable for exploring the conservation and development of local breeds given the complexity of the system where they exist. It allows analyzing the problem at different levels generating and prioritizing from general strategies to specific actions. Although it can be used to define and evaluate future options for single breeds, its potential is maximized when using it to define the common strategies across breeds based on analyses at the breed level. It enables one to evaluate the applicability of the common strategies to specific breeds and countries.

Introduction

The causes for the erosion of Farm Animal Genetic Resources (FAnGR) are multiple and stem from economic, technical, genetic, cultural and political grounds (Tisdell, 2003; Food and Agriculture Organization of the United Nations, 2007). Farm animal production involves many stakeholders with interrelated and ever changing elements. The investigations on conservation of FAnGR have usually tackled economic (Drucker *et al.*, 2001; Alderson, 2003), technical (FAO, 2010), genetic (Groeneveld *et al*., 2010), social (Tisdell, 2003), cultural (Gandini and Villa, 2003) and political (Fimland and Oldenbroek, 2007) issues separately. The integration of all these approaches is complex because the effect of many of them is difficult to measure and the methods have been developed for specific purposes. The evaluation of the impact of factors on FAnGR in a comprehensive manner may help us in the establishment of sound conservation strategies. In this respect, decision-making tools provide some help since they have been developed to elucidate the process of making choices in complex systems.

One of the most used tools is SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis which is an exercise of adjusting the internal behavior of an organization with its surrounding environment (Kangas *et al*., 2003). It begins by determining the driving factors of the organization and grouping them in internal and external. Internal factors refer to the organization features that can be exploited (Strengths) or have to be minimized (Weaknesses) to improve its functioning. External factors are features of the environment, and therefore cannot be controlled by the organization, whose performance they are fostering (Opportunities) or hampering (Threats) (Karppi *et al.*, 2001).

SWOT analysis is then used in four ways to develop strategies (Weihrich, 1989): using strengths to take advantage of opportunities (SO) or to reduce the likelihood and impact of threats (ST), using the opportunities to overcome weaknesses (WO) and being aware of limitations that emerge from the combination of weaknesses and threats (WT). The strategies are presented in a matrix called TOWS matrix (Weihrich, 1989), which allow one to visualize the interactions between internal and external factors.

SWOT analysis has proven to be a useful tool. Its power arises from the simplicity of its use and from the adaptability to wide range of situations (Impoinvil *et al*., 2007; Vonk *et al*., 2007; Lee *et al*., 2009). This adaptability has led to numerous approaches that depend on the aim of the analysis. Sometimes it has been used as a way of organizing the driving factors without going further in the analysis (Hill and Westbrook, 1997). Others have utilized it to select among pre-defined strategies (Kangas e*t al*., 2003; Lee *et al*., 2009). SWOT analysis has been used to define strategies, sometimes straight from the identified factors without any systematic approach (Vonk *et al*., 2007) and other times from the TOWS matrix (Yüksel and Dagdeviren, 2007). Many of these studies have not quantified the identified strategies and have ended up listing the potential strategies with prioritization left to the choice of the user. In this respect, two major weaknesses of the analysis have been identified; the subjective identification of the driving factors and the measurement of their relative importance (Hill and Westbrook, 1997). The subjective recognition of factors has been overcome by using a wide range of people in the identification process (Impoinvil *et al.*, 2007; Vonk *et al*., 2007). Several studies have developed quantitative SWOT analyses to assess the importance of the driving factors. Various studies have weighted driving factors but without quantifying the resulting strategies (Kurttila *et al.*, 2000; Impoinvil *et al*., 2007) while others have used factor weights in evaluating potential strategies (Yüksel and Dagdeviren, 2007). Regarding the quantification method, some studies have developed techniques based on a cardinal scale. The most popular one, the A'WOT method (Kurttila *et al.,* 2000; Kajanus *et al*., 2004) combines SWOT analysis with Analytical Hierarchical Process (Saaty, 1986). Some others have used an ordinal scale as the base of the weighting of factors arguing that, although the cardinal scale is more accurate, it is difficult to apply when there are many factors to be analyzed and when persons defining priorities are not able or willing to perform pairwise comparisons (Kangas *et al*., 2003; Kajanus *et al.,* 2004).

Regarding the problem of conserving and developing local cattle breeds in Europe, there are common causes and breed and country specificities (Gandini *et al*., 2012, -Chapter 2-). Therefore, the importance of a single driving factor may be different across a set of local breeds or countries. SWOT analysis seems to be a proper tool to tackle the problem. It has mainly been used to evaluate single cases while here there is a need to join the analysis over different situations (breeds) to identify common (across breeds) strategies.

The objectives of the paper are twofold. First, we propose a method to develop a SWOT analysis to identify and compare strategies for the conservation and development of local cattle breeds based on breed-specific analyses. The methodology should be developed to tackle the suboptimal properties of SWOT analysis. Second, we use the methodology to identify and compare potential strategies for a set of thirteen European local cattle breeds.

Material and Methods

Material

We analyzed thirteen breed cases from six countries: two breeds from Belgium (Dual Purpose Belgian Blue and Dual Purpose Red and White), Finland (Eastern and Western Finncattle), France (Ferrandaise and Villard de Lans), Italy (Modenese and Reggiana) and Spain (Avileña-Negra Ibérica and Alistana-Sanabresa) and three breeds from The Netherlands (Deep Red, Groningen White Headed and Meuse-Rhine-Yssel). There was a team of researchers in each country responsible for participating in the different phases of SWOT analysis.

A total of 371 farmers, selected following a stratified sampling according to herd size and geographical location, and 122 stakeholders were interviewed. Strengths, weaknesses, opportunities and threats for the conservation of the local breeds were surveyed by open-ended questions. The number of farmers interviewed ranged from 15 in Villard de Lans breed to 31 in both Spanish breeds and in Western Finncattle. The stakeholders were determined by the expert team for each country. The stakeholders covered agricultural and environmental authorities, research institutes, universities, state farms, trade and distribution companies, rural development agencies, slaughter houses and dairy cooperatives, artificial insemination centers and breeders' associations. The number of stakeholders interviewed ranged from 61 in Finland to 7 in France (Supplementary Table S1).

Methods

SWOT analysis contained the following steps. First, we set the scope of the analysis. Secondly, we determined the driving factors for the conservation and development of the breeds. Then, the influence of these factors was evaluated and quantified for each breed. Finally, potential common strategies for the conservation and development of the breeds were identified and compared. Based on these steps we divided the SWOT analysis into four phases: definition of the system, identification and grouping of the driving factors, quantification of the importance of the driving factors and identification and prioritization of the strategies.

Phase 1. Definition of the system.

First the system under study and the boundaries of the analysis were determined. The definition of the system depends on the aim of the analysis. We aimed to analyze the European Local Cattle Breeds' Farming System (ELCFS) to identify conservation and development strategies.

ELCFS involves many stakeholders (Fimland and Oldenbroek, 2007). The definition of the boundaries between internal and external factors depends on the stakeholder who is implementing the strategies derived from the analysis. This study is part of the EU funded EURECA project where a previous study (Gandini *et al*., 2012, -Chapter 2-) underlined the central role of farmers in the breed development process. Consequently, it was decided to implement the analysis from the farmer's perspective. The expert teams defined the scope and boundaries between the internal and external driving factors.

Phase 2. Identification and grouping of the driving factors.

The driving factors of the ELCFS were identified following a multi-stakeholder approach. The chosen stakeholders were asked through questionnaires to identify strengths, weaknesses, opportunities and threats for the conservation and development of each breed.

In our case, given the complexity of ELCFS, several driving factors of different type were expected to be identified. On the other hand, when making decisions the number of factors considered has to be small enough to be manageable (Saaty, 2008). To tackle this dichotomy, the driving factors were grouped according to their nature in order to keep all the identified factors in the analysis while simplifying the approach to the problem. The teams of experts discussed the grouping of factors. Internal factors (strengths and weaknesses) for a breed were categorized into six groups: "Animal", "Breed", "Products", "Farmers", "Marketing system" and "Production system". The "Animal" group referred to the production and functional features of the animals. The "Breed" group factors were related to the population features such as size and structure of the population. The "Products" group included factors regarding characteristics of the breed products. The "Farmers" group referred to such features as age but also to their involvement in organizations and collaboration. The “Production system” was related to technical, cultural and environmental characteristics and the “Marketing system” group gathered the factors related to the marketing of breed products controlled by farmers.

External factors (opportunities and threats) were divided into four groups: “Market of current products”, “Market of new products and functions”, “Other production systems” and “Stakeholders”. The “Market of current products” included aspects related to the demand of breed products and market competition. The “Market of new products and functions” referred to the demand of functions such as landscape management or touristic activities. The “Other production system” group was related to the competition with mainstream production system. Finally, the “Stakeholders” group referred to the activities of stakeholders.

As a result of this grouping, the driving factors were considered in a three level structure (Figure 1). The bottom level contained the driving factors themselves. They were divided at the intermediate level into factor groups according to a common attribute. At the top level, the factor groups were located under the categories Strengths, Weaknesses, Opportunities or Threats.

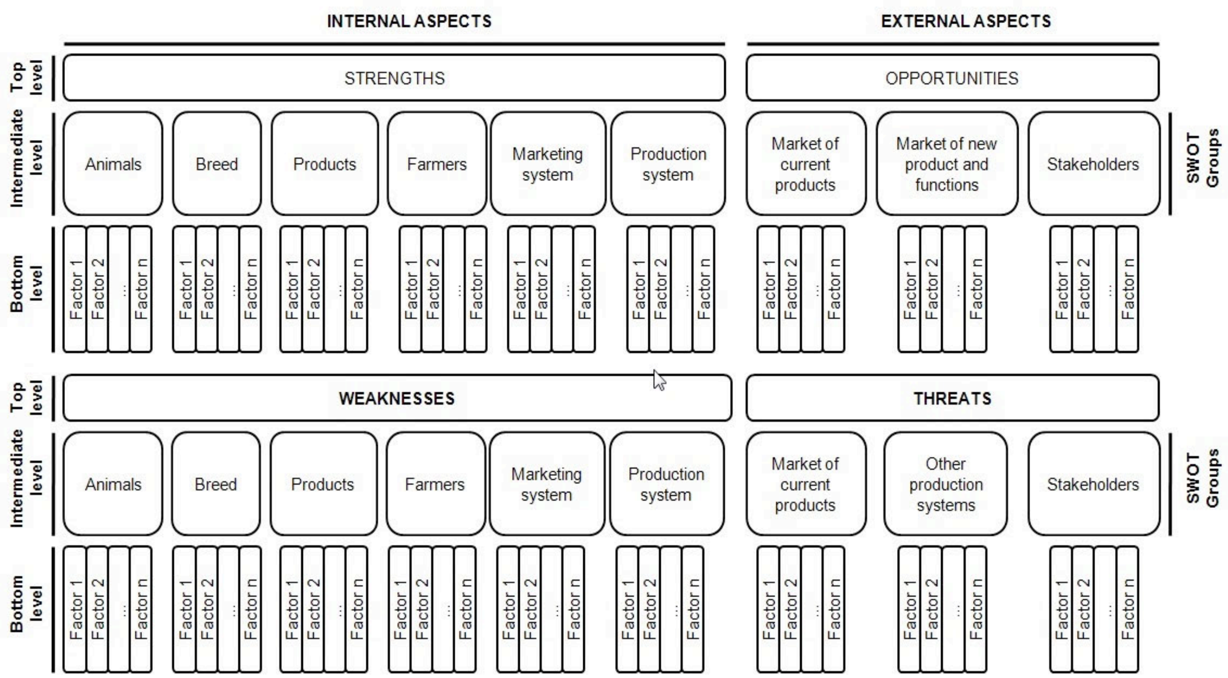

Figure 1 Organizational structure of driving factors of the European local cattle breeds’ farming system. SWOT= Strengths, Weaknesses, Opportunities and Threats

Factors were first identified for every single breed and organized in the above-mentioned structure. The number of factors in each of the groups was variable across breeds; e.g. 5 and 3 factors were determined in the “Animal group” for Avileña-Negra Ibérica and Reggiana, respectively.

Phase 3. Quantification of the importance of the driving factors.

Then the importance of the identified driving factors was weighted for each breed at a time. The choice of a quantification method had to cope with two major problems. Firstly, the factors were evaluated for each breed by the respective expert team. Therefore we had to use techniques that allow comparing weights made by different “judges”. Secondly, a large and unbalanced number of driving factors was expected to be identified across breeds. We needed a technique that accommodates this scenario. To overcome both problems, the weighting of the driving factors was based on an ordinal scale as a ranking. The teams of experts evaluated the factors by breed-specific ranks and then, we derived a weighting of the importance of each factor across breeds, based on order statistics.

First, driving factors were ranked within the factor groups. Thereby, comparisons were done among a small number of factors of the same nature. Second, weighting of factors groups were used to evaluate the overall importance of factors. The highest ranked driving factor of each group represented the group (Kurttila *et al.*, 2000). Therefore the comparison of the factor groups was actually a comparison between the highest ranked driving factors of the groups. In comparing the importance of Strengths, Weaknesses, Opportunities and Threats we followed a similar methodology. The highest ranked factor group of Strengths was compared with the highest ranked group of Weaknesses, Opportunities and Threats.

Finally, we derived an across breed weighting of the driving factors based on the rankings made at breed level. First, a value of zero was given to any factor that did not appear in a breed. Then, the ranks for every breed were reversed and normalized following the formula [1]. The transformed rank was called “weight” to clearly differentiate it from the original rank.

Weight of the f^{th} factor for the breed m: $w_{fm} = 1 + \frac{1-r_{fm}}{n_{fm}}$ [1]

where r_{im} is the rank of the f^{th} driving factor for a given breed m and n_{fm} is the number of factors in the corresponding group of the f^{th} factor for the breed m.

An example of the derivation of factor weights is shown in Table 1.

Table 1 *Derivation of the weights of the factors from the original ranks following formula [1]*

Factor group	Factor	Original rank	Missing = zero	Weight
Animal	Calving ease	3	3	0.6
	High longevity	4	4	0.4
	High fertility	2	2	0.8
	Robustness	1	1	1
	Good use of low nutritional pastures	5	5	0.2
	Easy management	+NI	0	0
	High esthetic value	NI	0	0

+NI refers to factors that were identified in many other breeds but did not have any score in Avileña-Negra Ibérica (ANI) – only two such factors are shown here as examples. Therefore, the number of factors (n_{fm}) of the "Animal group" in ANI breed to use in formula [1] is five.

Example for the factors within the "Animal group" in Avileña-Negra Ibérica breed.

Similarly, the weight of the g^{th} factor group for the breed m was calculated as follows:

$$w_{gm} = 1 + \frac{1-r_{gm}}{n_{gm}} \quad [2]$$

where r_{gm} is the rank of the g^{th} factor group for a given breed m and n_{gm} is the number of the factor groups under a category Strengths, Weaknesses, Opportunities or Threats for the breed m.

The calculation of factor groups weights is shown in Supplementary Table S2 continuing the example.

Finally, we derived the weights for the categories Strengths, Weaknesses, Opportunities and Threats from the ranks by the following formula,

$$w_{im} = 1 + \frac{1-r_{im}}{4} \quad [3]$$

where i refers to Strengths, Weaknesses, Opportunities or Threats and r_{im} is the corresponding rank in the breed m

Once the weights were calculated for each breed, across breeds weights (designated with capital W) were obtained by averaging the breeds' weight. Thus, we estimated W_f, W_g and W_i being respectively the across breed weight of the f^{th} factor, the g^{th} factor group and i^{th} category, i.e. Strengths, Weaknesses, Opportunities or Threats.

Finally, we calculated the overall across breeds' weight for f^{th} factor of the g^{th} factor group of the i^{th} category as the product of the respective weights.

$$OW_f = W_f \times W_g \times W_i \,,\ i = \{S, W, O, T\}$$

Similarly to Kurttila et al. (2000), given the organizational structure (Figure 1) we assessed the overall importance of the factor groups. We calculated the overall across breeds' weight of the g^{th} factor group as:

$$OW_g = W_g \times W_i \,,\ i = \{S, W, O, T\}$$

W_i is an overall across breed weight, therefore,

$OW_i = W_i \,, \qquad i = \{S, W, O, T\}$

We developed a Consistency index (CI) to evaluate the applicability of the across breed weights by comparing them with the weights given for the individual breeds. We first ranked the weights and then standardized them. The standardized ranks of the across breed weights were designated as Ra and the ones of individual breeds, Rb.

- CI of the f^{th} driving factor,

$$CI_f = 1 - \frac{\sum_{m=1}^{n} \left| Ra_f - Rb_{fm} \right|}{n} \ [4]$$

where n is the number of breeds, Ra_f the standardized rank of W_f and Rb_{fm} the standardized rank of w_{fm}.

The CI of the g^{th} factor group (CI_g) is calculated by formula [4] substituting Ra_f and Rb_{fm} by Ra_g and Rb_{gm} respectively being Ra_g the standardized rank of W_g and Rb_{gm} the standardized rank of w_{gm}.

The CIs for Strengths, Weaknesses, Opportunities and Threats were calculated in the same way.

Phase 4. Identification and prioritization of the strategies.

Strategies were derived using the TOWS matrix (Weihrich, 1989). They were identified at the three levels of the organization structure (Figure 1). At the bottom level, the specific actions fitting concrete factors were identified. At the intermediate level we defined the strategies focusing on different aspects of the local breeds (farmers, animals, etc). At the top level we compared the four general strategies (SO, WO, ST and WT).

The potential utility (U) of the strategies derived from the interaction of driving factors, factors groups and categories were calculated with the formulas [5], [6] and [7], respectively.

- $U_{fi,e} = OW_{fi} \times OW_{fe}$ [5], where fi refers to the factors related to S and W and fe to O and T.

- $U_{gi,e} = OW_{gi} \times OW_{ge}$ [6], where gi and ge refer to the factor groups related to S and W and O and T, respectively.

- $U_{I,E} = OW_I \times OW_E$ [7], where $I = \{S,W\}$ and $E = \{S,W\}$. Therefore we estimated U_{SO}, U_{ST}, U_{WO} and U_{WT}.

We used CIs to compare the overall utility across breeds with that computed for individual breeds. The procedure was equal to the one described for driving factors. First, the strategies were ranked according to their utility value, then the ranks were standardized and finally indices were calculated as described in the formula [4].

Results

Phase 1. Definition of the system

The decision of implementing the SWOT analysis from the farmers' perspective defined the boundary between internal and external driving factors. As internal factors, we considered the features of the animals and their products, production systems, farmers and their organizations and the aspects of the marketing of breed products (e.g. branding) that could be controlled by the farmers. However, other market aspects, such as the product demand, were out of farmers' control and thus are external factors. These consisted of features of farming area, infrastructures, market, policies and legislation that influence the local breeds' dynamics.

Phase 2. Identification and grouping of the driving factors

Across the countries and the breeds, 99 driving factors were identified: 38 strengths, 27 weaknesses, 20 opportunities and 14 threats. A detailed list of all factors, including the frequency of occurrence, is given in Supplementary Table S3. Regarding factor groups, Strengths contained six groups while Weaknesses lacked the “Products group”. The “Other production systems” group was not present in Opportunities and the “Market of new products and functions” did not appear in Threats. Therefore, Strengths had six factor groups, weaknesses had five and Opportunities and Threats had three factor groups each. Groups were formed by a varying number of driving factors, ranging from 2 to 12.

Phase 3. Quantification of the importance of the driving factors

Results and discussion sections were organized from the top to the bottom level following the logic of presenting general outcomes prior to specific ones.

At the top level, Strengths ($OW_S =$ 0.67) and Opportunities ($OW_O =$ 0.67) had the highest overall weight, followed closely by Weaknesses ($OW_W =$ 0.65). Threats ($OW_T =$ 0.52) had the lowest weight.

With regard to the factor groups, the most important were “Farmers” $(OW_g = 0.41)$ and “Animal” $(OW_g = 0.41)$ and “Farmers” $(OW_g = 0.45)$ and “Breed” $(OW_g = 0.43)$ for Strengths and Weaknesses, respectively. Factor groups within Strength and Opportunities related to “marketing system” $(OW_g = 0.12)$ and the “market of current products” $(OW_g = 0.39)$ respectively were considered the least important. The highest weighted group of Threats was the “market of current products” $(OW_g = 0.29)$. However, “Marketing of new products” $(OW_g = 0.49)$ was weighted at the top in Opportunities. “Stakeholder” seemed to positively influence ELCFS because its weight was close to the best in Opportunities $(OW_g = 0.48)$ and the last in Threats $(OW_g = 0.20)$.

At the bottom level, we obtained the ranks of all 99 identified driving factors based on OW_f. The frequency of their appearance across breeds ranged from 0.92 to 0.08. The ten most important factors across breeds, their frequency and *CI* are presented in Table 2. Three were weaknesses, four strengths and the rest opportunities. The most important factor was the weakness “Low production”, followed by three strengths: “High farmers’ interest on their breed conservation”, “High cultural value” and “Presence of efficient breeders’ association”. Two more weaknesses, “Small population size” and “Low collaboration among farmers” appeared the 5th and 6th in the ranking. None of the factors appeared in all the breeds. Their frequency of appearance across breeds ranged from 0.92, for “Low production” to 0.54 for the “Demand of special activities for tourism”.

