SCOTTISH EXECUTIVE

The Status of Traditional Scottish Animal Breeds and Plant Varieties and the Implications for Biodiversity

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THE STATUS OF TRADITIONAL SCOTTISH ANIMAL BREEDS AND PLANT VARIETIES AND THE IMPLICATIONS FOR BIODIVERSITY

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EXECUTIVE SUMMARY

1. Within the farming sector there is a huge variation within species, the great array of different crop varieties for instance, or the range of cattle breeds. Often these varieties and breeds are particular to certain locations or environments, having developed particular characteristics that make them well adapted to local conditions and climates. However, for decades there has been a trend away from using this variety, in favour of a small number of breeds that perform more uniformly. In this way, just a handful of varieties and breeds now account for the majority of agricultural production in Scotland. There are instances of just c.10% remaining varieties of particular crops, the rest having been lost.

2. Within the livestock sector, the trend has also been towards greater uniformity along with greater productivity. In the 1960’s foreign breeds, particularly from continental Europe were introduced. The numbers of individuals within traditional breeds have declined to such an extent that they have been classified by the Rare Breeds Survival Trust as either “minority” or “rare”. The recent foot and mouth outbreak highlighted the vulnerability of some of these breeds to extinction. When the numbers of individuals are small and they are concentrated within a relatively small geographical area, the risk of entire breeds being lost is a very real one.

3. It is also becoming clear that certain farming practices are likely to be beneficial to the maintenance and enhancement of biodiversity. The presence of agriculture can create ecological niches and help to maintain food chains, to the benefit of wildlife. However modern breeds of livestock and varieties of crops and the associated management practices may not always be appropriate for the management of biodiversity. This is particularly true of marginal lands in the uplands. There is an increasing realisation that traditional breeds and varieties may have much to offer in terms of maintaining farming in these areas.

4. The aim of this scoping study was to evaluate the effects on Scottish biodiversity of changes in the use of traditional breeds and varieties. The overall objectives were:

a) The evaluation of the importance of genetic loss from the reduction in use of these breeds and varieties, for example, the loss of unusual characteristics that might have been of particular local use.

b) An assessment of the impacts of reduction in the ability to conduct further breeding or research on rare and traditional varieties and breeds.

c) Identification of the loss of certain farming techniques associated with particular varieties and breeds.

d) An assessment of possible losses of biodiversity associated with reduction in the use of these breeds and varieties and the farming systems associated with them.

The specific objectives of the project were to provide:

1. A review of relevant research.
2. A list of organisations and individuals holding relevant genetic resources or information.
3. A review of ongoing genetic conservation projects.

4. A review of rare and traditional genotypes of livestock and crops on Scottish farms including their distribution.
5. A summary of the size and complexity of the genetic resource.
6. An overview of the contribution made to biodiversity of maintaining the traditional farming systems associated with particular breeds and varieties.
7. A detailed review of the contribution made to biodiversity of one traditional crop variety (Scots Bere) and one traditional breed of livestock (Blue Grey cows).
8. Recommendations for further work, for further research, practical developments and identification of opportunities for promotion of traditional breeds and varieties associated farming systems.

The project was divided into two parts - a livestock component (Part 1) and a crop component (Part 2).

PART 1 – LIVESTOCK

1. The livestock component concentrated on rare and traditional Scottish breeds of sheep and cattle as there are no distinctly Scottish pig breeds.

2. A review of the research which has been conducted on the role and performance of rare and traditional Scottish breeds of sheep and cattle indicated that virtually no research has been conducted on the role of these breeds in maintenance or enhancement of biodiversity, nor on their wider socio-economic role.

3. The performance of these breeds in terms of their live-weight gain, reproductive rate, milk yield etc. is fairly well documented, although few direct comparisons with other breeds have been undertaken. In many cases the efficiency with which traditional breeds of cattle utilise feed for carcass growth is as good or even better than Continental breeds.

4. A number of organisations hold information on these genetic resources, namely the breed societies and the Rare Breeds Survival Trust. A number of projects are attempting to conserve the rare and traditional Scottish breeds, but there is no mechanism by which these activities are co-ordinated.

5. The numbers of individuals of specifically Scottish breeds of sheep and cattle were estimated from a number of sources, including the British Cattle Movement Service, breed societies and surveys.

6. Some breed societies hold good records, including historical records, of numbers of animals, while others do not. Traditional Scottish cattle breeds for which historical records are available generally show a decline in numbers over the past few decades, with the exception of the Aberdeen Angus. The numbers of the mainstream Scottish sheep breeds in the UK have increased over the past few decades, in line with the general increase in sheep numbers. The status of the rare and minority sheep breeds is less certain.

7. For cattle the British Cattle Movement Service holds data on the numbers of each breed in each county. This provides a valuable source of data for identifying the location of different breeds and highlights the strong geographic concentration of some breeds in certain

regions, exposing those breeds to increased risk of a catastrophic fall in numbers because of disease.

8. For sheep, no equivalent data is available and so the vulnerability of some entire breeds to an outbreak of disease e.g. Foot and Mouth, is not known.

9. An overview of the size and complexity of the genetic resource of Scottish breeds of sheep and cattle is given. A detailed review of the breed structure of each breed is beyond the scope of this study, but there are indications that the breed structures of some breeds make them heavily dependent on only a few herds for replacement stock, thus narrowing their genetic base.

10. A case study of the Blue Grey cow revealed that although considerable information is available on the performance of this genotype in relation to other breeds and crosses, little is known as to whether it contributes to wider biodiversity in a way which is different to other breeds.

11. Virtually no research has been conducted on the role of rare and traditional breeds in farming systems or the extent to which these breeds contribute to biodiversity.

12. A workshop convened to explore this (at which a range of interested parties contributed) indicated that there was anecdotal evidence to suggest that rare and traditional breeds had attributes that made them particularly suited to some production systems, but there is little independent evidence to support these claims.

Recommendations for further work

1. A full and systematic review of the numbers and geographical distribution of different breeds of sheep should be undertaken as a matter of urgency.
2. There is a need to review breed improvement programmes in Scottish breeds and to assess their actual or potential impact on genetic diversity.
3. Consideration should be given to a review of Scottish breeds outwith Scotland and the UK. Opportunities for the use of Scottish Breeds outwith Scotland should be explored.

Research requirements

Research requirements were identified firstly, in relation to the conservation of the animal genetic resource and secondly on farming systems and wider biodiversity.

In the area of conservation of genetic resources research is needed on:

a) Development of registration management software, ideally designed to help make breeding decisions.

b) The genetic affinities of Scottish sheep breeds. Coupled with this there is also a need to conduct research on the extent and degree of introgression of genes from other populations.

c) Development of the most cost effective way of operating cryopreservation programmes for collection and storage of embryos and semen for conservation of genetic resources.

d) The nature and genetic consequences of population structures of the Scottish breeds.

Virtually no research has been conducted on the role of rare and traditional Scottish breeds in farming systems, their impact on wider biodiversity and their socio-economic role.

Specific areas on which research is needed are:

a) Differences in foraging behaviour of different breeds and potential effects on vegetation and other aspects of biodiversity.

b) A better understanding and quantification of the characteristics of breeds to explain how these characteristics appear to suit particular production systems. There is also a requirement to identify if particular breeds are suited to systems which use species-rich pastures, including whether hay making can be integrated into farming systems with traditional breeds and methods for enabling species-rich swards at a more advanced physiological stage than is usually used for silage.

c) The effects on vegetation of year-round grazing rather than summer-only grazing, since some breeds of cattle may be more suited to out-wintering.

d) Systems-level research is needed to identify the potential gains in biodiversity that could be achieved from more mixed farming systems, especially in the uplands, and how rare or traditional breeds may contribute to this.

e) Identification of differences in susceptibility of different Scottish breeds to internal, and perhaps external parasites to identify if some breeds are more resistant to parasites than others and require less use of anthelmintics.

f) The socio-economic role and importance of such breeds.

Practical developments

1. Ways of providing more precise definitions of the breeds and crosses entered in the British Cattle Movement Service data base should be explored.

2. Urgent consideration should be given by Government to ways of collecting information on the numbers and spatial distribution of different breeds of sheep so that vulnerability to catastrophic events such as disease outbreaks can be assessed.

3. As part of its responsibility under the Convention on Biodiversity, Government should consider how better co-ordination may be achieved in genetic conservation schemes.

4. A greater degree of co-operation between farmers is needed, especially for finishing and marketing rare and traditional breeds.

Opportunities for promotion of rare and traditional breeds and associated farming systems

1. Further opportunities for the use of Scottish breeds outwith Scotland should be explored.

2. Information about the performance of different sheep breeds and their crosses should be made available so that market niches can be developed.

3. There may be a case for providing enhanced levels of support to farms that keep rare or traditional breeds in order to assist in the preservation of these genetic resources.

4. An in-depth study of the opportunities for marketing products from rare and traditional breeds should be undertaken. Practical support from Government and other agencies (eg. local authorities, local enterprise companies) to initiate marketing schemes would not only help with the conservation of traditional and rare breeds but also encourage rural employment and development.

PART 2 - CROPS

1. The crop component of the project concentrated on barley and oats with a brief overview of other crops. Special attention was paid to Scots Bere.

2. The historical changes in the areas of different crops in Scotland are documented. In the last few decades there has been a decline in the areas of oats, and an increase in barley and in wheat.

3. There has been a continual change in the cultivars of oats and barley used as new varieties are produced, displacing older varieties from the National and Recommended Lists. For varieties to be placed on the National List they have to perform well over the whole of the UK and this mitigates against the recognition of specific regional adaptation.

4. Research on Scots Bere, a six-row barley, traditionally grown in Scotland in the 18^{th} and 19^{th} centuries but now grown on only 5-15ha in Caithness and Orkney each year, has shown that not only is it acid tolerant, but it has a number of other characteristics. It has high diastatic power and alpha-amylase activity.

5. Scots Bere has proved useful in research on the control of traits important in Scottish barley, especially early heading and maturity.

6. A number of collections around the world hold Scottish cultivars. The most important is that in the John Innes Centre, Norwich, but there are also collections in Sweden, Germany, Poland and the USA which hold Scottish cultivars of barley and oats.

7. There are many organisations concerned with conservation of cereal germplasm mainly co-ordinated by the International Plant Genetic Resources Institute in Rome.

8. The role of traditional Scottish cultivars on wider biodiversity is not well documented, although cereal crops provide a habitat and food for a range of taxa.

Recommendations for further work

1. A survey of genetic variation related to the tolerance of Scots Bere to acid soil should be undertaken.

2. Genetic variation for nitrogen use efficiency in Scots Bere compared to other varieties should be studied.

3. The nutrient value of Scots Bere for animal feed and human food should be quantified.

4. The practical implications of using composite crossing techniques in tandem with modern genetics to develop varieties suitable for low-input systems should be examined.

Research requirements

1. There is a need for further research into the effect that traditional barley and oat cultivars have on the biodiversity of the environments in which they are grown.

2. There needs to be a quantification of the traits traditional cultivars exhibit in relation to wider biodiversity.

3. Research is needed on how best to manage cereals, particularly diploid oats for grazing and silage, to maximise biodiversity.

4. Research should be conducted on the development of a Scottish Seed Conservation mix to encourage farmland birds.

5. Investigations need to be carried out on the susceptibility of traditional barley and oat cultivars to diseases such as mildew and smut.

6. There needs to be a general review of plant breeding programmes, to identify if important traits have been lost as a consequence of selection for traits of use in modern systems.

7. Consideration should be given to using new breeding techniques to move traits from tall, six-row ear types of barley to the shorter two-row types widely used in Scotland.

Practical developments

1. Encouragement needs to be given to farmers to co-operate with each other on seed production and the development of new cultivars.

2. Further work is needed to look at objective techniques of prioritisation of seed conservation – the lack of a cereal gene bank in Scotland hampers cereal research.

Opportunities for promotion of rare and traditional varieties and associated farming systems

1. Aspects of the performance of traditional cultivars need to be made available to allow their market niches to be identified.

2. There is an opportunity for greater promotion of local cereal-based products, based on traditional varieties.

3. There are opportunities to market the products of traditional cultivars by modern methods e.g.. internet-based sales, development of more efficient distribution systems, supermarket promotion.

CHAPTER ONE: INTRODUCTION

CONTEXT

1.1 Within the farming sector there is a huge variation within species, the great array of different crop varieties for instance, or the range of cattle breeds. Often these varieties and breeds are particular to certain locations or environments, having developed particular characteristics that make them well adapted to local conditions and climates. However for decades there has been a trend away from using this variety, in favour of a small number of breeds that perform more uniformly. In this way, just a handful of varieties and breeds now account for the majority of agricultural production in Scotland. There are instances of just c.10% remaining varieties of particular crops, the rest having been lost. For instance the seeds for some cereal varieties formerly grown in the Western Isles are now difficult to obtain. It is possible to find some farms across Scotland where traditional forms of agriculture depend on these local, specialised varieties (such as the "small barley" variety grown in Uist which can withstand particularly high soil pH levels).

1.2 Within the livestock sector, the trend has also been towards greater uniformity along with greater productivity. In the 1960's foreign breeds, particularly from continental Europe were introduced. The numbers of individuals within traditional breeds have declined to such an extent that they have been classified by the Rare Breeds Survival Trust as either "minority" or "rare". Even once common breeds like Belted Galloway cattle and the Border Leicester sheep now fall into the minority category. The recent Foot and Mouth outbreak highlighted the vulnerability of some of these breeds to extinction. When the numbers of individuals are small and they are concentrated within a relatively small geographical area, the risk of entire breeds being lost is a very real one.

1.3 It is also becoming clear that certain farming practices are likely to be beneficial to the maintenance and enhancement of biodiversity. The presence of agriculture can create ecological niches and help to maintain food chains, to the benefit of wildlife. However modern breeds of livestock and varieties of crops and the associated management practices may not always be appropriate for the management of biodiversity. This is particularly true of marginal lands in the uplands. There is an increasing realisation that traditional breeds and varieties may have much to offer in terms of maintaining farming in these areas.

AIMS AND OBJECTIVES

1.4 This was a scoping study to evaluate the effects on Scottish biodiversity of changes in the use of traditional breeds and varieties. The overall objectives were:

The evaluation of the importance of genetic loss from the reduction in use of these breeds and varieties, for example the loss of unusual characteristics that might have been of particular local use.

An assessment of the impacts of reduction in the ability to conduct further breeding or research on rare and traditional varieties and breeds.

Identification of the loss of certain farming techniques associated with particular varieties and breeds.

An assessment of possible losses of biodiversity associated with reduction in the use of these breeds and varieties and the farming systems associated with them.

Specifically this report provides:

1. A review of relevant research.
2. A list of organisations and individuals holding relevant genetic resources or information.
3. A review of ongoing genetic conservation projects.
4. A review of rare and traditional genotypes of livestock and crops on Scottish farms including their distribution.
5. A summary of the size and complexity of the genetic resource.
6. An overview of the contribution made to biodiversity of maintaining the traditional farming systems associated with particular breeds and varieties.
7. A detailed review of the contribution made to biodiversity of one traditional crop variety (Scots Bere) and one traditional breed of livestock (Blue Grey cows).
8. Recommendations for further work, for further research, practical developments and identification of opportunities for promotion of traditional breeds and varieties associated farming systems.

METHODS

Livestock component

1.5 The livestock component of the project concentrated on cattle and sheep since these are the species where particular breeds are closely linked with particular environments. Scottish sheep and cattle breeds are classified as rare, minority or traditional. There are also many crossbreds which are associated with particular systems or environments (Table 1).

Table 1. Rare, minority and traditional breeds of sheep and cattle.

Sheep			
Rare	Minority	Traditional	Crossbred
Boreray Castlemilk North Ronaldsay Soay	Border Leicester Hebridean Shetland	Lanark Blackface Lewis Blackface Perth Blackface Newton Stewart Blackface North Country Cheviot South Country Cheviot	Greyface Scottish Halfbred
Cattle			
Rare	Minority	Traditional	Crossbred
Shetland	Beef Shorthorn Belted Galloway Highland Luing	Aberdeen Angus Ayrshire Galloway	Blue-Grey

Literature Review

1.6 Part of the project involved a review of the published scientific literature. This was undertaken using standard internet based library search engines.

Population data

1.7 An important part of the project was to identify the numerical status of the different traditional breeds of cattle and sheep. This included not only rare and minority breeds, but also traditional breeds and crossbreds. With respect to sheep, there are no official records of numbers in different breeds. The British Cattle Movements Service (BCMS) provided information on breeds of cattle broken down by county boundaries. Since the BCMS has only been formed relatively recently, they were unable to provide any historical information on the trends in numbers within breeds and their geographical locations.

1.8 Some statistical information on numbers of different breeds was obtained from the Rare Breeds Survival Trust (RBST). They were able to provide information on the minority and rare breeds. For some of the rarer breeds, this was the best source of information.

1.9 The secretaries of all the relevant breed societies were contacted and asked to provide information on the numbers of animals registered. This met with a mixed response since the information stored varies widely between societies. Some societies do not register animals and were therefore unable to provide any information, while some have excellent records dating back many years. Of those societies which do register animals, most recognised that there are significant numbers of animals which are unregistered.

1.10 In order to try to identify historical trends in the breed structure of Scottish farming, old copies of Scottish Farmer dating back to 1960 were consulted. Reports of agricultural shows and market reports were studied along with any relevant articles relating to breeds of livestock.

Genetic conservation

1.11 Dr Saffron Townsend of the RBST was consulted on matters relating to genetic conservation. She was able to provide information on current and proposed projects which RBST and others are either involved with or hope to initiate. She was also able to provide background information on the techniques of genetic conservation.

Farming systems and techniques

1.12 A workshop was held in late November 2001 to which a number of interested parties were invited (see Appendices One and Two). Those invited represented a wide body of interests including practical farmers, conservation bodies, breed societies, policy advisers and scientists. The workshop was designed to address the following issues:

How rare and traditional breeds fit into livestock systems.

How rare and traditional breeds and crops fit into mixed farming systems.

What are the issues with respect to the conservation and promotion of rare and traditional breeds?

1.13 The workshop was divided into a number of sessions to address these issues and the results of the discussions were incorporated into the report. In addition a great deal of useful information was gleaned from telephone interviews with a number of individuals. These included farmers and representatives of a number of the breed societies.

Plant varieties component

1.14 The project was progressed by literature reviews, internet searches, consulting statistical sources and speaking to local experts.

Literature review

1.15 The extensive modern literature on barley genetics, genetic diversity and the origin of cereal crops was consulted and relevant papers summarised. The scope of these studies ranges from the traditional phenotypic observation to recent papers using molecular biological techniques. Previous surveys of UK cereal agriculture were consulted and historically significant papers were scanned to identify significant features of traditional variety uses.

Statistical sources

1.16 Statistical sources were used to identify the changes in crop areas in Scotland. Apart from the major change from oats to barley the fate of minor crops such as beans was also followed. Seed production statistics were used to examine the current use of traditional cultivars.

