Research and Development – offered article

Farm animal genetic resources: safeguarding national livestock biodiversity

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Summary

Long regarded in the UK as the responsibility of individuals, breeders' groups or charitable organizations, livestock breed conservation has now been recognized by the Government as a national responsibility. The National Standing Committee on Farm Animal Genetic Resources was set up in 2006 to promote conservation and sustainable development of livestock biodiversity in general. It is putting into effect a National Action Plan comprising 38 Recommended Actions. This article reports on the composition and activities of the Committee and emphasizes the importance for agricultural sustainability of a full appreciation of the value of these resources.

Keywords

Genetic resources; biodiversity; conservation

Introduction

Livestock farming accounts for a relatively small proportion of agricultural turnover in the UK, though it occupies over a third of our land area and is of course integral to the food industry. Grazing livestock are fundamental to the landscape in most areas of pastoral and natural beauty and have been extremely important in shaping the countryside generally. Very many breeds are associated with specific counties or regions and traditionally they have been favoured in these areas because they are considered to be adapted to the local environment and markets. Some livestock breeds are found very widely because they are fundamental to the systems of which they are part. Almost every breed has a breed society to promote its interests.

These are the main reasons why such a wealth of native breeds has arisen in Britain – over 130, counting all cattle, sheep, pigs, goats, horses, ponies, and poultry. This article explains why this genetic diversity is important for the farming of the future, and describes an important initiative towards its conservation and sustainable use.

With modern science-based husbandry and veterinary care, and advanced technologies for food manufacturing, one might argue that the adaptations breeds may have to their local environments and markets are not, now, as important as they once were. Today the reality is that the actual contribution of the vast majority of our native breeds to national food supply is very small. Dairying is dominated by the Holstein cow, the pig and poultry industries by small numbers of lines marketed by multinational companies, while beef and sheep meat supplies owe much of their genetic endowment to a handful of international breeds such as the Limousin, Charolais, Texel and Suffolk.

Nevertheless the diversity of native breeds needs to be maintained so farming can respond to the challenges of the future. Some of these challenges are predictable, others are not. Emphasis in livestock breeding has been on production characteristics such as product yield – interest is now shifting towards traits that relate to survival, such as welfare-related behavioural traits and disease and parasite resistance. Genes for such traits may well be at high frequency in breeds that have not been heavily selected for production and this means that breeds that are not currently fashionable need to be protected, even if they do not respond as well as the

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international breeds to intensive husbandry. Also, genetic diversity within these breeds as well as within the major commercial breeds must not be squandered.

Historical background

"It is certain that several entire breeds have been lost which ought to have been carefully preserved". So wrote Professor David Low in 1842 (Hall and Clutton-Brock, 1988); and as is very well known the process has only been arrested in the UK by the foundation of the Rare Breeds Survival Trust in 1973. Since the lamented extinction of the Lincolnshire Curly Coat pig in 1972 no British breed has died out, and the foundation of the RBST has been rated (Kubbinga et al., 2007) as the "first milestone" in the world story of livestock biodiversity conservation. The two subsequent milestones were considered by these authors (who are FAO officers) to be the Technical Consultation on Animal Genetic Resources held by FAO in 1980, and the signing of the Convention on Biological Diversity in 1992.

The CBD acknowledged the economic value of biodiversity and the principle was agreed that nations are ethically obliged to conserve these resources for the benefit of future generations. In September 2007 at an FAO International Technical Conference at Interlaken, Switzerland, these principles were reaffirmed and extended and made more specific to farm animal genetic resources (FAO, 2007). The Interlaken Declaration binds governments (including the UK) to several significant commitments and makes many important points – including that traditional breeds and the knowledge that go with them are of cultural significance and worthy of conservation for that reason also.

This means there are not just utilitarian reasons for conserving breeds. They have cultural significance, like other physical manifestations of human needs and aspirations such as art and architecture.

Closer to home, while the RBST has deservedly been in the limelight for its activities, very many other organizations and individuals have been indispensable to the process. The breed societies, the Royal Agricultural Society of England, and dozens of dedicated individuals and other organizations, have had a very long-standing interest in breed conservation and sustainable development. A recent newcomer, the Sheep Trust was conceived during the foot and mouth epidemic of 2001 to protect breeds which, too numerically strong to fall within the RBST's area of concern, were nevertheless threatened because of their concentrations within small geographical areas (Bowles et al., 2004).

The full history of livestock biodiversity conservation in the UK is yet to be written. When it is it will undoubtedly pay tribute to the support given by Defra and its predecessor, MAFF.
MAFF had held "meetings of interested parties" about farm animal genetic resources starting in 1995. In December 2001 a Consultative Committee was set up to prepare the UK submission (Defra, 2002; Roper, 2004) to FAO's "State of the World's Animal Genetic Resources". This led to a Defra National Steering Committee to prepare an Action Plan for Farm Animal Genetic Resources which was published in November 2006 (Defra, 2006), and the Government including the Devolved Administrations accepted all 38 of its Recommended Actions.