Table 2 *Description of important driving factors ranked according to overall across breeds weight, with their frequency of appearance across breeds and the Consistency index*

Factor group	**Driving factor**	**[+]Rank**	**Frequency**	**Consistency index**
([++]W) Animal	Low production	1	0.92	0.59
(S) Farmers	High farmer interest on their breed conservation	2	0.85	0.44
(S) Production system	High cultural value	3	0.85	0.41
(S) Farmers	Efficient breeders’ association	4	0.77	0.53
(W) Breed	Small population and effective population sizes	5	0.62	0.50
(W) Farmers	Low collaboration among farmers	6	0.62	0.42
(O) Market of new products and functions	Increase of landscape management demand	7	0.62	0.46
(O) Market of new products and functions	Demand of "special" activities for tourism	8	0.54	0.39
(S) Animal	Robustness	9	0.69	0.43
(O) Market of new products and functions	New possibilities for added value products and functions	10	0.46	0.45

[+]Ranks are based on overall across breeds weight for each factor (OW_f).
[++]Capital letter refers to Strengths (S), Weaknesses (W), Opportunities (O) or Threats (T) where the factor group belongs.

The distribution of the CIs is given in Figure 2. There were two different slopes. For the subset of the higher ranked factors (ranks between 1 and 20) the CI increased with the rank. For the rest of the factors the lowest ranked factors tended to show higher CIs.

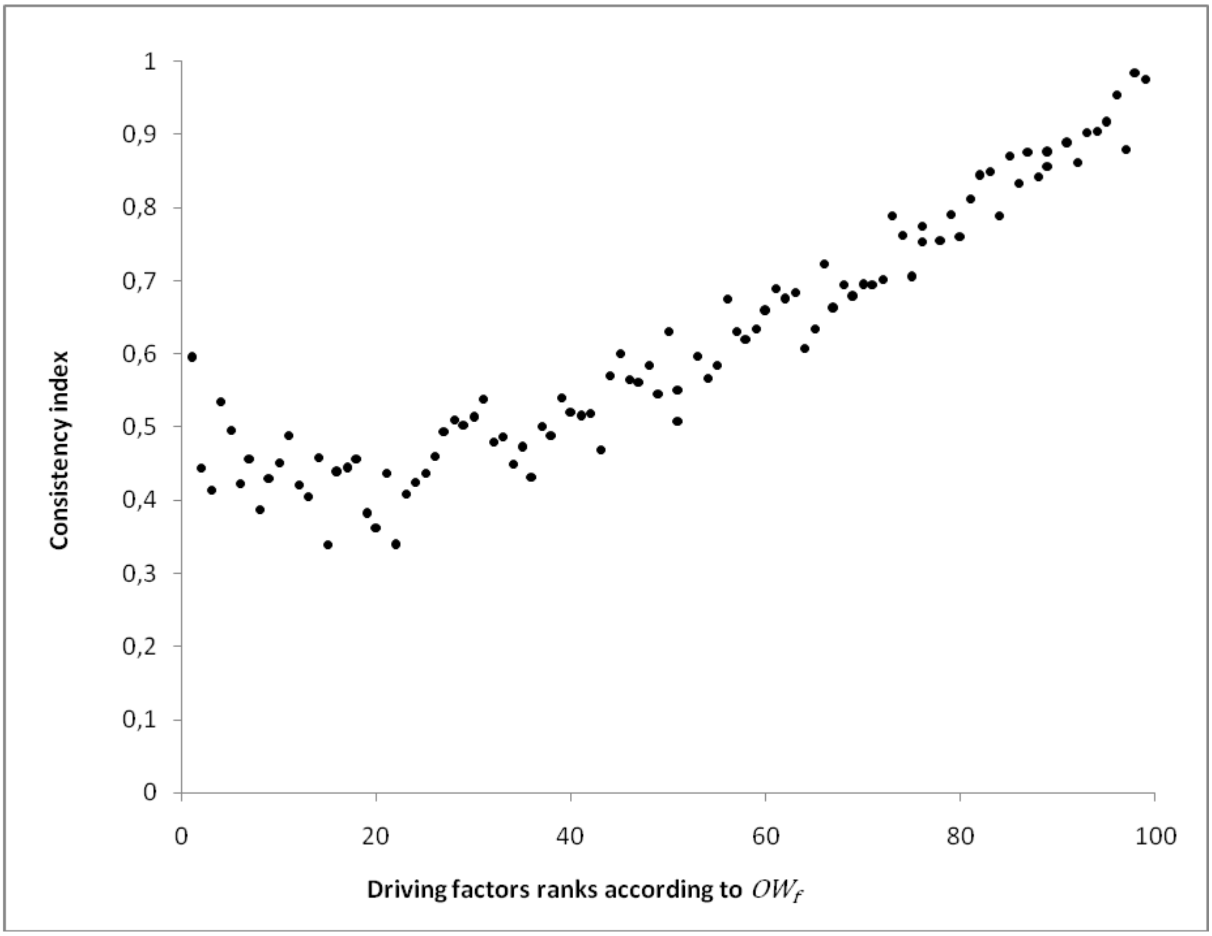

Figure 2 *Distribution of the Consistency indices of the 99 driving factors ranked according to overall across breeds weight*

Phase 4. Identification and prioritization of the strategies

We assessed strategies using the three level structure (Figure 1), gaining specificity when going from the top level to the intermediate and finally down to the level of driving factors.

At the top level, the SO strategy had the highest utility value $(U_{SO} = 0.45)$, followed by WO $(U_{WO} = 0.44)$, ST $(U_{ST} = 0.35)$ and WT $(U_{WT} = 0.34)$. The *CI* of these values was 0.73, 0.81, 0.81 and 0.73, respectively.

At the intermediate level, the ten top rated potential strategies related to the factor groups (Table 3) could be divided into two different types; those that use Strengths to take advantage of Opportunities and those utilizing Opportunities to overcome Weaknesses. These strategies are specifically related to the factor groups of “Animals” and “Farmers” of Strengths and “Animals”, “Farmers” and “Breed” of Weaknesses and “Market of new products and functions” and “Stakeholders” of the Opportunities. *CIs* ranged from 0.64 to 0.54.

Regarding the factors themselves, we included in Table 4 the fifteen highest rated strategies. The first four should be oriented to overcome the “low production” of animals. To do so the “increasing demand of landscape management”, the “new possibilities for added value to breeds products”, the “support to traditional and local products” and the “environmental awareness” will provide the opportunities. The next three strategies involved strengths related to “farmers” and “production system”. “High farmers’ interest on their breed conservation”, “presence of efficient breeders’ association” and “high cultural value of the production systems” may benefit from the “new possibilities to add value” to the breeds. *CIs* were rather low compared to the strategies of the intermediate and top levels.

Table 3 *10 top rated strategies for the conservation and development of the studied breeds related to factor groups*

		Opportunities	
		Market of new products and functions	Stakeholders
Strengths	Animal	+5 (++0.57)	6 (0.57)
	Farmers	5 (0.64)	6 (0.65)
Weaknesses	Animal	5 (0.56)	6 (0.65)
	Breed	3 (0.57)	4 (0.54)
	Farmers	1 (0.55)	2 (0.55)

+Numbers refer to ranks based on Utility values of strategies. Items with the same rank have the same utility value.
++Consistency indices.

Table 4 *Fifteen top rated strategies derived from the interaction between internal (Strengths and Weaknesses) and external (Opportunities and Threats) driving factors*

		Opportunities					
		Market of current products	Market of new products and functions		Stakeholders		
		Incr. of products-linked to the breed demand	Incr. of landscape management demand	New possibilities for added value	Development Agencies interest	Support to traditional and local products	Environmental awareness
Strengths	Farmers						
	Efficient breeders' association	-	[+]7 ([++]0.54)	14 (0.56)	-	-	-
	High farmer interest on their breed conservation	-	5 (0.51)	12 (0.56)	-	-	-
	Production system						
	High cultural value	-	6 (0.54)	13 (0.55)	-	-	-
Weaknesses	Animal						
	Low production	8 (0.34)	1 (0.42)	2 (0.32)	11 (0.31)	3 (0.40)	4 (0.42)
	Breed						
	Small population size	-	9 (0.46)	15 (0.50)	-	-	-
	Farmers						
	Low collaboration among farmers	-	10 (0.54)	-	-	-	-

[+]Ranks based on utility values of strategies (U_f).
[++]Consistency indices.

Discussion

Scope of analysis

We used SWOT analysis to find strategies for the conservation and development of FAnGR in a situation full of complexities. We adapted the analysis to a decision making tool that allows us to analyze in a systematic and structured way the problem of identifying and prioritizing strategies, and applied it to analyzing the case of 13 European local cattle breeds kept in six countries. The proposed methodology permits comparison of breed cases across countries and helps policy makers, authorities, breeders' associations and other stakeholders in defining and choosing the strategies to further develop and/or conserve local breeds. It starts from the investigations at the breed level and ends at performing a joint overall analysis.

We overcame the most relevant weaknesses typical to the SWOT analysis (Hill and Westbrook, 1997): the risk of oversimplifying the problem, the subjectivity in determining the driving factors and the lack of quantification for establishing priorities.

Tackling complexity with simplicity and flexibility

The power of SWOT analysis is its simplicity. When it is used to analyze complex systems it should be kept simple to avoid the risk of clouding the decision making process. To do so, some authors have limited the number of factors in the analysis (Gable *et al*., 2007) taking a risk of ignoring significant ones. Here, we propose to structure the analysis in three levels (Figure 1). This approach increases flexibility in two ways. First it allows analyzing the problem at different levels from general strategies to detailed actions. Second, the structure can be used to focus on different areas of the problem (factor groups). We used the analysis to find the most important factor groups from which the strategies should be developed. However, we could have focused on other factor groups.

We applied the SWOT methodology developed to a specific case leaving other options out. We calculated the utility of strategies across breeds although the same methodology could have been applied to evaluate strategies for each specific breed. Another perspective would be related to the main stakeholder in the system. We analyzed the conservation problem from the farmers' perspective, but the results might be useful for other stakeholders. The stakeholders, such as politicians devoted to agriculture, with the capacity to modify the factors that are external to farmers, can use the outcome of our analysis to design conservation and development measures from their own perspective.

Overcoming subjectivity with a multi-stakeholder approach

To avoid subjectivity in the definition of the system and in the identification of the driving factors we used a multi-stakeholder approach, similarly to Impoinvil *et al*. (2007). Many times the number of internal and external factors in SWOT analysis is unbalanced (Karppi *et al*., 2001), biased towards the perspective of the stakeholder implementing the analysis. The multi-stakeholder approach permits to incorporate different perspectives ensuring that all relevant factors are included in the analysis and therefore avoiding the problem of subjectivity. We observed that the more stakeholders are included in the process, the more factors are identified.

The quantification method: development of weighting factors

The quantification method proposed aimed to create user-friendly decision-making tools to assess conservation strategies. It is based on the measurement of the relative importance of the driving factors, since dividing a problem into smaller constituents allows the development of accurate priorities (Saaty and Takizawa, 1986). However, we have to be aware of the complexity of comparing strategies. It is difficult to weight the influence of factors where the impact is not always quantitative by nature (Yüksel and Dagdeviren, 2007). Nevertheless, if one knows in depth the system it might be possible to derive tangible judgments even when intangible factors are involved (Saaty, 2008). We used ordinal scales in our analysis since they would reflect the way the mind works (Saaty, 2008). The use of cardinal weighting would derive more accurate comparisons than ordinal weighting. Although the information relative to the distance between two factors consecutive in importance is lost, there are some situations - when many factors are involved or people are not able to perform cardinal comparisons (Kajanus *et al*., 2004) - when ordinal weighting is more suitable. Also, "priority comparison in cardinal scales could lead to more biased estimates of true preferences than when applying ordinal inquiries*"* (Kangas *et al*., 2003*)*. In addition, due to the complexity of our analysis, it is doubtful whether one could develop accurate cardinal weights for the influence of the factors.

We used weights determined by an expert team to rank the factors for each breed. A similar approach has been done in other studies (Kangas *et al*., 2003; Impoinvil *et al*., 2007). The use of ordinal scales enables the comparison of judgments across breeds. However, it would have been desirable to use several values per breed in the ranking process to evaluate the consistency. This would have introduced a large degree of complexity in the process. The results of the analysis may vary due to the subjective view of the experts but this is not a reason for rejecting the results since the nature on decision making problems is anyway rather subjective (Yüksel and Dagdeviren, 2007). Nevertheless, with a meticulous selection of experts one could reduce subjectivity. It would be interesting to do further research on this aspect to be able to develop a risk analysis that provides a confidence interval for the value of each specific factor.

Considerations for the application of the SWOT analysis results

The use of ordinal weights has some interesting properties, described above, but also important implications in applying the results. Ranks do not measure distances between consecutively weighted factors or strategies. When taking decisions based on the outcome of the analysis, one has to reckon this limitation. The definitive choice of strategies depends also on the costs, the difficulties and the probability of success in their implementation.

The strategies derived from the analysis are not necessarily mutually exclusive. The final decision could be a combination of several strategies. Nevertheless, when using the TOWS matrix it is necessary to reckon that all the interactions of factors cannot be converted into strategies.

When using SWOT analysis we have to accept the time and space dependency of the results. The applicability of the strategies derived from the analysis depends on the environment (Opportunities and Threats) and may vanish if conditions change (Yüksel and Dagdeviren, 2007).

The case of the 13 European cattle breeds

The SWOT analysis performed for the 13 European breeds confirmed the heterogeneity of the situation observed in the previous study (Gandini *et al*., 2012, -Chapter 2-). The importance of the identified driving factors was variable across breeds. The *CIs* showed this heterogeneity. The interpretation about high *CI* with high frequency across breeds is straight forward, but the interpretation of indices with low frequency is somehow trickier (Table 2). These factors do not appear very often but when they do, they are so overwhelming that they raise the overall value. This implies that these factors should be carefully explored when analyzing their incorporation in policies and programs. In addition, the *CIs* of the most important factors were lower than those of the less important ones (Figure 2), meaning that although the main factors may vary across breeds, less relevant factors exhibit less variation.

Although the situation is heterogeneous, it can be stated that the future of these particular breeds can be promising. At the top level of analysis, Threats received the lowest weights, while Opportunities and Strengths had the highest, closely followed by Weaknesses.

However, this may not be a problem because by definition Weaknesses are modifiable by farmers.

The *CI* of the utility values of overall strategies across breeds decreased as they gain specificity (Tables 3 and 4). Hence, the European strategies should be based on general aspects and be flexible to enable their adaptation to the country and breed requirements. The low consistency of specific strategies at factor level implies that when implementing them jointly for several breeds, it has to be confirmed that the specific driving factors are relevant for every single breed.

The conservation of local breeds has usually focused on either strengths or weaknesses related to the animal features, mainly robustness, adaptation to specific environments, high product quality and low input requirements. This study has determined that farmer and production system features are also key aspects to be considered (Table 2).

Local breeds can have high cultural (Gandini and Villa, 2003) and environmental value (Rege and Gibson, 2003). The results of our analysis confirmed the higher relevance of the cultural value of these breeds (Table 2). There is a parallel social support to traditional and local products. This potential has to be explored. However, environmental value did not appear among the top ranked factors (“High environmental value” is ranked in the 41th position).

Opportunities coming from the “market of new products and new functions” and from “stakeholder” support were rated at the top. The increase of the income from new products and functions is seen as an important potential opportunity to be taken into account. In strategic terms, it is not only necessary to promote traditional products but also to develop new ones. However, accepting the time and space dependent nature of external driving factors, we have to assess whether the social support is going to last until the development of new options is a reality.

The most important strengths were related to “Animals” and “Farmers”. It might be worth working on farmers’ motivation, collaboration, and capacity building (Gandini *et al*., 2012, -Chapter 2-). Once this is achieved the product development would be easier.

Regarding the strategies at the level of the driving factors, the development of breed specific products could utilize the high cultural value that the breed has, given that there is an increasing social interest on rural culture. Marketing could also be designed to reach the social sectors that are supporting traditional and local products. It might be worth developing synergies with rural development agencies and involve them in the strategies to find added values and to overcome the losses due to low production. These strategies should consider utilizing breeders' associations and the farmers' high interest in the conservation by involving them in pilot projects and new farming experiences. The involvement of farmers could also be a way of fostering farmer collaboration that has been seen as a major weakness in maintaining local breeds.

Conclusions

The proposed SWOT analysis helps to get a deep insight on the conservation and development of FAnGR. The analysis can be done at different levels. The level structure allows analyzing the conservation problem from general down to specific perspectives. An essential part of the process is the quantification of the driving factors and the deduced strategies. The across breed analysis of the 13 European local cattle breeds highlights the consistency of irrelevant factors. There is high heterogeneity among the most relevant factors and strategies. However, the strategies increase eligibility as they lose specificity. Thus, the strategies embracing many breeds should refer to general issues while the specific strategies and actions should be identified at breed level. Moreover, the most promising factors and strategies emphasize the importance of positive aspects (Strengths and Opportunities) of the current situation of European local cattle breeds.

Acknowledgements

We thank farmers and stakeholders participating in the survey. We also thank the breeders' association of the thirteen local breeds and all scientists involved in the EURECA Consortium for their support to the study. We acknowledge the EU (012 AGRIGENRES 870/2004) and the Institutions of the EURECA Consortium for their support and funding.

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Supplementary Table S1 *Number of interviewed stakeholders per category in each country*

+Stakeholder category	Country					
	Belgium	++Finland	France	Italy	Spain	The Netherlands
Agriculture authorities	3	5	1	2	4	2
Environmental authorities	-	2	1	-	1	1
Research institutes and universities	1	9	2	2	4	2
Rural development agencies	-	-	-	-	1	-
Trade and distribution companies	-	4	-	1	3	4
State farms	-	4	-	-	2	-
Slaughter houses	-	-	-	1	2	-
Dairy cooperative	-	-	-	3	-	-
Artificial insemination centers	1	2	1	-	-	2
Breeders' associations	4	15	2	2	2	4
Others	-	20	-	-	-	-
Total number	9	61	7	11	19	15

+The stakeholder interviewed in each country gave their opinion about the strengths, opportunities, weaknesses and threats of the different breeds of the country included in the study.
++In Finland also agricultural students and persons working in tourism and media were included in the survey.

Supplementary Table S2 *Derivation of weights of factor groups from the original rank following formula [2]. Example for the factor groups belonging to Strengths of Avileña-Negra Ibérica (ANI) breed*

	Factor group	Original rank	Zero adding	Weight ( )
Strengths	Animal	4	4	0.4
	Breed	+NI	0	0.0
	Product	3	3	0.6
	Farmers	1	1	1.0
	Production system	5	5	0.2
	Marketing system	2	2	0.8

+NI refers to factors that were not identified in ANI breed but were so in other breeds

Supplementary Table S3 *Driving factors affecting European local cattle dynamics and its relevance across the thirteen studied breeds*

Categories	Groups	Factors	+Frequency
Strengths	Animal	1. Robust/good health	0.69
		2. Multipurpose	0.62
		3. High longevity	0.62
		4. High fertility	0.62
		5. Good use of low nutritional pastures	0.54
		6. Calving ease	0.38
		7. Easy management	0.31
		8. Size well adapted to prod. system	0.23
		9. Behavior well adapted to prod. system	0.23
		10. High esthetic value	0.15
		11. High carcass value	0.15
		12. Uniqueness	0.08
	Breed	1. Good rates of herd book registration	0.54
		2. Existence of breed gene banks	0.54
		3. Population trend stable or increasing	0.46
		4. Existence of animal genetic conservation plans	0.46
		5. Wide breed distribution	0.38
		6. Good information and studies on the breed	0.31
		7. Inadequate population /effective size	0.23
		8. Successful breeding system	0.15
	Farmers	1. High farmer interest for breed conservation	0.85
		2. Presence of efficient Breeders Association	0.77
		3. High collaboration among farmers	0.31
		4. Good farmer's entrepreneur capacity	0.15
		5. Good collaboration with the AI center	0.15
	Production system	1. High cultural value	0.85
		2. Low comparative input cost	0.54
		3. High environmental value	0.31
		4. High diversity of farm profiles	0.31
		5. Good economic competitiveness	0.23
		6. Low ecological impact	0.15
		7. Low comparative investment necessities	0.15
		8. Fit for organic farming	0.08
	Products	1. High product quality	0.69
		2. Product directly linked to the breed	0.38
		3. Traditional prestige	0.08
	Marketing system	1. Presence of consortiums	0.46
		2. Good marketing structure	0.46

Weaknesses	Animal	1. Low production	0.92
		2. Size problems	0.23
		3. No special features	0.15
		4. Low health	0.08
		5. Behavior problems	0.08
	Breed	1. Small population/effective size	0.69
		2. Lack of information and studies about the breed	0.38
		3. Small herd size and high rates of mixed herds	0.31
		4. Not enough bulls	0.31
		5. Insufficient herd books registration	0.15
		6. Insufficient ex-situ conservation programs/actions	0.15
		7. Small historical breed distribution area	0.08
		8. Decreasing population trends	0.08
	Farmers	1. Low collaboration among farmers	0.69
		2. High farmer age/lack of generation transfer	0.54
		3. Low farmer entrepreneur capacity	0.31
		4. Presence/efficiency of breeder association	0.23
		5. Ignorance of breed features/management system.	0.15
		6. High proportion of hobby farmers	0.08
		7. Others	0.08
	Marketing system	1. Insufficient development of channels	0.69
		2. Lack or insufficient product differentiation	0.54
		3. Insufficient products/breed publicity	0.38
		4. Low product supply capacity	0.31
	Production system	1. Insufficient farming economic competitiveness	0.38
		2. High dependency on subsidies	0.23
		3. Poor technological level	0.15
Opportunities	Market of current products	1. Increasing "quality" food products demand	0.46
		2. Increase of products breed- demand	0.38
		3. Increasing food quantity demand	0.15
		4. Accessibility to potential markets	0.15
	Market of new products and functions	1. Increase of landscape management with cattle demand	0.69
		2. Demand of "special" activities for rural and eco-tourism	0.54
		3. Existence of new possibilities for added value products and functions	0.46
		4. Increase of caring farming demand	0.15
	Stakeholders	1. Increase of social environmental awareness	0.69
		2. Increase of social support to traditional and local products and breeds	0.46
		3. Increasing Media interest on local breed	0.38
		4. Key persons support local breeds	0.38
		5. Social interest on rural culture	0.38
		6. Support from other breeds Associations or Federations	0.31
		7. Rural Development Agencies are interested on local breeds	0.31
		8. Presence of infrastructures usable by local breed	0.23

		famers	
		9. High cooperation among key stakeholders	0.23
		10. Increasing Agriculture Colleges and Universities interest on local breeds	0.15
		11. Support of Associations of consumers of quality products (organic, slowfood…)	0.08
		12. Demand of "welfare" animal production	0.08
Threats	Market of current products	1. Negative farming and macro-economic trends	0.69
		2. Competition against mainstream International products	0.31
		3. Risk of product falsification	0.23
		4. Competition against other local breed products	0.15
		5. Risk of having higher breed products offer than market demand	0.15
		6. Bull-calves are not appreciated market	0.15
		7. Competition against other National/European "quality" products	0.08
		8. Increasing demand of breeding cows for crossbreeding	0.08
	Productions system	1. Competition against mainstream breeds	0.38
		2. Breed features modification due to short-term fashionable interests may compromise the original breed traits	0.38
		3. Competitions against more technological systems	0.15
	Stakeholders	1. Lack of social awareness on local breed situation	0.31
		2. Competition against other economic activities	0.31
		3. Lack of support from other breeds Associations or Federations	0.23

[+]Frequency of appearance of each factor across the studied breeds.