Plant breeding

1.17 The Annual Reports of the Scottish Plant Breeding Station were consulted to place local breeding efforts in the context of changing crop use. The British Society of Plant Breeding and member companies were also consulted.

Internet searches

1.18 Internet searches were used extensively to tabulate the location of seed samples of traditional cultivars. The collections with cultivar performance data, particularly the USDA collection, were interrogated.

Consultation

1.19 Consultation with experts played a large role in the location of cereal collections and to obtain information on the local use of traditional cultivars.

Farming systems and techniques

1.20 As noted under the “Livestock component” a workshop was held and focussed on the role of traditional varieties in modern farming.

Part one LIVESTOCK COMPONENT

CHAPTER TWO: REVIEW OF RELEVANT RESEARCH ON THE ROLE AND PERFORMANCE OF RARE AND TRADITIONAL BREEDS

2.1 This section of the report gives an overview of the research which has been conducted on the role and performance of rare and traditional breeds. The review has been divided into four key areas.

(a) The role of the grazing process in the biodiversity of ecosystems.

(b) Research which looks specifically at rare or traditional breeds and their role in biodiversity.

(c) The performance and physical characteristics of rare and traditional breeds in relation to their modern and imported counterparts.

(d) Research into the economic and social implications of rare or traditional breeds.

A. THE ROLE OF THE GRAZING PROCESS IN THE BIODIVERSITY OF ECOSYSTEMS

2.2 The grazing process has been the subject of research for many years and so there is a considerable body of knowledge on the dynamics of grazing. Historically, much of the research was aimed at maximizing the utilization of the grazed resource, but more recently research has been conducted on how grazing can be used to achieve environmental objectives, especially in relation to the impact on vegetation.

2.3 Much of the research has considered the effect of the intensity of grazing and the species of grazer. Compared with sheep, cattle are relatively unselective as grazers, due to their larger mouth parts (Gordon and Iason, 1989), and their lower metabolic requirements relative to their body weight means that they can survive on poorer quality forage than sheep. Thus, sheep tend to select a greater proportion of the preferred plant species and plant parts in their diet than cattle and this can affect the floristic diversity of vegetation communities.

2.4 On *Nardus stricta* - dominated grassland, cover of *Nardus* decreases with increasing grazing pressure by cattle, but with sheep there is little effect (Grant et al, 1996b). Cattle consume a greater proportion of *Nardus* in their diet than sheep, especially at higher grazing pressures and as a result, their diet is of lower digestibility (Armstrong et al, 1997). In some cases the cover of the broad and fine-leaved inter-tussock grass species increases (Grant et al, 1996b), but in others it does not, possibly as a consequence of site differences in nutrient availability (Common et al, 1998). Mixed grazing by cattle and sheep can bring about similar changes to that of cattle grazing alone, although the changes in the floristic composition are slower (I.A.Wright, unpublished results).

2.5 On *Molinia ceruleae*-dominated heath it has been shown that high levels of utilization of *Molinia* leaf reduces the *Molinia* content of the sward (Grant et al, 1996a). Floristic diversity was enhanced by grazing by cattle compared to areas that were ungrazed, where *Molinia* became very dominant.

2.6 On heather moorland, grazing intensity and pattern can have major impacts on floristic diversity. Grant et al (1982) demonstrated that if utilisation of the current season's shoots of *Culluna vulgaris* exceeded 40%, the growth of the plant was reduced. High levels of grazing of heather results in the replacement of heather by grasses, sedges and herbs. Recently, the role of the spatial distribution of grass patches within a grass/heather mosaic has been explored and it has been shown that the utilization of heather at the boundary of grass and heather is several fold higher than the average level of utilisation (Hester and Ballie, 1998). This has important implications for the dynamics of the competition between grass and heather.

2.7 On improved pasture, the level of intensity of grazing has relatively little impact on the botanical composition. Long term studies have suggested that reducing grazing pressure, and maintaining sward height of 8cm compared to 4cm has only a small effect on botanical composition (Marriott et al, 2002), although complete cessation of grazing can have a large impact on botanical composition.

2.8 Grazing intensity has a large effect on the structure of vegetation, even though the botanical composition may not be influenced greatly. Such differences in structure can lead to differences in invertebrate populations. Although understanding of these responses is not comprehensive, some studies have been conducted. Gardner et al (1996) investigated the effects of grazing on the development of heather and the effects on ground beetles. Ground beetle distribution was strongly influenced by soil organic matter content and the height of the heather. Dennis et al (1997) examined the effects of grazing regime on a *Nardus*-dominated sward on invertebrate populations. It was found that some of the species of ground beetle were strongly influenced by the grazing regime. It was concluded from the study that a rotation of varied management over time, including different combinations of grazing animals, would encourage a wider diversity of beetles, through the creation of a mosaic of different structures within the sward. The impact of grazing on other taxa, e.g. moorland birds and small mammals, especially in upland vegetation is not well understood, but new studies are beginning to explore these effects.

B. RESEARCH LOOKING SPECIFICALLY AT THE ROLE OF RARE OR TRADITIONAL BREEDS IN THE PROMOTION OR ENHANCEMENT OF BIODIVERSITY

2.9 There are several cases of rare or traditional breeds being used in grazing systems to promote biodiversity. The Royal Society for the Protection of Birds, for example, uses Highland cattle on some of its nature reserves. At Vane Farm reserve in Fife, a herd of Highland cattle is used to control rushes and maintain species-rich grassland. Highland cattle are also used on Rhum, where, as a result, there has been an increase in variety of plants in most plant communities. Hebridean sheep are used by Lincolnshire Wildlife Trust as part of the management of their nature reserves. However, there has been very little research done to compare the grazing behaviour, diet selection, herbage intake and impact on vegetation of rare and traditional breeds with modern or imported breeds.

2.10 One of the few studies was conducted by Newborn (2000) comparing the ability of Swaledale and Hebridean sheep to control invasive purple moor grass (*Molinia caerulea)* in Yorkshire.

Table 2.1 Effects of grazing by Hebridean and Swaledale sheep on leaf density and percentage of leaves grazed in purple moor grass (Newborn, 2000)

	Breed	1992	1993	1994	1995	1996	Overall Mean+/- SE
Leaf density(no/m^2)	Swaledale	2406	4309	3230	1732	2312	2798 +/- 313
	Hebridean	2196	3101	3092	1365	2193	2389 +/- 279
% leaves grazed	Swaledale	42	30	17	21	5	23.0 +/- 4.5
	Hebridean	66	58	54	50	75	60.6 +/- 6.2

Table 2.2 Effects of grazing by Hebridean and Swaledale sheep on cover of *Calluna* (%) (Newborn, 2000)

	1992	1993	1994	1995	1996
Swaledale	3	6	7	0.5	1
Hebridean	12	14	17	29	22

2.11 Over a five year period (1992-1996) grazing by Hebridean sheep led to a consistently higher level of utilisation of *Molinia* although the overall leaf density of the purple moor grass was not significantly altered (Table 2.1). It is therefore possible that this apparent preference for purple moor grass by the Hebridean sheep could be exploited to reduce the content of purple moor grass significantly by imposing a higher stocking rate. There was a significant increase in the heather cover under grazing by Hebridean sheep (Table 2.2), although the author could not draw any conclusions about the reasons for this, except that further study is required to fully understand the mechanisms involved.

2.12 Dwyer and Lawrence (1997) observed that when Blackface and Suffolk ewes grazed in a field comprising improved pasture and semi-natural vegetation, the Suffolk ewes tended to graze the improved pasture and the Blackface ewes the semi-natural pasture. However this does not demonstrate differences in grazing behaviour, since the differences could be due to competition between the larger Suffolk sheep, and the smaller Blackface ewes for the better resource.

2.13 The difficulty with breed comparisons of grazing behaviour, is that differences between populations of animals could be learned as well as being genetic in origin. It is well recognized that animals can learn, especially from their mothers (Thorhallsdottir et al, 1990). Therefore any breed comparisons must take this into account. There is a major gap in our knowledge about the foraging behaviour of different breeds and to what extent genotype and learned behaviour influences diet selection and foraging. Research is needed in this area.

C. THE PERFORMANCE OF RARE AND TRADITIONAL BREEDS IN RELATION TO THEIR MODERN AND IMPORTED COUNTERPARTS

Cattle

2.14 The most comprehensive comparative study of traditional beef breeds with their imported counterparts was carried out by the Meat and Livestock Commission in the 1970's

(Southgate et al, 1982). They looked at live-weight growth and efficiency of food utilization of steers from a range of different breeds and crosses. The trial looked at both summer and winter fattening systems. The cross-bred steers were all born to Blue-Grey or Hereford x Friesian dams. The main performance results of the trial are shown in Tables 2.3 and 2.4 for the winter and summer fattening trials respectively. It has to be borne in mind that these cattle were fed high quality fattening diets typical of intensive systems.

2.15 Although some of the larger continental breeds had higher live-weight gains, in the winter fattening system some of the traditional breeds compare very well in terms of efficiency of live-weight gain with their imported counterparts. Charolais, Limousin and Simmental crosses all performed less well than some of the traditional breeds, particularly Aberdeen Angus and Lincoln Red crosses. While purebred Luing steers were less efficient, Welsh Black steers were among the most efficient. The larger body size of the imported breeds will lead to a greater maintenance requirement. Under a summer fattening regime, the breed which displayed the greatest feed efficiency was the purebred Galloway, although the Luing was once again one of the least efficient.

Table 2.3. Daily food intake, daily live-weight gain and efficiency of live-weight gain for a range of cross-bred and pure-bred cattle on a winter fattening system (Southgate et al., 1982)

Breed	Liveweight at slaughter (kg)	Daily food intake (kg)	Daily live-weight gain (g)	Efficiency of gain (g/kg)
Crossbreds (Sire Breed)				
Aberdeen Angus	393	8.9	766	86
Charolais	494	10.2	837	82
Devon	419	8.9	783	88
Hereford	410	8.8	779	88
Limousin	454	9.2	782	85
Lincoln Red	428	9.6	851	89
Murray Grey	405	8.6	682	81
Simmental	490	10.2	857	84
South Devon	451	9.2	772	84
Sussex	428	8.9	760	85
Dam Breed				
Hereford X Friesian	445	9.4	797	86
Blue Grey	429	9.2	776	85
Purebreds				
Luing	404	8.4	685	83
Welsh Black	437	8.2	715	88

Table 2.4 Daily food intake, daily live-weight gain and efficiency of live-weight gain for a range of cross-bred and pure-bred cattle on a summer fattening system over approximately 3 months prior to slaughter (Southgate et al, 1982)

Breed	Live weight at slaughter (kg)	Daily food intake (kg)	Daily live-weight gain (g)	Efficiency of gain (g/kg)
Crossbreds (Sire Breed)				
Aberdeen Angus	408	10.1	963	95
Charolais	525	11.1	1067	96
Devon	444	9.9	1002	100
Hereford	442	10.0	998	100
Lincoln Red	465	10.9	1050	97
Simmental	526	11.4	1082	95
South Devon	488	10.8	1060	98
Sussex	461	10.2	1028	101
Dam Breed				
Hereford x Friesian	478	10.7	1038	97
Blue Grey	461	10.4	1024	98
Purebreds				
Galloway	424	9.1	927	102
Luing	451	9.9	899	91
Welsh Black	477	9.7	920	95

2.16 The animals from this trial were slaughtered and evaluations were made of the carcasses. The results are shown in Tables 2.5 and 2.6. In terms of total saleable meat, and the saleable meat of higher priced cuts, all the crossbreds and purebred steers performed similarly. However, the Charolais and the Limousin cross-breds had higher killing out percentages under a winter fattening regime. Under a summer fattening regime, the imported breeds again had an advantage in terms of killing out percentage. Purebred Galloways had the highest proportion of saleable meat, although all the crossbreds and purebreds were similar in terms of the proportion of meat in the higher priced cuts. Under both winter and summer fattening regimes, the imported breeds always had better conformation, although the Aberdeen Angus were only marginally lower. It should be noted that these trials were conducted indoors, with even the “summer fattened” steers being housed. Thus any potential differences between breeds in their efficiency of grazing would not have been detected.

Table 2.5 Carcass characteristics of winter fattened cattle (Southgate et al, 1982)

Breed	Killing out (g/kg)	Conformation (15 point scale)	Saleable meat in carcass (g/kg)	Saleable meat in higher priced cuts (g/kg)
Sire Breed				
Aberdeen Angus	525	9.9	725	441
Charolais	548	11.2	727	448
Devon	527	8.6	716	440
Hereford	523	8.7	719	441
Limousin	547	11.0	733	454
Lincoln Red	523	8.5	708	443
Murray Grey	534	9.1	720	443
Simmental	530	9.9	720	448
South Devon	532	8.1	720	443
Sussex	531	9.5	726	439
Dam Breed				
Hereford x Friesian	534	9.6	722	444
Blue Grey	530	9.4	721	444
Purebreds				
Galloway	-	-	-	-
Luing	528	7.2	705	438
Welsh Black	531	8.7	729	441

Table 2.6. Carcass characteristics of summer fattened cattle (Southgate et al., 1982)

Breed	Killing out (g/kg)	Conformation (15 point scale)	Saleable meat in carcass (g/kg)	Saleable meat Higher priced cuts (g/kg)
Sire Breed				
Aberdeen Angus	510	10.1	720	440
Charolais	527	11.0	719	448
Devon	510	9.3	713	439
Hereford	511	9.9	714	444
Lincoln Red	509	8.8	707	441
Simmental	522	10.9	717	447
South Devon	518	8.7	712	441
Sussex	518	9.9	716	441
Dam Breed				
HerefordxFriesian	517	9.9	714	442
Blue Grey	515	9.7	715	443

Purebreds				
Galloway	511	9.8	722	437
Luing	507	8.5	698	435
Welsh Black	520	9.1	717	439

2.17 Although not with Scottish breeds, a recent study by Wright et al (2000) provides one of the few examples of documented interactions between breed and grazing resource. They compared the performance of purebred Welsh Black and Charolais-cross steers when they grazed on either improved permanent pasture or on semi-natural grazings dominated by purple moor grass. It was found that there was no significant difference in live-weight gain between the breeds when grazing the improved permanent pasture. However, when grazing the semi-natural, purple moor grass swards, the live-weight gain of the Charolais-cross steers was significantly lower than that of the Welsh Black. The conclusion which was drawn was that the continental breed was less suited to grazing systems which rely on the use of semi-natural vegetation for part of the grazing season.

2.18 Apart from the data in the tables above, there has been little comparative research carried out on the characteristics of cattle breeds. In a report for MAFF, Mercer et al (1997) drew together information from a variety of sources. This information is summarised in Table. 2.7.

Table 2.7 Some physical characteristics of breeds of beef cattle (Mercer et al, 1997)

	Shetland	Beef Shorthorn	Belted Galloway	Galloway	Whitebred Shorthorn	Charolais
Bull ht at withers (cm)		146		137		
Cow ht at withers (cm)	100-122	140		124		
Male birth wt (kg)		43		38		44
Female birth wt (kg)		38				42
Male 200 day wt (kg)		263-265	194-196	188-196	202	318
Female 200 day wt (kg)	198	222-227	168-169	168-176		277
Male 400 day wt (kg)		470-490	270-324	362-392	408	627
Female 400 day wt (kg)		371-374	261-265	289-301		451
Male mature wt (kg)		800-1150		470		
Female mature wt (kg)	300-400	500-700	535	470		
Bull backfat depth (mm)		1.8				2.9-3.3
Bull muscling score		8		10.0-10.1		11.0-11.2

Sheep

2.19 Comparative data for sheep breeds is even more scarce than for cattle. Mercer et al (1997) drew upon data from a variety of sources. This information is summarized in Table 2.8.

Table 2.8 Physical characteristics of a number of rare breeds of sheep (Mercer et al., 1997)

	Ram wt (kg)	Ewe wt (kg)	Av litter size (%)	Birth wt-twins (kg)	Fleece wt (kg)
Castlemilk Moorit	55	40	144-146		1.0-1.5
North Ronaldsay		25	125-155	1.5-2.3	1.0-2.5
Soay	37	22-25	110-136	2.0	1.5-2.3
Hebridean		35-36	136-152	3.1	1.5-2.3
Boreray		28-30	133-139		Insignificant
Shetland	65	35-45	138-156	2.8	1.0-1.5

D. RESEARCH INTO THE SOCIO ECONOMIC IMPLICATIONS OF RARE AND TRADITIONAL BREEDS

2.20 There seems to have been very little work done in this area. The only published paper which was found does not deal specifically with rare or traditional breeds, but livestock in general. Waterhouse et al (1993) reviewed the development of tourist sites which attempt to interpret the work of livestock farms to visitors. They documented the numbers of these sites, showed how they have been increasing over the years, and how the number of visitors to these sites has doubled over the last 10 years. They concluded that in the correct location, and with appropriate facilities, farm based attractions have a considerable potential. Unfortunately they do not state how many of these attractions feature rare or traditional breeds as part of their marketing strategy. Research is needed into the socio-economic role of the rare and traditional breeds.

CHAPTER THREE: A LIST OF ORGANISATIONS AND INDIVIDUALS HOLDING RELEVANT GENETIC RESOURCES OR INFORMATION

Table 3.1 lists organisations holding information on genetic resources, provides a contact name and a brief summary of the type of information held.