National Standing Committee on Farm Animal Genetic Resources

The first of these was the establishment of the National Standing Committee on Farm Animal Genetic Resources. The Chairmanship and posts on the Committee were advertised from late 2006, and the first meeting was held in March 2008.

The Chairman is Professor Geoff Simm of the Scottish Agricultural College. Several members of the Committee are, as individuals, office holders or members of breed societies and other organizations including the Rare Breeds Survival Trust but none, apart from the representatives of the Devolved Administrations are *ex officio* members. The principal institutional affiliations of members are the Scottish Agricultural College, University of Lincoln, Liverpool John Moores University, Roslin Institute, National Sheep Association, British Pig Association, Cobthorn Trust,

First Milk Project, Quality Meat Scotland, Genus Breeding, Aviagen, Genesis Faraday Partnership, Grassroots Ltd. and Natural England.

The Committee is charged with putting into effect the other 37 Recommended Actions, and these can be summarized as follows:

1. Actions towards identifying and monitoring UK native breeds, their breed structures, and risks to their genetic composition;
2. Actions in relation to prioritization of breeds for conservation, including definition of "thresholds for geographical concentration, local adaptation and breed distinctiveness";
3. Actions in relation to complementary policy objectives including applications of breeds in sustainable systems, and including communications and publicity, education and specialist training;
4. Actions in relation to animal health – monitoring impact of the National Scrapie Plan, contributing to development of livestock disease control policies, welfare codes (in relation to breeding technologies and programmes).

The Committee also helps to propose specifications for research to be commissioned by Defra, with a view to achieving specific aims of the Action Plan, and it also helps to foster "joined-up thinking" for example by contributing to the Farm Animal Welfare Council's deliberations on the welfare implications of new breeding technologies. In a very significant new development, populations of traditional sheep and cattle breeds are now assessed with respect to genetic conservation as one of the "Biodiversity Indicators In Your Pocket" which enable national progress towards overall biodiversity conservation to be monitored (JNCC, 2009). There are linkages with other sciences too. With new developments in reference genome sequences and high-throughput genomic technologies for livestock species, there is the opportunity to characterize the genetic endowments of native breeds so as to understand how their specific adaptations can be understood and utilised.

The UK Government's adoption of the Convention on Biological Diversity signals its commitment to livestock biodiversity but this needs to be reconciled with other sustainability goals as well as with potentially countervailing pressures. In spite of very small amounts of public money being available explicitly for this conservation, it is proving possible to achieve a leverage effect, for example by exploiting the Farm Animal Genetic Resources supplementary measures within the Higher Level Stewardship scheme (Natural England, 2008). By December 2008, 228 agreements covering 10,000 hectares had been set up under these measures, meaning that £6 million has been committed to supporting native breeds in environmental management in England over the next ten years. The Chillingham cattle (Hall, 2006; http:///www.chillinghamwildcattle.com) are also beneficiaries of this scheme.

Thus, the Committee has goals which relate to the conservation of breeds because they are elements of the biological diversity which the Convention exists to protect. It must be remembered that the Convention extends further than merely imposing a duty for conservation. It also asserts that countries have the right to benefit from the exploitation of that biodiversity.
The Committee therefore has a remit to promote the sustainable exploitation of farm animal genetic resources. Its axiom is that this will not be possible unless current breeds and the genetic diversity within them are conserved, whether or not the breeds are rare or threatened.

Principles of conservation of farm animal genetic resources

Why does conservation of farm animal genetic resources take the form of conservation of current breeds? In principle, the current genetic variation existing in a livestock species could be maintained if breeds were combined into a single pooled conservation population with random selection and in which matings were managed so as to control inbreeding. If the population were large enough (of the same order as the UK dairy herd), new mutations would arise in sufficient number to be accessible (Hill, 1982). If individuals are fully characterized genetically it would then be possible to identify individuals carrying any specified gene which could then be used in breeding programmes. This would work for traits which are controlled by a single genetic locus

but most traits of practical importance have modes of inheritance that involve many loci and the pooled population approach would not work for them. And such populations would be extremely expensive to maintain. This is why, in scientific practice, farm animal genetic resources are best conserved as currently existing breeds. And of course a pooled population approach would throw away the individual identities of breeds which are of very great cultural significance.

What is the point of keeping breeds that are very scarce and have therefore been shown to have little or no commercial value for farming as a whole? Breeds can sink to extremely low numbers and then suddenly find favour. The Lleyn sheep of north Wales (Plate 1) numbered only some 500 ewes in ten flocks in the mid 1960s (Hall and Clutton-Brock, 1988) in 2002 (Defra, 2002) it numbered 129,643 registered ewes. The appeal of the breed has been in its prolificacy, ease of management, convenient body size, and ability (unlike crossbred maternal genotypes) to produce its own flock replacements, a combination of attributes which only came to notice because the breed had been kept as a recognizable entity. However, this is not typical. Rather more moderate success stories are to be found among the breeds listed at various times by the RBST as having been of concern. RBST criteria have changed in details over the years, but the threshold numbers of registered breeding females that have, generally, applied, are as follows: cattle, 750; goats, 500; horses, 1500; pigs, 500; sheep, 1500. Numbers in 2002 for the breeds that now most markedly exceed these thresholds were as follows: British White cattle, 1368; Longhorn cattle, 1500; Gloucester Old Spot pigs, 628; Hebridean sheep, 2981. Essentially these breeds supply niche markets and while their contribution in tonnage terms to national food production is trivial they are usually highly visible to the public and can play an important new role in connecting urban people to the countryside, in addition to their very significant role in enriching the lives of those who live in rural areas.