CHAPTER 4

This chapter entirely reproduces the following paper under revision in Agricultural Systems Journal.

Defining farmer typology to analyze current and future prospects of a local animal breed: the Avileña-Negra Ibérica cattle breed as a case study

D. Martín-Collado[1], K. Soini[2], A. Mäki-Tanila[2], M. A. Toro[3], C. Díaz[1]

[1]*Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria (INIA), Madrid, Spain*

[2]*MTT Agrifood Research Finland, Jokioinen, Finland*

[3]*Departamento de Producción Animal, Escuela Técnica Superior de Ingenieros Agrónomos, Universidad Politécnica de Madrid, Madrid, Spain*

Defining farmer typology to analyze current and future prospects of a local animal breed: the Avileña-Negra Ibérica cattle breed as a case study

Abstract

A general farmer typology is developed to help in analysing the herd dynamics and farmers' decision making and designing strategies for the development of local breeds. The typology is built on few measurable socioeconomic factors that are often used as indicators of the economic and cultural capital of farmers. A group of 85 farmers raising the Spanish Avileña-Negra Ibérica (ANI) local cattle breed is used to illustrate and test the procedure. The farmer types are defined by a hierarchical cluster analysis with a set of canonical variables derived from the following five the socioeconomic factors; the formal educational level of the farmer, the year the farmer started keeping the ANI breed, the percentage of the total family income covered by the farm, the percentage of the total farm land owned by the farmer and age of the farmer. The present ANI farmers' types are more complex than the traditional ones in the past. The farmer types are found to be linked to with several other attributes used to summarise farm profiles. They also differ in making farm management decisions related to variation of herd size in the past and breeding aims and in the involvement on common activities with other farmers. In addition, the farmer types have variable dependency on subsidies payments for local breeds implying that changes in subsidy programme will lead to a redistribution of farmer types. The typology could be utilized in determining effective specific support measures for the local breed keeping farms differing in production condition and socioeconomic features of the farmers.

Introduction

Typology revealing appropriate policies

There is a continued need to improve the effectiveness of agricultural, rural or environmental programmes and policies (Landais, 1998; Emtage *et al*., 2006). This is particularly important in the case of local and regional breeds many of which are threatened or in danger of becoming threatened (Food and Agriculture Organization of the United Nations, 2007). Local breed dynamics are complex since they are affected by a wide variety of external and internal factors (Martín-Collado *et al*., 2012, -Chapter 3-). In addition, these breeds are nowadays raised by highly diverse farmers in equally diverse farms (Van Diepen *et al*., 2007;

Gandini *et al*., 2010). In order to develop sound and optimal policies and strategies for developing local breeds, it is crucial to consider the socioeconomic features of farmers with respect to the management and decision-making related to farm animal breeds (Emtage *et al*., 2007; Martín-Collado *et al*., 2012, -Chapter 3-) and the impact of policies and programs (Emtage *et al*., 2006).

In the recent years in many European countries agri-environmental subsidies have been paid for the maintenance of local breeds. Although subsidy programmes in general have been regarded as inefficient (Cong and Brady, 2012), they have been successful in stopping the decline of many local breeds. However, it is still unclear, what is the long-term role of the subsidies for the conservation of local breeds. Furthermore, it is unknown how stopping such subsidy programmes may affect the local breeds' dynamics. Some surveys have revealed that many farmers would keep local breeds even without subsidies (Takamaa and Soini, 2007; Soini *et al*., 2012). However, many others would be seriously affected by such changes. According to our interview results (data not published) on six Spanish local cattle breeds, after the removal of subsidies 20-70% of the farmers, depending on the breed, will stop keeping animals of the breed. In this line of thought some researches have been seeking for factors that favour the self-sustainability of breeds (Hiemstra *et al*., 2010) or farming practices which provide sustainability through embedded cultural values instead of subsidies (Pretty, 2003; Burton and Paragahawewa, 2011).

Typologies are a widely used tool to itemise our knowledge on complex and diverse issues, such as the development of local breeds. Typologies summarise the characteristics of archetypal persons or items, and the typology is underpinned by detailed information about the characteristics and the analysis of their relationships (Landais, 1998). There is long tradition for typology research in the field of agriculture (Kostrowicki, 1977). Farmer typology usually aims to determine the factors influencing behaviour of people, to illustrate variation in behaviour, to provide an insight to the reasons behind the variation and to guide the interpretation of the diversity of farmers' value systems and socioeconomic characteristics (Emtage *et al*., 2007). The main aim of agriculture typologies is to assist policy makers or/and any stakeholder involved in the development of farming, to develop a range of relevant solutions adjusted to the needs and means of different types of farms (Landais, 1998).

One approach to develop agriculture related typologies is to pay attention to specific practices (e.g. Siegmund-Schultze and Rischkowsky, 2001). The deduced typologies are used to design targeted policies and programmes to assist adoption of the best-management in the specific practice. Such typologies cannot be generalised for assessing the aspects beyond the specific practises (Emtage *et al*., 2007). The other approach is to develop typologies considering landowners' features and attitudes in the broad sense (Emtage *et al*., 2006, 2007) aiming to illustrate variation among landowners with respect to a variety of purposes (Landais, 1998). The development of general typologies seems to be a useful tool to understand management decisions by the local breed farmers. Recently, there has been an increased interest in analysing local breeds' dynamics via analysing the respective farmers (Hiemstra *et al*., 2010; Gandini *et al*., 2012; Martín-Collado *et al*., 2012, -Chapter 3-). However, to our knowledge, up to now there has been only one attempt of developing farmer typologies for local breeds (Soini *et al*., 2012, -Annex-).

There are many methodological and theoretical issues that need to be taken into account when developing typologies (Emtage *et al*., 2007): selection of criteria to classify farmers into a set of types, the technique to define the types, the assessment of the validity and utility of the typology and the possible changes in importance among the criteria across time and geographical location.

Cultural and economic capital and farmers' behavior

Farmers, like any occupational group of people, are considered as a rational decision maker who acts as if balancing costs against benefits to arrive at actions that maximize personal welfare. However, there is also evidence that local breed farmers kept favoring the breed even though they thought it was economically less profitable than mainstream breeds (Takamaa and Soini, 2007; Gandini *et al*., 2010; Soini *et al*., 2012). Therefore, farmers' choice of a breed might be influenced by non-economic issues or other forms of capitals. Bourdieu (1986) proposed the existence of three forms of capital (economic, cultural and social capital) and maintained that "*the structure of the distribution of the different types and subtypes of capital (…) represents the immanent structure of the social world (…) which governs its functioning (…) determining the chances of success for practices*".

Following this approach we explore the creation of a typology based on relatively easily measured variables, which characterise the economic and cultural capital of the farmers and possibly influence the farmers' management decisions. In the following paragraphs we briefly describe the main characteristics of the Bourdieu's theory of capital (1986) and its applications in agricultural studies.

According to Bourdieu (1986) the capital can take the form of *economic capital* (resources as material property), *cultural capital* (resources in the form of knowledge, skills, dispositions, and possession of culturally significant objects) and *social capital* (resources that can be mobilized via social connections and mutual obligations). *Economic capital* responds to the classical definition of capital, it is immediately and directly convertible into money. C*ultural capital* exists in three principal states: *Embodied cultural capital* that is the permanent dispositions in the individual person i.e. knowledge and habits, *Institutionalized cultural capital* that stems from the possession of formal academic qualifications and *Objectified cultural capital* that describes the possession of valued objects such as paintings or books. *Social capital* is, for Bourdieu, an entity of potential resources that are related to the social relations that people have, which provide all the members collectively owned capital. Further on, social capital has been considered more broadly as anything that facilitates individual or collective action, generated by networks of relationships, reciprocity, trust, and social norms (Coleman, 1988). It is important to emphasize that every form of capital contains value, and therefore it is an object of interest and implies investment strategies, both at the individual level as well as the group level. The different forms of capital can be converted into one another although with varying degrees of difficulty (Bourdieu, 1986). Much of the empirical research on cultural capital has looked at the aggregate impact of education as affecting economic and social outcome (Throsby, 2001).

Bourdieu's concepts of capitals have been applied in the farming context. The *economic capital* refers to the capital required for agricultural production, such as land, buildings and machinery. *Cultural capital* is linked to the farmer's formal education (*institutionalized cultural capital*) and to farmer's traditional knowledge that is actually a form of *embodied cultural capital* but also to the prestige derived from commonly accepted symbols of 'good farming' (Burton and Paragahawewa, 2011). These symbols may include labor, production and land management (Silvasti, 2003; Johnsen, 2004) or well-looked after livestock (Gray, 1998; Haggerty *et al*., 2009). As Burton *et al.* (2008) points out, all these symbols could be perceived by other members of the farming community. In the farming context, *social capital* constitutes the networks and social relations which constitute the basis for the informal (mutual help and exchange of information) and formal (production and marketing cooperatives) cooperation between the farmers (Svendsen and Svendsen, 2000).

Emtage *et al*. (2006) found that there are several factors consistently reported to differentiate among landowner types: economic factors such us farm size, productivity and degree of dependence on the property for income, social factors such as the history of family ownership and family size among others and personal characteristics such as the formal education level. These can be immediately related to the three forms of capital.

Objectives of the study

The aim of this paper is to develop a farmer typology based on economic and cultural factors, which can be used to analyse the management decisions by farmers and the breed dynamics on the farm. In the analysis we apply and use the sociological framework of economic and cultural capital. A typology based on these criteria could then be applied to building policies and programmes for the development and conservation of local breeds. Specifically we aim to answer the following questions:

1. How cultural and economic variables are linked to farmer types?

2. Which farmer types could be based on economic and cultural factors?

3. Are the farmer types linked to different farm profiles?

4. Are the farmer types different for management decisions?

Material and methods

The Avileña-Negra Ibérica regional cattle breed

The Avilena-Negra Ibérica (ANI) cattle breed was used as a case study to develop the farmer typology. The current research team is providing the expert interpretation needed in developing typologies (Kostrowicki, 1977; Emtage *et al*., 2007) and in testing their validity and utility (Emtage *et al.*, 2007) based on the wide knowledge on the breed and the long and fruitful collaboration with the ANI Breeders' Association (e.g. Vassallo and Díaz, 1986; Martín-Collado *et al*. 2012, -Chapter 3-). ANI breed is one of the most important autochthonous beef cattle breeds in Spain. It is linked to a very extensive production system, therefore with a high dependency on pasture land. It is mainly located in the centre and southwest of Spain. Traditionally ANI breed has been raised by two kinds of farmers: wealthy farmers from high-class families that owned farmland where they raised cattle as a way of living while they had other sources of income, and peasants that usually lived in villages and raised cattle using public common land. However, the farmer types have evolved in the last two decades. The breed society was formed in 1970 and it has been very active trying to maintain the breed that has to compete with the mainstream cattle breeds. Further information about the breed and the breeders' association can be found in de Haas *et al.* (2010) and Martín-Collado *et al.* (2010).

Development of farmer types

We have used 5 variables related to cultural and economic capital (Bourdieu, 1986) to build farmer typologies. These variables have consistently been used to define landowner types regardless the aim of the typology (e.g. Siegmund-Schultze and Rischkowsky, 2001; Kristensen *et al.*, 2004; Emtage *et al.*, 2006). The five variables in our analysis were the following: formal educational level (now on we will refer to this variable as EDUCATION), year the farmer started keeping the ANI breed (BREED YEARS), percentage of the total family income covered by the farm (INCOME IMPORTANCE), percentage of the total farm land owned by the farmer (OWNED LAND) and age of the farmer (AGE). We used these variables as indicators of the economic and cultural capital of farmers. The first three variables are direct indicators of the institutionalized cultural capital, embodied cultural capital and economic capital, respectively. We consider OWNED LAND as an indicator of both economic and cultural form of capital. In the one hand, land is a commodity/property that the farmer possesses and has a monetary value, thus is economic capital and, on the other hand, we believe that the farmers have a link with the farmland they own that can be considered as embodied cultural capital with various symbolic meanings accumulated by farming practices (Burton, 2008). Finally, AGE was included as an indicator of the embodied cultural capital that is accrued over time (Bourdieu, 1986). AGE also determines the society where the farmer grew up incorporating the contemporary specific values and habits.

The data set used in this study was based on a structured survey of farmers of ANI cattle breed that was carried out in 2011. We interviewed 85 farmers face-to-face. Farms were selected according to the number of animals and geographical location to have a representative sample. The survey was designed to gather information on the five variables we used to build the typologies as well as on a wide range of other characteristics of farmers and farms which may be used to further describe the farmer types. In addition to the variables used to define farmer types, we also looked at three other sociological variables such as the farmer's dedication to farming (whether they were FULL-TIME farmers or not), the family history with farming (whether they came from a FAMILY OF FARMERS or not) and the involvement of family members in the farming activities (number of family members working in the farm). Regarding the farm profiles we considered eleven variables: FARM SIZE (ha) and Nº OF DAMS, farming intensity (dams/ha and dams/worker), employment (Nº OF EMPLOYEES), farm inputs (self-sufficient farms, farms buying most of their production inputs), movement of animals (TRANSHUMANCE and moving of livestock between lowland and mountain pastures) and the relative importance of ANI breed (percentage of ANI dams and sires).

The canonical analysis and hierarchical cluster analysis were used to classify the farmers. With the canonical analysis we transformed the initial five variables into canonical variables (Kobrich *et al*., 2003; Dossa *et al*., 2011). Then we developed the typology for the farmers by the hierarchical cluster analysis on the chosen canonical variables using the Ward's minimum-variance minimizing the total within-cluster variance) as a measure of distance (Siegmund-Schultze and Rischkowsky, 2001; Dossa *et al*., 2011). At each step, the pair of clusters with minimum cluster distance are merged. The Ward's method consists on finding, at each step, the pair of clusters that leads to minimum increment in the total within-cluster variance after merging. The increment is a weighted squared distance between cluster centers. Both the canonical and hierarchical cluster analysis were implemented by the Aceclus and Cluster procedures of SAS software (SAS Institute 2004). To determine the final number of clusters we used the criterion pseudo t^2 statistics, given by the Cluster procedure of SAS software. Based on the criterion we got some few possibly good clustering levels -number of clusters-. The final number of clusters was established by the visual inspection of the hierarchical clustering tree (Köbrich *et al.*, 2003) and evaluating the interpretability of the results (Emtage *et al*., 2007; Dossa *et al*., 2011).

Analysis of the effect of farmer types on various farm/farmer profile descriptors

Once farmers' typologies were determined, we analyzed whether between the types there were differences for commonly used farm/farmer profile descriptors. For the normally distributed variables, we used ANOVA and we applied the Duncan's multiple comparisons test to make inferences on the differences. Regarding the non-normally distributed variables the Kruskal-Wallis test and Wilcoxon's test for multiple comparisons were used. Finally, the Fisher's exact test was used to analyze pair-wise differences of discrete variables among farmer types.

Analysis of the effect of farmer types on management decisions

We evaluated the influence of farmer types on the following four aspects related to farm management decisions:

Herd size and breed composition variation in the past and future. We looked at the variation of total number of dams and the percentage of ANI dams in the herd over the last ten years and the farmers' plan for the coming five years.

Breeding aims. We analyzed the mean proportion of animals sold for slaughtering and for use as reproducing animals. We divided farms selling reproducing animals into two groups: the farms where the main objective was producing breeding animals, both sires and dams mainly for pure breeding (we will call the aim *breeding animals* in the rest of the paper), and the farms where the main objective was producing beef but that also sold dams -given the opportunity-, mainly for crossbreeding (*dams* in the rest of the paper).

Involvement in common activities with other farmers. We considered three potential common activities. Two of them in relation to the collaboration through the activities organized by the Breeders' Association related to fattening animals for slaughter and labeling of products. Thus, farmers were asked whether they join the common feedlots for fatten calves after weaning and whether they sell animals whose meat is commercialized under the breed label or not. The other one was the collaboration with other farmers in punctual farming activities such as the management of the herd for vaccination, weaning or movement between farm parcels.

Effect of changes in subsidy policies. We analyzed the assessed farmers' reactions towards a hypothetical scenario of removing subsidies. Farmers were asked to indicate what their decision in that kind situation would be in terms of increasing, decreasing or maintaining the number of ANI dams, or stopping raising the breed.

Results

The two first canonical variables accounted for 95% of the total variation of the five original variables (Table 1). These variables were mainly related to EDUCATION and OWNED LAND with respective standardized canonical coefficients for the canonical variables being by far the largest. The coefficients of all the other three initial variables (FARM YEARS, AGE and INCOME IMPORTANCE) were below 0.25 for the first two canonical variables, meaning that they had little impact on the definition of these two canonical variables.

Therefore, the farmer clusters were developed using the two first canonical variables. The chosen criterion to select the number of clusters we found five main types of farmers. We show in Figure 1 the distribution of the individual farmers across farmer types (named A, B, C, D, E) according to the canonical variables and their relationship with EDUCATION and OWNED LAND.