Table 3.1 Organizations holding genetic resource information for sheep and cattle

Organization	Contact Name	Types of information held
Rare Breeds Survival Trust, National Agricultural Centre, Stoneleigh Park Warks, CV8 2LG	Dr Saffron Townsend	Information on numbers of individuals within breeds. Genetic conservation schemes
Highland Cattle Society, 59 Drumlanrig Street, Thornhill, Dumfriesshire	Hamish Wilson – Secretary Susan Campbell – Registrations Officer	Details of pedigree animals registered with the society. Also information on members who are using Highland cattle for biodiversity grazing
Galloway Cattle Society, 15 New Market Street, Castle Douglas, DG7 1HY	Alistair McDonald – Secretary	Details of pedigree animals registered with the society. Also information on members who are using Galloway cattle for biodiversity grazing
Shetland Cattle Society, Hogan, Bridge of Walls, Shetland Isles, ZE2 9NT	Mrs Evelyn J Leash- Secretary	Details of pedigree animals registered with the Society
Aberdeen Angus Cattle Society, Pedigree House, 6 Kings Place, Perth, Scotland, PH2 8AD	Mr Robert Anderson – Secretary	Details of all animals registered with the Society
The Belted Galloway Cattle Society, Parklea, Tongland, Kirkcudbrightshire, DG6 4ND	Miss Myrna Corrie – Secretary	Details of registered animals, although no information was forthcoming for this project
Ayrshire Cattle Society, 1 Racecourse Road Ayr, Scotland , KA7 2DE	Mr David Sayce – General Manager	Has details of animals registered, but was only able to give approximate figures for this project
Whitebred Shorthorn Association, High Greenhill, Kirkcambeck, Brampton, Cumbria, CA8 2BL	Mrs R Mitchinson – Association Secretary	Has records of animals registered. But was unable to give details for this project since a census is currently being undertaken

Table 3.1 (Continued)

Luing Cattle Society Ltd., Incheoch, Alyth, Blairgowrie, PH11 8HJ	Mrs McGowan – Secretary	Details of animals registered with the society
Beef Shorthorn Cattle Society, 4th Street, National Agricultural Centre, Stoneleigh, Warks, CV8 2LG	Mr Frank Milnes – Secretary	Details of pedigree animals registered with the society
Hebridean Sheep Society, Knox Mill, Knox Mill Lane, Harrogate, Yorkshire	Mr Eric Medway – Secretary	Details of animals registered with the society
North Country Cheviot Sheep Society, 16 St Vincent Road, Tain, Rosshire	Mr W Morrison – Secretary	Approximate numbers of ewes and rams
Blackface Sheep Breeders Association, Brae View, Drumharvie, Crieff, PH7 3PG	Mrs Aileen McFadzean	There is no registration scheme, therefore there are no records of numbers of individuals within the breed
The Cheviot Sheep Society (South Country), Holm Cottage, Langholm, Dumfriesshire, DG3 0JP	Isobel McVittie – Secretary	No details of animal numbers were forthcoming
The Society of Border Leicester Sheep Breeders, Greenend, St Boswells, Melrose, Borders, TD6 9ES	Nesta D Todd – Secretary Mrs Marian Miller – Registrations Secretary	Details of ewes and rams going back many years
The Half-Bred Sheep Breeders Association, Greenend, St Boswells, Melrose, Borders TD6 9ES.	Nesta D Todd – Secretary	No records are available
Shetland Sheep Breeders Group, Bartiestown, Hethersgill, Carlisle, Cumbria CA6 6JB	Mrs Elizabeth Brown – Secretary	No records were made available

CHAPTER FOUR: ONGOING GENETIC CONSERVATION PROJECTS

4.1 Much of the work in this area falls to the RBST. Below is a list of RBST and other projects.

NATIONAL REGENERATION BANK

Organisation involved

The Rare Breeds Survival Trust.

Objectives

4.2 To create a store of genetic material to provide protection against a possible future disease outbreak which could destroy some or all of the rare and "at risk" breeds.

Status of project

4.3 The project has started, and will continue as quickly as funding will allow.

Funding

4.4 The project will cost an estimated £2.5 million. This will all have to come from charitable donations. At present some £300,000 has been raised.

Comments

4.5 This is a major project and will involve not only the collection of genetic material, but also the creation of a library of information on rare breeds. Collection of semen and embryos has already started as has the collation of information for the library. The library will draw on information from herd and flock books and breeding records. This information will be analysed using software designed to trace the lineage of individual animals. The information this generates will enable the sampling of the genetic material to be targeted towards those individual animals whose genetic resource is most valuable for long term storage.

DNA ANALYSES OF HORSES

Organisation involved

Rare Breeds Survival Trust

Objectives

4.6 To analyse the DNA of breeds of horses to determine the genetic variability within and between breeds.

Status of project

4.7 Ongoing.

Funding

4.8 The project is funded by RBST which relies on donations from the public.

Comments

4.9 If funds allow, the work will be extended to other species.

RECORDING SCHEME FOR RARE BREEDS

Organisations involved

Rare Breeds Survival Trust, Breed Societies

Objectives

4.10 To record traits of individuals within breeds in order to have a database of the performance characteristics of those breeds.

Status of project

4.11 Ongoing.

Funding

4.12 None

Comments

4.13 The RBST is keen to have such a scheme, but in the absence of funding it relies on members of the breed societies collecting the data themselves on a voluntary basis. The Trust provides protocols for measurements in order to achieve consistency.

HERITAGE GENE BANK

Organisations involved

University of Leeds, University of York, Scottish Agricultural College

Objectives

4.14 To protect the Herdwick breed of sheep in the Cumbrian fells from possible eradication due to Foot and Mouth disease. The project aims to establish a bank of stored semen and embryos.

Status of project

4.15 Started, and will hopefully be extended to cover other breeds.

Funding

4.16 This project is jointly funded by DEFRA and the Garfield Weston Foundation.

Description

4.17 The project was set up very quickly as a response to the very real possibility of Foot and Mouth disease spreading to the Cumbrian fells from the lowlands where the disease was spreading rapidly. The Herdwick breed of sheep is native to the fells of North West England and there was a very real possibility that the breed would be lost if the disease got into the fells. This would have had serious ramifications for not only the Herdwick breed but also for the natural heritage of the region. The ecosystem of the fells depends on grazing and the loss of hefted sheep, adapted to the area, would have been serious.

GENETIC DIVERSITY OF TRADITIONAL BREEDS

Organisations involved

University of East Anglia, University of Cardiff

Objectives

4.18 To examine the genetic diversity of 50 traditional breeds of sheep and cattle.

Status of the project

4.19 This project has only just started.

Funding

4.20 The project is funded under Framework V of the European Union.

Comments

4.21 The work will study the genetic diversity of 50 breeds of traditional sheep and cattle in Europe. The work will involve the analyses of DNA micro satellite markers.

OTHER PROJECTS

4.22 Since the mid 1990's other work has been going on to look at the genetic diversity of rare breeds of cattle and sheep. The London Institute of Zoology ran a project in this area for 3 years. The results of this study are not yet published. A similar EU-funded project under Framework IV finished in 2000. This involved 6 institutes across Europe, including the Institute of Zoology and the University of East Anglia. The study involved using DNA analysis to look at the genetic diversity of sheep and goats.

CONCLUSIONS

4.23 Although there are several projects aimed at the conservation of the genetic resources of rare breeds, these projects are not co-ordinated. The RBST is attempting to co-ordinate some of this activity, but relies on charitable donations. Consideration should be given to the role that government can play in co-ordinating and funding these activities.

CHAPTER FIVE: A REVIEW OF LIVESTOCK FOUND ON SCOTTISH FARMS

SOURCES OF INFORMATION

5.1 The British Cattle Movements Service provided data on the numbers of different breeds in each Scottish county.

5.2 All the breed societies for the relevant traditional and rare Scottish breeds were contacted and asked to provide data on the numbers and distribution of animals throughout Scotland. The information held by breed societies is very variable. Some hold comprehensive information while others do not hold any information on numbers. The RBST also provided information on numbers.

5.3 The Meat and Livestock Commission conducted a survey of sheep breeds in the winter of 1996. Two previous similar surveys were carried out in 1971 and 1987. The survey was sent to a random 10% of those registered as producers with the British Wool Marketing Board and asked about the breeds of sheep kept. Some 30% of the survey forms were returned. The survey looked not only at the breed structure, but also at the numbers of breeding ewes and how the national flock is distributed between the hills, the uplands and the lowlands.

5.4 To examine the trends which have taken place in the breed structures of the Scottish cattle and sheep industries, back copies of the Scottish Farmer were examined, especially sales reports.

CATTLE

5.5 The British Cattle Movements Service provided data on the numbers of male and female cattle of each breed, over 30 months of age, for each of the old Scottish counties. These data included purebreds and crossbreds.

Table 5.1 Numbers of cattle over 30 months in each Scottish county

County	Overall total cattle numbers	Number of purebreds	% purebreds
Aberdeen	221845	40301	18.2
Angus	52698	10985	20.8
Argyll	63391	23040	36.3
Ayr	21928	110982	52.4
Banff	62194	9932	16.0
Berwick	49297	10291	20.9
Bute	18877	9529	50.5

Caithness	47076	6359	13.5
Clackmannan	2690	638	23.7
Dumfries	166622	69197	41.5
Dunbarton	16807	6932	41.2
East Lothian	17780	3320	18.7
Fife	58908	17342	29.4
Inverness	39089	8331	21.3
Kincardine	44811	10171	22.7
Kinross	9284	3662	39.4
Kircudbright	125776	45544	36.2
Lanark	123213	55743	45.2
Mid Lothian	29525	7282	24.7
Moray	33502	8726	26.0
Nairn	10506	2727	26.0
Orkney	78918	10274	13.0
Peebles	19893	3746	18.8
Perth	78363	18226	23.3
Renfrew	36405	18728	51.4
Ross and Cromarty	31769	5258	16.6
Roxburgh	54713	11273	20.6
Selkirk	11605	2290	19.7
Shetland	4963	1805	36.4
Stirling	43485	14977	34.4
Sutherland	7209	1307	18.1
West Lothian	18199	7533	41.4
Wigtown	140524	61146	43.5
Scotland	1931865	617597	31.9

5.6 The figures for overall cattle numbers, the numbers of purebred animals, and their percentages of the total are shown for each county in Table 5.1. The counties in the South and West of the country generally have a much higher proportion of purebred animals. This is important since it means that the reservoir of purebred genetic material tends to be concentrated in these areas.

Table 5.2 Numbers of purebred female beef cows (over 30 months) of traditional Scottish Breeds in each Scottish county

County	Aberdn Angus	Belted Galloway	Luing	Highland	Shetland	Galloway	Beef Shorthorn
Aberdeen	2682	52	118	604	20	49	72
Angus	1351	16	143	367	0	9	81
Argyll	455	27	1663	2621	16	844	7
Ayr	1872	125	89	408	8	272	7
Banff	766	32	23	325	8	32	1
Berwick	1057	51	77	139	1	240	4
Bute	250	3	42	160	0	78	0
Caithness	388	8	157	198	6	79	67

Clackmannan	5	1	0	62	0	0	0
Dumfries	2485	171	500	177	12	1818	22
Dunbarton	131	0	37	121	0	9	1
East Lothian	140	3	145	21	0	21	0
Fife	682	34	23	387	3	7	61
Inverness	833	56	175	1483	43	176	24
Kincardine	733	3	5	220	0	11	6
Kinross	140	0	13	205	1	60	0
Kircudbright	1256	232	221	178	0	2963	39
Lanark	950	41	295	448	92	85	19
Mid Lothian	190	3	45	34	0	18	21
Moray	697	7	10	348	2	0	0
Nairn	505	8	1	13	4	0	0
Orkney	1912	4	59	67	40	17	59
Peebles	197	62	122	82	1	124	0
Perth	1805	23	655	1289	28	195	81
Renfrew	755	13	33	455	7	92	2
Ross and Cromarty	601	14	80	898	6	34	0
Roxburgh	1183	22	855	122	0	889	36
Selkirk	165	1	226	31	1	487	0
Shetland	195	0	5	7	262	0	15
Stirling	259	5	52	248	0	154	1
Sutherland	155	17	75	331	6	49	3
West Lothian	86	80	317	26	1	36	1
Wigtown	1422	223	13	77	0	995	64
Scotland	26303	1337	6274	12152	568	9843	694

5.7 When examining the geographical spread of the individual breeds, this phenomenon becomes even more marked (Table 5.2). For example although the Galloway breed, can be found throughout Scotland, some 58% of the cows are concentrated in the counties of Dumfries, Kircudbright and Wigtown. If the border counties of Roxburgh, Selkirk and Peebles along with Ayr and Argyll, are also included, then over 85% of the pure Galloway cows are accounted for.

5.8 A similar trend can be seen with other breeds. For example the Shetland breed, which is numerically small anyway, has 46% of the cows in the Shetland Isles and the Ayrshire breed of dairy cow is also concentrated in a relatively small area, some 59% being found in the South West.

Table 5.3 Numbers of purebred male animals (over 30 months) of selected breeds in each Scottish county

County	Aberdeen Angus	Charolais	Limousin	Simmental	Whitebred Shorthorn
Aberdeen	1198	1620	1734	942	0
Angus	480	311	291	265	0
Argyll	211	152	551	216	15
Ayr	836	421	1772	727	0
Banff	282	605	441	349	0
Berwick	429	222	390	235	0
Bute	82	38	176	65	1
Caithness	190	304	310	157	0
Clackmannan	5	40	16	9	0
Dumfries	1088	595	1529	272	22
Dunbarton	65	33	144	28	0
East Lothian	62	59	175	152	0
Fife	347	219	324	206	0
Inverness	281	83	327	212	5
Kincardine	387	153	293	196	0
Kinross	71	19	33	39	0
Kircudbright	470	427	706	603	14
Lanark	492	408	1365	276	0
Mid Lothian	146	199	186	53	0
Moray	308	194	242	268	7
Nairn	169	115	71	10	0
Orkney	851	492	361	110	0
Peebles	36	97	106	70	0
Perth	825	533	871	346	5
Renfrew	382	219	287	245	0
Ross and Cromarty	239	102	174	97	1
Roxburgh	368	259	503	181	13
Selkirk	71	74	60	21	5
Shetland	65	16	15	11	0
Stirling	123	187	639	193	0
Sutherland	38	17	36	19	0
West Lothian	80	47	181	131	0
Wigtown	428	359	1735	443	4
Scotland	11105	8619	16044	7147	92

5.9 Table 5.3 shows the numbers of male animal of several breeds of beef cattle. The most numerous of the traditional finishing sires is the Aberdeen Angus which is well distributed throughout Scotland. For comparison, data are shown for the number of male animals of some of the popular continental breeds. The popularity of continental breeds is such that overall, the three breeds shown outnumber the Aberdeen Angus by almost three to one. The Whitebred Shorthorn is numerically very small, but many of these bulls will be used to cross with Galloway cows to produce Blue-Grey cows. They are predominantly located in the same areas as the Galloway cows (see Table 5.2).

Table 5.4 Numbers of dairy cows of different breeds in each Scottish county

County	Ayrshire	Friesian & Holstein	Others	% of Total Ayrshire Population
Aberdeen	508	12816	959	2.03
Angus	62	3432	6	0.25
Argyll	1853	8328	49	7.41
Ayr	6833	74439	351	27.32
Banff	1	2107	24	>0.01
Berwick	26	3242	13	0.10
Bute	528	6087	24	2.11
Caithness	454	839	14	1.81
Clackmannan	0	289	0	0
Dumfries	2119	41317	227	8.47
Dunbarton	743	3606	7	2.97
East Lothian	7	693	220	0.03
Fife	444	9316	11	1.77
Inverness	302	959	22	1.21
Kincardine	254	4647	4	1.02
Kinross	198	2081	0	0.79
Kircudbright	2228	26311	58	8.91
Lanark	2518	34725	161	10.07
Mid Lothian	127	3645	6	0.51
Moray	61	3730	221	0.24
Nairn	1	1220	15	>0.01
Orkney	251	3139	22	1.00
Peebles	2	1290	3	0.01
Perth	281	4409	10	1.12
Renfrew	955	10337	28	3.82
Ross and Cromarty	13	1039	12	0.05
Roxburgh	1	1958	127	>0.01
Selkirk	3	98	0	0.01
Shetland	7	676	3	0.03
Stirling	352	6889	555	1.41
Sutherland	47	10	3	0.19
West Lothian	253	4008	7	1.01
Wigtown	3577	36359	438	14.30
Scotland	25009	314041	3600	

5.10 Within the dairy industry, Table 5.4 shows the dominance of the Friesian and Holstein breeds. The traditional Ayrshire breed, while being spread throughout Scotland has its strongholds in the counties of the south and west.

5.11 The data supplied by BCMS are extremely comprehensive. While there is no reason to believe that the data on purebred animals is not accurate, there may be some confusion of some of the definitions of some of the crossbreds (data not shown in this report). The numbers of animals of some crosses in some counties held in the BCMS database are lower than those known privately by the authors. For example Blue Greys could be recorded as Blue Greys, or Shorthorn crosses, Galloway crosses or Whitebred Shorthorn crosses. This is less likely to be a problem with purebred cattle although there may exist a similar problem among the pure Shorthorns. There is ample scope for confusion between Shorthorn, Beef Shorthorn and Whitebred Shorthorn.

5.12 Even allowing for these problems with the data, it is clear that among some of the pure breeds, there is a very limited geographical distribution. Clearly this puts these breeds at risk were there to be another outbreak of a disease like Foot and Mouth.

Galloway Cattle

5.13 There were 5160 Galloway cattle in the UK in 1999 (Table 5.6) Good information was obtained from the Galloway Cattle Society on registrations dating back to 1981 (Table 5.5)

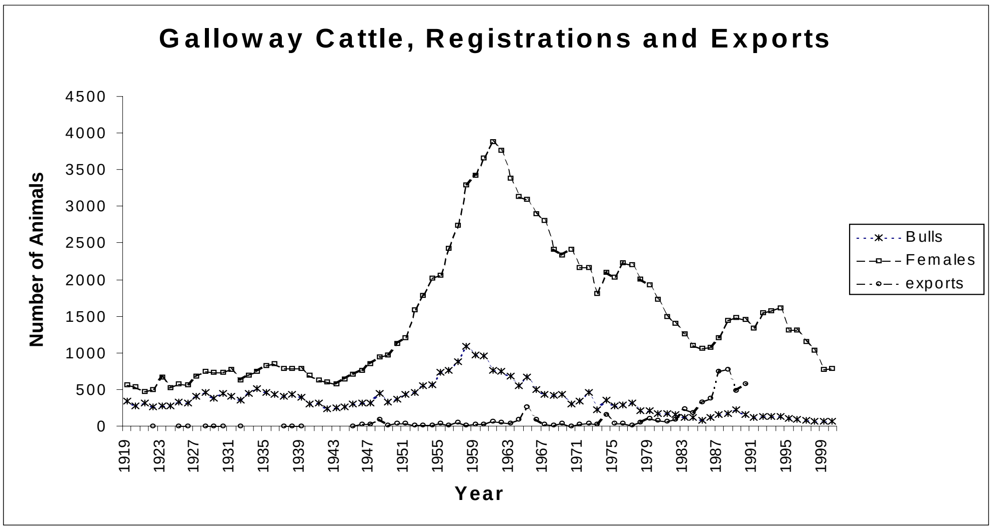
Table 5.5 The number of registrations of Galloway Cattle, 1981-2000

Year	Male	Female
1981	171	1500
1982	152	1404
1983	115	1265
1984	103	1099
1985	84	1060
1986	114	1075
1987	155	1202
1988	177	1445
1989	220	1486
1990	156	1460
1991	118	1398
1992	131	1546
1993	125	1577
1994	130	1608
1995	108	1312
1996	89	1316
1997	82	1148
1998	70	1041
1999	69	769
2000	65	791

5.14 A recently published book on the history of the Galloway breed and Society (Graves, 1997) contains information on the registrations of bulls and cows dating back to 1890 (Figure 5.1). There was a steep increase in registrations from around 1950 till 1960 followed by a steady decline. This increase in the 1950's was probably due to the introduction of subsidies after the last war, e.g. winter keep scheme, and the general increase in intensification, which resulted in greater demand for Galloway cattle as mothers of Blue Greys. The decline in Galloway numbers from the early 1960's may be related to the importation of continental breeds at this time. The export boom, particularly to continental Europe in the 1980's and 1990's resulted in a substantial increase in prices and many traditional Galloway buyers in Scotland were put off the breed by the high prices (personal communication from Mr A McDonald – Breed Secretary). This had a knock-on effect on the breeders of Blue Greys, many of whom switched to other breeds and did not return to the Galloway. As a consequence, the number of Blue-Grey cows has declined markedly.