Plate 1: Lleyn sheep in Lincolnshire. Once very rare, this breed now has a strong following with flocks located all over the UK. It was chosen for this college flock because of its ease of handling and its commercial attributes

Many of our breeds have mysterious and romantic histories (for example, Bagot goats: Plate 2 overleaf). And at least some of these breeds may be particularly suited to conservation grazing projects, in which the floral and faunal biodiversity of grasslands is protected and enhanced by a grazing regime.

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Plate 2: Bagot goats at an agricultural show. With a mysterious history (and a firm association with the former Bagot's Park in Staffordshire) this breed, Britain's rarest goat, is unlikely to have characteristics of direct relevance to the farming of the future but it has a definite place in the history and diversity of the British countryside.

What about breeds that are not numerous, but not rare? Many once very familiar breeds such as Ayrshire and the Shorthorn breeds (Plate 3 overleaf) are now very much in the minority (7000 and 3500 cows respectively in 2002). Yet these and many others are, respectively, parts of global breeds and as such can benefit from breed developments overseas as well as serve as a genetic resource population and they have viable commercial roles in supplying niche markets. Another group of breeds that require special attention are the geographically concentrated breeds which are relatively numerous but confined in a small area, which makes them very vulnerable in the event of disease outbreaks. Twelve sheep breeds including the Herdwick, Shetland and South Wales Mountain are placed by the Sheep Trust in this category (Carson et al.,2009) and the Rare Breeds Survival Trust has also adopted a geographical criterion of this kind. Here, the conservation challenge is in finding ways of protecting these genetic resources in the event of a disease control slaughter programme.

What are the prospects for commercial exploitation of these genetic resources? This can be at several levels. Transferring genetic material by a transgenic process from one breed, or even species, to another involves substantial difficulties both practically and in terms of public acceptability. More realistically, farmers can switch from one breed to another; breeds can be kept pure and mated to produce crossbred animals which often benefit from hybrid vigour; new composite breeds can be formed combining the merits of two or more founder breeds (Simm, 1998; Hall, 2004). All these processes are well understood and all depend for their sustainability on the continued maintenance of pure breeds. As breeds cannot be patented (Hall, 2004, p. 178) the capture of economic benefits is the privilege of the breeder, whether a private farmer or a large company.

What about genetic variation within breeds? Today, modern breeding techniques based on precise recording of performance and advanced computation mean that commercial breeds and varieties are very high performing in terms of output and profitability under current economic regimes. Should a new characteristic be needed in one of these breeds, its introduction from a different breed is likely to impose a serious performance penalty. Attempts to increase prolificacy of modern pig varieties by matings with the Meishan and other highly fecund Chinese breeds have given rise to prolific new varieties but in most cases these do not compete in leanness and growth rate. This means it is very important to maintain genetic variation in the commercially dominant breeds such as the Holstein, and modern poultry varieties, so that should new requirements arise they can be bred for within the breeds themselves. Commercial confidentiality means that an independent audit is generally not possible of how effectively this is being done by the breeding companies.

Plate 3: Shorthorn cattle, County Durham. A valuable genetic resource providing flexibility for the dairy industry of the future, and of very great historic significance as one of the world's most influential cattle breeds.

Maintaining genetic variation within breeds is also key to their survival. Pedigree breeders know about the risks of inbreeding and traditionally have minimized these by pedigree analysis of their own flocks and herds. However, inbreeding is not the only determinant of loss of genetic variation at the level of the entire breed. It is now possible to obtain a genetic overview of an entire breed (provided the pedigree information is electronic) making it possible to monitor the situation and, if necessary, devise schemes to maintain genetic variation at the level of the breed (Hall, 2004, chapter 9). Large numbers of genetic markers have now been located within the genetic material of livestock species, primarily for use within mainstream breeding populations, and these can in principle be used to validate and develop conservation breeding schemes for smaller breeds.

Conclusions

Concern for farm animal genetic resources therefore goes a lot further than arguing for the maintenance of rare breeds. This is one reason why the National Standing Committee on Farm Animal Genetic Resources includes experts from the commercial breeding world as well as from academia and the traditional breed conservation community. It also has links with counterparts in other countries and is part of European and global initiatives, championed by the European Association for Animal Production and FAO respectively, towards conserving the genetic assets that are essential for global food security. It is fitting that a committee that aims to serve livestock biodiversity should itself be of such diverse composition and in its own way be a demonstration of hybrid vigour.

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