Table 1 *Description of the canonical variables derived from the five initial economic and cultural factors differentiating the farmers*

	Standardized Canonical Coefficients				
Initial factors	Canonical variable 1	Canonical variable 2	Canonical variable 3	Canonical variable 4	Canonical variable 5
Education	1,40	2,69	0,26	0,27	-0,03
Owned land	3,71	-1,75	-0,42	0,15	0,32
Income importance	0,14	0,11	-0,07	1,17	0,38
Age	-0,24	0,19	1,57	0,13	0,07
Breed years	-0,22	-0,01	0,47	-0,16	1,12
Cumulative variance accounted	0,72	0,95	0,98	0,99	1,00

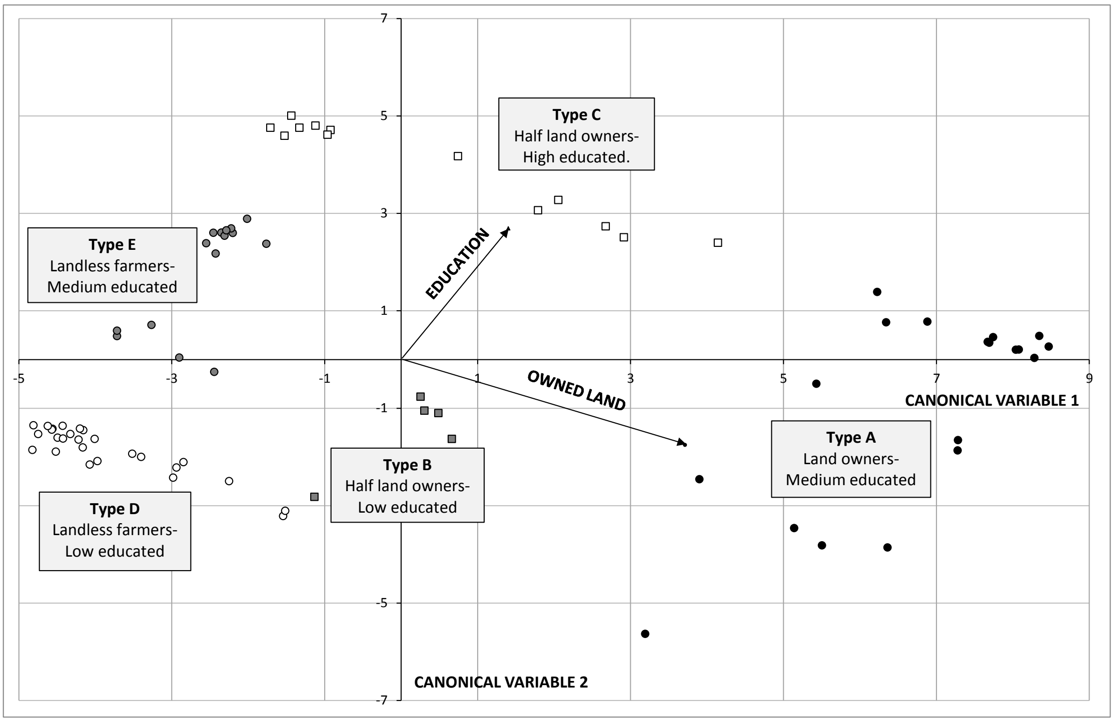

Figure 1 *Graphical distribution of farmer types according to the first two canonical variables. Arrows represent the OWNED LAND and EDUCATION values of the standardized canonical coefficients of the two canonical variables*

Although AGE, INCOME IMPORTANCE and BREED YEARS did not contribute much to the variation, since they were correlated with EDUCATION and OWNED LAND, we were interested to study how farmers' types differ in those attributes. Using ANOVA or the Kruskal-Wallis and Wilcoxon test, we found that farmer types had different AGE and farm INCOME IMPORTANCE and we also observed a trend in BREED YEARS (Table 2). In the following sections we introduce and describe the five farmer types summarizing in Table 3 their levels of economic and cultural capital.

Types of farmers *(with respect to EDUCATION and OWNED LAND)*

Type A farmers

The main characteristic of the type A farmer is that they own most of their farmland (Table 2). They are usually middle-aged, middle-high educated people. Therefore in terms of capitals (Table 3) they have a high economical and medium-high institutionalized cultural capital. It is worth noting that they are the type of farmers that are less dependent on the income from the farm. They have usually had ANI animals for some decades what, together with their age, gives them a considerable embodied cultural capital in maintaining ANI breed.

Type B farmers

The type B is the rarest of all the types and only five farmers could be categorized to belong to this group (Table 2). They are middle - low educated farmers that on average own around half of the land they practice farming. They are usually old people with high level of dependency on the income from the farm. Like the type A farmers, they have been usually breeding ANI animals for a long time. Therefore, although the type B farmers have medium-low institutionalized cultural capital, they carry high embodied cultural capital and medium-high economical capital (Table 3).

Table 2 *The mean values of the initial cultural and economic factors across the types*

	Farmer types				
	Type A	Type B	Type C	Type D	Type E
Factors	n=19	n=5	n=13	n=26	n=16
+Education	3.3b	1.8 d	4.0 a	1 e	2.7 c
Owned land	94% a	42 % b	18% c	8% d	3% d
Age	49 ab	59 a	42 ab	46 ab	39 b
Income importance*	2.8 b	4.2 a	3.3 ab	4.0 ab	3.4 ab
Breed years	1980	1978	1992	1983	1991

Same letters are not significantly different according to Duncan test. Factors with no letter do not significantly differ across types.
+The higher the value is the higher the level of education and economic dependency on the income obtained by the farm.

Type C farmers

The main feature of the C type farmers is their high education level (Table 2). On average, they own less land that the previous two types of farmers although with quite a lot of variation (Figure 1). They are relatively young farmers with a medium dependency on the farm income. They, together with Type E farmers, are the farmer types that started breeding ANI animals later, as average in 1992 and 1991 respectively. Therefore, their main capital is the institutionalized cultural capital with low embodied cultural capital and medium economical capital (Table 3).

Type D farmers

The D type is the most common type among the ANI farmers (n=26). The D type farmers are landless farmers with the lowest education of all (Table 2). This means low capital farmers both in terms of economic and institutionalized cultural capital (Table 3). The D type farmers are mostly middle-aged people and highly dependent on the farm income. Like type A and B, they have long experience in keeping ANI animals which had given them a good knowledge about the breed and the main strength in terms of embodied cultural capital.

Table 3 Distribution of *the different forms of capital among the farmer types*

Types of farmers	Economical capital	Institutionalized cultural capital	+Embodied cultural capital
Type A	High	Medium-high	High
Type B	Medium-high	Medium-low	High
Type C	Medium	High	Low
Type D	Low	Low	High
Type E	Low	Medium	Low

+Embodied refers to the cultural capital related to the knowledge on the ANI breed and its production system due to BREED YEARS and AGE.

Type E farmers

The farmers in this group do not own a large proportion of land but, opposite to the type D farmers, have a middle level education (Table 2). They are still dependent on the farm income but considerably less than type D. They are young farmers and have started raising ANI animals more recently than the A, B and D farmers. Therefore type E farmers have medium institutionalized cultural capital, low embodied cultural capital and also low economical capital (Table 3).

Relationship between the farmer types and various farm/farmer profile descriptors

The two socioeconomic variables that showed significant differences among the farmer types (Table 4) were FULL-TIME farmers and FAMILY OF FARMERS. The type B and D farmers (or less educated farmers) came always from a farming family background while more than 20% of the type A farmers lacked previous family connection to farming. A similar situation was found in the dedication to farming; the type A farmers had the lowest (47%) proportion of FULLTIME farmers among all the types which excluding the type A had over 80% FULLTIME farmers.

The types of farmers were also associated with the variation in farm profiles. The statistically significant farm profile descriptors are included in Table 4. The type A farmers had the highest Nº OF EMPLOYEES and also the largest farm sizes in ha and Nº OF DAMS. The type B farmers were related to quite large farms while the types C, D and E had similar and smaller farms. TRANSHUMANCE seems to be related to the percentage of owned land with the landless types (D and E) being most occupied in transhumance while no type A farmers followed this practice. Finally, the farmer types also differed statistically in Nº OF EMPLOYEES they hired. The type A farmers (land owners) were the ones that hired the highest number of employees while the landless types (D and E) had almost no hired labor.

Table 4 *The averages of farmer/farm features exhibiting significant variation across the farmer types*

		Farmer types				
		Type A	Type B	Type C	Type D	Type E
Features		n=19	n=5	n=13	n=26	n=16
Farmer features	+Family of farmers	79% a	100% ab	92% ab	100% b	94% ab
	+Full-time	47% a	100% b	83% b	81% b	81% b
Farm features	*Farm size (ha.)	677 a	554 ab	277 b	365 ab	392 ab
	*Nº of dams	171a	173 ab	95 b	94 ab	91 ab
	+Transhumance	0% a	20% ab	15% ab	27% b	44% b
	*Nº of employees	2.1 a	1.2 ab	0.85 b	0.12 b	0.18 b

*Farmer types are statistically different (p<0.01) in an ANOVA test. Same letters are not significantly different (p<0.05) according to Duncan test.
+Same letters are not significantly different (p< 0.05) according to Fisher exact test.

Management decisions

Herd size and variation in the breed composition of the herd.

Some trends were observed in herd size variation over the last ten years (Table 5). The types C, D and E farmers tended to increase the size of the herd some 20% while the types A and B farmers tended to keep it constant. The variation of the importance of ANI dams in the herd during the last ten years caused statistically significant differences among the types of farmers. On average, the type A, B and D farmers considered ANI dams more important with an increment of 29, 38 and 170%, respectively. On the contrary, landless types (D and E) increased slightly the number of ANI cows. However, future planning did not seem to differentiate the farmer types (Table 5). All types of farmers, except the type B, planned to increase the herd size (12 - 20%) in the coming 5 years. In addition, they were also planning to focus on the ANI breed by increasing the number of ANI dams 37 - 51% in their farms. Due to the small number of the type B farmers, their low values in these features (Table 5) were highly influenced by one farm that is disappearing. The other four farmers for the type behaved like the rest of the types.

Breeding aims

Table 5 Variation for *management decisions across the farmer types*

		Farmer types				
		Type A	Type B	Type C	Type D	Type E
		n=19	n=5	n=13	n=26	n=16
Past variation[1]	Nº of dams (Avg. perc.)	0%	7%	18%	20%	24%
	*ANI cows	29% a	38% a	170%ab	12% b	10% b
Future variation[2]	Nº of dams (Avg. perc.)	20%	-13%	12%	18%	15%
	ANI cows	47%	-4%	37%	51%	44%
Breeding aims	Avg. proportion of animals sold for slaughtering	74%	83%	82%	91%	90%
	Avg. proportion of cows sold as dams	4%	2%	2%	4%	9%
	**Avg. proportion of animals sold as breeding animals	22 %a	15% ab	16% ab	5% ab	1% b
Common activities	+Use of common fattening facilities	37%a	0%ab	23%ab	19%ab	12.5%b
	Sold beef under the ANI breed label	58%	40%	46%	54%	44%
	++Give and receive help from other farmers	47% a	80% abc	69% ab	96% c	100% c

*Same letters are not significantly different (p<0.05) according to Wilcoxon test.
**Same letters are not significantly different (p<0.055) according to Duncan test.
+Same letters are not significantly different (p< 0.1) according to Fisher exact test.
++Same letters are not significantly different (p< 0.05) according to Fisher exact test.
[1]Variation in the last ten years.
[2]Planned variation for the coming five years.

Some differences related to the farm objectives were found across the types of farmers (Table 5). The type A farmers focused more on selling breeding animals than the type D and E farmers. Over 20% of the animals sold by the type A farmers were breeding animals while this percentage was 5 and 0.5% in the D and E types of farmers, respectively. Obviously the proportions of animals sold for slaughtering were opposite: around 90% by the type D and E farmers and down to 74% by the type A farmers.

Involvement in common activities

The proportion of farmers involved in common activities depended on the activity and varied among the types of farmers (Table 5). The type A farmers had the highest proportion using the fattening facilities (37%) shared by the Breeders' Association members. This percentage was below 23% in the rest of the types with the extreme case of the type B farmers with no member using this facility. The percentage of farmers selling beef under the ANI breed label was far more balanced across the types from 58% of the type A farmers to 40% of the type B. The collaboration between farmers in narrowly targeted activities was very important among the landless farmers. Over 95% of the D and E farmers practiced this kind of collaboration. This kind of activity is still important in the types B and C (80 and 69%, respectively) but much less (47%) in the type A.

Subsidy dependency

All the interviewed farmers were very responsive to the questions about the scenario of subsidy removal. In that respect, more than 50% of cattle keepers will either abandon raising the ANI breed animals or decrease the number of ANI dams. Over 50% of the type B, C and D farmers will stop maintaining the ANI breed if subsidies were removed. However we found statistical differences among the types regarding the reaction to the hypothetical case of no subsidies (Table 6). The type A and E farmers seemed to be less dependent on subsidies than the others, i.e. 40% of the farmers in both types would not change the farm size if subsidies were removed. Even 5% and 6% of the type A and B farmers, respectively, considered increasing the number of ANI dams. However, the type E farmers were different from the type A ones with 30% and 16% quitting keeping farming after the change.

Table 6 *Farmers' response to subsidy removal across the farmer types*

	Farmer types				
	+Type A a	Type B b	Type C ab	Type D b	Type E ab
Disappearing farms	16%	80%	54%	54%	31%
Farms decreasing number of ANI dams	42%	0%	23%	23%	25%
No changing farms	37%	20%	23%	23%	38%
Farms increasing number of ANI dams	5%	0%	0%	0%	6%

+Farmer types with same letters are not significantly different ($p < 0.05$) according to Fisher exact test.

Discussion

Emtage *et al*. (2007) state that landowners typologies that seek to consider their values and attitudes in a broad sense, fail to give sufficient details about their practices to understand how to improve the productivity of their enterprises. In this study we have aimed to construct typology based on easily measured variables, which reflect the farmers' economic and cultural capital, and to analyze how the farmer types differ in farmers' decision making concerning the on-farm breed development. We have used the ANI cattle breed to typify its farmers starting from a limited number of variables indicating economic and cultural capital. We divided the ANI farmers into five groups based on their formal education level and on the percentage of farmland they own. The farmers also differed in age, the relative importance of the farm income over the total family income and the number of years keeping the ANI animals. We have used the generated typology for a variety of purposes which supports the idea that general typologies might be useful as suggested by Landais (1998). The farmer types we have described differed also in other socioeconomic aspects that were not included in the typology definition and they raise the cattle in cattle farms with different profiles. Furthermore, we have seen how the farmer types make different management decisions on changing the farm size, on the aims of operations and the future plans reflecting of the hypothetical subsidy variation. All these relationships between the types and the variables not used in the clustering procedure validate the determined typology (Emtage *et al,* 2007).

Relationship between types of farmers and economic and cultural capital

There is documented evidence on how economic and cultural capitals, in particular the institutionalized cultural capital, are linked (Bordieu, 1986; Throsby, 2001); the amount of economic capital held by a person facilitates the access to other types of capital. We have corroborated that economic and cultural capitals are not independent forms of capital and further showed how they interact in the different farmer types. In addition, although we did not actually focus on social capital, we found out that the farmers with more economic and institutionalized cultural capital had also more social capital in the sense that they were more involved in social networks and cooperation related to the local breed (see discussion section “Farmer types and management decisions). As Bourdieu (1986) notes, social capital is never independent as it is always linked with cultural and economic capital.

In many farmer typology studies, education is often used as a socio-economic variable in identifying farmer types (Siegmund-Schultze and Rischkowsky, 2001; Emtage *et al.*, 2006). Farmers are usually classified according to their education level, that is to say their institutionalized cultural capital. We realized that institutionalized cultural capital is often related to more dynamic decision-making, entrepreneurship vision on farming and less dependency on subsidies. The farmers with lower institutionalized cultural capital (B and D) tended to be older than the more formally educated ones (C and D). This of course reflects the evolution of the Spanish society with an increase in the general education level over the last decades. However, type A farmers that are also older are medium-high educated but they also had high economic capital. This is an example of how economical capital might be related with institutionalized cultural capital, since traditionally the members of families with more capital were more likely to also maintain it (Bourdieu, 1986). The type A farmers are the least dependent on the farm income while farmers with low institutionalized cultural capital (types B and D) were the most dependent. Therefore, traditionally with more institutionalized cultural capital a farmer was less dependent on the income from the farm he was living in. It seems that the older farmers (A, B, D types) showed more diversity in terms of institutionalized cultural capital and economic capital than the younger ones. These latter ones (types C and E) were more balanced in terms of institutionalized cultural capital.

Relationship between types of farmer and farm profiles

The ANI farmer types were much more complex than what we had previously seen. Typologies have evolved with the changes in the Spanish society with people having more access to institutionalized cultural capital which might be related to a higher entrepreneurial attitude related to ANI cattle production as is discussed in the last but one paragraph of discussion section “Farmers types and management decisions”. On average, the land owners used to have the largest farms both in ha. and in the number of cattle and they still do so and usually they hired people to work in the farm which they continue doing now (Table 4). Landless farmers moved and moved their cattle in the summer to mountain pastures that are public common lands. In the autumn they moved down and still move their animals either to the pasture they have hired or own around the villages in the valleys or do transhumance to southwestern Spain (where the weather is far gentler) where they hire land. On the other hand, the type B farmers, who own farmland and practiced and still practice transhumance, used to own and still own properties in both the mountains and southwestern Spain. We could see the types C and E as evolvements to the types B and D through acquiring more institutionalized cultural capital. We can see in Table 4 what a remarkable proportion of these four types of farmers are still doing transhumance, which is used to optimize the use of pasture production and reduce the feeding cost. The statistical clustering of the farmers seems to be reflecting the real situation and history of the ANI breed showing again the validity of the developed typology.

Both types of low educated farmers (types B and D) came always from a farming family, while this was different for the other types. There might be two kinds of new farmers. On one hand there are people with high economic capital who already own land or buy land and decide to raise ANI animals. They could be classified as *Sustainable* or *Traditionalist* farmers according to Soini *et al*. (2012). On the other hand, we have young people living in the rural areas who decide to raise ANI breed cattle since they see the activity as a feasible way of living in the villages. This type of farmers would be the *Opportunistic* farmers defined by Soini *et al.* (2012).

To conclude, we have shown how different types of farmers with different cultural and economic capital run different types of farms. Thus, we might have to consider farmer-farm as a duo. Therefore when adjusting the breed development strategies to a farm (Landais, 1998) we should have to take into account the socioeconomic features of its farmer and the expected reactions and management decisions. The link between the farmer type and management decisions is discussed in the following section.

Farmer types and management decisions

The farmer type C and landless farmers with medium and low education (D and E) have increased the total size of their herds with some 20% while the other two types have more or less maintained the size (Table 5). The changes in the herd size might be related to an improved farm profitability since the other types (A and B), typically with higher economic capital, were the ones that had smaller increments in the farm size. Ten years ago the herd size of the C, D and E farmers was on average 54, 41 and 69 dams, respectively. These figures were 38, 29 and 49% of the herd size on the type A farms which at that time had on average 142 cows. Nowadays, the herd size on the types C, D and E, farms have on average increased up to 95, 94 and 91 dams, respectively. These values are 56, 53 and 55% of the current average herd size of the type A farmers (171 cows). Although the past differences in the farm size across the types have reduced, they are still remarkable.

The evolution of the importance of the ANI breed over the past ten years showed a different figure. Ten years ago, the breed had the highest relative importance within the herd of the type A, B and D farmers; the ANI dams represented on average 76, 68 and 69% of the total number of dams in the herd, respectively. Meanwhile the type C and E farmers were less devoted to the ANI breed, where the proportions were 41 and 53%, respectively. These differences are related to the level of embodied cultural capital attached to the ANI breed by the former types of farmers. The current focusing by the type C farmers on the breed might, in turn, be related to an opportunistic attitude (Soini *et al.*, 2012) towards the breed. The attitude could be based on the increase of social support to indigenous breeds that is exploited in the subsidy programmes and on the increased demand of the ANI breed products. In any case, nowadays the importance of ANI breed across the farm types is far more balanced than in the past ranging from 69% to 81% (results not shown).

The future plans regarding farm size are in line with the past trends although the differences among the farmer types are somewhat reduced. All the farmer types, except type B, planned to increase the farms size and to focus even more on the ANI breed. In this way the differences in the prestige of the ANI breed might be reduced among the farmer types; the proportion of ANI dams in the herd will represent from the average 80% of the type B farms and to the 88% of the type C farms.

The type A farmers sold a high proportion of breeding animals while types D and E mainly focused on beef production. The type A (and B) farmers were the ones who founded the Breeders' Association and their families have been always linked with the breed. In this sense there is a link between cultural, economic and social capital (Svendsen, 2001). The type A farmers invested their high economic and cultural capital in creating the ANI Breeders' Association and therefore created social capital that would be useful in the future, as it has been the case (e.g. the creation of the breed label, creation of an integrated production system "from farm to fork"). As suggested by Coleman (1988) the social capital created (embedded in the Association) benefits not only the farmers that created the Association but also all the farmers that have joined it afterwards or will do so in the future. However, the type A farmers might be retained more of it than the rest since they have the highest prestige within the ANI breeders in line with Bourdieu's (1986) example on nobility title. This prestige is translated into the higher demand of breeding animals from their herds than from a herd of other types of farmers. This obviously benefits the type A farmers and is somehow an economic benefit of the investment they made when building up the Association. One of the key issues for the future of the breed is whether or not the prestige of farmers is related to the genetic level of the animals. Vassallo *et al*. (1989) found out that the average level of performance of herds did not agree with the layer they occupy in the pyramidal structure of the ANI breed development programme Vassallo *et al*. (1986). Thus, the herds in the top nucleus (closely connected to the type A farmers, see "Breeding aims" in Management decisions section of Results) that were supplying breeding bulls to the rest of the population, did not seem to have the highest genetic level. However, after that a selection programme was established and farmers have objective animal records (estimates of breeding values) available for selection criteria to help them on the purchase of animals. One of the key implications of this finding for the future of the breed is whether or not the prestige of farmers is related to a sound use of the selection tools.

The type A farmers are also the main users of common fattening facilities since they have the economic capital for investing and taking risks and the cultural capital to foresee the benefit from the activity. The type C, D and E farmers have lower economic capital to invest and may also be more reluctant to implement common activities, possibly due to the lower institutionalized cultural capital of the type D farmers and embodied cultural capital of the types C and E. However, most farmers regardless of the type seem to see the benefit in marketing the products under the breed label. This activity does not require investments, it is easy to carry out and the benefits are evident to all of them. The ability to collaborate has been identified as an indicator of self-sustainability for local breeds (Gandini *et al.,* 2012, -Chapter 2-).