5.15 The Galloway is mainly found in South West Scotland, its native area. However the breed does stretch eastwards as far as Selkirk and there are a number of herds to the east of Carlisle. There are also a large number in Devon and Exmoor, although the National Park Authority is unhappy with cattle being outwintered. There is also a number of Galloways in the Brecon Beacons area of South Wales.

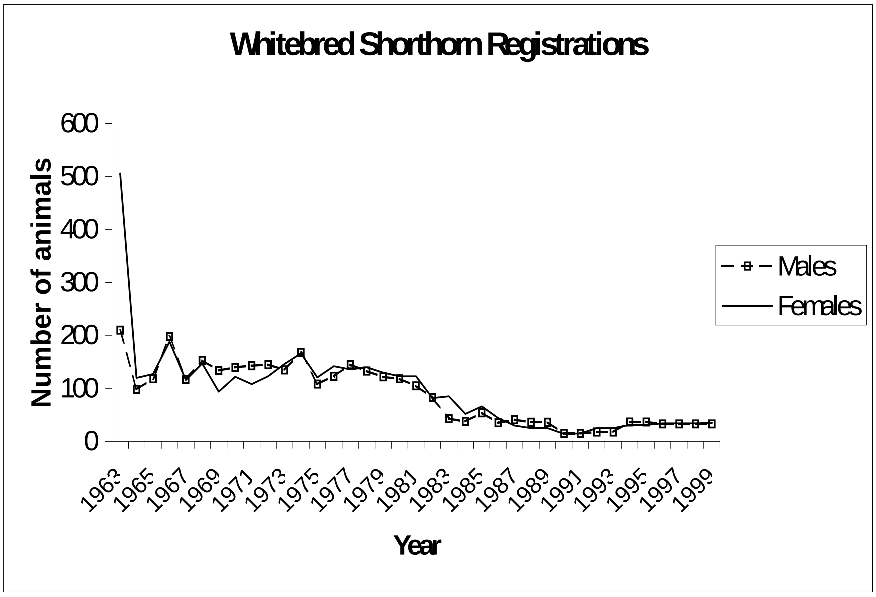
Figure 5.1 Galloway Cattle registrations and exports, 1919-2000



Whitebred Shorthorn Cattle

5.17 There were 230 Whitebred Shorthorn cattle in the 1999 UK survey (Table 5.6) Currently there are 257 female animals registered in 38 herds. There are 97 bulls registered with the society. It is thought there are approximately another 50 bulls which are not registered, but are used in herds for crossing with Galloway cows to produce Blue Greys. A small number is also used to cross with Highland and Welsh Black cattle. A new census is currently underway, however it is not thought that the numbers will be substantially different from those above. The breed is mainly found in the area around the English/Scottish border. Registrations since 1963 are shown in Figure 5.2.

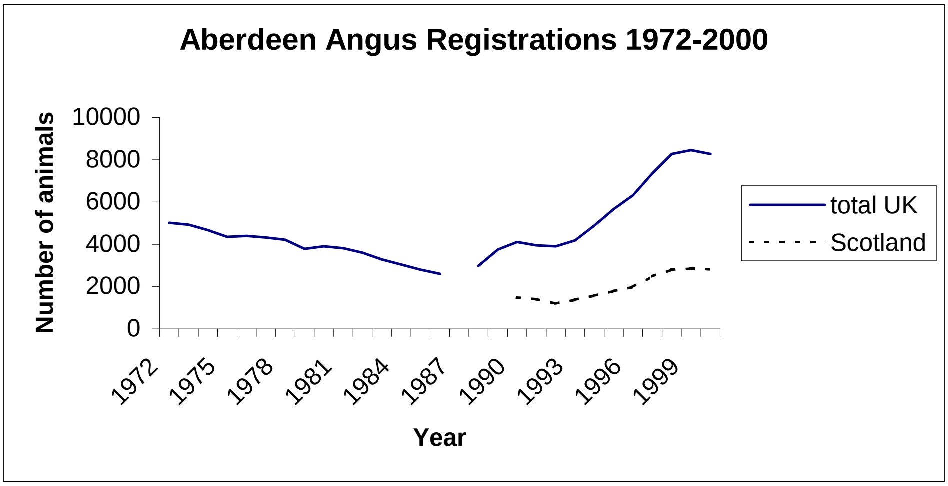
Figure 5.2 Whitebred Shorthorn registrations



Aberdeen Angus Cattle

5.18 The 1999 survey indicated that there were 8100 Aberdeen Angus cattle (Table 5.6) The breed society figures suggest there are currently some 8269 Aberdeen Angus Cattle in the UK, some 2818 of which are in Scotland. As with many of the other breeds, there is a large number of animals which are not registered. Registrations since 1972 are shown in Figure 5.3.

Figure 5.3 Aberdeen Angus registrations, 1972-2000



Beef Shorthorn Cattle

5.19 The breed society does not carry out a herd census but the 1999 survey showed 1740 cattle (Table 5.6). However there are currently 62 registered breeders in Scotland who in the year 200 registered or transferred a total of 256 animals.

Ayrshire Cattle

5.20 No numbers are available from the Breed Society for the number of Ayrshire Cattle in Scotland. However there are 75 pure-bred herds and approximately 50 mixed herds. Most of these are in the South West of Scotland. In 1999 there were 60600 Ayrshire cattle in the UK (table 5.6).

Belted Galloway Cattle

5.21 No information on this breed was made available by the breed society. However Table 5.6 shows 1120 cattle in 1999.

Highland Cattle

5.22 Table 5.6 shows 4400 Highland cattle in the UK as a whole.

Luing Cattle

5.23 The 1999 survey (Table 5.6) shows 1602 Luing cattle, although there are currently approximately 2000 breeding cows in Scotland, registered to produce Luing calves, suggesting an underestimation in the survey. Approximately 30% of registered cows in Scotland are on the Island of Luing. There is an increasing number in the Borders area of Scotland and in Lanarkshire.

Shetland Cattle

5.24 There are currently approximately 350 cows registered with the breed society (300 in the 1999 survey, Table 5.6) with approximately 30% of these on Shetland.

5.26 Table 5.6 gives details of the numbers of selected cattle breeds in the UK. The data are from the DEFRA United Kingdom Genetic Resource Base. The data were collected by the RBST in 1999.

Table 5.6 Numbers of relevant rare and traditional cattle breeds in the UK in 1999 (RBST, 2000)

Breed	Males	Females	Total
Aberdeen Angus	600	7500	8100
Ayrshire	600	60000	60600
Beef Shorthorn	20	1720	1740
Belted Galloway	70	1050	1120

Galloway	160	5000	5160
Highland	142	4258	4400
Luing	62	1540	1602
Shetland	24	300	324
Whitebred Shorthorn	30	200	230

SHEEP

5.27 The numbers of rare and traditional sheep breeds in the UK are shown in Table 5.7. Data are from DEFRA UK Genetic Resource Database, collected by RBST in 1999.

Table 5.7 Numbers of traditional, rare and minority sheep breeds in 1999 in the UK (RBST, 2000)

Breed	Males	Females	Total
Scottish Blackface	Not recorded	Not recorded	
Bluefaced Leicester	4,500	27,000	31,500
Border Leicester	630	5,040	5,670
Boreray	10	74	84
Castlemilk Moorit	32	439	471
Cheviot	3,000	150,000	153,000
Hebridean	200	1,965	2,165
N Country Cheviot	10,000	100,000	110,000
North Ronaldsay	66	401	467
Shetland	321	2,094	2,415
Soay	76	689	765

5.28 The survey of sheep breeds conducted by MLC (MLC, 1998) found that while there was a general increase in sheep numbers between 1987 (the previous survey) and 1996, in Scotland there was a slight fall in the relative proportion of animals on the hills (Table 5.8).

Table 5.8 Estimated numbers of sheep (000's) in the different strata of the Scottish Sheep Industry (MLC, 1998)

Category	1971	1987	1996
Hill	2291 (69.8%)	2287 (59.6%)	2097 (53.0%)
Upland	607 (18.5%)	1079 (28.1%)	1245 (31.4%)
Lowland	384 (11.7%)	468 (12.2%)	618 (15.6%)
Total	3282	3834	3960

Table 5.9 Estimated numbers of ewes mated of different breeds in the UK (000's) (MLC, 1998)

Breed	No 1971	No 1987	No 1996
Scottish Blackface	2338	2567	2954
NC Cheviot		497	530
SC Cheviot		13	81
Shetland	1	11	25
Hebridean	<1	2	<10
Soay	<1	1	<10
Suffolk	179	429	371
Charollais	<1	5	51
Texel	<1	97	201

5.29 The numbers of the main hill breeds were relatively stable or even increased from 1987-1996. In spite of this the minority and rare breeds are seriously threatened since they do not fit easily into the stratified structure of the sheep industry. There has been a big increase in the number of important terminal sire breeds, like the Texel and the Charollais. Such breeds are also increasingly being used as a sire on hill and upland breeds as well as in their more traditional role of siring lambs for slaughter out of crossbred ewes.

Scottish Blackface Sheep

5.30 No records of numbers are kept by the Blackface Sheep Breeders Association, but the MLC survey (Table 5.9) shows 2,954,000 ewes mated in the UK in 1996 with a slight increase from 1987 to 1996.

North Country Cheviot Sheep

5.31 In 1999 it was estimated that there were 110,000 North Country Cheviot sheep in the UK (Table 5.7), but the North Country Cheviot Sheep Society indicated that in the year 2000 there were approximately 86,000 ewes. Approximately 85-90% are in the North of Scotland, particularly Sutherland and Wester Ross.

South Country Cheviot Sheep

5.32 Prior to the outbreak of Foot and Mouth disease the South Country Cheviot Sheep Society figures showed a population of breeding ewes of approximately 65,000. Up to 17th April 2001 it was estimated that some 16,000 ewes had been slaughtered, either as a result of the infection or as part of the contiguous cull. The annual ram sale in Lockerbie averages around 440 rams. Almost 25% of the breeders selling at this sale have had their flocks destroyed.

Border Leicester Sheep

5.33 Table 5.7 shows that there were some 5670 animals in the UK in 1999. This compares to 4919 ewes registered to the Border Leicester Sheep Society, which were put to the ram that same year. Details from the society show that there has been a steady decline in numbers over the years for which accurate records are available (Figure 5.4). The situation in Scotland is shown in figure 5.5. While there has been a decline in the number of flocks in all areas, this has been most dramatic in the South West.

Figure 5.4 The number of Border Leicester ewes mated in the UK

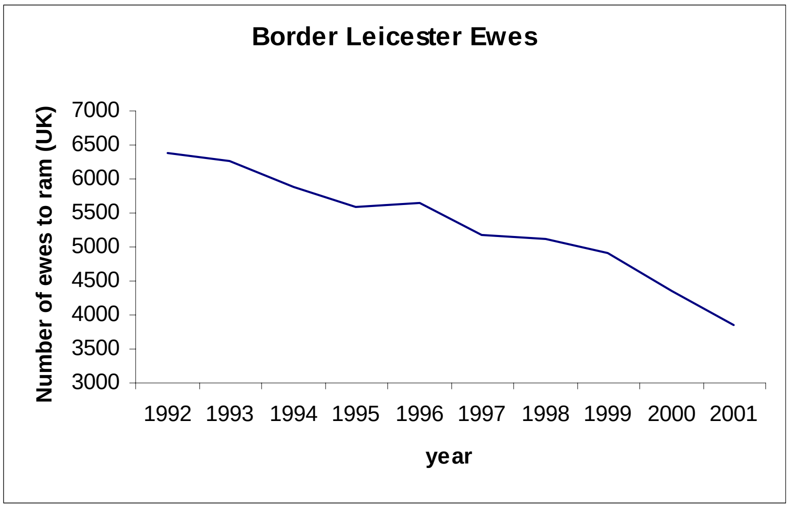
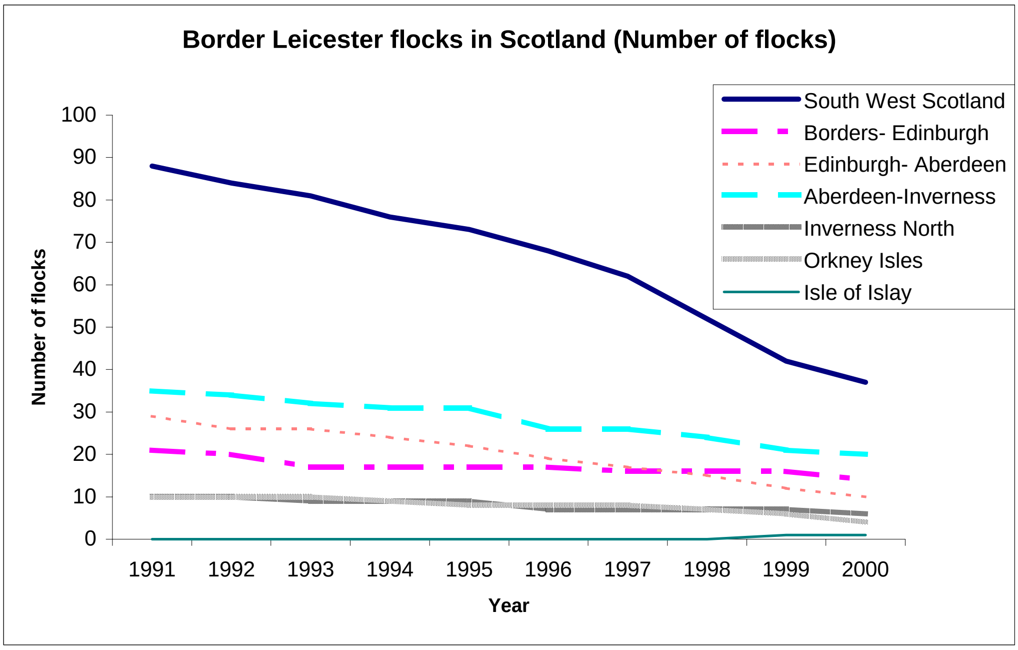


Figure 5.5 The distribution of Border Leicester sheep flocks in Scotland



Hebridean Sheep

5.34 Table 5.7 shows 2165 Hebridean sheep in the UK, but there are currently about 3500 registered Hebridean ewes in the UK and the breed society registers about 100 lambs each year. There was a dramatic rise in numbers during the 1990's, from about only 400 ewes in 1988. Much of the recent expansion has been in Scotland, particularly in the Highlands and Islands. Most Hebrideans are kept in extensive situations in the uplands, but a few are kept on lowground conservation sites. Much of the resurgence in the numbers of this breed is due to the work of the Rare Breeds Survival Trust and the breed's perceived reputation as a grazer which is able to control invasive plant species.

It was reported in Scottish Farmer on 23rd September 2000 that the first ever special sale of Hebridean sheep was to take place in Oban the following week.

Shetland Sheep

5.35 No information on the numbers or distribution of Shetland sheep was obtained from the Shetland Sheep Breeders Group, but Table 5.7 shows 2415 animals on the UK mainland in 1999.

Boreray

5.36 Table 5.7 puts the population of Boreray sheep at only 84 animals, 74 ewes and 10 rams in 1999.

Castlemilk Moorit

5.37 The 1999 estimate of numbers of Castlemilk Moorit sheep is 439 ewes and 32 rams (Table 5.7)

North Ronaldsay

5.38 The population of North Ronaldsay sheep on the UK mainland was estimated in 1999 at 401 ewes and 66 rams (Table 5.7).

Soay

5.39 There were 689 female and 76 male Soay sheep in the UK in 1999 (Table 5.7) excluding the feral population.

HISTORICAL MARKET REPORTS

5.40 The best source of information on the changes in breed structures are old market reports. These can provide indications of how the proportions of different breeds within the industry have changed, although the absolute numbers will be influenced by other factors such as the overall intensity of farming, and the degree of geographic mobility of purchasers at markets.

5.41 On 16th September 1961 the Scottish Farmer reported the annual sale of rams at Kelso. The breeds for sale were, Border Leicester, Suffolks, Oxford Downs, Bluefaced Leicester, Hampshire and Dorset Downs. There was no mention of any of the imported breeds which are now common. The most numerous breed at the sale was the Suffolk which numbered 1654. The second most numerous breed was the Border Leicester, of which 837 were offered for sale.

5.42 By the 1970's there appears to have been little change, with the same breeds being dominant. There was no mention of any other breeds. However in the early 1970's the first imports of the Texel breed from Holland began. By 1980 they were becoming well established as a popular terminal sire. Other breeds were to follow and by 2000 the list of breeds and the numbers offered for sale at Kelso were as shown in Table 5.10.

Table 5.10 The numbers of different sheep breeds offered for sale at the annual Kelso ram sales in 2000.

Breed	Number
Suffolk	2811
Texel	1304
Bluefaced Leicester	630
Charollais	505
Beltex	53
I'll de France	5
Rouge de l'Ouest	4

Lleyn	17
North Country Cheviot	72
South Down	9
Oxford Down	18
Vendeen	7
Bleu'du Maine	4
Border Leicester	122

5.43 Breeds like the Scottish Blackface and Cheviot have always had special sales. These are still ongoing at places like Castle Douglas, Newton Stewart, Lanark and Kelso amongst others.

5.44 It is obvious from past issues of publications such as Scottish Farmer that the main change as far as the breed structure of the sheep industry is concerned has been the much greater choice of breeds available to producers. This is particularly true in terms of the choice of terminal sire.

5.45 With dairy cattle there has not been the same diversity of breeds. In the 1960's the predominant breed of dairy cow was the Ayrshire. There were some Friesian cattle as well, but there was no mention of the Holstein which is now the predominant breed of dairy cow. Over the years the British Friesian and the Holstein have become so close that the breed societies have merged and the name Friesian has been dropped from the title.

5.46 The breed structure of the beef industry in Scotland has, if anything, undergone even greater changes than the sheep industry. Until the early 1960's the traditional breeds such as the Aberdeen Angus, the Shorthorn, the Galloway dominated. However in the 21st October 1961 edition of the Scottish Farmer there was a report of a telegram sent by the Ayrshire Cattle Society to the Secretary of State for Scotland. The telegram was expressing concern at the Government's refusal to allow the importation of live Charolais bulls from the continent. There was obviously a strong desire to try out imported breeds to increase productivity. On 2nd September of the same year a representative of Farmers Meat Company reported on a recent visit he had made to France to inspect Charolais cattle where he was very impressed with the breed and was keen that they should be imported to the UK. Another article, this time on 23rd September 1961 explained that an English breed, the Lincoln Red was a good bull to cross with the Aberdeen Angus and was a viable alternative to the Charolais.

5.47 By 1970 the Charolais breed was well established. The first ever sale of British-bred Charolais bulls at Hexham recorded the highest ever prices to date for any breed. On 12th September 1970 the first batch of imported Simmental cattle were released from quarantine in Dundee. The editorial of the Scottish Farmer of that week called for the speeding up of the veterinary testing procedures to allow more imports of foreign breeds of cattle. Coming up to date to the Perth bull sales of 2000, the reports in The Scottish Farmer centred on the Simmental and Charolais breeds. The other traditional breeds were barely mentioned.

CHAPTER SIX: A SUMMARY OF THE SIZE AND COMPLEXITY OF GENETIC RESOURCES WITHIN ANIMAL BREEDS AND THE IMPACTS ON GENETIC DIVERSITY OF THEIR REDUCED USE

6.1 A genetic resource is an animal breed or crop variety in which genes or gene combinations of actual or potential value are found at high frequency. Generally these genes or gene combinations are linked with a visible phenotypic feature and there is usually supporting paperwork that certifies that a particular individual animal or plant belongs to a specified breed or variety. This is the definition that has applied in the past and which underpins the current relationships between genetic resources and the rest of agriculture. However it is conceivable that new advances in molecular and quantitative genetics will lead to a concept of genetic resources that is more individual-based than population-based. This section considers Scottish breeds as genetic resources within the traditional definition and suggests further investigations that would deepen our understanding of their place in world and national biodiversity.

PEDIGREE AND BREED STRUCTURE

6.2 Formally, only pedigree or registered animals can be considered as genetic resources but in the commercial sector unregistered animals which conform to breed type are very important and probably in the majority. In practice, beef cattle and sheep tend to have a pyramidal breed structure with the herds and flocks at the apex being mainly composed of registered animals, which provide breeding stock to so-called multiplier herds and flocks, which themselves supply (usually unregistered) animals to the commercial sector. In dairy cattle the use of AI makes the multiplier sector superfluous and the practice of milk recording means that animals of high merit can be identified in the commercial sector for possible recruitment to the apex of the breed. Scottish breeds generally have strong and active breed societies but the costs of running these operations are high. Further research and development of registration management software, ideally designed to help in making breeding decisions, is needed.

BREED AFFINITIES

6.3 The histories of Scottish breeds have been well documented, especially over the last 200 years, and genetic studies have tended to confirm historical accounts of their breed affinities. Genetically they are distinct from English, Welsh and other north European breeds. Mitochondrial DNA studies of present-day Scottish cattle and fossil aurochsen (the wild ancestor of cattle that died out in Britain in the Bronze Age) have been taken to imply that incoming Neolithic herders mated their cattle with local aurochsen {Bailey, Richards, et al. 1996 ID: 4127}). This genetic distinctiveness could mean (1) Scottish breeds are a genetic resource that would be valuable for future farming needs that are currently not predictable; or (2) that there is potential for exploiting heterosis in crossbreeding them with other breeds.

6.4 Most of our knowledge of affinities among Scottish sheep breeds comes from historical studies and comparative work on fleeces (Ryder, 1968). Canadian microsatellite studies (Farid *et al*, 2000) show the South Country Cheviot and North Country Cheviot to be closely related. The Scottish Blackface appears quite close to north Continental European breeds. In cattle there has been more genetic work. Early studies of blood protein polymorphisms (Jamieson, 1966) revealed ‘genetic affinities which cut across differences in the commercial purposes of distinct breeds … the Ayrshire, Galloway and Highland breeds show four transferrin genes in roughly similar proportions …'. Gene frequencies in the Aberdeen Angus were thought to reflect founder effects, with small numbers of important ancestors having strong influences on the breed. (Blott *et al*, 1998) found that microsatellite differences 'reflected geographical origin and common ancestry rather than function'. While the Ayrshire had affinities with the Friesian (this was also noted by (Kantanen *et al*, 2000), the Scottish breeds did form a fairly distinct subgroup, though even closely related breeds such as the Galloway and the Belted Galloway were distinct.

6.5 If the purpose of genetic conservation is to conserve the maximum amount of evolutionary history (Nee & May, 1997) and if this history is to be deduced from neutral marker genes then perhaps all the traditional Scottish cattle breeds have an equal claim. Further work is needed in two areas – firstly, on objective techniques of prioritisation for conservation (see for example (Ruane, 2000) and secondly on understanding the genetic affinities among Scottish sheep breeds.

CROSSBREEDING AND INTROGRESSION

6.6 Crossbreeding, when it is based on the maintenance of pure breeding populations which are mated for the production of the generation that is marketed commercially, is a highly efficient system for the sustained exploitation of heterosis (hybrid vigour).

6.7 Most Scottish sheep and cattle operations (the main exceptions being dairying and traditional hill sheep farming) are based on systematic crossbreeding whereby the animals that are sold for slaughter are genotypically a mixture of breeds. This may not be the case for all time; a move towards self-contained units which breed their own replacement females rather than buying them in, might be expected because stability of breeding groups is favoured on both welfare and disease limitation grounds.

6.8 Crossbreeding becomes grading-up when the crossbred animals are added to the breeding population; the effect is that genes from a different breed are moved into the breeding population. This is also known as introgression and is a rapid way of adapting a breed to meet new requirements although it can have harmful side effects. In the European dairy industry, the introgression of North American Holstein genes has increased milk yields but has also decreased fertility {Hoekstra, van der Lugt, et al. 1994 ID: 5425};{Lidauer & Mantysaari 1996 ID: 1195}; {Royal, Darwash, et al. 2000 ID: 8533}).

6.9 Most Scottish cattle breeds have been influenced by genes from overseas or from elsewhere in the UK; the number of Aberdeen Angus cows with no Canadian or New Zealand ancestry is now perhaps as low as 50 (Hart, 1999). Hill Scottish Blackface flocks have often used Swaledale rams (avowedly to improve maternal qualities) while the South Country Cheviot has received considerable input from the North Country Cheviot to increase body size. This is significant in that numerical status of a breed may not be the only important indicator of its conservation status – the degree of introgression it has undergone will also be important. There are no data on the extent or degree of these introgressions and a comparative study of these processes is needed.

WITHIN-BREED IMPROVEMENT

6.10 The main contemporary example of systematic within-breed improvement of a native Scottish breed is the SAC project to reduce carcass fat in the purebred Scottish

Blackface (Conington *et al*, 1998). The campaign to rid the Galloway breed of the tibial hemimelia gene is another example, though rather different in that a specific gene has been vigorously selected against (p.325 of{Nicholas 1987 ID: 6049}). When there is a strong AI industry, as in dairy cattle, the genetic variation within a breed can be rapidly eroded by within-breed improvement for aspects of economic performance. A general survey of improvement programmes in Scottish breeds is needed.

USE OF SCOTTISH BREEDS IN OTHER COUNTRIES

6.11 Sales abroad have of course been hit by BSE and by Foot and Mouth Disease, and scrapie control will be another constraint on exports of breeding sheep. Looking to the longer term, there is a strong interest in maintaining an international red and white dairy breed as an alternative to the Holstein (Ruane *et al*, 1999). However the Scottish Ayrshire is unlikely, because of its small population, to have much contribution to make to this process. Scottish beef cattle are appreciated for grazing management schemes aimed at promoting plant biodiversity and exploiting rough grazing, especially in the Netherlands and in Germany, but even without import restrictions this is unlikely to represent a big market. Generally the main market for Scottish breeding stock is likely to be within the UK and the Scottish breeds are probably to be seen as genetic resources within the UK context. A review of the numbers of animals of Scottish breeds outside the UK was outwith the scope of this study. A survey of such breeds should be considered and opportunities for the use of Scottish breeds outwith Scotland should be explored.

SPECIALISATION

6.12 The most specialised Scottish breed is probably the Border Leicester which is used for production of crossbred lowland breeding sheep out of hill ewes. This is likely to be under threat from other crossing sires like the Bluefaced Leicester and from breeds which can combine the crossing and terminal sire roles, like the Rouge de l'Ouest. Information about the performance of such breeds and their crosses needs to be made available so their market niches can be developed.

6.13 The Aberdeen Angus seems to have strengthened its specialisation as a crossing sire for dairy cows, as suggested by the pattern of registrations. In the current herd book 40% of the 8269 registrations in 2000 were of males, implying a ready market for bulls outwith the breed. In contrast, in the Galloway only 8% of the 856 registrations in a similar period were of males. Thus, the Galloway is clearly specialised as a maternal or dam-line breed.

6.14 As is general in biological systems, specialisation poses threats as well as opportunities. A documented example of how a breed can change its specialisation comes from Southdown sheep (Hall, 1989). This breed used to be specialised for the production of purebred, light, early-maturing lamb from chalk grassland but from the 1950s this came to an end as chalk grasslands were taken over by cereals. Breeders then concentrated on producing specialised terminal sires (supplying about 2% of the ram market, for which only a small ewe population was sufficient). As that application has faded, the Southdown has now increased in numbers again, mainly as a purebred meat sheep kept in relatively small flocks which are not the main business of the farm.

6.15 Breed societies should attempt to keep and develop their specialised markets but must not lose their flexibility to respond to new market conditions. This is best done by encouraging new entrants to the breed as a dispersed system of relatively small flocks and herds is effective in maintaining genetic variation. Breed societies should not dismiss the advantages of association with the Rare Breeds Survival Trust, though there may be public relations issues. There should also be systematic programmes of cryoconservation (freezing of semen and embryos), preferably with a regeneration protocol. This protocol would reduce the risks of stored material proving unusable in the future because of new, unanticipated veterinary restrictions, and would involve the regeneration of animals from stored material, and the storage of semen and embryos therefrom. Research is needed on the most effective way of operating such programmes.

CONSERVATION OF GENETIC VARIATION

6.16 A strongly pyramidal breed structure (in which only a few herds or flocks supply sires for use elsewhere in the breed) is more conducive to genetic improvement (and thus antagonistic to conservation of genetic variation) than a more ‘democratic’ structure in which a high proportion of herds or flocks supply sires. In British rare and minority sheep (Hall, 1986; Hall, 1989) the proportion of flocks that supply sires is between 29 and 37%. This relatively high proportion means that the breeds are not dominated by the breeding goals of a small number of breeders. In Galloway cattle, which are declining in numbers, the average proportion between 1997 and 2000 was 23%, which implies a relatively pyramidal structure. In England, the Lincoln Red has about one third of the annual registrations of the Galloway and in 1997 and 1998, 60% and 41% of herds respectively supplied the sires. In at least some minority Scottish breeds, therefore, a decline in total numbers may be accompanied by a breed structure which could be inimical to genetic conservation. Further research is urgently needed on the nature and genetic consequences of the population structures of the Scottish breeds.

INSTITUTIONAL STRENGTHENING

6.17 Under the Convention on Biodiversity the UK Government has a responsibility for the conservation of agricultural genetic resources. One way of discharging this responsibility in an economical manner would be for Government to support the breed societies. Breed societies were not established to maintain inventories and are not organised in such a way as to facilitate this. Databases on livestock do not map onto each other in ways which permit the status of breeds to be monitored. Government should consider making funding available for the effective management and cataloguing of genetic resources.

CHAPTER SEVEN: AN OVERVIEW OF THE CONTRIBUTION MADE TO BIODIVERSITY OF MAINTAINING THE TRADITIONAL FARMING SYSTEMS ASSOCIATED WITH PARTICULAR BREEDS OF LIVESTOCK.

WHAT IS "TRADITIONAL"?

7.1 When considering traditional farming systems it is useful to try to define exactly what the term "traditional" means. The Oxford English Dictionary definition " That is such according to tradition" is not very helpful. "Tradition" is defined more usefully as " That which is handed down, a statement, belief or practice transmitted from generation to generation. More vaguely: a long established and generally accepted custom or method or procedure, having almost the force of a law".

7.2 In the context of farming systems it is therefore difficult to define a starting point where systems can be defined as the "tradition". Farming has over centuries evolved from the days when man was simply a hunter-gatherer, sustaining himself from what he could find or trap and/or kill. He began to cultivate crops around his settlements to provide nutrition for himself and for the wild animals he began to domesticate. Farming was born, and has evolved ever since. This evolution has continued largely as man has increased his understanding of his crops and animals, how they work and how they interact with the wider environment. This evolution has been most rapid in the last century, and particularly since the end of World War II.

7.3 Science has sought successfully to gain a much greater understanding of the processes which make up our agriculture, from the chemical and cellular level, right up to the catchment and landscape level of resolution. This has allowed much altered management of systems and the manipulation of the inputs to those systems. Those inputs also include the genetic resources, as animals and crops have been selected and crossed to encourage the traits desired for the production system. It therefore follows that there can be no definitive "traditional" system in an evolution. Also "traditional" implies looking always to the past. Man and society are ever changing, particularly the human population. Agricultural evolution has largely been a function of the changes in population and society.

7.4 It is easy to conceive of some supposed idyllic rural way of life in the past. The reality was often that "traditional" farming systems, as for example in the period between the two World Wars involved long hours of backbreaking work. There are many reports of life on Scottish farms during that period, but a short story by David Toulmin sums it up: " I widn'a be a loon again" (Toulmin, 1992).

7.5 Instead of just looking at "tradition", it is perhaps appropriate to think more broadly. The objectives society sets for agriculture are, as they always have been, changing. Food production is no longer the only goal. The environmental impacts of agriculture are now extremely important. There is increasing pressure on farmers to reduce the undesirable impacts of their activities on the environment, and a willingness for society to pay for the more positive impacts of agriculture.

7.6 Systems from the past must be examined in relation to how they might, either wholly or in part, satisfy the objectives society now sets for agriculture. It is also important, however, to bear in mind the advances in understanding and consequently in management which have occurred. In short, it is important to look both forward and backwards in time and adapt what is appropriate from the past with the improvements in understanding and technology that are available now and are likely to be available in the future

7.7 Environmental sustainability and highly intensive agriculture are not always compatible. Because of this, many argue for a reduction in intensity in agriculture overall. Others have argued (Wilkins, 1994 and Pollock, 2000) that in the future there may be a polarisation of agriculture, with intensive agriculture continuing on the most favourable land, with high levels of inputs and using the latest technological advances, while on less productive land the objectives for land management may be more environmentally based. In these areas it is therefore likely that the future will involve lower stocking rates and the use of lower inputs.

THE ROLE OF RARE AND TRADITIONAL BREEDS IN FARMING SYSTEMS

7.8 Little research has been conducted into the role of rare and traditional breeds in farming systems. Much of the information in this section of the report was gathered at a workshop held at SCRI on 28th November 2001. (For the objectives of the workshop and for a list of attendees see Appendix One and Two)

7.9 Those systems into which rare and characteristic breeds of cattle and sheep can fit and in which biodiversity can be maintained and enhanced, will vary with the location and the environmental goals which are desired. The level of stocking will have to take account of the range of objectives for the countryside and the environment.

7.10 The lowest intensity systems are generally those located in the hills and uplands. The climate, soils and topography in these areas combine to limit severely the choices open to the farmer in terms of agricultural production. As has been discussed earlier in this report, the grazing of these areas is important if the delicate ecosystems are to be maintained. A balance needs to be struck to ensure that the conservation objectives are met, while still providing economic return for those who farm such areas. The breeds commonly found in these areas have evolved and adapted over many years to survive in these harsh places. However it is not clear to what extent these breeds are an integral part of the farming system. While they undoubtedly form part of the cultural heritage of these areas, and their production characteristics may be suited to these environments it is not clear to what extent these breed characteristics contribute to the wider biodiversity associated with these systems. There is therefore a need for research to establish the role of rare and traditional breeds in contributing to wider biodiversity.

THE NEED FOR CATTLE IN HILL AND UPLAND AREAS

7.11 There is some evidence that the range of habitats and the associated biodiversity which is desired cannot be achieved without the use of grazing by cattle. There are problems, however, in increasing the number of cattle on the hills to achieve the grazing management required for biodiversity purposes. Firstly, cattle have to be purchased involving the need to access capital. Replacement stock for traditional breeds will not be cheap. Cattle require management, and feed needs to be provided to avoid overgrazing in winter and to ensure acceptable levels of productivity and adequate animal welfare.

7.12 On some farms winter housing will be required, and this will need to be provided. On many farms where there are disused cattle buildings, these are often not suitable for today's low-labour systems. Outwintering in the absence of adequate buildings is a possibility, and this is where some of the native breeds may have an advantage. There does, however, need to be a better understanding and quantification of the characteristics of these breeds and to define how these characteristics appear to suit particular production systems. There is plenty of anecdotal evidence that our rare and characteristic breeds are very well adapted to low intensity systems, particularly in harsh climates. However there is little scientific evidence of why these adaptations occur.

7.13 Providing winter feed for cattle can be a problem on many hill farms because of the lack of land suitable for the conservation of fodder. Silage-based systems require the use of expensive machinery, and it still needs to be transported to the animals. Making hay can be labour intensive, and particularly in the west of Scotland, very risky due to bad weather. There also needs to be skilled labour available to look after the animals, particularly at calving time. One option is to have greater co-operation between upland and lowland farmers, whereby the stock can be wintered on lowland farms, where winter feeding can be more easily provided and then returned to the hills for the summer grazing period.

7.14 On the islands of Islay and Mull, Highland cattle are being used in very extensive grazing systems in order to maintain a particular ecosystem. Bignal et al (1998) argue that the grazing animals have too often been seen simply as tools for achieving environmental goals. Instead, they argue that the grazing system needs to be seen as part of a wider set of objectives which include social, economic and cultural goals. The whole farming system needs to be examined.

7.15 Historically the "Sheiling" system was adopted where hill cattle and sheep spent the summer away from the farm on more distant pastures. This meant that the land near the farm could be used for limited arable cropping and for haymaking. The livestock would then be returned to the in-bye land for over-wintering. Such a system allowed the desirable grazing of the pastures to control species such as purple moor grass and thus encourage biodiversity. It also allowed a measure of self sufficiency in terms of winter feeding with less reliance on bought-in hay and concentrates. However many farmers have abandoned such systems in favour of more intensive methods of production. Instead of using breeds like the Highland and Galloway, imported breeds are used. Silage is made from well fertilised swards composed of fast growing and late heading ryegrass monocultures rather that more species diverse swards.

MARKETING OF PRODUCTS FROM RARE AND TRADITIONAL BREEDS

7.16 The economic viability of these low-intensity systems of farming in hill and upland areas is extremely fragile (Scottish Executive, 2001), particularly with the pressure to operate at world market prices. If these systems are to be used there needs to be not only financial support as a payment for the environmental benefits they provide, but there needs to be support and encouragement for novel marketing initiatives. These systems are not likely to fit easily into the industrial model of food production, processing and marketing. It is more likely that to make a reasonable economic return, the output from these systems will have to be marketed in a way which adds value, fully exploiting the “natural” perception of the product. It is within this context that the rare and characteristic breeds will have a role to play. The meat from these animals is already seen as a quality product, produced in a natural manner which is valued by consumers and this will have to be exploited more fully than in the past. To exploit the market to the best advantage, the infrastructure required to slaughter and process locally will need to be provided. Recent legislation has led to the closure of many local abattoirs, making local slaughter and processing, which adds value to the product, very difficult. Government and other agencies (local authorities, local enterprise companies) need to consider how best to assist in the development of marketing schemes which would not only help with the conservation of traditional and rare breeds but would also encourage rural employment and development.