We found that different types of farmers had different reactions towards the hypothetical variation in subsidies. Although all types of farmers reacted negatively to their removal, the most affected ones were the type B and D, which are more dependent on the farm income and have less institutionalized cultural capital. These features together with the age profile of these farmers may reduce the ability to adapt their farms to changing conditions. Regardless the percentage of farmers abandoning the ANI breed as a reaction to the subsidy removal, it is positive to acknowledge that for the types A and E more the 40% stated their willingness to continue with the ANI cattle raising and more than 20% of the C and D farmers also say so. This scenario emphasized how important the cultural capital is to ensure farmers' future prospects (Burton and Paragahaweva, 2011). We have seen how typologies could help to understand the current situation regarding subsidy dependency. It is true as Takamaa and Soini (2007) and Soini *et al*., (2012, -Annex-) established that there are farmers with low dependency on subsidies, but it is also true as we have observed in the Spanish local beef cattle breeds (data not shown) that there are farmers highly dependent on subsidies.

Conclusions: Strategic and policy implications

The results of our study have some implications for the development of breed strategies. Farmers seem to have different capability and interest in marketing and breeding, as well as in on-farm breeding planning. This confirms the results from the previous studies. There are differences between the farmers' interests in local breeds (Soini *et al.,* 2012, -Annex-): some farmers are keener on animals and breeding itself (Type A - 'sustainable cattle farmers' in Soini *et al*.); some of them see local cattle purely as a form of livelihood (Type C and E - 'opportunists'). This means that there should be a variety of policies, which take into account the differences among the farmers.

Consequently, the typology based on farmers' cultural and economic capital, could be used as indicators, when predicting the farmers' decision-making concerning the on-farm breed development. The results of our study suggest that the high economic and cultural capital will lead to more dynamic and diverse breed management strategies, which might be often effective considering the animal genetic resources policies. However, the farmers with less economic and cultural capital might have high embodied cultural capital related to the breed, which is also valuable capital worth maintaining. Regarding subsidies, the variable dependency we have found across the types of farmers showed that drastic changes in the subsidy programmes may lead to a redistribution of the number of farmer types. This redistribution might have important implications for the development of breeds. Finally, the results of this study highlight the utility of using farmer typologies to foresee the effect of livestock policies and measures.

Acknowledgements

We thank Avileña-Negra Ibérica breeders Association for providing the data and helpful comments for the interpretations of the results of this study. DMC has been funded by the Collaboration Agreement (CC09-009) between INIA and FEAGAS supported by Spanish Ministry of Agriculture, Food and Environment. DMC wish to thank MTT Agrifood Research Finland for financial support for a research stay at MTT Jokioinen during the course of this investigation.

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CHAPTER 5

Combining approaches for the analysis of the genetic structure of the Avileña-Negra Ibérica beef cattle breed

D. Martín-Collado[1], K. J. Abraham[2], M. A.Toro[3], M. J. Carabaño[1], S. T. Rodríguez-Ramilo[1], and C. Díaz[1]

[1]*Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria (INIA), Madrid, Spain*

[2]*Departamento de Biologia Celular, Faculdade de Medicina de RibeirãoPreto, Universidade de São Paulo RibeirãoPreto SP, Brazil*

[3]*Departamento de Producción Animal, Escuela Técnica Superior de Ingenieros Agrónomos, Universidad Politécnica de Madrid, Madrid, Spain*

Combining approaches for the analysis of the genetic structure of the Avileña-Negra Ibérica beef cattle breed

Abstract

Livestock breeds are not panmictic populations but rather have demographic structures that usually are of pyramidal type. These structures are the consequence of farmer's decisions regarding the use of sires. The demographic structure of a breed is correlated with its genetic structure and therefore has important implications for the design of breeding and conservation programs. Nowadays there is a renovated interest in studying the population structure since it can bias the prediction of genomic breeding values and GWAS. In this paper we first assessed the utility of graphical clustering algorithm (GCA) to identify the genetic structures of real livestock populations comparing it to Bayesian clustering algorithm (STRUCTURE). We paid particular attention to the influence that the presence of close related individuals and the genetic differentiation of subpopulations can have on the population structure inferences. To do so, we evaluated the performance of the algorithms in simulated populations. Then we have inferred the genetic structure of the population of the Spanish cattle breed Avileña-Negra Ibérica (ANI) by the analysis of a data set of 13343 animals from 57 herds that were genotyped for 17 microsatellites. The results have been interpreted to the light of information obtained from the herdbook of the breed such as the probability of breed origin and the classification of herds between "genes recipients" herds (herds that buy sires from other herds) and "gene contributors" herds (herds that buy and sell animals). For the simulated scenarios, when F_{ST} was sufficiently high, both algorithms consistently inferred the correct structure of the simulated populations regardless of the presence of related individuals. However, when genetic differentiation among subpopulations was small, STRUCTURE identified the familiar structure while GCA did not provide any consistent picture. The GCA showed to be a fast method to infer genetic structure with very high ability to determine the core hidden structure of populations with complex history and relationships. GCA could also be used to narrow down the number of clusters to test in STRUCTURE. Both, STRUCTURE and GCA describe a similar structure for the ANI breed. This population has three genetically differentiated subpopulations that could correspond to three linages. These are directly related with the herds with a major contribution into the breed according to the herdbook. In addition, ANI breed has also a loose pool that grouped individuals that constitute an admixture of origins. The clustering profile is coherent with the history of the breed. Finally, we discussed

the potential influence of the demographic structure of ANI breed and the relationships between its farmers on its genetic structure and the implication of this structure for the genetic management of the breed.

Introduction

Livestock breeds do not constitute panmictic populations but rather have demographic structures in which herds are subpopulations with different degrees and patterns of connections (movements of animals) among them. In particular, this is the case of populations where artificial insemination is not extensively used as in the case of many local livestock breed populations raised under extensive production systems. Most of the time, the demographic structure of these breeds is of pyramidal type. A pyramidal structure is consequence of farmers' decisions regarding the use of sires (Vasallo and Díaz, 1986). This demographic structure of a population is correlated with its genetic structure and has a strong influence on two key parameters of conservation genetics: the genetic variability and the inbreeding. Therefore, the demographic structure of breed population has important implications for the design of breeding and conservation programs since it affects its genetic status which is a key issue for its future perspectives.

On the other hand, nowadays genomic information is leading changes in livestock industry which seeks to implement genomic selection in order to achieve a faster genetic improvement of livestock. Population stratification could cause bias on the prediction of genomic breeding values as well as on the results of GWAS (Janss *et al.*, 2013). In addition, the molecular information is being widely used for the study of population studies such as linkage disequilibrium patterns across breeds (Badke *et al.*, 2012; Lu *et al.*, 2012). Population stratification could also be an issue if it is not taken into account when sampling animals. Therefore, there is nowadays an added interest to study the demographic and genetic structure of livestock populations.

The best way to describe the genetic structure of the breed is by genealogical analysis. However, the usefulness of pedigrees is strongly determined by its depth, i.e. the number of generation for which information is available. Unfortunately, the quality of pedigree records in local breeds is usually rather poor (Gutiérrez *et al.*, 2003). Several methodologies have been developed to study the genetic structure of a population using molecular markers. These methodologies have been developed in ecology to detect hidden structures of natural populations where demographic or pedigree records are not available or are incomplete or unreliable. The Bayesian methods and in particular STRUCTURE (Pritchard *et al.*, 2009) has become very popular. However, STRUCTURE has also some limitations. Pritchard *et al.* (2009) warned that it could overestimate the number of clusters when closely related individuals are present in an evaluated data set. This issue was investigated by Rodríguez-Ramilo and Wang (2012) and they suggest that when closely related individuals are suspected to be frequent in a sample, these individuals should be first identified and removed before conducting a population structure analysis. There are other non-bayesian approaches such as the distance methods *(*Rodríguez-Ramilo *et al*., 2009*)* or the Principal Components Analysis (Patterson *et al*., 2006) that also works reasonably well. In this chapter we introduce two new algorithms; one of them was previously used in the context of system biology (Williams *et al.,* 2011). They make use of the molecular coancestry matrix to determine the most genetically isolated individuals and built on them the subpopulations. We compare this new method with STRUCTURE using simulated populations and real microsatellites data of the Spanish local cattle breed Avileña-Negra Ibérica (ANI).

ANI breed is an example of a population with complex relationships. The genealogical structure of the breed was studied some decades ago by Vasallo and Díaz (1986). They found that ANI breed had a pyramidal structure with around six percent of the herds being the "nucleus" herds. Nucleus herds were defined as herds that never used sires from other herds and that usually sell sires. They also found that the majority of herds recurrently bought bulls from the same leading herds. Therefore, the genetic status of the breed was highly dependent on the genetic management of those few leading herds. Since then the ANI population has evolved. Recent studies in this breed, have allowed us to identify farmers typologies and the implication of those types in their past, present and future breeding decisions (See Chapter 4). Thus, it is important to assess if changes in the demographic structure of populations generated by farmer decisions may have an impact on the dynamic. If so, it will highlight the complexity of predicting the genetic status of existing population just by taking into consideration genetic indicators.

Thus, this work has four main objectives. First, to assess the utility of graphical clustering algorithms (GCA) to identify the genetic structure of livestock populations. Secondly, to study the performance of such algorithm compare to Bayesian clustering algorithms (STRUCTURE). Thirdly, to study the current genetic structure of Avileña-Negra Ibérica beef cattle breed and, finally to identify implications of this structure for the genetic management of the breed.

Material and Methods

Material

The Avileña-Negra Ibérica cattle breed, which is one of the most important autochthonous beef cattle breeds in Spain, is reared under very extensive conditions. Its breed society was formed in 1970 (Vasallo and Díaz, 1986) and is under a selection program since 1990. Since 2005 the Breed Society has made a great effort to assess the pedigree using a panel of 17 microsatellites. As a result, they have made available to us a database of 13343 individuals from 57 herds. The number of animals genotyped per herd goes from 10 to 1019 animals. Table 1 summarizes the number of alleles and the expected and observed heterozygosity found in this database. None of the microsatellites is in Hardy-Weinberg equilibrium (HWeq). The high number of alleles and a high value for the observed and expected heterozygosity should be noted. The observed heterozygosity is below what would occur if mattings among relatives were avoided (Toro *et al.*, 2011) as it has been the case. This also explain the negative values (-0.043) of the F_{IS} Wright' fixation index (Wright, 1965). The F_{ST} differentiation index among herds was on average 0.089, ranging in the different microsatellites from 0.071 to 0.115. Finally, the average molecular coancestry between (f_{ii}) and among (f_{ij}) herds was 0.342 and 0.277 respectively. The estimation of the different statistics was made with Metapop (Perez-Figueroa *et al.*, 2009) except for the HWeq which was calculated with Genepop (Rousset, 2008).

In order to reduce the presence of closed related individuals in the sample we extracted from the complete data set of 13343 animals (13343 dataset in the rest of the chapter) a small set of 3996 trios, father-mother-offspring based on pedigree information. The validity of the trios was confirmed with the microsatellites information. The corresponding offspring constituted the 3996 dataset. The animals came from 39 herds and the number of animals varied from 10 to 572 animals. HWeq was also very low in this 3996 data set; only one of the microsatellites was in HWeq. F_{ST} differentiation index, f_{ii} and f_{ij} values among the 39 herds where very close to those of 13343 dataset; *avg.* F_{ST}=0.092 (0.077 to 0.116 in the different microsatellites), f_{ii}=0.345 and f_{ij}=0.277)

Table 1 *Summary statistics in the microsatellite marker analysis showing the average number of alleles per locus, observed and expected heterozygosity*

Microsatellites	Nº of alleles	0bserved Heterocigosity	Expected heterocigosity
BM1818	9	0.626	0.654
BM1824	6	0.680	0.717
BM2113	11	0.817	0.852
CSRM60	10	0.643	0.689
ETH3	10	0.717	0.747
ETH10	9	0.690	0.721
ETH185	13	0.706	0.727
ETH225	8	0.731	0.762
ILST006	12	0.790	0.836
INRA005	5	0.643	0.661
INRA023	11	0.741	0.765
INRA063	6	0.557	0.577
SPS115	8	0.374	0.387
TGLA53	18	0.781	0.811
TGLA122	22	0.831	0.858
TGLA126	8	0.684	0.726
TGLA227	13	0.803	0.830
Average	10.5	0.695	0.725

Simulation methods

We analysed some of the situations simulated by Rodríguez-Ramilo and Wang (2012). The allele frequencies at a locus for the entire population, p_i (i = 1, 2,…,k), were drawn from a uniform Dirichlet distribution, with all parameters setting a value of 1. Using these allele frequencies and the parameter F_{ST} the allele frequencies of subpopulation j, p_{ij} (i = 1, 2,…, k) were then also drawn from a Dirichlet distribution with parameters $p_i\ (1 - F_{ST}) \,/\, F_{ST}$. The genotypes of full-sib individuals with a given relationship from a given subpopulation were then generated for each marker locus using the allele frequencies of the subpopulation. We simulated four populations, all of them with n=3 subpopulations, N=150 sampled individuals, 50 individuals per subpopulation and 20 microsatellites with 20 alleles. Three populations were studied with F_{ST}= 0.2, the first without siblings, the second with a family of 16 full-sibs in one of the populations and the third with a family of 16 full-sibs in each of two subpopulations. The fourth population was equal to the second but with a F_{ST}=0.01.

Methods to infer population structure

Two main approaches to infer population structure were used. The first was the widely used model based algorithm implemented by STRUCTURE (Pritchard *et al*., 2000) and the second was a graphical clustering algorithm (GCA) that was developed in the context of system biology (Williams *et al*., 2011) and has been adapted to infer genetic structures for this study.

Method implemented in STRUCTURE

It is a bayesian clustering algorithm that can assign either the individuals or a fraction of their genome (a proportion of inferred ancestry) to a number of clusters (K) based on multilocus genotypes. The method operates by maximizing HWeq and minimizing linkage disequilibrium (LD) and involves Markov Chain Monte Carlo (MCMC) approaches. The parameters for the implementation of STRUCTURE comprised a burn-in of 10000 replicates following 10000 replicates of MCMC. Specifically, the admixture model and the option of correlated allele frequencies between populations were selected. Lambda, the parameter of the Dirichlet distribution of allelic frequencies, was set to one, as advised by the Structure manual. For each data set, ten runs were carried out for each possible number of clusters (K) in order to quantify the variation in the likelihood of the data for a given K $(L(K))$. The range of tested K was set according to the true number of simulated populations and of the total number of herds (57) analyzed in ANI breed data sets. To determine K we use Evanno's *et al.* (2005) criterion based on an *ad hoc* quantity based on the second order rate of change of the likelihood function with respect to K (ΔK). They suggest to estimate ΔK as $avg\ (|L(K + 1)-2L(K)+L(K - 1)|)\ /\ sd\ [L(K)]$, where *avg* is the arithmetic mean across replicates and *sd* is the standard deviation of the replicated $L(K)$. The value of K selected will correspond to modal value of the distribution of ΔK. The grouping analysis was performed on the results from the run with the maximal value of the likelihood of the data for the estimated K.

Graphical clustering algorithm

The algorithm starts from a symmetric matrix whose off-diagonal elements are the values of the correlation between the corresponding elements to be clustered. In our case, the matrix contains the molecular coancestry among all individuals present in each of the study cases.

The algorithm runs in two steps. First, all possible independent hub nodes (in our case individuals) are identified using a modification of a method shown in (Abraham and Fernando, 2012) and second, clusters are found using a self-avoiding random walk (walk that do not visit the same point more than once) on the lattice defined by the graph where the starting points of the walk are all hub nodes as described in detail in (Williams *et al*., 2011).

1st step. To define independent animals the user defines two thresholds (values of molecular coancestry). The first threshold is the one below that the animals are declared to be independent. The algorithm of Abraham and Fernando (2012) has been modified in such a way that in each step the next animal added to the list of independent animals is chosen so that it is distantly related (below the first threshold) to all animals already in the list of independent animals and it is also closely related (above a second threshold) to as many animals in the population as possible. The output of the algorithm is then a list of animals that are all mutually independent of each other but also closely related to as many other animals as possible. This second requirement is the key difference from earlier work (Abraham and Fernando, 2012). As in earlier work, the algorithm is a stochastic algorithm; therefore the key point is how to choose the starting node because it could condition the results. Thus, a number of sweeps is required to determine a consistent set of independent animals. In each run, the number of sweeps was 150. Three different sets of thresholds have been used to declare independent animals. The thresholds were established according to the percentile distribution of molecular coancestry values. Thus, for the first threshold the percentiles 1.25, 2.75 and 5 were tested. For the second threshold, the value 0.9 was used which is a value higher than the maximum entry in the molecular coancestry matrix. The choice of final independent set of animals (which will be the representatives of the clusters and to which the rest of the animals of the subpopulation will be aggregated in the 2nd step) was based on the sum of the number of occurrences of the members of the independent set in all the sweeps.

2nd step. A cluster is constructed from each of the animals included in the set of independent animals (we will call this animals cluster nodes) by adding animals that are closely (above a given threshold) related to all animals that are already present in the cluster using methods described in (Williams *et al*., 2011) Thus, the final cluster includes only animals that are mutually closely related. This clusters construction is repeated several times (sweeps) because the algorithm is stochastic in nature; successive clusters from the same starting animal may not be identical. The final choice on which animals to include in a given cluster is made by choosing only animals which appear in 10% or more of the total number of sweeps. Once this procedure is repeated for all cluster nodes, we get a groups of animals clustered around every node. This is a quite conservative procedure to cluster animals and hence we will call these clusters "tight" along the paper.

It may turn out that certain animals are associated with more than one cluster node by our conservative definition of clustering, suggesting that certain animals are linked to more than one cluster, i.e. sub-population. We use a posterior probability for belonging to a cluster to determine the definitive cluster to which these animals are assigned. This posterior probability is defined as follows: let there be m starting points and for some animal let $\{n_1, n_2, \ldots, n_m\}$ be the number of times this animal is assigned to a cluster. In this case, the posterior probability for assignment to a cluster around some starting point *j* is defined by $n_j / \sum n_i$ where the sum in the denominator runs over all starting points. In this point of the algorithm the procedure for assignment to clusters is very conservative, thus there may be many animals, which do not really fit into any clusters as defined above. In this case, the assignment of animals to clusters proceeds by seeing to which tight cluster the "close relatives" of each animal belong to. More precisely the posterior probability for assigning some animal to a preexisting cluster is defined by n_j / N where n_j is the number of "close relatives" of that animal, which are present in some pre-existing tight cluster and N is the total number of "close relatives" of that animal in the total data set. Therefore, new animals could be added to the tight clusters by a less conservative criterion; we will name this group of animals "loose pool". Two different thresholds for this second step were used. Those corresponded to the percentiles 75 and 80 of the distribution of the molecular coancestry values of the data set.

Herdbook Study

We analyzed the ANI breed herdbook of the Breed Society to complement and interpret the result genetic analysis. The herdbook included data of 209694 animals belonging to 732 herds. In order to assess the gene flow among herd, these were classified as only "genes recipients" herds (herds that buy animals from other herds but do not sell) and "gene contributors" herds (herds that buy and sell animals). We also calculated the ratio of use of the own bulls versus the use of bull from. To study the contribution of the different herds to the genetic composition of the ANI breed, we calculated the probability of gene origin of the ancestors (Boichard *et al*., 1997) and then we summ up the contribution values of the ancestors belonging to each herd. The reference population consisted of all animals in de pedigree with known sire and dam. To do so, we used ENDOG, version 4.6 (Gutiérrez and Goyache, 2005).

Results

Analysis of simulated populations

Results of STRUCTURE and the GCA for the simulated populations are shown in Table 2. Both methods correctly inferred the number of subpopulations of the cases with F_{ST}=0.2. GCA correctly inferred the structure of these cases regardless of the thresholds used in the 1st and 2nd steps of the algorithm. This was so regardless of the presence or not of close relatives. Furthermore, all individuals were correctly assigned to their corresponding subpopulation with a very high probability of assignation. In STRUCTURE software we use the proportion of inferred ancestry as a measure of the probability of assignation of individuals to clusters. Opposite to the first three simulated cases, the genetic structure of the forth case with a F_{ST}=0.01 was incorrectly inferred by STRUCTURE. However, the GCA did not clearly identify any structure. The number of independent nodes (this is the number of inferred clusters) varied from 2 to 4 depending on the thresholds used. The number of independent nodes increased as the threshold relaxed; 2 cluster for the threshold of the percentile 1.25, 3 for the percentile 3.75 and 4 for the percentile 5.

Looking into detail the results of the inference of the structure of case 4, we saw that one of the two clusters determined by STRUCTURE was actually the 16-full-siblings family. The other cluster was formed by the rest of the individuals of the simulated population, this is 134 individuals. However, for the GCA if, by chance, one of the individuals of the family was selected as one of the cluster nodes, then, in the next step of the algorithm, all the family members together with other individuals were aggregated to that cluster.

Table 2 *Description of simulated populations and the structure inferred by STRUCTURE and the Graphical Clustering Algorithm*

Simulations			STRUCTURE			Graphical clustering algorithm		
+Population	Relatives	F_{ST}	Nº of inferred clusters	Percentage of individuals correctly assigned	Nº of individuals with a proportion of inferred ancestry >0.9	+++Nº of inferred clusters	Percentage of individuals correctly assigned	Nº of individuals assigned with a probability of >0.9
1	No	0.2	3	100%	148	3	100%	150
2	1 family of 16 siblings	0.2	3	100%	149	3	100%	149
3	++2 families of 16 siblings	0.2	3	100%	149	3	100%	150
4	1 family of 16 siblings	0.01	2	-	-	2-3-4	-	-

+Simulated population consisted of 150 individuals divided in 3 subpopulation of 50 individuals each.
++The two families are each in one different subpopulation.
+++ GCA correctly inferred the structure of these cases regardless of the thresholds; Results shown correspond to the inference with thresholds 1.25 and 80 for the 1st and 2nd step of the algorithm respectively.

Analysis of the genetic structure of Avileña-Negra Ibérica population

STRUCTURE solution

STRUCTURE inferred 3 genetic clusters in the 13343 data set and 2 in the 3996 data sets (Table 3). However, we also analyzed the case of 3 clusters for the 3996 data sets to compare it with the previous data set. For both data sets we proceed similarly; firstly we analyzed the clusters including all the animals of the data sets and secondly we analyzed the case in which the clusters are formed only by those animals with at least 90% of their genome (this is proportion of inferred ancestry) assigned to a specific cluster. We will call these groups PB90 cluster and their corresponding animals PB90 animals in the rest of the paper. The PB90 animals represented between the 24% (in the 3 clusters of the data set 13343) and the 47% (in the 2 clusters of the 3996 data set) of the total number of animals.

The number of loci in HWeq increased with respect to the original situation where data set are considered an unique population (Table 3). The highest HWeq was achieved in the PB90 clusters what is expected because STRUCTURE looks to maximize HWeq. There was a parallel change in the F_{ST}. Although the F_{ST} of the clusters never reached the F_{ST} of the original data sets (considering herd as subpopulations), in the cases of three PB90 clusters F_{ST} values were very close. For the 3996 dataset F_{ST} increased when going from 2 to 3 clusters.

Table 3 *Descriptive statistics of the genetic structure of ANI population inferred by STRUCTURE*

$^{+}$Data set	Nº of herds	$^{++}F_{ST}$	$^{+++}$H-W eq.	Nº of inferred cluster	Cluster	Nº of individuals		H-W eq.		F_{ST}	
						All indiv.	$^{\#}$PB90 indiv.	All indiv	PB90 Indiv.	All indiv	PB90 Indiv.
13343	57	0.089	0	3	1	3077	1134	12	16	0.026	0.083
					2	6055	1054	4	9		
					3	4211	1015	7	11		
3996	39	0.092	1	2	1	1943	914	5	7	0.019	0.044
					2	2053	979	5	11		
				$^{\#\#}$3	1	1009	439	13	17	0.032	0.078
					2	1446	454	5	9		
					3	1541	516	6	8		

$^{+}$The data set name refers to the population size.
$^{++}F_{ST}$ is calculated considering herds as subpopulations.
$^{+++}$The number refers to the number of loci in H-W equilibrium considering all individuals as a unique population. Total nº of loci is 17.
$^{\#}$Individuals with a proportion of inferred ancestry >90%.
$^{\#\#}$The number of cluster inferred is 2 but we also analized the 3-cluster case to compare it with the 3 clusters inferred from the 13343 data set.

Table 4 *Molecular coancestry within and across the clusters (f_{ii} and f_{ij}) of the Avileña-Negra Ibérica population inferred by STRUCTURE*

Data set 13343							
All individuals clusters				$^{+}$PB90 clusters			
Clusters	1	2	3	Clusters	1	2	3
1	0.307	0.268	0.263	1	0.343	0.244	0.241
2	0.268	0.287	0.266	2	0.244	0.311	0.239
3	0.263	0.266	0.294	3	0.241	0.239	0.343
Data set 3996							
All individuals clusters				PB90 clusters			
Clusters	1	2	3	Clusters	1	2	3
1	0.312	0.272	0.264	1	0.340	0.252	0.247
2	0.272	0.294	0.266	2	0.252	0.316	0.248
3	0.264	0.266	0.302	3	0.247	0.248	0.346

Elements in the diagonal of the matrices correspond to the molecular coancestry within clusters (f_{ii}) while those off-diagonal correspond to the molecular coancestry between clusters (f_{ij}).
$^{+}$Clusters formed by individuals with a proportion of inferred ancestry >90%.

The f_{ii} was higher and the f_{ij} smaller in the PB90 clusters than in the all individuals clusters in both data set (Table 4 and 5); f_{ii} was 26% to 33% higher than f_{ij} in the PB90 clusters and 8% to 15% higher in the all individuals clusters. The differences between the values of f_{ii} and f_{ij} between PB90 cluster and the all individuals clusters were higher in the 3-cluster (*avg* 13%) case than in the 2-cluster cases (*avg* 5%).

Table 5 *Molecular coancestry within and across the clusters of the Avileña-Negra Ibérica population inferred by STRUCTURE*

Data set 3996					
All individuals clusters			+PB90 clusters		
Cluster	1	2	Cluster	1	2
1	0.293	0.265	1	0.311	0.243
2	0.265	0.291	2	0.243	0.302

Elements in the diagonal of the matrices correspond to the molecular coancestry within clusters (f_{ii}) while the off-diagonal correspond to the molecular coancestry between clusters (f_{ij}).
+Clusters formed by individuals with a proportion of inferred ancestry >90%

In Figure 1, it is shown how the individuals of the different herds were distributed across the three clusters inferred for the 13343 data set and among the three and two clusters inferred from the 3996 data set. There were fourteen herds which majority of individuals (above 90%) are always associated to the same cluster (four to cluster 1, and five to clusters 2 and five to cluster 3) in both data set independently of considering all the individuals or those that are associated with PB90 clusters. These herds are highlighted in grey in the table. Then, only in the PB90 clusters, there were other fifteen herds which majority of individuals that (above 90%) were associated to the same cluster (four to cluster 1, seven to clusters 2 and four to cluster 3) in every data set but. Finally, there was another group of twenty eight herds which individuals were assigned to different clusters in both data sets. Focusing on the two-cluster case (last four columns of Figure 1), we observed that, in general terms, clusters 1 and 2 of the three-cluster cases were joined into cluster 1 of the two-cluster case. Herds highly associated to a specific cluster (those highlighted in grey) in the 3-cluster cases, continued to be highly associated to a cluster in the 2-cluster case. Cluster 3 (of case the 3-cluster case) would correspond to cluster 2 (of the 2-cluster case); the herds associated to those clusters (21, 22, 23, 24 and 25) were consistent.

Figure 1 *Distribution of the individuals of the different herds among the clusters inferred by STRUCTURE*

	Data set 13343						Data set 3996						Data set 3996			
	Clusters all indiv.			Clust indiv. p>0.9			Clusters all indiv.			Clust indiv. p>0.9			Clusters all indiv.		Clust indiv. p>0.9	
Herd	1	2	3	1	2	3	1	2	3	1	2	3	1	2	1	2
1	100	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-
2	99	-	-	100	-	-	100	-	-	100	-	-	100	-	100	-
3	99	-	1	100	-	-	100	-	-	100	-	-	100	-	100	-
4	90	10	-	100	-	-	-	-	-	-	-	-	-	-	-	-
5	86	13	1	100	-	-	100	-	-	100	-	-	100	-	100	-
6	85	15	-	100	-	-	-	-	-	-	-	-	-	-	-	-
7	73	25	2	94	6	-	78	22	-	100	-	-	100	-	100	-
8	71	20	9	95	5	-	98	2	-	100	-	-	100	-	100	-
9	1	98	1	-	100	-	-	100	-	-	100	-	94	6	100	-
10	1	93	6	-	100	-	-	-	-	-	-	-	-	-	-	-
11	-	92	8	-	100	-	-	-	-	-	-	-	-	-	-	-
12	-	91	9	-	100	-	-	-	-	-	-	-	-	-	-	-
13	7	91	2	2	96	1	3	97	-	-	100	-	95	5	100	-
14	7	90	3	-	100	-	20	80	-	-	100	-	100	-	100	-
15	9	89	2	-	100	-	-	-	-	-	-	-	-	-	-	-
16	7	88	4	-	100	-	17	78	5	-	100	-	83	17	100	-
17	2	88	10	-	100	-	-	-	-	-	-	-	-	-	-	-
18	6	86	8	-	100	-	-	-	-	-	-	-	-	-	-	-
19	2	85	13	-	94	6	1	83	16	-	93	7	73	27	74	26
20	4	85	11	-	94	6	2	93	5	-	100	-	57	43	94	6
21	-	-	100	-	-	100	-	-	100	-	-	100	-	100	-	100
22	-	-	100	-	-	100	-	-	-	-	-	-	-	-	-	-
23	1	2	97	-	1	99	-	-	100	-	-	100	-	100	-	100
24	4	1	95	-	-	100	3	-	97	-	-	100	3	97	-	100
25	1	6	93	-	1	99	3	2	95	-	-	100	3	97	2	98
26	4	14	82	-	-	100	6	14	80	-	-	100	13	87	-	100
27	5	21	73	-	5	95	1	14	85	-	-	100	6	94	-	100
28	15	14	71	4	-	96	15	10	75	-	-	100	20	80	13	87
29	15	16	69	-	-	100	17	11	72	-	-	100	20	80	7	93
30	-	67	33	-	100	-	-	-	-	-	-	-	-	-	-	-
31	-	38	62	-	22	78	-	8	92	-	-	100	1	99	-	100
32	44	51	5	19	81	-	72	24	4	100	-	-	96	4	100	-
33	35	25	39	11	33	55	32	30	38	-	80	20	59	41	87	13
34	35	25	41	50	-	50	64	29	7	-	-	-	86	14	100	-
35	25	70	5	-	100	-	68	18	15	-	-	-	91	9	100	-
36	25	72	3	11	89	-	46	54	-	-	-	-	100	-	100	-
37	24	28	48	7	17	76	14	9	77	3	-	97	18	82	5	95
38	22	17	61	5	4	91	13	15	72	1	3	95	24	76	11	89
39	21	66	13	31	62	8	-	-	-	-	-	-	-	-	-	-
40	15	57	29	8	63	29	17	54	29	12	71	18	43	57	36	64
41	15	60	25	-	91	9	-	-	-	-	-	-	-	-	-	-
42	13	46	40	18	58	24	49	12	39	55	9	36	54	46	70	30
43	13	37	49	-	43	57	20	20	60	-	-	-	20	80	-	100
44	12	83	5	-	100	-	15	76	9	17	83	-	89	11	100	-
45	11	55	34	-	25	75	-	9	91	-	-	100	9	91	-	100
46	11	51	38	-	100	-	5	76	19	-	100	-	62	38	50	50
47	10	78	12	-	100	-	43	57	-	-	-	-	100	-	100	-
48	10	55	35	-	-	-	8	69	23	-	100	-	38	62	60	40
49	10	74	16	5	91	5	13	81	6	-	100	-	60	40	83	17
50	10	78	12	13	87	-	-	-	-	-	-	-	-	-	-	-
51	8	61	31	-	85	15	-	-	-	-	-	-	-	-	-	-
52	8	54	38	-	-	100	-	-	-	-	-	-	-	-	-	-
53	7	61	31	-	63	37	7	66	27	-	85	15	48	52	46	54
54	7	40	53	-	-	100	20	20	60	-	-	100	40	60	25	75
55	6	37	57	17	39	44	3	22	75	20	-	80	9	91	6	94
56	2	48	49	-	25	75	12	-	88	-	-	100	24	76	-	100
57	2	43	56	-	43	57	-	-	-	-	-	-	-	-	-	-

Numbers refer to the percentage of individuals of a given herd that are grouped in each cluster. The size of the bars is proportional to this percentage.

Graphical clustering algorithm solution

A description of the genetic structure of the individuals of the 13343 and 3996 datasets is presented in Table 6. The data shown refer to the tight clusters determined in the second step of the algorithm. In the 1st step of the algorithm we used the threshold 1.25 and 2.5 for analysis of 13343 and 3996 dataset respectively. In the 2nd step we used the threshold 75 for both datasets. The animals assigned to the tight cluster represented the 9 and 11% of the total number of animals of the 13343 and the 3996 datasets, respectively. Therefore there was a very large proportion of animals assigned to the loose clusters. The HWeq within these three clusters was very high; almost all the microsatellites were in equilibrium. This equilibrium was even higher than the equilibrium of the PB90 clusters inferred by STRUCTURE (Table 3) although we have to note that the tight clusters of the GCA had a smaller number of individuals than the STRUCTURE PB90 clusters.

Table 6 De*scriptive statistics of the genetic structure of ANI population inferred by the graphical clustering algorithm*

+Data set	Nº of herds	++F_{ST}	#H-W eq.	Nº of inferred cluster	Cluster	"Tight" clusters		
						Nº indiv.	H-W eq.	F_{ST}
13343	59	0.089	0	3	1	458	15	0.076
					2	534	16	
					3	257	15	
3996	39	0.092	1	3	1	108	17	0.090
					2	218	17	
					3	98	16	

+The data set name refers to the population size.
++F_{ST} refers to the data set considering the herds as subpopulations.
#The number refers to the number of loci in H-W equilibrium considering all the individuals as a unique population. Total nº of loci is 17.

As expected, the molecular coancestry within (f_{ii}) clusters was higher than among cluster (f_{ij}) (Table 7). The molecular coancestry within (f_{ii}) and among (f_{ij}) the tight clusters was higher than the one of any cluster inferred by STRUCTURE, getting values above 0.4 and 0.3 respectively (Table 7). Both the f_{ii} and the f_{ij} of the tight clusters of the 13343 data set were higher than the ones of the 3996 data set.

In the Figure 2 we show the distribution of the animals among the different tight clusters of both the 13343 and the 3996 data sets. In order to make easier the comparisons between the results of STRUCTURE and the GCA, the pattern of colors and lines in which the herds are presented in the figure correspond to those in the Figure 1. Similarly to STRUCTURE solution, we found two kinds of herds; those whose majority of animals are assigned to the same tight cluster and those whose animals are assigned to different tight clusters. In general, many herds have individuals assigned to cluster 1 and 2. This is expected from the values of f_{ii} and f_{ij} (Table 7).

Table 7*Molecular coancestry within and across (fii and fij) tight clusters of the Avileña-NegraIbérica population inferred by the graphical clustering algorithm*

Data set 13343			
Clusters	3	2	1
1	0.417	0.366	0.306
2	0.366	0.409	0.327
3	0.306	0.327	0.427
Data set 3996			
Clusters	1	2	3
1	0.406	0.342	0.258
2	0.342	0.408	0.316
3	0.258	0.316	0.421

Elements in the diagonal of the matrices correspond to the molecular coancestry within clusters (f_{ii}) while those off-diagonal correspond to the molecular coancestry between clusters (f_{ij})

Figure 2 *Distribution of the individuals from the different herds among the tight clusters inferred by the graphical clustering algorithm for both data set*

	Data set 13343			Data set 3996		
	"Tight" clusters			"Tight" clusters		
Herd	1	2	3	1	2	3
1	-	-	-	-	-	-
2	95	5	-	82	18	-
3	95	5	-	78	22	-
4	100	-	-	-	-	-
5	83	17	-	93	7	-
6	67	33	-	-	-	-
7	95	5	-	15	85	-
8	95	5	-	95	5	-
9	-	100	-	-	100	-
10	5	95	-	-	-	-
11	20	80	-	-	-	-
12	-	100	-	-	-	-
13	-	100	-	-	-	-
14	-	100	-	-	-	-
15	40	60	-	-	-	-
16	6	94	-	-	100	-
17	-	100	-	-	-	-
18	-	100	-	-	-	-
19	1	99	-	-	96	4
20	8	85	8	-	100	-
21	2	9	89	-	19	81
22	-	50	50	-	-	-
23	-	9	91	-	-	100
24	-	-	100	-	-	100
25	6	11	83	-	8	92
26	7	64	29	-	75	25
27	9	73	18	-	100	-
28	33	27	40	11	22	67
29	3	24	73	-	72	28
30	-	100	-	-	-	-
31	-	43	57	-	-	-
32	10	90	-	-	100	-
33	20	73	7	-	100	-
34	33	67	-	-	100	-
35	50	50	-	33	67	-
36	20	80	-	-	100	-
37	63	32	5	-	80	20
38	47	30	23	-	27	73
39	27	67	7	-	-	-
40	35	65	-	33	67	-
41	21	71	7	-	-	-
42	8	80	12	33	33	33
43	20	80	-	-	-	-
44	50	50	-	-	-	-
45	-	71	29	-	-	-
46	100	-	-	-	100	-
47	13	75	13	-	-	-
48	-	-	-	-	-	-
49	15	77	8	-	100	-
50	-	100	-	-	-	-
51	30	50	20	-	-	-
52	-	100	-	-	-	-
53	20	76	4	-	100	-
54	-	100	-	-	-	-
55	20	80	-	-	100	-
56	33	33	33	-	-	-
57	-	92	8	-	-	-

Numbers refers to the percentage of individuals of a given herd that are grouped in each cluster. The size of the bars is proportional to this percentage.

Herdbook study

We found that few herds are the origin of the majority of the genes in the population; 64% of the genes came from 5 herds. The vast majority of herds are “gene recipients”; 579 out of the 732 registered herds do not sell animals to other herds. According to the herdbook 15 out of the 57 genotyped herds were “gene recipients” while the rest were “gene contributors” herds. We also calculated the proportion of use of own bulls versus bulls from other herds and found that 45 out of the 57 herds used mostly bulls from other herds. Moreover, 15 of these herds only used sires from other herds.

Discussion

The analysis of the simulated populations by both STRUCTURE and the GCA was inferred correctly when the subpopulations were differentiated (F_{ST}=0.2). This also happened in the cases where there were family structures. However, Rodríguez-Ramilo and Wang (2012) indicated the opposite using the same simulated populations in a specific study about the effect of close relatives on unsupervised Bayesian clustering algorithms. Differences may arise because they used the proportion of inferred ancestry to estimate the number of subpopulations (K) while we used the criterion suggested by Evanno *et al.* (2005) based on the second order rate of change of the likelihood function with respect to K (ΔK). Therefore, we may have to add the criterion used to estimate K to the list of factors (Rodríguez-Ramilo and Wang, 2012) that may influence the accuracy of estimated K of STRUCTURE in populations with close relatives. Further study in this direction is needed.

When subpopulations were not well differentiated (F_{ST}=0.01), STRUCTURE identified the existing familiar structure in the simulated data while the GCA was not able to infer any structure. This result support the results of Latch *et al*. (2006) who found that below a F_{ST} of 0.05, STRUCTURE incorrectly identified the number of subpopulations. The influence of the degree of differentiation among subpopulations on the correct inference of the genetic structure of the population was also pointed out by Rodríguez-Ramilo and Wang (2012). Waples and Gaggiotti, (2006) remarked that, when subpopulations are slightly differentiated it could be considered that there is not a genetic structure. In this sense, GCA has provided a more reliable description since it does not identify any consistent number of subpopulations.

When analyzing the genetic structure of ANI breed from the whole dataset both approaches, STRUCTURE and the GCA, inferred similar genetic structures; this coincidence suggests that the results are robust. However, there were some differences in terms of computational time require to achieve results. The Bayesian algorithm of STRUCTURE needs to be run for all potential number of clusters to evaluate the likelihood and determine the most probable solution. Furthermore, if one is using the *K* determination criterion we applied in this study, the algorithm needs to be run several times (about ten) per *K* to calculate an *sd* of the replicates. In the case of livestock breeds in which the potential number of subpopulations might be rather high, the STRUCTURE requirements might be a constraint. Serrano *et al*. (2009) dealing with the genetic structure of a goat population with 22 existing flocks and a F_{ST}=0.074, had to test *K* from 2 to 23, 15 times per *K*, to infer an optimum subdivision of sixteen subpopulations as indicated by the criterion suggested by Evanno *et al.* (2005). In our case, we tested the algorithm for a range of *K* from 1 to 57 (the true number of herds). It was very time consuming; it required several weeks to run. On the other hand, the GCA does not require a long time to finish with the complete analysis. Even if we had tested the STRUCTURE algorithm for a more modest *K* it would have taken far more time than the GCA. On the other hand, to select accurate values for the thresholds of the GCA needs to analyze the distribution of coancestry values in the populations before running it. In addition, to avoid achieving any arbitrary solution, CGA requires to be run for several thresholds in the first and the second step. We run three thresholds for the first step and two for the second. Therefore, we run the algorithm 6 times in total and it took less than an hour to obtain the whole set of solutions for the whole dataset. In this respect, if one is willing to use STRUCTURE to study a population, the first step of the GCA could help to determine a reduced set of clusters to be tested with STRUCTURE. The GCA algorithm, as it is now, is quite strict in the selection of individuals to be assigned to the tight clusters. We are now in the process of understanding how to deal with animals that are assigned to the loose clusters. We think that for populations with and homogeneous distribution of coancestries, as it is the case of ANI breed, the loose clusters could just represent a picture of the current status of ANI population. This idea will be further developed in the next section.

Genetic structure of Avileña-Negra Ibérica breed

The values of the observed, expected heterozygosity and number of alleles we estimated (0.695, 0.725 and 10.5) were higher than the values of a previous study (0.589, 0.692 and 6.97), which sampled 50 individuals taken at random and used 16 microsatellites (Cañón *et al*., 2001) but not far from a more recent study (Martín-Burriel *et al*., 2011) that got values of 0.656, 0.721 and 8.1 for the same parameters. The only notable difference is in the number of alleles that can be attributed to the higher number of animals sampled in the present study. In addition, the F_{ST} differentiation index among herds we determined (0.089) is also higher than the F_{ST} value of 0,071 estimated for eighteen European breeds (Cañón *et al*., 2001) and similar to the F_{ST} value of 0,086 estimated for 40 Iberian breeds (Martín-Burriel *et al*., 2011). These figures highlight the importance of the sampling process in studies where the objective is to characterize breed diversity and breed distances.