CO-OPERATION BETWEEN FARMERS

7.17 The way farmers operate their businesses will also require examination. A greater degree of co-operation between farmers is needed, particularly for finishing and marketing. Markets require consistency of product and continuity of supply in order to secure and retain a reliable customer base. Without co-operation between producers this will be hard to achieve with rare and traditional breeds. Traditional cattle breeds like the Highland, cannot be finished from hill swards in the time required. One option may be to finish the weaned calves on lowland farms on much higher quality diets and to use a different breed of bull to sire the calves in order to produce a quality finished steer at the time required by the market. One of the most successful co-operative marketing schemes is the certified Aberdeen Angus marketing scheme.

PASTURE TYPE

7.18 Even on the more intensive farms, the in-bye ground of hill farms and in the uplands there may need to be a re-evaluation of the production systems which are used. On these units sheep and cattle graze long- or short-term sown pastures. Where cattle are grazed, the breeds of cows used are often imported in origin, usually with an imported breed used as the terminal sire. These animals, while extremely productive require good quality diets to sustain those high levels of production. The roughage component of those diets is based on grazing very productive pastures in summer and high quality silage in winter. The pastures used are productive but are not species rich. They are based on modern varieties of perennial ryegrass perhaps with some white clover in the mixture. Since silage digestibility drops off rapidly when the sward starts to develop seed head, modern varieties of grasses have been bred to delay the onset of seed head formation until the crop has reached the appropriate stage for cutting. As a consequence these species-poor swards rarely get to the stage of being able to shed seeds which will return to the soil and spread in the wind.

7.19 A return to the traditional breeds with lower nutrient requirements and less intensive systems would perhaps allow hay to be made instead of silage. This would allow for more species-rich seed mixtures to be sown with a consequent increase in biodiversity. However a switch to hay making is not without problems. Haymaking is a fundamentally more risky operation, since the crop is exposed to the weather for a much longer period between cutting and being transported to storage. It is also less efficient in terms of the much larger dry matter losses during the haymaking process compared to silage making. Much of the leafy component (the most nutritious part of the plant) of the crop can be lost in haymaking. The resulting crop therefore is less valuable as a feed for productive animals. Research is needed on whether hay making may be integrated into grazing systems which use traditional breeds.

7.20 For cows and sheep which are spending much of the winter period on a maintenance diet, the feeding of hay is quite acceptable. However for stock which are expected to be gaining weight, silage is a much more desirable method of securing a winter fodder supply. Research needs to be conducted into how best to ensile species-rich swards, perhaps at a more advanced physiological stage than is usually used for silage.

OUT-WINTERING OF CATTLE

7.21 The out-wintering of cattle was at one time commonplace. However most intensive systems are now reliant on cattle being brought indoors during winter. Some of the hardier breeds are better adapted to remaining outdoors. If these breeds, such as the Highland, and the Galloway are to be used to promote biodiversity, research needs to be done to investigate the effects of year-round grazing compared to summer only.

MIXED LIVESTOCK AND CROPPING SYSTEMS

7.22 Both sheep and cattle farms have tended over the last few years to specialise in grazing, relying on bought-in concentrate feeds, with less crops grown, especially on upland farms. The growing of crops like oats and barley for feed creates a further range of habitats and feed sources, especially for birds. Cereal growing has become highly specialised, relying on large machinery which is not well adapted to the hills and uplands. A return to more mixed systems, which could include the rare and traditional breeds would help to increase overall biodiversity. Systems-level research is needed to identify the potential gains in biodiversity which could be achieved from more mixed farming systems in the uplands.

SUSCEPTIBILITY TO PARASITES

7.23 More extensive systems require less anthelmintics than intensive systems. It has been shown that some worming products, especially the invermectins, can pass through the animal and reduce the numbers of insects in the dung (Strong and Wall, 1994). This is important for the birds which habitually feed on insects found in animal dung. Investigations need to be carried out on the susceptibility of different breeds to internal, and perhaps external parasites to identify if some breeds are more resistant to parasites and require less use of anthelmintics.

LABOUR COSTS

7.24 The impact of the cost of labour should not be underestimated. Extensive systems of production, particularly with out-wintering are not easy to manage when labour is in short supply. Animals are brought inside, often because that is the most convenient way to manage them. The cost of in-wintering often means that highly productive animals such as the continental breeds are required to justify the large capital investment encouraging the use of high cost, high input and high output systems.

CONCLUSIONS

7.25 To help promote biodiversity, systems need to be designed which will achieve the goals which are set. As a first step in this process, the objectives for land management including the management of vegetation need to be clearly defined. These objectives will vary from place to place so the resulting systems will also vary. There is no one prescription which will cover all circumstances.

7.26 We also need to take into account changes in management practices which have occurred and developments in technology. The difficulties of implementing systems are often practical in nature and are related to labour or capital requirements. The sharing of machinery between farms and the pooling of labour for particular operations may become more important in the future.

CHAPTER EIGHT: THE CONTRIBUTION TO BIODIVERSITY MADE BY THE BLUE GREY COW

8.1 This chapter considers a case study of a traditional genotype. The Blue Grey cow is an interesting animal to study, since it is a crossbred between a bull which is classed as a minority breed (Whitebred Shorthorn) and a cow of a traditional Scottish breed (Galloway). The resultant cow is subsequently crossed with a variety of breeds, often continental breeds, to produce a finished beef animal for slaughter.

8.2 The pure Galloway is a true hill breed, kept in relatively harsh environments, particularly in the hills and uplands of southern Scotland. There are only a limited number of breeds which could be used in these types of farming systems. The Blue Grey cow is also able to survive in such conditions while able to produce calves which will satisfy the requirements of the market for quality meat.

THE PERFORMANCE OF THE BLUE GREY COW

8.3 There have been a number of experiments done over the years looking at the performance of Blue Grey cows and their calves. A comprehensive review of the reproductive performance of Blue Grey cows was undertaken by Osoro and Wright (1992). They reviewed the performance of a total of 321 spring-calving cows which had been used in a series of grazing experiments between 1984 and 1987 at the Hartwood Research Station of the Macaulay Land Use Research Institute. 237 of the cows were Hereford x Friesian while the remaining 84 cows were Blue Greys. The study looked at the performance of spring-calving cows (mean calving date 27th March). The mating period which was 10 weeks long each year started 1 week after turnout in the middle of May.

8.4 Earlier work, (Wiltbank et al, 1964; Dunn et al, 1969; Hansen et al, 1982 and Rutter et al, 1984) had established that a number of factors were responsible for the length of time taken to get cows back in calf. These included milk production, age of the cow, suckling and genotype. Also heavily implicated was the condition of the cow at calving which in turn is a function of the level of nutrition in the period up to calving.

8.5 By the end of the mating period, there were significantly more Blue Grey cows in calf than Hereford x Friesians, with Blue Grey cows achieving a pregnancy rate of 90% compared to only 83% in the Hereford x Friesian cows. Of those cows which were pregnant, the period from the start of mating to conception was shorter for the Blue Grey at 17 days as opposed to 27 days for the Hereford x Friesians. At calving the body condition score of the Blue Greys was higher (2.54 compared to 2.37). The calves, which were all sired by Charolais bulls, were however significantly heavier at birth when their dams were Hereford x Friesian cows rather than Blue Greys (41.2kg compared with 36.5kg). The calves of Hereford x Friesian cows also grew faster at 0.95kg/day rather than 0.84kg/day achieved by those from Blue Grey cows, presumably as a consequence of the higher milk yield in the Hereford x Friesian cows (Wright and Russel, 1987). As a consequence calves from Blue Grey cows tend to be 10-15kg lighter at weaning than those from Hereford x Friesian cows (Hodgson et al, 1980; Wright and Russel, 1987).

8.6 As part of the study, the age of the cow was also taken into account. Up to the age of 7 years there was no difference in the percentage of cows which were successfully got back into calf. However above this age, there was a significant decrease in the number of Hereford x Friesian cows which became pregnant. At 10 years of age virtually 100% of the Blue Greys became pregnant while just over 60% of the Hereford x Friesians were able to get back in calf. This suggests that the replacement rate of the Blue-Grey cows would be considerably less than the Hereford x Friesian.

8.7 Other studies on the Blue Grey cow suggest that they calve slightly lighter than Hereford x Friesian cows, that their intake at pasture is less, but their milk yield is lower. Wright and Russel (1987) reported milk yields of 8.93kg/day for Hereford x Friesian cows and 6.88kg/day for Blue Greys. This lower milk yield is primarily a function of their partitioning less of their energy towards milk production and more towards body reserves. As a consequence they tend to be fatter than more productive genotypes and lose less weight in lactation (Hodgson et al, 1980). It is not clear if the superior reproductive performance of the Blue Grey compared to the Hereford x Friesian observed by Osoro and Wright (1992) is simply a consequence of their having a higher level of body condition. Body condition is known to have a strong effect on reproductive performance (Wright et al, 1992).

8.8 In an experiment looking at the post-weaning nutrition of calves Wright and Russel (1987) found that the Charolais-cross progeny of Hereford x Friesian cows were heavier than those from Charolais cross Blue Grey cows. The weight difference remained constant throughout the experiment. This suggests that the difference was not due to higher potential for growth, but to the higher milk yields which have been reported for Hereford x Friesian cows. McDougal (1978) argued that the milk yield of the Blue Grey could be improved by more rigorous selection of Whitebred Shorthorn bulls. This would require records to be kept of calf performance in order to identify those bulls which conferred improved milking ability on their daughters.

8.9 In conclusion, the Blue Grey cow tends to be fatter at calving and has higher reproductive performance and a more compact calving interval. Since it tends to be fatter at calving, it requires less expensive winter feeding. It also loses less weight during lactation and therefore requires less autumn feeding to return it to condition fit for calving. It is also able to sustain its higher reproductive rate to an older age thus leading to a much lower replacement cost than a Hereford x Freisian cow. The weaning weights of the calves are, however, lower than for genotypes with higher milk yield potential.

8.10 For these reasons, the Blue Grey is well suited to extensive production systems. Without the large fluctuations in body condition, the Blue Grey is well adapted to systems of lower inputs.

CONTRIBUTION OF BLUE GREY COWS TO WIDER BIODIVERSITY

8.11 Common et al (1998) showed that Blue Grey cows could be used to bring about changes in the cover of different plant species is *Nardus* - dominated hill pasture. However it is not clear whether similar effects could have been achieved with other genotypes. Anecdotal evidence indicates that Blue Grey cows may be more prepared to forage over wider areas than the more productive genotypes such as Hereford x Friesian, but there is no experimental evidence to support this. Despite the considerable research on the Blue Grey there is a large gap in information as to whether it, or indeed any other breed or cross, contributes to greater biodiversity than other breeds.

CONCLUSIONS

8.12 Since the Blue Grey cow is a crossbred, its loss would have a serious detrimental effect on the population of its parent breeds. The Galloway in particular is important, being a true hill breed. The production of females for subsequent crossing with the Whitebred Shorthorn is a significant market for many Galloway breeders. Significant reductions in the numbers of Galloways would in turn have implications for the biodiversity of hill and upland swards.

8.13 The Blue Grey cow itself is important in that it can apparently survive in relatively harsh conditions on terrain which may be difficult to graze with other genotypes. The Blue Grey is well adapted to extensive conditions and is longer lasting and cheaper to feed than some other, larger types of suckler cows. The Blue Grey is also easier to manage in terms of its reproductive performance, being easier to get back in calf after giving birth.

8.14 There is a need however for further studies of the impact of the Blue Grey (and indeed other breeds) on biodiversity and in particular its impact on the composition of upland swards. As has been stated earlier, little research has been conducted on the impacts of different genotypes on biodiversity.

CHAPTER NINE: RECOMMENDATIONS FOR FURTHER WORK, RESEARCH REQUIREMENTS, PRACTICAL DEVELOPMENTS AND OPPORTUNITIES FOR PROMOTION OF TRADITIONAL BREEDS

9.1 A series of gaps and recommendations have been identified throughout Part 1 of this report. This chapter summarises and expands on them.

RECOMMENDATIONS FOR FURTHER WORK

9.2 This review has partly identified the size of the cattle and sheep genetic resource and its distribution in Scotland. For cattle the data held by the British Cattle Movement Service is comprehensive, although there is some confusion regarding the definition of different breeds and crosses entered by farmers. For sheep there is no comparable information. Although studies of numbers of different breeds exist, their distribution is not known and so their vulnerability to for example disease outbreaks is uncertain. ***A full and systematic review of the numbers and location of different breeds of sheep should be undertaken as a matter of urgency.***

9.3 There are a number of genetic improvement programmes for rare and especially traditional breeds. Some of these are organised by breed societies, others by research organisations in collaboration with breed societies. There is little collaboration between such programmes. ***There is a need to review breed improvement programmes in Scottish breeds and to assess their actual or potential impact on genetic diversity.***

9.4 A number of the Scottish breeds have populations situated outwith Scotland and the UK. ***Consideration should be given to a review of such breeds to determine the size of this genetic resource.***

RESEARCH REQUIREMENTS

9.5 Research requirements were identified in relation to the conservation of the animal genetic resource and on farming systems and wider biodiversity.

9.6. Breed societies are generally strong and active but the costs of maintaining records are high, and there is little opportunity for using such records for research purposes because of differences in recording systems etc. ***Research is needed on development of registration management software, ideally designed to help make breeding decisions.***

9.7 To understand the importance of Scottish breeds in genetic diversity, it is necessary to understand the genetic affinities. While some work has been done on cattle, ***research is needed on the genetic affinities of Scottish sheep breeds. Coupled with this there is also a need to conduct research on the extent and degree of introgression of genes from other populations.***

9.8 Some cryopreservation of semen and embryos of rare and traditional breeds has started, as a way of protecting the genetic resource against catastrophic events, such as disease. So far this has been on an *ad hoc* basis. Consideration should be given to developing systematic programmes of cryopreservation of semen and embryos. ***There is a need for research to develop the most cost effective way of operating such programmes.***

9.9 The breed structure has major impacts on the genetic variability within a breed. ***Further research is urgently needed on the nature and genetic consequences of population structures of the Scottish breeds.***

9.10 There is a major gap in knowledge on the role of rare and traditional Scottish breeds in farming systems, their impact on wider biodiversity and their socio-economic role. Virtually no research has been conducted in these areas. Specific areas on which research is needed are:

9.11 ***Differences in foraging behaviour of different breeds and potential effects on vegetation and other aspects of biodiversity.*** Anecdotal evidence suggests such differences may exist, but as yet there is no scientific evidence to support this.

9.12 Although farmers and others recognise that some breeds are better suited than others to some farming systems, ***there is a need for a better understanding and quantification of the characteristics of breeds and to explain how these characteristics appear to suit particular production systems. There is also a requirement to identify if particular breeds are suited to systems which use species-rich pastures, including whether hay making can be integrated into farming systems with traditional breeds and methods for enabling species-rich swards at a more advanced physiological stage than is usually used for silage.***

9.13 Some breeds of cattle are apparently more suited to out-wintering than others. ***Research needs to be conducted to investigate the effects on vegetation of year-round grazing rather than summer-only grazing.***

9.14 No research has been conducted on whether particular rare or traditional breeds are more suited to mixed farming systems, which may deliver biodiversity benefits. ***Systems-level research is needed to identify the potential gains in biodiversity that could be achieved from more mixed farming systems, especially in the uplands, and how rare or traditional breeds may contribute to this.***

9.15 It is known that susceptibility to internal parasites has a genetic component. ***Research should be conducted to identify if there are differences in susceptibility of different Scottish breeds to internal, and perhaps external parasites to identify if some breeds are more resistant to parasites than others and require less use of anthelmintics.***

9.16 No research has been conducted on the socio-economic implications of using rare and traditional breeds. These breeds undoubtedly form an important part of the cultural heritage of Scotland (one only has to consider the number of postcards with pictures of Highland cattle or Scottish Blackface sheep). ***The socio-economic role and importance of such breeds should be studied and quantified.***

PRACTICAL DEVELOPMENTS

9.17 Information on the number and distribution of different breeds is difficult to obtain. For cattle the BCMS now has data on numbers and location, by county, of different breeds. However there is some confusion as to the exact definitions used by farmers when supplying breed information, especially for cross-bred animals. ***Ways of providing more precise definitions of breeds and crosses in the BCMS database should be explored.***

9.18 For sheep there is no central inventory of numbers and distribution of breeds. ***Urgent consideration should be given by Government to ways of collecting such information on a regular basis.***

9.19 There are a number of different conservation programmes, but these are conducted by a range of organisations, with little co-ordination. ***As part of its responsibility under the Convention on Biodiversity, Government should consider how better co-ordination may be achieved in genetic conservation schemes.***

9.20 Rare and traditional breeds exist in small herds/flocks and total numbers are low. This can make marketing difficult. ***A greater degree of co-operation between farmers is needed, especially for finishing and marketing.***

9.21 ***Government and other agencies (local authorities, local enterprise companies) need to consider how best to assist in the development of marketing schemes which would not only help with the conservation of traditional and rare breeds but would also encourage rural employment and development.***

OPPORTUNITIES FOR PROMOTION OF RARE AND TRADITIONAL BREEDS AND ASSOCIATED FARMING SYSTEMS

9.22 Historically Scotland has been a source of high quality breeding stock which has been exported to other countries. ***Further opportunities for the use of Scottish breeds outwith Scotland should be explored.***

9.23 Different breeds have different characteristics and can fit niche markets. ***Information about the performance of different sheep breeds and their crosses should be made available so that these market niches can be developed.***

9.24 While there are undoubtedly benefits to biodiversity of promoting and encouraging some farming systems or aspects of systems, there is no clear evidence at present that the promotion of any particular breed is likely to bring greater and/or wider biodiversity benefits than any other. Thus, currently, on the basis of objective evidence, the case for government support for particular breeds can only be justified from the perspective of maintaining the genetic resource and not from an environmental perspective. ***However there may be a case for providing enhanced levels of support to farms that keep rare or traditional breeds in order to assist in the preservation of these genetic resources.***

9.25 There are several examples of marketing schemes which promote rare and traditional breeds. The best known example is probably the Certified Aberdeen Angus Scheme, but there are also schemes to promote meat from Beef Shorthorns and milk from Ayrshire cows.

There are probably considerable opportunities for similar schemes from a range of other breeds, but a comprehensive review of marketing opportunities is outwith the scope of this project. ***An in-depth study of the opportunities and practical support required from Government and other agencies (eg. local authorities, local enterprise companies) to initiate and support such schemes should be undertaken.***

PART 2 - CROP VARIETIES

CHAPTER TEN: INTRODUCTION

10.1 The crop component of the project concentrated on barley and oats, with a brief overview of other crops. Scots Bere is given as a particular example of a traditional Scottish crop and is reviewed in some detail. Barley and oats were important components of pre-historic Scottish agriculture and, unlike other crops, had developed as “landraces”. Historically, oats were the most widespread crop but have steadily declined since the 1950s and now are grown on less than 10% of the cereal area. In contrast, barley crops have a long history in Scottish agriculture but have been less important than oats until the rapid expansion of malting barley production in the 1960s. Winter wheat (Scottish barley and oat crops are mainly spring sown) was a minor crop until entry of the UK into the EU changed the economics of grain whisky distillation and provided a new market for soft milling wheat.