In the analysis of the 13343 data set, both approaches depict the same structure. GCA identified three tight clusters (which included 9% of individuals in the data set) and a loose pool where most animals were assigned. The proportion of individuals assigned to PB90 in STRUCTURE, was a bit higher; 24% of individuals were clearly assigned to clusters. PB90 cluster resulted in an increase between 5 and 13% of f_{ii} with respect to the all individuals clusters. The ratio f_{ii} / f_{ij} was 30% higher in the PB90 clusters versus the all animals one, what may suggest the use of preferential mating within clusters. PB90 clusters were also associated to an increase in the number of markers in H-W equilibrium. All the individuals not assigned to the tight (in GCA) and the PB90 clusters (in STRUCTURE) may represent a relatively homogeneous population, if we considered that the molecular coancestry is a realization of the relationships infer from the pedigree.

The distribution of the individuals of the different herds among the three clusters (Figure 1 and Figure 2) was quite consistent when comparing GCA and STRUCTURE inferences. Most differences came from herds that were mostly using bulls from outside. As we show in the results there were two kinds of herds, the ones whose animals were mostly associated to one cluster and those whose individuals were distributed in different clusters. In the first group of herds we can find three out of the five herds that have had a major contribution to the breed. Each of these three herds was assigned to a different cluster. Genotypes from the other two major contributors were not available. The second group of herds were mostly represented by herds that mostly used bulls from outside (25 out of 28) with an important representation of "gene recipient" herds (10 out of 28) Thus, according to the molecular analysis (Figures 1 and 2) most of these "gene recipients" herds received genes from the three different linages. However, we have to take into account that when analyzing the 3996 data set the algorithms were not consistent. Although GCA identified 3 clusters, STRUCTURE inferred the existence of two clusters, though statistics were indicating three; these two clusters were found to have lower f_{ii}, F_{ST} and HWeq (Table 3) than the 3-clusters cases. On the other hand observing Figure 1, we see how two of the clusters of the 3-cluster case merged into one in the 2-cluster case. Therefore, it seems that two of the three lines are more related to each other than with the third one.

The population structure based on molecular information should be a realization of what one observed through the pedigree study. The genetic structure of ANI was studied a long time ago (Vasallo and Díaz, 1986). A nucleus of five herds was then identified, with a recurrent use of bulls coming from those herds. The picture offered by the molecular information will not enter in contradiction with what it was observed in that study. On the other hand, this description is not very far from what it could be expected from the study of typologies (see Chapter 4) in this breed. Only two out of the five defined farmer types had as a major objective to sell breeding animals. These farmer types were also the ones associated with the constitution of the breed. The other three types were mostly oriented to meat production, therefore they would be expected to constitute part of the recipients herds and be mostly represented in the “loose pool”. Most animals in the pool belong to herds recently created or old herds which have not influenced the breed.

Provided the effect of farmers’ decisions on the future of the breed (see Chapter 4) it would be very interesting to deep on the relationship between farmer types and the genetic structure that we have just described. In addition, due to the large number of herds included in the “loose pool” and the limited number of herds with a major contribution to the breed, it will be of great importance to understand the composition of the pool and see how it is related with the existing genetic variability of the breed.

Conclusions

In populations with a clear degree of differentiation, even in the presence of family structures, both types of algorithms have a correct performance. CGA is computationally much faster than STRUCTURE. The molecular structure of ANI shows a stratification that corresponds with the demographic evolution of the breed. In addition to three linages, there is also a large “loose pool” of animals with an admixture of origins whose composition we need to understand and see how it is related with the existing genetic variability of the breed.

Acknowledgments

We thank Avileña-Negra Ibérica breeders Association for providing the data and helpful comments for the interpretations of the results of this study. DMC has been funded by the Collaboration Agreement (CC09-009) between INIA and FEAGAS supported by Spanish Ministry of Agriculture, Food and Environment. KJA wishes to thank CAPES/Brazil for financial support during the course of this investigation.

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CONCLUSIONS

Conclusions

1. Quantitative methods (multivariate statistical techniques, logistic regression, quantified version of SWOT analysis, choice experiments) can be used to approach the complexity of local livestock breeds dynamic, identify both the common factors and specificities and design and prioritize sound strategies and programmes for the conservation and development of farm animal genetic resources.

2. As it seems from the Alistana-Sanabresa breed case study, it would be expected that many local cattle breeds have a significant public good value. In this regard, valuation of non-market attributes of local breeds through choice experiments can be used to inform the design of conservation strategies. Strategies should focus in the breed attributes that people value the most. These values could also be used as criteria for resources allocation between breeds.

3. Socioeconomic and cultural factors could strongly influence the success of conservation and development of local cattle breeds. On one hand, these factors (place of living, attitude towards economic development-environment conflicts, awareness) conform different profiles of people who place different values to different public attributes of the breeds. On the other hand, socioeconomic and cultural features (formal education level, land ownership, age, years keeping the breed, farm income importance) also define farmer types who show similar behavior in relation to their on-farm breeding plans, reaction to scenarios of subsidies removal or form and degree of collaboration with other farmers. These factors have also a large influence on farmers' capability and interest in marketing and breeding. Any policies, conservation program or development strategy should take socioeconomic and cultural factors into consideration.

4. There are some common factors affecting local breeds' viability in Europe. The age of the farmer and the collaboration should be highlighted. Both influence farmers' dynamism and hence the ability to adapt to changing environments. This adaptive capacity is a key point in local breeds' viability provided the transitional state of livestock farming. It might be worth working on farmers' motivation, collaboration, and capacity building.

5. The demography structure of a breed is determined by farmers' decisions. The demography of the breed is related to the genetic structure of populations and in the end to the existing genetic variability. Therefore, farmers types appear to be a key issue in the genetic management of breeds.

6. Graphical clustering algorithms using the molecular coancestry matrix seem to be a fast and reliable tool to infer populations' structure. For the particular case of the Avileña-Negra Ibérica breed, it shows a stratification that corresponds with the demographic evolution of the breed. In addition, there is a large pool of animals with an admixture of origins whose composition needs to be explored. Studying how this admixture relates with the existing genetic variability of the breed might provide further insight on the genetic status of this breed.

ANNEX

This annex entirely reproduced the following paper published in the Journal of Animal Breeding and Genetics (2012), 129, 436-447.

Developing a typology for local cattle breed farmers in Europe

K. Soini[1], C. Díaz[2], G. Gandini[3], Y. de Haas[4] T. Lilja[1], D. Martín-Collado[2], F. Pizzi[5], EURECA – consortium and S. J. Hiemstra[4]

[1]*MTT Agrifood Research Finland, Jokioinen, Finland*

[2] *Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria (INIA), Madrid, Spain*

[3]*Department VSA, University of Milan, Milan, Italy*

[4]*Centre for Genetic Resources, Wageningen University and Research Centre, Lelystad, the Netherlands*

[5]*Instituto di Biologia e Biotecnologia Agraria, CNR, Lodi, Italy.*

Developing a typology for local cattle breed farmers in Europe

Summary

Recognizing cultural diversity among local breed farmers is crucial for the successful development and implementation of farm animal genetic resources (FAnGr) conservation policies and programmes. In this study based on survey data collected in the European Regional Cattle breeds project from six European countries, a typology of local breed farmers was designed and profiles for each of the farmer types were developed to assist these policy needs. Three main farmer types were constructed: production-oriented, product and service-oriented and hobby-oriented farmers. In addition, seven subtypes were characterized under the main types: sustainable producers, opportunists, multi-users, brand makers, traditionalists, pragmatists and newcomers. These types have many similarities to the 'productivist', 'multifunctional' and 'post-productivist' farmer types. The typology not only reveals the high level of diversity among local cattle breed farmers in Europe, which presents an opportunity for the *in situ* conservation of animal genetic resources, but also a challenge for policy to meet the differing requirements of the farmer types.

Introduction

The conservation and preservation of diversity among domesticated breeds has been considered important from the perspectives of agriculture and the food industry, cultural heritage and nature conservation, rural development and science (e.g. Gandini and Villa, 2003; Mendelsohn, 2003; Verrier *et al*., 2005; Oldenbroek, 2007; Soini, 2007a). Special attention has been given to local breeds, which often have unique characteristics or combinations of characteristics. Most literature sources treat local breeds synonymously with native breeds and indigenous breeds. However, following the EURECA project, we use the term 'local breed' in referring to breeds that are characterised by their limited geographical distribution (Hiemstra *et al*., 2010). These breeds, which have adapted to the local environmental conditions over a long period of time, have in many parts of the world become rare, threatened, and in some cases even extinct (Food and Agriculture Organization of the United Nations -FAO-, 2007). International conventions and national conservation programmes aim to conserve and develop these breeds by means of *in situ* and *ex situ* conservation measures.

In situ on-farm conservation has been considered the most favourable means to preserve genetic material (Oldenbroek, 2007). Most farm animal genetic resources (FAnGr) conserved *in situ* are owned by private farmers, and farmers who raise local breeds on their farms can therefore be considered as the main *in situ* conservation actors. On-farm *in situ* conservation implies special challenges for FAnGr, as the success of the conservation depends on many internal and external factors that affect the choice of the breed (Gandini *et al*., 2010). In addition, it is suggested by this article that there are cultural aspects that cannot always be explained by internal or external factors. By cultural aspects, we broadly refer to farmers' values, attitudes, beliefs, motives and interests related to local breeds and with cultural diversity variation of the cultural aspects. Cultural diversity has been considered an important aspect in biodiversity conservation (UNESCO and WCED, 2003). Usually, the connection between the cultural diversity and biodiversity is found among indigenous cultures, where biodiversity is highly connected to local cultural practices, traditions and knowledge. However, it is suggested by this article that recognition of the cultural diversity of farmer types is necessary for the successful development and implementation of on-farm *in situ* FAnGr conservation policies and programmes also in the Western countries, as the needs of each farmer type are distinct in terms of policy. In this article, a "farmer" refers to any person raising a local cattle breed and a "farm" to the place where the cattle are kept.

This study was a part of the EURECA project (Toward self-sustainability of EUropean REgional CAttle breeds), which was carried out during 2006–2009 with the support of the European Council GENRES programme. The project aimed to elaborate methods and gather data that will be of value when new policies and programmes concerning farm animal genetic resources and rural development are designed. Based on the material collected within the EURECA project, the aim of this study was to 1) examine the profiles of local cattle breed farmers, 2) develop a typology of local cattle breed farmers, and 3) consider how the various farmer types can be assessed in terms of 'productivist', 'multifunctional' and 'post-productivist' farmer types identified by Burton and Wilson (2006) and how the types are met by various policy measures and conservation programmes.

Policy measures concerning animal genetic resources

Policy measures are usually classified into three categories: regulatory (sticks), economic (carrots), and information (sermons) (Vedung, 2003). These measures are also available for and applied to the conservation of local breeds and their sustainable use. The Convention on Biological Diversity (CBD) (1992) and regulations of the Common Agricultural Policy (CAP) within the European Union are examples of regulatory frameworks for *in situ* conservation. However, the CBD in particular remains very loose in terms of conservation practices, as responsibility for the concretion and implementation of the regulations is mainly delegated to individual nations. Therefore, national strategies and action plans that can consider conservation from the point of view of a respective nation and even a single breed are needed to promote conservation at the national and regional levels. (Fimland and Oldenbroek, 2007). For example, the conservation law introduced by the Republic of Sakha in 2001 to protect Yakutian cattle is quite a unique example of a national regulatory framework concerning the conservation of a single breed (Granberg *et al*., 2009; Soini *et al*., 2012).

Economic incentives such as subsidies for local breeds have become quite common, especially in the European Union along with the introduction of agri-environmental policy as a part of the CAP. Incentives that are addressed directly at maintaining local breeds are usually paid per unit of animal. Furthermore, the maintenance of local breeds may indirectly be supported by various rural development programmes connected with landscape management or local food.

Information is considered as the softest measure compared to regulations and economic measures (Vedung, 2003). It refers to the raising of awareness thorough the transfer of knowledge, the communication of reasoned argument and persuasion. In this sense, many would view information as democratic governance in its most ideal form. In the context of FAnGr conservation information often accompanies other policy measures, regulations and economic incentives, as in the case of extension services related to agri-environmental subsidies. It can also be used as a measure of its own, for example, when raising the awareness of traits of local breeds or threats of inbreeding.

The choice of policy instrument is critical, as they have varying effects in terms of their effectiveness, efficiency, legality and democracy (Bemelman-Videc, 2003). In this respect, it has recently been realised that successful and sustainable conservation of biodiversity requires the engagement of the various actors (Berkes, 2006; Soini *et al*., 2012). Therefore, emphasis in the conservation of local breeds, similarly to other forms of biodiversity conservation, has started to shift from top-down policies primarily based on regulations and economic incentives towards community-based management and participatory planning (Köhler-Rollefson, 2003; FAO, 2007) or the self-sustainability of the breeds (Hiemstra, 2010, 9). The concept of self-sustainability, which was introduced by the EURECA project, refers to the situation where breeds could exist without any external regulatory programmes or economic support (ibid.). In addition to conservation policies, market is becoming more and more important player in the conservation of local breeds. In particular in the Western countries, the markets for local breed products and services are developing as a result of new trends in food consumption that favour quality, gastronomic characteristics, locality and health aspects (Soini and De Haas, 2010). Along with these turns in policy and markets, the use and appreciation of information as a policy measure is increasing. The change in policies and markets calls for more intimate understanding of farming cultures, as farmers cannot be treated only as objects, but rather as actors of conservation policies and the local breed markets.

Farmer typologies

Typology research refers to research that aims at analysing complex reality by grouping objects that are of the same kind and presenting them as a system of types (typology) (Landais, 1998). Particularly in Western Europe, there has been an increase in farmer typology research. The increase in farmer typology research can be associated with so-called post-productivist rural development, with diversifying rural livelihoods and populations, as well as the development of multifunctional agriculture with diversifying production styles, tasks and meanings. Along with these developments, there is a need to improve the effectiveness of agricultural, rural or environmental programmes and policies, as well as extension methods (Landais, 1998; Emtage *et al*., 2006). Thus, farmer typology research has seriously adopted the notion of Morris and Evans (2004) that farmers are not of one culture, but multiple ‘agricultures’.

Farmer typology research can be considered as a form of segmentation research that takes into account the social and cultural values of farmers, as well as their approach to farming and areas of interest within it (Emtage *et al*., 2006). Typologies have been developed, for instance, with respect to landscape management practices (Swagemakers and Wiskerke, 2004), the probability to turning to organic farming (Darnhofer *et al*., 2005). Moreover, farmers’ adaptation of environmental (Morris and Potter, 1995) and technical innovations (Frank, 1994), as well as new crops (Vuorio *et al*., 2005) and new farming styles (Thomson, 2002; Mesiti and Vanclay, 2006), have been examined. Farmer typologies have also been designed according to their identities related to the various strategies in agricultural production (Battershill and Gilg, 1996).

Burton and Wilson (2006) have examined the productivist, post-productivist and multifunctional farmer types. They have suggested that farmer self-concepts comprised multiple identities, rather than single one: characteristics of an agricultural producer, conservationist, diversifier and agribusiness identity to a varying extent. By an 'agricultural producer' they refer to a conventional productivist farmer who maintains cultural notions of stewardship. An 'agribusiness person' is a farmer who concentrates on agricultural production to the extent that the profit motive dominates and stewardship concerns are lessened. A 'conservationist' focuses on environmental and life-style concerns and a 'diversifier' shifts the focus away from standard agriculture towards non-agricultural sources of income (ibid.).

To date there has been relatively little socio-economic or cultural research on livestock keepers who raise local breeds. Most of the existing research has been conducted in developing countries (e.g. Anderson, 2003; Ngowi *et al*., 2008; Granberg *et al*., 2009). In these countries the situation is different, as the local breeds might be an integral part of the local food production system, while they are at the margin of food production in more advanced societies. Few studies have been conducted, however. Research on the perceptions of Finnish local breed farmers has indicated diversity among the farmers in their opinions concerning local breeds and their usage, as well as in their motives and future plans for keeping local breeds (Takamaa and Soini, 2007). Studies have also demonstrated that most local breed farmers are highly committed to keeping a particular breed, even if the subsidies paid for the local breeds were to be reduced or even removed, revealing the non-economic factors underlying the choice of breed (Takamaa and Soini, 2007). Research conducted by Bertaglia *et al*. (2004) on local goat breed keepers in Southern France pointed out a strong link between the perceptions of the farmers concerning the breed and pastoralism and their general values and attitudes towards society. The aim of this study is to develop a preliminary typology of the local cattle farmers to promote future research of farmers involved in *in situ* on-farm conservation and to assist policy-making and implementation of FAnGr.

Material and methods

In this study, we focus on a total of 321 famers in six countries keeping thirteen local cattle breeds were analysed within EURECA project (Table 1). The farmers were selected by the participating researchers of each country with the aim of maximising the diversity of the farmers in terms of herd size, farmers' age, education and use of cattle, among other factors. The farmers were asked 42 questions about their farm, farming activities and perceptions of the breeds (for further information see Gandini *et al.,* 2010). The interviews were conducted during 2008, either face to face on the farm or by phone, and notes were taken. The questionnaire included five open-ended questions (Table 2), which were used as the main source of data for this analysis. Although the farmers were asked these questions, they raised other issues relevant to local breed farming, providing a good additional source of material for a qualitative analysis of farmer types.

Table 1 *Origins of the data exploited in this study*

Country	Breed	Nº of herds/ farmers analysed	Purpose	Nº of cows (Breed population trend)
Belgium	Dual-Purpose Belgian Blue	23	[+]Dual	4400 (stable)
	Dual-Purpose Red and White	18	Dual	3000 (decreasing)
Finland	Eastern Finncattle	30	Dual	700 (increasing)
	Western Finncattle	31	Dual	3000 (decreasing)
France	Ferrandaise	19	Dual	730 (increasing)
	Villard de Lans	15	Dual	340 (stable)
Italy	Bianca Val Padana	26	Dual	650 (stable)
	Reggiana	30	Dairy	1500 (increasing)
The Netherlands	Deep Red	21	Dual	454 (increasing)
	Groningen White-Headed	22	Dual	1500 (stable)
	Meuse-Rhine-Yssel	24	Dual	14400 (decreasing)
Spain	Avileña-Negra Ibérica	31	Beef	100000 (stable)
	Alistana-Sanabresa	31	Beef	2000 (increasing)

[+]Dual: milk and meat; dairy: milk; beef: meat

To develop farmer profiles and a typology for local cattle farmers, we utilised qualitative content analysis, which has been characterized as “a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns” (Hsieh and Shannon 2005, 1278). The method has primarily been developed in anthropology, qualitative sociology and psychology in exploring the underlying meanings of a studied phenomenon. Qualitative content analysis pays particular attention to unique themes that illustrate the range of meanings of the phenomenon rather than the statistical significance of the occurrence of particular texts or concepts. In addition, it aims for reducing the large amount of qualitative material and identifying the core consistencies and meanings (Patton, 2002, 453). It should also be noted that characteristically for qualitative content analysis, there is no single “truth” of final interpretations, as the analysis is always affected by the personal views, emotions and intuition of the researcher (Denzin, 1989). The principal authors of this analysis have previous research experience of studying farmers’ motives and values keeping local breeds (Takamaa and Soini, 2007; Soini and Partanen, 2009; Soini *et al*., 2012).

Table 2 *Questions used in analysis*

Questions addressed to the farmer
Which are the main reasons (one or more than one) for starting to keep- or continue keeping this local breed?
What kind of opportunities do you think there are for having the local breed in the future on your farm?
What kind of threats are there related to keeping local breed in the future on your farm?
If the local breed is declining in the country: what are the main reasons for this declining in your opinion?
If the local breed is becoming more popular in the country: what are the main reasons behind this recent popularity?

The qualitative content analysis is usually inductive, based on the examination of topics and themes, as well as the inferences drawn from them in the data (Patton, 2002; Hsieh and Shannon, 2005). It often produces typologies on how the actors view a certain issue, making the given phenomenon more comprehensive (Berg, 2001). The method starts from reading and re-reading of the research material, followed by identifying the relevant categories and attributes, aiming to concentrate on the most essential information. Finally, the main types are clustered, re-clustered and named. The types created through this process are ideals: a certain type is not meant to correspond to all of the attributes and categories. Therefore, a certain type may exist in reality, but not necessarily.