HISTORICAL CONTEXT

10.2 The early history of most crops, in detail, is obscure with older records being less reliable or more difficult to interpret than modern agricultural statistics (Agriculture in Scotland, Annual reports, HSMO). The most readily available early data on Scottish Agriculture “The New Statistical Account of Scotland” lists crops and “describes” methods but does not have the same information content as modern statistics. Many books and papers have been published on Scottish Agriculture since 1596 and older records can be accessed via Symon (1959), who records their location. Archaeological studies have established the succession of crops in the Middle East (Harlan, 1995) and more recently “genetical archaeology” has suggested centres of origin and dispersal routes of ancient agriculture (Badr et al, 2000; Heun et al, 2000).

10.3 Local landraces of cereals evolved from crops domesticated in the Middle East some 10,000 years BP, particularly in the Fertile Crescent. The development of local landraces involved genetic adaptation as the crops migrated north and west from the centres of their origin. The most significant factor determining adaptation is time of flowering. In barley, time of flowering is affected by a number of genes controlling response to vernalization and daylength as well as earliness *per se* (Laurie, 1997; Laurie et al, 1995; Bezant et al, 1996). With current knowledge it is obvious that the process of unconscious selection for date of heading and maturity would have had widespread effects on the genome. It is not possible, however, to be sure of the efficiency of “natural” selection as many land-races may have been sown in both autumn and spring.

10.4 Early flowering, conditioned by a day-length response and low vernalization requirement, is appropriate to Mediterranean latitudes. Typically, in dry, rain-fed, situations early flowering is important to exploit winter rainfall and avoid drought stress associated with high temperatures in mid-summer (van Oosterom and Acevedo, 1992). In contrast, the highest crop yields occur in moist, cool environments in which long days allow slow plant development (Ellis and Kirby, 1980; Kirby and Ellis, 1980; Ellis and Russell, 1984; Russell and Ellis, 1988). In this context it is useful to note that crops in North America and South Australia are grown in environments that resemble Mediterranean conditions more closely than North West European agriculture so that the relationship between grain composition and malting quality is not constant (Swanston et al, 1997). The contrast between the Mediterranean climate and that of North West Europe resulted in many changes within and between crops. It is, for example, suggested that oats started as a crop weed in the Middle

East but in Northern France out-competed barley and predominated in the crop as a response to an increase in rainfall (Thomas, 1995).

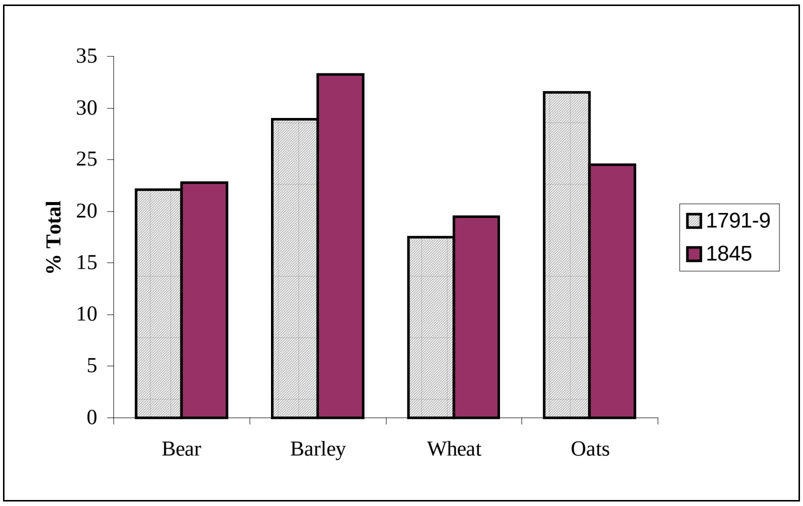
10.5 In addition to day-length and rainfall, soil composition has a dramatic effect on crop growth. While barley is more tolerant of salt than wheat (Harlan, 1995), acidic soils cause greater stresses in barley because metal ions such as Mn^{++} and Al^{+++} are more toxic to barley than to wheat or oats (van Essen and Dantuma, 1962). In contrast to the majority of barleys, Scots Bere is relatively tolerant of acidic soils due to a single gene on chromosome 4H (Stølen and Andersen, 1986). The basic mechanism of aluminium tolerance is still obscure (Kidd et al., 2001) with the possibilities that vacuolar sequestration, exclusion from the root or immobilisation in the soil by root exudates may play a part.

10.6 Scottish agriculture has been reviewed extensively both separately and together with the rest of the UK. It is notable that the reviews by Britton (1969), Coppack (1976) and Food from Britain (1983), do not consider Scots Bere. This contrasts with local interest groups particularly from the Orkneys (Davidson, 1982) where the Orkney Biodiversity Record Centre runs courses in Wildlife Identification and the Birsay Heritage Trust maintains Barony Mills, a traditional watermill, that is still used to mill Scots Bere (http://www .orkney.com/birsayheritage/mill.htm). An overview is needed of the effect of the traditional crops on tourism, the wider environment and local interests but, in detail, this is beyond the scope of this report.

CHANGES IN THE IMPORTANCE OF CROPS

10.7 The pattern of cropping in Scotland has changed considerably with Scots Bere widely grown in the 18th and 19th centuries (Figure 10.1). The export of Scots Bere to Norway and the Netherlands, with subsidy support, was recorded as early as 1695 (Symon, 1959). In 1769 more Scots Bere than barley was grown on Highland farms but the area of barley was extended by progressively liming soils. A farm hand-book (McConnell, 1904) records four types of Scots Bere; Common Bere, Black Four-row, Victoria and Winter White Bere. It would appear that only the first type has been preserved in collections. Since 1856 the

Figure 10.1 A comparison of the records of bear (Scots Bere), barley, wheat and oats in The New Statistical Account of Scotland for 1791-99 and 1845. The references to the four crops change little but give no clear indication of the relative importance in terms of the area sown.



relative positions of the major crops has changed considerably (Figure 10.2). Oat crops have declined and barley increased in area while other crops have also decreased. It is difficult to compare major and minor crops on the same scale but the use of a $\log_{10}$ scale allows the decline of rye, beans and orchards in the 1950s to be observed. The area used to grow soft fruit remained constant until 1995 and has then declined.. The major changes in crop importance were reflected in programme changes at the Scottish Plant Breeding Station (Table 10.1) with barley breeding starting in 1968 and oat breeding ceasing in the late 1970s.

Figure 10.2 Areas of selected crops 1856 – 1997 plotted to illustrate the changes between the major crops (grass and oats) and crops of intermediate importance in total area (potatoes, barley, turnips).

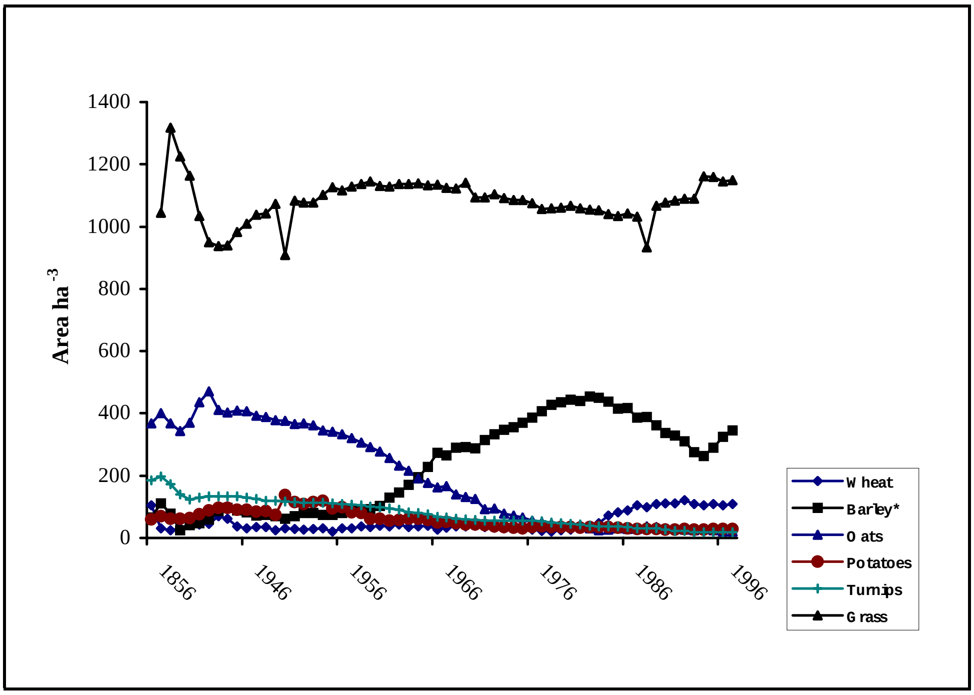


Figure 10.3. Areas of selected crops 1940 – 1970 plotted on a $\log_{10}$ scale to illustrate the differences between major crops (grass and oats), minor crops (orchards, soft fruit, rye, beans) and intermediate crops (potatoes, barley, turnips).

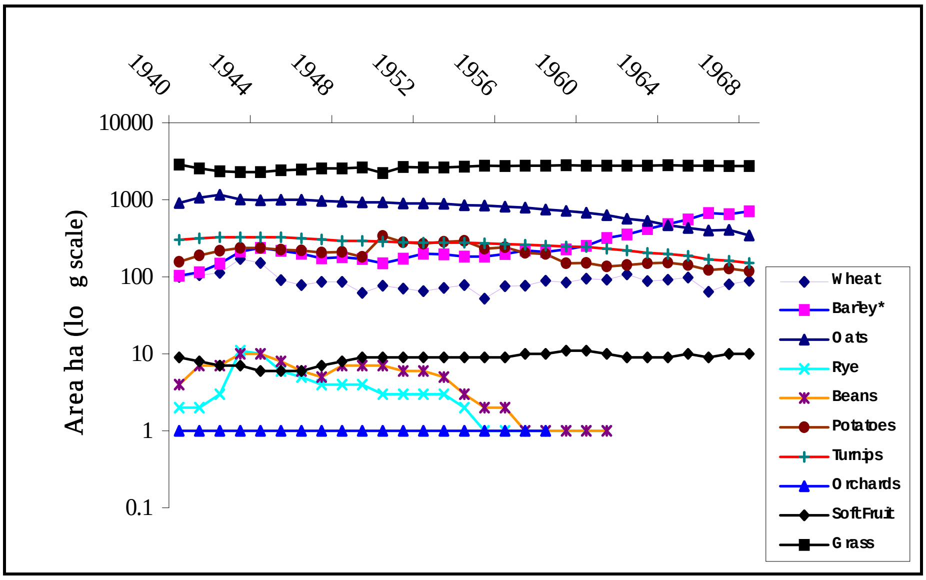


Table 10.1 Selected events from the programme of the Scottish Plant Breeding Station

Year	Event
1929	Experiments with *Plantago maritima* into genotype with environment interaction
1932	Bell oats registered
1935	Scots Common barley selection started – Craigs Triumph released in 1944
1954	Trials of oats bred for alkaline soils (Machair) tested in Tiree, Uist and Orkney
1955	Laboratory moved from East Craigs to Pentlandfield
1967	Use of oat composite crosses in Tiree to develop oats for Machair areas
1968	Start of high diastase barley breeding programme
1973	Start of malting quality breeding programme – Tyne released 1986
1980	Multiplication of the British/Israeli collection of *Hordeum spontaneum*
1988	Tyne barley recommended for use in Scotland

10.8 The recorded exchange throughout Europe of barley cultivars and breeding material has been extensive (Plarre and Hoffmann, 1963) with widespread development of cultivars selected from landraces. The main centres of barley and breeding were at Weihenstephan and Hadmersleben in Germany, Abed in Denmark, Svalof in Sweden and Cambridge in England. It is notable that Scottish barley landraces have made no genetic contribution of any sort to barley improvement i.e. are not represented in the pedigrees of modern cultivars. This is in great contrast to Sweden where landraces from Gothenburg made a substantial contribution to malting - quality barley development. This contrast reflects the localisation of activity in breeding programmes and differs greatly from the objective of modern commercial breeding programmes that aim to produce pan-European cultivars. The fact that adaptation of cultivars, produced by any breeding programme, is dependent on the geographical span of the in-built trialling system, was recognised after collaborative testing in Europe (Ellis and Schmuetz, 1981).

10.9 The need for wider adaptation was recognised in the publicly-funded cereal breeding programmes of the Plant Breeding Institute, Cambridge; the Welsh Plant Breeding Station, Aberyswyth and the Scottish Plant Breeding Station, Edinburgh. Local trials were latterly supplemented, particularly for barley, by an exchange of material at both the row selection and replicated-plot trial stages. The efficiency of improved trials technique (Robinson, Kershaw and Ellis, 1988) gave increased flexibility and efficiency in trials run by breeders and in National List and Recommended List testing. Close collaboration between workers at the Scottish Plant Breeding Station and member companies of the British Society of Plant Breeders resulted in setting up a system of national trials in parallel to National List Trials (NLT) (Talbot and England, 1984).

TRADITIONAL CEREAL CULTIVARS

10.10 It is difficult to define what is meant by a traditional cultivar because older cultivars are often heterogeneous. Pragmatically, barley and oats that show particular adaptation to Scotland can be considered in three broad categories: 1) only present in germplasm collections, 2) still cultivated in traditional systems and 3) ex-Recommended List but no longer in main-stream commerce (Table 10.2). Newer cultivars may be as well adapted, particularly as global climate causes marked change in rainfall and/or temperature, but have not been assessed as completely as those listed below.

10.11 New cultivars are assessed in a system of National List Trials (NLT) in which good plot performance over the whole UK is the first hurdle that the candidate must exceed. A few of the entries for NLT reach Recommended List Trials (RLT) and succeed in being recommended. The rate of attrition of breeding material has been reviewed (Ellis, 1986) and appears to preclude the recognition of specific regional adaptation in a new cultivar.

10.12 The barley variety Golden Promise is an example of the ex-Recommended List category and is very well adapted to Scottish conditions, well liked by farmers, maltsters, brewers and distillers. It is no longer on the National List, so is not protected as a plant variety, but it is still used by brewers who prefer its malting performance. Golden Promise seed was sown on 481 ha in 2000 i.e. 1.6% of the total Scottish seed production (Figure 10.4). The equivalent figures for Tyne and Prisma were 2 % and 5% respectively. Consideration should be given to reviewing procedures for National List Trends to accommodate regional differences with a view to encouraging greater diversity in varieties used.

Table 10.2 Examples of barley and oat varieties adapted to Scottish conditions and their status.

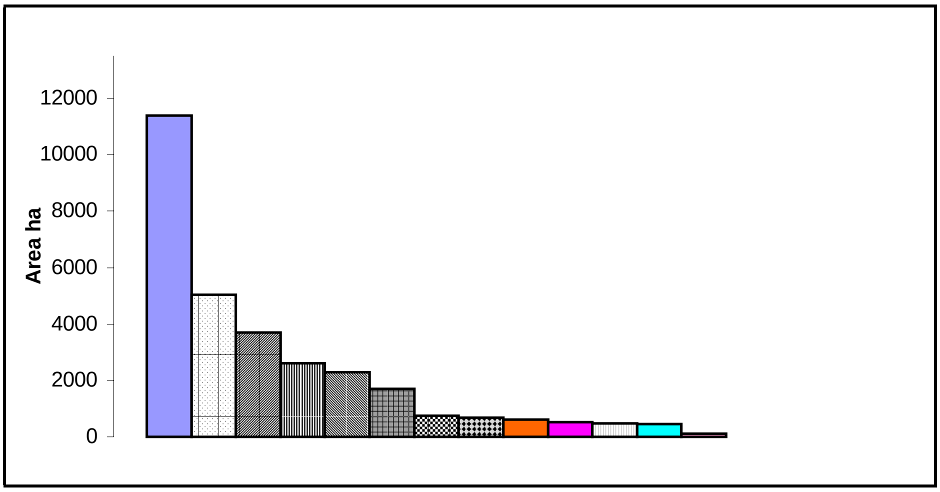
Barley

Collection	Traditional	Ex-Recommended List	
		Golden Promise	Camargue
Scots Annat[1]		Midas	Golf
Scots Common		Tyne	Triumph
Ymer	Scots Bere	Prisma	Kym

Oats

Collection	Traditional	Ex-Recommended List
Ayr Commander	Albyn Empress	Dula
Castleton Potato	Bell	Blenda
Tiree Oat	Sandy	Onward

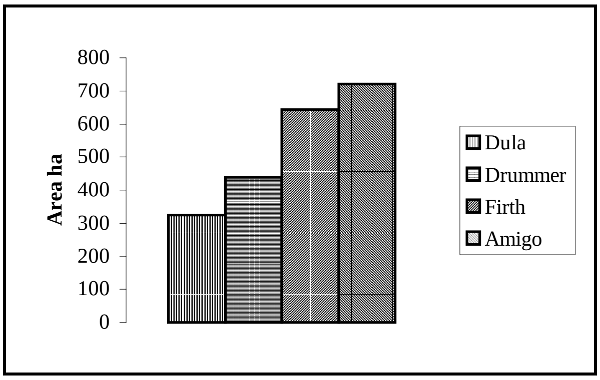
Figure 10.4 Seed production in Scotland for spring barley in 2000 – areas accepted for certification. The cultivars (left to right) are Optic, Chalice, Decanter, Riviera, Chariot, Prisma, Maresi, Tyne, Static, Hart, Golden Promise, Delibes and Derkado.



10.13 The other "traditional" barleys are not represented in the formal seed production system and there are no records for informal seed production. Oat seed production is on a much smaller scale that barley (Figure 10.5). The area sown to produce seed of Dula in 2000 was 324 ha, somewhat less than Golden Promise. Again there is no certified seed production of other traditional cultivars of oats.

[1] Note that reference to a single variety name does not specify the number of samples that exist

Figure 10.5 Areas of oat seed sown and accepted for certified seed production in Scotland in 2000.



OTHER CROPS

10.14 In the case of potatoes the traditional Scottish role has been the production and export of seed potatoes to England and Wales. Some traditional varieties such as Pink Fir Apple and Kerr's Pink have been grown for specialist purposes. The major European Potato collections have been catalogued (Kehoe, 1986) and the Scottish Agricultural Science Agency are currently compiling a European Community Potato Cultivar Database of some 4,500 accessions. Fruit production in Scotland has been limited by climate to localised areas that specialise in e.g. raspberry production. SCRI has collected and assessed the genetic diversity of wild Scottish raspberries (Graham et al, 1997).