Table 3 *Categories and attributes that define local breed farmers' typologies*

Categories	Attributes
(1) Use of the local breed	Milk or meat production Diversity of usages (production, grazing, companion animal)
(2) Economic aspects in cattle farming production	Source of profit (quantity or quality) Assessment of profitability (in the long or short term) Attitudes to the subsidies
(3) Professionalism in cattle farming	Type of profession (farming, other field) Need for external support in cattle farming Attitudes towards professionalism
(4) Becoming engaged with the breeds	Conscious choice Coincidence Sudden fancy
(5) Reasons for the conservation of local breeds	Genetic reasons Ethical reasons (conservation of nature or cultural heritage) Traditions
(6) Traits of the cattle	Purely aesthetic phenotype Aesthetic related to production traits Adaptation to the local environment and farm conditions
(7) Scope and scale of thinking	Personal Farm Regional National Global
(8) Networking	No networks related to cattle Networking with actors involved in cattle breed farming Networking broadly with consumers, media, researchers
(9) Support needed	Research (e.g. on genetics, traits and productivity, meat and milk quality, added values) Developing products and services Economic support (subsidies) Practical knowledge on cattle breeding and agriculture
(10) Future threats	Inbreeding Low prices Bureaucracy and sanitary requirements

The method of qualitative content analysis, as we used it, can be divided into the following five steps:

1. Becoming familiar with the data. We read and re-read the notes made by interviewers.

2. Determination of categories. We identified the main categories that marked differences between the farmers (Table 3).

3. Determination of the attributes for each category. We considered the farmers' reactions in each category as attributes using a phrase as a unit of analysis (Table 3) .

4. Construction and description of farmer types. We determined, described and named the different farmer types based on the different combinations of categories and attributes.

5. Finalising the typology. We presented the preliminary typology to the members of the research group who had not participated in the construction of the typology, and who were representing Italy, Finland, France, the Netherlands and Spain. The group agreed with the typology with minor changes to the names of the types.

Results

Identification of categories and attributes

From the data we identified ten *categories* that marked differences between the farmers: (1) the use of local cattle breeds, (2) economic aspects in cattle production (3) professionalism in cattle farming, (4) becoming engaged with the breeds, (5) reasons for conserving the breeds, (6) the appreciation of traits of the breeds (7) the scope and scale of thinking, (8) networking, (9) support needed and (10) future threats. For each category, two or more attributes were constructed. The ten categories identified and the corresponding attributes constructed are presented in Table 3 and briefly discussed in the following.

The use of local cattle breeds

This category describes the various forms of using cattle breeds on the farm, whether the farmers viewed their cattle only as production animals or whether they mentioned other uses for their animals. The cattle were most often used for milk and/or meat production. In addition, some animals were used in landscape management - some farmers stated that their animals are exceptionally good for that purpose – and also as social companions, therapeutic animals or attractions for farm visitors. Some of the farmers seemed to consider their cows primarily as pets, or members of their family, although they milked them or used them for landscape management.

Economic aspects in cattle production

This category describes farmers' considerations of cattle farming as an economic activity. Some farmers preferred bulk production and emphasised the quantity of production, while for others the economic value of their cattle was derived from the quality of the products and production. For the latter farmers, promotion of the quantity of production through a systematic breeding programme was usually important. Some farmers calculated the costs and benefits of cattle farming, emphasizing factors such as the health and longevity of the animals, the lower feed costs and the value of other uses for the cattle (e.g. landscape management and quality products), while other farmers considered the costs and profits in the shorter term. Our data also revealed that some farmers had started to keep a local breed due to the payment of subsidies, whereas for other farmers the subsidies were a secondary or even irrelevant aspect. Some farmers appeared to consider the payment of subsidies for the local breeds to simply be a part of modern agriculture, whereas others saw them as a serious constraint and for a very small proportion of farmers, subsidies were the only reason for keeping local breeds.

Professionalism in cattle farming

This category describes the biographical and educational backgrounds of the farmers and their knowledge of cattle farming. There were differences among the farmers in their professional background (see also Gandini *et al*., 2010). Some of the farmers had an education in agriculture or cattle farming, whereas others had come to the profession from outside agriculture and had gained their expertise in cattle farming through practice. There were also farmers who lacked information about modern cattle farming and the bureaucracy related to it, and who were in need of external support. Professionalism in cattle farming does not refer here only to the level of education or professional background of farmers, but also to their perception of the need for experience and capabilities in cattle farming. Some farmers set a requirement for high qualifications among persons keeping cattle, whereas others considered that anyone could raise local breeds, because they were considered easy to handle: *"An inexperienced person can also take care of these cattle"*.

Becoming engaged with the breeds

This category refers to how the farmers had become engaged with the local cattle breeds. Some of the farmers had started keeping the breeds through a conscious decision, and others as a result of coincidence or just due to a sudden fancy.

Reasons for conserving the breeds

There were a variety of reasons for keeping local cattle breeds, which can be clustered in the following way: Some farmers emphasized the genetic reasons, i.e. importance of the preservation of breed traits, whereas others emphasised the ethical perspective ("right thing to do") considering ecological or cultural reasons, or the continuation of farm traditions.

Appreciation of traits

This category describes how the farmers perceived the traits of the local breeds. The aesthetics of animals have been very important in traditional selection as well as in animal breeding (see e.g. Soini and de Haas, 2009): breed classifications have been based on the exterior traits of the breed. For some farmers, the aesthetic value of their cattle seems to arise from good production traits such as muscularity, health, size or shape, indicating the farmers' knowledge of the breed and cattle farming, whereas other farmers focused on the phenotype, that is, the colour or the patterns of the coat, viewing cattle more as a "painting". The adaptation of the breeds to the local environment or farm conditions and buildings was appreciated by some farmers. A few farmers stated that local breeds were considered easy to handle.

Scope and scale of thinking

This category describes how the farmers located local breeds and their breeding in the wider contexts of society. Some farmers considered their personal interests and preferences for the breeds, or the suitability of a breed in relation to the farm characteristics. Others discussed the local breeds from a broader perspective, for example with respect to their contributions to environmental development or food production at regional, national or even on a global scale.

Networking

There were also differences in how the farmers acted in practice: some of them worked rather independently or in collaboration with other cattle breeders and experts closely linked with cattle breed farming (extension persons, researchers), whereas others were more oriented to the society at large: to the consumers, media and scientists. Some farmers had no networks related to the local breeds.

Support needed

The farmers had different ideas, what kind of support they or the local breed productions would need. Some of them called for more research on genetics, unique traits of the cattle, the special characteristics of milk and meat or developing value added products. Subsidies were often mentioned. There were also farmers, who were in need of practical information of cattle farming. Some farmers called for respect of local breeds and the farmers' work with their preservation.

Future threats

The farmers had also different ideas, what are the future threats of the local breeds. Some of them mentioned inbreeding, like small populations and small number of bulls. Others were more concerned of low market prices of the products. Increasing bureaucracy and sanitary requirements were also mentioned as a threat.

Typology of the local breed farmer types

The categories *use of cattle* and *economic aspects in cattle farming*, which marked the clearest differences between the farmers, was used as the first organiz ational category in developing the typology. Based on these categories, three main types of farmers were identified: production oriented, product and service oriented and hobby oriented. These main types were further divided based on the attributes of the the remaining categories into a total of seven subtypes (Figure 1). In the following sections we introduce the three main farmer types and their subtypes.

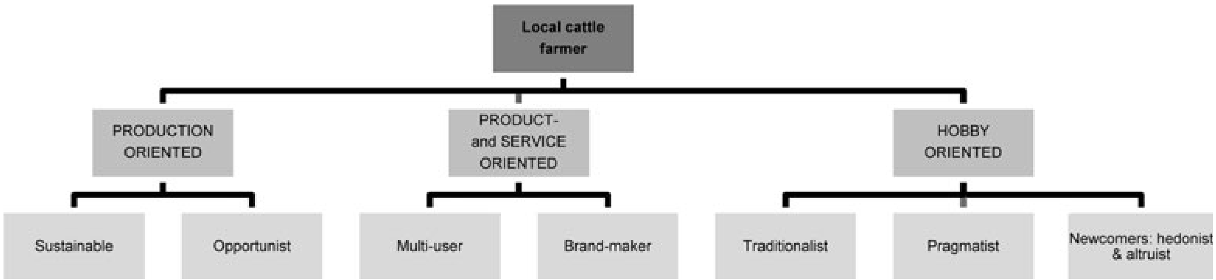

Figure 1 *Typology of local breed farmers*

Production-oriented farmers

The objective of *production-oriented* farmers is to perform economically profitable cattle farming based on local breeds. Farmers of this type are interested in basic milk and/or meat production. Although they are aware of and highly appreciate the quality of milk and meat products, they are not themselves interested in processing or branding products, as they have specialised in primary production in the milk or meat production chain. However, differences were identified between production-oriented farmers in how they considered that economic profitability should be achieved: in the long term through careful and professional cattle farming or in the short term by exploiting subsidies. Based on these differences, production-oriented farmers were further divided into *sustainable producers* and *opportunists.*

Sustainable producers can be characterised as professional local breed farmers, who usually have an education or long experience in cattle farming, and who are eager to learn more about the breeds and production. Many of them were also committed to continuing the old traditions of their farm by keeping the local breed. They viewed cattle farming as a serious occupation: "*I don't want to live like Robinson Crusoe; my cows are production animals, not pets,"* or as one female farmer put it: *"Local breeds are more than farm decorations." Sustainable producers* are particularly interested in improving the quantity of production through breeding and good management: *"If cows are managed correctly, they produce as much milk as other dairy breeds."* For these reasons, some of the *sustainable producers* consider "hobby farmers" (3.3) a threat to local cattle breeding, as they are not necessarily very experienced in cattle farming or interested in breeding. *Sustainable producers* consider that conservation strategies are needed to preserve the good traits of the cattle for future breeding. Aesthetic values of the animals arise from good functional traits, such as health and longevity, which make cattle farming "sustainable" in their view.

Sustainable producers seek economic profitability in the long term, whereas *opportunists* seek to maximise economic benefits in the short term. They typically argue that: “*The subsidies should be increased.*” Economic subsidies are extremely important for them, sometimes even the main reason for starting to keep local breeds, maintaining them, or for re-orienting production from other breeds to local breeds. Compared to *sustainable producers*, *opportunists* are not very keen on cattle farming or the traits of the cattle; instead, the cattle represent to them a form of income. Therefore, opportunists concentrate on beef production, which is less labour-intensive than dairy production. Cattle can make it possible to live on the farm or to keep the farm alive. They do not want to put extra effort into cattle production, and they are not therefore interested in processing or branding their products; nor do they have a special interest in conservation issues. They may stop keeping the local breed if economically more attractive ways of earning a living appear.

Product and service-oriented farmers

Product and service-oriented farmers acknowledge the unique and multiple traits of the local cattle as a basis of additional value for various economic activities, tourism, food processing, care farming and environmental education. For this group, two subtypes were distinguished: *multi-users* and *brand makers.*

Multi-users see a local breed as an element of variety for on-farm economic activities such as tourism, on-farm selling, landscape and nature management: “*Local cattle breeds can be combined well with other farming activities.*” Here, the multiple traits of cattle such as an attractive aesthetic phenotype and good grazing abilities become valuable: “*Local cattle are extremely well suited to grazing management in nature reserves: Good use of natural pastures all year around.*” One Dutch farmer who had a lot of visitors argued that “*it is nice to have a cow with nice patterning and that is a Dutch breed.*” They emphasise the quality of the cattle-related products and services instead of quantity, although they are not themselves interested in processing cattle products on a large scale. The reasons for conserving local breeds are multiple, ranging from genetic to cultural and ethical considerations. The scope of thinking and acting of the farmers is usually farm-based.

In turn, for the *brand makers,* cattle farming should be a profitable business. They may have a background in some other sector than farming, but they are active in developing more expertise in cattle farming and especially in the processing and/or marketing of products.

They place emphasis on the gastronomic qualities of products rather than production quantity: *"The meat of culled cows and the calves has a good conformation."* In order to make business work, they actively collaborate with the various actors in the food chain (restaurants, slaughterhouses, dairies, cheesemakers, researchers), and they are also active towards the media, which indicates their wide scope of thinking and acting and willingness to network. They want to promote the conservation and preservation of the cattle through the added value of the products and services the breed provides, and they are eager to enhance and preserve the niche character of the cattle. In branding, they consider the needs and expectations of the consumer: *"Food safety and local food has come to the fore via the media. Local breeds are appreciated in this respect."* Genetic diversity establishes the basis for quality products, while the aesthetic and cultural values of the breed provide tools for marketing. One farmer was searching for a unique local breed product that would fit with the region and the centuries-old farm.

Hobby-oriented farmers

For *hobby-oriented farmers*, the economic profitability of cattle farming is not of importance, as other aspects related to the breeds go beyond this. Three subtypes of hobby-oriented farmers can be identified based on other categories and attributes: *traditionalists, pragmatists and newcomers*.

Traditionalists typically represent older farmers or those who are already retired from active cattle farming, but who are strongly committed to maintaining the breed on their farm, as "*The breed represents the traditional prestige of the farm,"* or *"It is a breed that has always been on the farm."* Although they have expertise in farming, the production system might be old-fashioned and they feel a need for external support, especially to deal with bureaucracy. *"It is too administrative; there are too many documents to fill in."* Products are used in their household or given away or sold in the neighbourhood. The main reasons for keeping the breed arise from farm traditions and the personal commitment of these farmers to life-long work with cattle, which they would like to transfer to the next generation. From their perspective, modern agriculture constitutes a threat to local breeds.

Pragmatists are professional farmers whose cattle farming is primarily based on mainstream breeds. They do not apply economic rationality to the local breed animals, which are rather considered as pets for themselves and for their family. They might have started to keep local breeds by coincidence. *"We got the first cows by accident, but since then we just haven't been able to get rid of them, because they are so cute."* They might also have left a few local breeds in the herd when turning to the mainstream breed, or bought a couple of local breed cows, onto which they can project their values of sustainable farming. They have recognised the genetic and cultural values of local breeds and they want to contribute to the conservation of these breeds by keeping a few local breeds among the mainstream breeds, even if it is not economically profitable to do so.

Finally, there are *newcomers,* who usually have no background in farming. Production or breeding is not as important as the animals themselves, whose other values are highly appreciated. Either these farmers can afford to keep a couple of animals as a hobby or they are ready to keep the cattle, even if they must lower their standard of living. Owing to these two orientations, we can further distinguish two subtypes, *hedonists* and *altruists*. For *hedonists,* the willingness to keep local cattle mainly arises from personal interests: the cattle fit their lifestyle or cows are just so nice and attractive: *"Because I like the breed, I was infatuated with it..."*. These farmers are not necessarily very committed to keeping cattle, but the cattle are kept as long as it is easy and enjoyable to do so. *Altruists* think that it is ethically appealing to have local breeds. They want to contribute to "saving the world" by keeping these breeds. For both the *hedonists* and *altruists*, farming practices and bureaucracy, such as subsidies and environmental legislation, may cause problems and a need for external support, but they might think that *"Everybody has a right to keep local breeds."*

Discussion

Productivist, multifunctional and post-productivist local breed farmers

The typology developed and introduced in this article identified three main types and seven subtypes of farmers. These types correspond relatively well with the identities of farmer types in respect to agricultural change reported by Burton and Wilson (2006).

In our study, *sustainable producers* mainly represent the 'productivist' farmer type, which is dominated by a agricultural producer type of identity focusing on production and economic rationality, but also having a conservationist orientation: The *sustainable producers* emphasised the local breeds as a sustainable choice in cattle farming and revealed their respect of traditions. As noted by Burton and Wilson, diversification is considered negatively by ‘productivists’, which was also the case in our *sustainable producers*. Although the profitability of the cattle farming was important for the sustainable producers, the profit was the clearly dominating motive among the *opportunists* suggesting a strong agribusiness identity.

Product and service-oriented farmers in our typology were closer to ‘multifunctional’ farmers. *Multi-users* typify farmers among whom the diversifier, agricultural producer and conservationist characteristics might even co-exist, as suggested by Burton and Wilson. Although *brand makers* also had many of these characteristics, they seem to have a stronger orientation towards agribusiness than multi-users.

As the *hobby farmers* identified by this study were not economically oriented local breed farmers, they could be recognized most closely to the ‘post-productivist farmers’. Rather, they represented smaller-scale approaches to local breed farming influenced by multiple values and emotions derived from ethical, cultural and environmental concerns. Therefore, some of the hobby farmers, can even be characterised as ’ non-productivists’ who can be described as ‘lifestylers’, ‘resource limited’ or ‘traditional’ farmers (Howden *et al*., 1998) and who had no economic activities related to the local breeds. However, as far as the product and service oriented farmers and hobby farmers are concerned, the borderline between multifunctional and post-productivist is not easy to determine. This was the case also in study of Burton and Wilson. These concepts are also controversial from the policy discourse point of view (Wilson, 2001).

Policy implications of the typology

As expected, regulatory frameworks related to the conservation of local breeds, such as the Convention on Biological Diversity, remain relatively distant for local breed farmers. The only regulations they have to deal with are those concerning economic subsidies. For the local farm animal breeds in question, it is unlikely that there will be any laws for their conservation that would make the conservation of the breeds an obligation as is the case for certain wild animal species. Therefore, it is probable that the role of regulations in FAnGr conservation will remain relatively weak considering their direct effect on farmer. However, the bureaucracy associated with the regulations underlying economic incentives was considered complicated by many local breed farmers, particularly by *newcomers* and *traditionalists*. Consequently, the regulations could even have a negative effect on local breed farming.

Economic incentives are most important for *production-oriented* farmers, and particularly for *opportunists*. Consequently, an increase in subsidies would most probably increase the relative proportion of farmers who are not committed to or keen on the cattle farming and breeding. This is not necessarily a benefit considering the aims of FAnGr conservation in the long term, and neither does it promote the self-sustainability of local breeds. Economic incentives seem to have less meaning among the *product and service oriented farmers*, who were more concerned of the added values of the local breeds and even no special meaning for *hobby farmers*, as there were other values behind their decision to maintain local cattle breeds.

Information and all types of communication related to local breeds seem to be important for most of the farmer types. *Sustainable producers* appear to perceive a lack of respect for their work among the stakeholders (administrative persons, extension persons and veterinaries) and society. Publicity in the mass media concerning local breeds, for example, might encourage them to continue. Information on the multiple values of local breeds might help the *opportunists* to reconsider local breed farming from other than a purely economic point of view. *Traditionalists* may need very concrete information and support in bureaucracy issues related to modern cattle farming in general and local breeds in particular, whereas *newcomers* may even need basic information on cattle farming and breeding practices provided by the extension organisations for example. *Multi-users and brand makers* seem to be the most self-sufficient in terms of the information they require for local breed farming.

It should be noted that the farmer types identified by this study are not necessarily ideal, and neither are they static. It might be very difficult, for example, to find a 'pure' *hedonistic* farmer, as compared to farmers that have most of the features of this type. Besides, a farmer might transfer from one type to another as a result of changes in external or internal conditions. For example, a *pragmatist hobby* farmer having a few local breeds among the conventional herds may decide to concentrate on local breeds only and become a *sustainable producer*. Similarly, a *sustainable producer* may change to become a *traditional hobby farmer* when becoming older and a *newcomer* may become a *brand-maker* or *sustainable* *producer* after gaining experience in cattle farming. Furthermore, entirely new farmer types may emerge.

The results suggest a high degree of cultural diversity among local breed farmers across European countries, confirming the results of previous Finnish case studies (Takamaa and Soini, 2007). The diversity of these farmers can be considered positive for *in situ* FAnGr conservation in the face of changing environmental and political conditions. Therefore, all farmer types should find their place in breed conservation and development activities. Even the hobby farmers are needed, although these farmers have smaller herds of local breeds, but they might have an important role in making the local breeds better known among the general public and therefore it would be important to develop policy measures that also support their work. If one type of farmer gives up local breeds for one reason or another, other types may nevertheless continue. It can also be assumed that some farmer types, such as *sustainable producers* and *traditionalists*, have considerable knowledge of breeds, which should be considered memory bank (Nazarea, 1998), which needs to be conserved as well and passed on to the next generation of farmers who keep the breeds.

Conclusions

The typology for local breed farmers developed and introduced in this article can be considered as pioneering work aiming at providing an overall picture of farmers who are raising local breeds in some European countries. It clearly illustrates the heterogeneity among the farmers, which can be considered an advantage for conservation, but a challenge for *in situ* conservation policies. In short, the results call for variety of policy measures that are sensitive to the different farmer types.

However, further research is needed to make the typology even more efficient in considering policy needs with respect to the following points: The typology was developed from data collected in Western Europe and it is therefore only applicable in a context where the market provides opportunities for farmers to specialise in a certain type of production and where the standard of living may also allow farmers to have production animals as pets. In non-European or developing countries, different farmer types may exist. Therefore, we suggest that the typology should be tested and further developed in different social, political and cultural contexts. Moreover, as this analysis was made based on open-ended answers of a questionnaire, a more intimate cultural analysis of the farmer types should be performed. It would also be interesting to examine the socio-economic characteristics of each farmer type by quantitative means, and also to estimate the relative numbers of each farmer type with respect to the breeds they maintain. Research activities of this kind would be of great importance in the development of community-based and self-sustainable conservation of farm animal genetic resources.

Acknowledgements

This research formed part of the EURECA project (Hyperlink, http://www.regionalcattlebreeds.eu/). We would like to thank all the scientists involved in the EURECA Consortium, whose support and opinions have been vital to this study and two anonymous referees for very thorough review of the manuscript and constructive comments. We also acknowledge the European Commission and the institutions of the EURECA Consortium for their support and funding. Last, but not least, we are very grateful to the farmers and stakeholders for their time and thought, which made it possible to carry out this research.

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