CHAPTER ELEVEN: REVIEW OF RELEVANT RESEARCH

11.1 Scots Bere was included in a large diallel cross carried out at the Scottish Plant Breeding Station as part of a project that aimed to investigate the genetic control of traits important in Scottish barley. A major target of the then current breeding programmes was to provide new cultivars, adapted to Scotland, with high diastatic power in the malt (Allison et al, 1979). The development of a successful cultivar would allow the replacement of imports from Canada with locally grown crops (Table 11.1). A number of difficulties were encountered such as the high susceptibility of exotic cultivars to powdery mildew, six-rowed cultivars with tall weak straw and so judged to be unsuitable parents, an association of low yield and high diastatic power and a problem in recovering high yielding lines from 2-row by 6-row crosses. It was seen as a necessity that the outcome of the programme would be commercially attractive cultivars. At that time the National Seed Development Organisation (NSDO) located in Cambridge marketed cultivars bred in the publicly - funded programmes. NSDO guidance was that new cultivars with wide adaptation were preferred to locally adapted material.

11.2 The lines included in the diallel experiment did not result in the development of cultivars but lines from a second cycle of crossing between the two-row cultivars Akka and Maris Mink i.e. Tweed ((Akka x Maris Mink) x Maris Mink) entered National List Trials in 1983 (Ellis, 1986).

11.3 Samples of Scots Bere were used in a composite cross population approach to the development of new cultivars. A collection of grain samples was made from the sites available and they have been deposited in the BBSRC Cereal Collection held at the John Innes Centre. At the same time a collection of Scots Common was also made but as this traditional variety did not show acid soil tolerance the samples were not used in breeding but were simply deposited in the BBSRC cereal collection. The difference in low soil pH tolerance between Scots Bere and Scots Common is in agreement with the way in which these landraces were used in Scottish agriculture and was reflected in the effort devoted to their improvement at the SPBS. Work on the use of Scots Bere germplasm ceased when the SPBS barley work moved to Dundee and was replaced by a programme in winter barley that was short lived because of the difficulty of breeding in isolation from adequate selection resources.

Table 11.1 Cultivars used in the diallel cross grown at SPBS, Pentlandfield in 1970 and 1971. Olli and Pirkka were regarded as the best source of high diastase, Ymer was grown widely in Scotland but was in the process of replacement by Golden Promise.

Cultivar	Pedigree	Origin	Role in Scotland
Scots Bere	Land-race	Scottish Landrace	Major long-term
Olli	Finnish land-race selection	Finland	Grain import
Pirkka	(Maskin x Finnish) x (Olli x Manchurian)	Canada	Grain import
Ymer	Maja x (Segar x Opal)	Sweden	Major cultivar
Golden Promise	Gamma-ray from Maythorpe	Milns, Chester	Major cultivar

Midas	((Proctor x Wong) x MR "A") x Gamma-ray from Maythorpe	Milns, Chester	Major cultivar

11.4 The Scottish Plant Breeding Station carried out a programme of oat breeding (Cameron and Phillips, 1974) part of which aimed to produce lines tolerant of highly alkaline soils of the Machair of the Western Isles. This involved the use of a site with alkaline soil (pH 8) at Archerfield in East Lothian as well as testing lines at sites in Inverness and Argyll (Simmonds, 1970). The Machair areas are a particularly important example of an environment in which traditional agriculture and wild species coexist. Cropping is significant factor in maintaining the local biodiversity and experiments with composite crosses were initiated in collaboration with local crop advisers in Tiree (1967) and Benbecula (1970). The work was completed and the material gifted to the adviser on Tiree for exploitation in 1974 (Cameron and Phillips, 1975).

CONTEMPORARY GENETICS

11.5 The Scottish Crop Research Institute (SCRI) has developed a programme of genetic research based on genotyping spring barley cultivars with a wide range of DNA - based markers. In particular, a recent programme funded under the BBSRC GAIT initiative used forty-eight SSRs to scan 800 cultivars (winter and spring). This large data matrix is being used to identify linkage disequilibrium (non-random associations between genetic loci) and using the information on the patterns of diversity to find associations with varying agronomic traits. A recent appointment to Biomathematic and Statistics Scotland is investigating the statistical aspects particular to the diversity patterns found in barley (relating this work to the explosion of interest in mapping of genetically complex human diseases by similar means). This data allows the investigation of genetic diversity over time or in response to selection in breeding programmes, as illustrated in Figure 12.1 below.

BIODIVERSITY IN TREE SPECIES

11.6 As a signatory to the Rio Convention on Biological Diversity, the UK has a commitment to the conservation and enhancement of biodiversity. The devices to achieve this include the National and Local Biodiversity Action Plans, and a range of grant schemes to encourage land management practices that promote biodiversity. Efficient use of these resources depends on an understanding of the diversity present and knowledge of how this diversity interacts with other ecosystem components. A recent project aimed to integrate genetic and biochemical diversity with taxonomic diversity and ecological function, in order to assess how biodiversity interacts at different levels. Previous work in this area has focused on Scots pine (*Pinus sylvestris*), a high conservation priority species. The data collected during this project suggested that a large degree of genetic homogeneity characterized the European Scots pine, which can be related to a common origin of these populations after the last glaciation from a single population, with no evidence for multiple origins of Scots pine in Scotland.

More recently, joint funding has been secured by the Scottish Crop Research Institute, the Macaulay Institute and the Royal Botanic Gardens Edinburgh to examine the species diversity, genetics and ecology of high conservation priority sub-arctic willow communities.

Such a project will provide a conceptual understanding of the relationships of biodiversity at three different levels:-

i. species diversity of willows,
ii. genetic diversity of willows,
iii. species and genetic diversity of associated communities.

This will provide the baseline scientific background to develop informed conservation management and species recovery programmes.

CHAPTER TWELVE: SUMMARY OF CULTIVARS IN COLLECTIONS AND REVIEW OF ORGANIZATIONS CONCERNED IN THE CONSERVATION OF CEREAL GERMPLASM

12.1 Collections of cereals were surveyed by consulting experts, literature searches and through internet searches. Historically the cereal collections of the Plant Breeding Institute, Cambridge (PBI) the Welsh Plant Breeding Station, Aberyswyth (WPBS) and the Scottish Plant Breeding Station, Edinburgh (SPBS) were centralised at the Plant Breeding Institute during the review that led to the amalgamation of the Scottish Plant Breeding Station with the Scottish Horticultural Research Institute to form the Scottish Crop Research Institute. The sale of the PBI plant breeding programme to Unilever PLC resulted in the move of the Biotechnology and Biological Sciences Research Council Cereal Collections to the John Innes Centre, Norwich (JIC). Curatorship of the cereal collection passed to Dr M. Ambrose, then in charge of the JIC *Pisum* collection. Access to the collection is possible by consulting a catalogue by the then AFRC Institute of Plant Science Research and the John Innes Institute, but this has not been updated since 1989, or for barley through the European Barley Database (EBDB)[i], currently hosted at the Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany [ii]. Access to material in the collection is excellent but the level of duplication, implicit in the triplicate origin of the collection, is problematic.

12.2 The reduction of the publicly-funded plant breeding in the UK was mirrored by changes in Europe and worldwide. As a result of international treaty obligations the UK has contributed to the European Cooperative Programme for Crop Genetic Resources Networks (ECP/GR). The work is coordinated through the International Plant Genetic Resources Institute (IPGRI). IPGRI is based in Rome and is funded through the Consultative Group on International Agricultural Research (CGIAR). A wide range of networks has resulted in co-ordination of efforts through meetings of researchers concerned with genetic conservation of crops (Gass et al, 1999) including cereals (Maggioni et al, 2001), barley (Maggioni et al, 1999), oats (Maggioni et al, 1988), potatoes (Hoekstra et al, 2001), forage (IPGRI, 1991). Some attention has been given to on-farm conservation and collecting but this does not extend to Scottish cereals (Laliberté et al, 2000).

i http://barley.ipk-gatersleben.de/ebdb.php3

ii Institute of Plant Genetics and Crop Plant Research
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D-06466 Gatersleben
GERMANY Tel: +49-39482-5327 Fax: +49-39482-5286

12.3 Within Germany re-unification has resulted in the amalgamation of collections, e.g. the barley collections at Braunschweig and Gatersleben are in the process of amalgamation. It is to be hoped that this will result in an increase in access to the barley collection but the difficulties of removing duplication etc. are considerable and the programme will be prolonged. In Sweden the Nordic Genebank announced a change in policy and will no longer maintain germplasm that originates from outside the Nordic countries. A more positive development is that the large collection of barley mutants created by Dr U. Lundqvist at Svalof is to be incorporated into the Nordic Genebank..

12.4 The result of searches for Scottish barley and oat cultivars is given in Tables 12.1 and 12.2. Even over the short time scale of the project access to information via the internet has improved. This is particularly true for barley where the European Barley Data Base was updated in November 2001. Other databases are in the process of updates so it is important to keep up - to - date with this aspect of the project work. As might be expected, given the historical origin, the largest numbers of "Scottish" cultivars were found in the collection of the John Innes Centre (JIC). The JIC collection holds 32 barley and 70 oats that appear to be adapted to Scottish conditions. The next largest collection, in terms of positive "hits" is that of the USDA, accessed via PCGRIN (personal computer version of the database for the Genetic Resources Information Network). Other collections have been explored, for example those held in New Zealand, but the short time-scale of this project may have resulted in some collections being overlooked.

12.5 A contrast between the livestock and crop component of the study lies in the use of genebanks to deposit seed of cultivars. Gene banks suffer from a number of inherent faults. The genetic diversity of an accession depends on systematic collection and efficient maintenance. In practise the ideal can rarely be achieved and many European landrace varieties have been lost. Given these limitations it is still possible for suitably equipped organisations to obtain small seed samples from a genebank, multiply the seed under high quality agronomy, check the identity and produce enough seed to grow replicated trials to assess agronomically important traits. SCRI has carried out an historical survey of spring barley germplasm from North West Europe and demonstrated the considerable gain in yield from breeding programmes between 1920 and 1970 (Figure 12.1). Care was taken to ensure that the seed from the JIC and other collections was true to type by comparing rows in the field with descriptions of the cultivars. DNA was extracted from samples grown in the glass house and used to provide SSR fingerprints that could be used for later identification and also to explore the genetic relationship between the cultivars (Russell et al, 2000). This latter exercise was most illuminating given that the alleles present in a representative collection of North West European cultivars could be traced back to just seventeen foundation cultivars, a good indication of the low level of genetic diversity in modern spring barley.

Table 12.1 Scottish barley cultivars found in searches of databases in Europe and the United States

"Scottish" Cultivars in Collections

Cultivar	Collection					
	JIC	NGB	IPK	VIR	POL	USNP
Annat						1
Bere	14					1
Common	5					
Craigs Triumph	1					
Golden Promise	2					2
Midas	3	1	1	1		1
Scotch Annat	1					
Scotch Common	1					
Scots Bere		1	1	1		1
Scots Common		1				1
Scottish Annat	1					
Scottische Annot		1				
Tiree 6-row					1	
Triumph						2
Ymer	4	1			1	1

Key to collections

JIC = John Innes Centre, Norwich
NGB = Nordic Genebank, Alnarp, Sweden
IPK = Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany
POL = Poland, National Centre for Plant Genetic Resources
USNP = United States National Plant Germplasm System

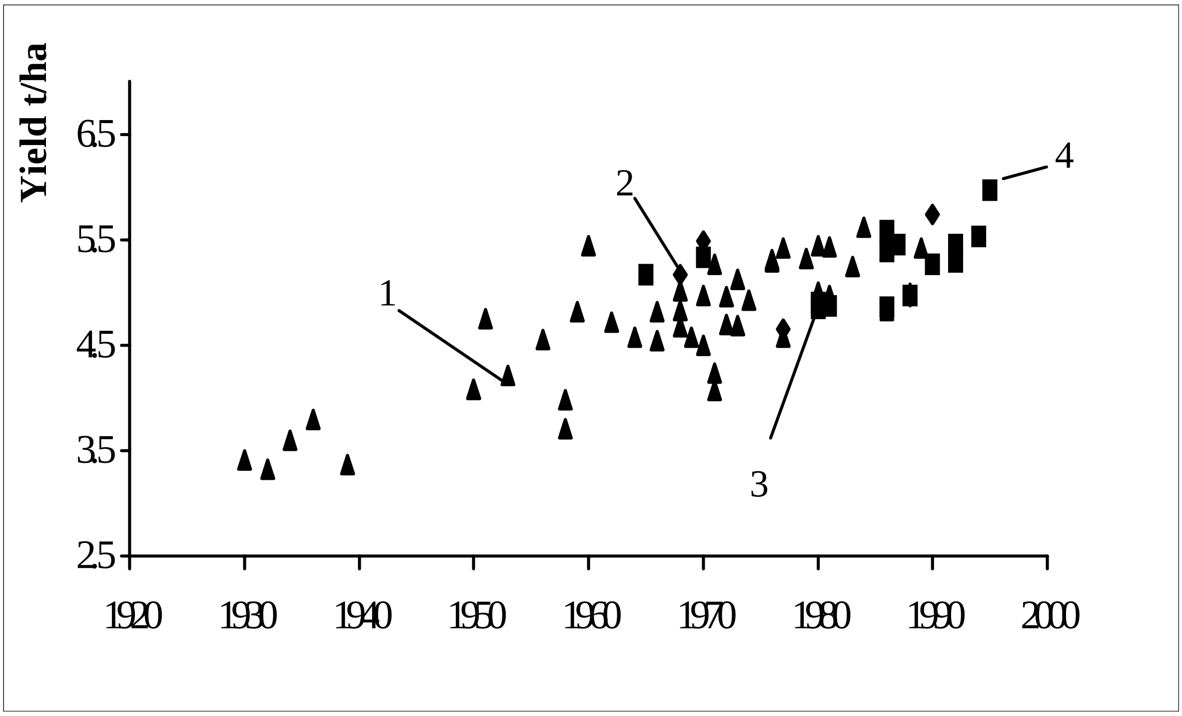
Table 12.2 "Scottish" oat cultivars found in searches of databases in Europe and the United States.

	JIC	BAZ	IPK	VIR	POL	USNP
Ayr Ally	1					
Ayr Bounty	2					
Ayr Commando	2					
Ayr Everest	2					
Ayr Fusilier	1					
Ayr Grenadier	1					
Barbacklaw	2					
Bell	2		1	1		3
Black Tam Findlay	1					
Blainslie	2		1			1
Castleton	1					2
Castleton Potato	2			1		2
Castleton Sandy	1			1		
Craigs Afterlea	2					3
Early Miller		1		1		2
Glebe	2			1		
Gordon	4		1	1		1
Gordon Sandy	1			1		
Grange	2					
Leven	2			1		
Monarch	2					4
Murkle	8					
Pentland Provender	1					
Potato	7			10		4
Sandy	6			3		
Scotch Berlie	3					
Scotch Hopetown				1		
Scotch Potato				1		
Scottish Chief	2	2				5
Shearer	1					
Tam Findlay	3					2
The Waverley	1					2
Tiree Oat	3			1		

Key to collections

JIC = John Innes Centre, Norwich
BAZ = Braunschweigg, Germany
IPK = Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany
POL = Poland, National Centre for Plant Genetic Resources
USNP = United States National Plant Germplasm System

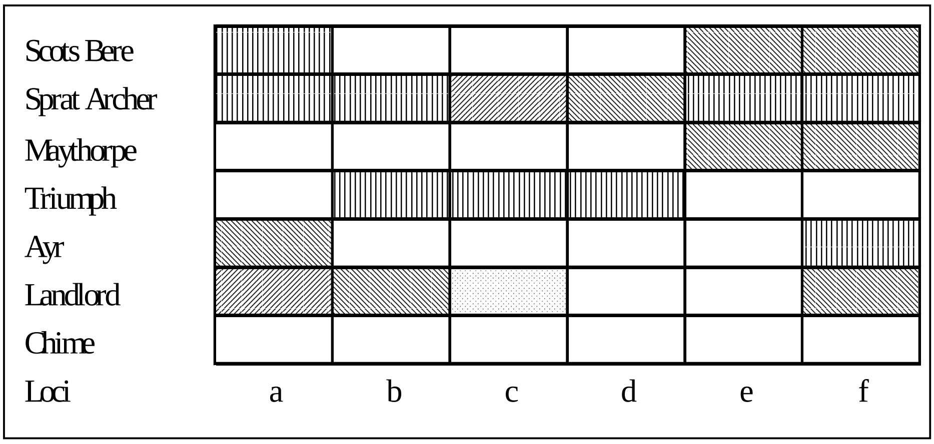
Figure 12.1 Plot of yield against year of commercialisation for varieties multiplied at the Scottish Crop Research Institute from seed held at the BBSRC collection at the John Innes Centre. The cultivars indicated are 1) Proctor, 2) Golden Promise, 3) Triumph, 4) Optic.



CHAPTER THIRTEEN: IDENTIFICATION OF THE SIZE AND COMPLEXITY OF THE GENETIC RESOURCE WITHIN CROP VARIETIES AND IMPACTS ON GENETIC DIVERSITY OF REDUCED USE

13.1 Estimates of genetic diversity have been made in European spring barleys by the use of genetic markers such as AFLPs (Ellis et al, 1997) and SSRs (Russell et al, 2000). Scots Bere and other traditional cultivars have not been explored in a detailed examination of inbred lines from crosses, as in the case of the Derkado x B83-12/21/5 doubled haploid population (Thomas et al, 1998), but genome scanning has been carried out to assess allelic variation at a discrete number of genetic loci. The results of genome scanning for six loci on chromosome 4H are summarised in Figure 13.1. This chromosome was identified as carrying a gene for acid soil tolerance (Stølen and Andersen, 1978) so it is highly likely that one of these markers has a close association with the low pH tolerance gene. Scots Bere and Sprat Archer have the same allele at locus a) but differ from the other cultivars. At loci b) through d) Scots Bere has the most common allele that is present in Maythorpe, Ayr and Chime. Scots Bere has less common alleles at loci e) and f) and this suggests that these markers may have potential for marker assisted backcrossing. The development of this potential requires more precise mapping of low pH tolerance than was possible with morphological markers (Stølen and Andersen, 1978). The identification of closely linked markers will permit marker-assisted backcrossing, a process that is quicker and more precise than the conventional crossing and cultivar development procedures that were available in the 1970s.

Figure 13.1 Results from an experiment to assess genetic diversity in spring barley cultivars. SSR alleles at six loci (a-f) on chromosome 4H coded to indicate contrasts in allele size.



13.2 Genetic diversity within a crop has the potential to increase the overall biodiversity of the environment. Scots Bere, as a typical landrace, would not have been subject to the purification processes typical of the production of a modern cultivar. The need to prove that a new cultivar is Distinct, Uniform and Stable theoretically means that a National Listed cultivar is essentially a single genotype. During the SCRI genome scanning experiment, in which cultivars produced between 1890 and 1995 were genotyped, the effect of the 1964

Plant Varieties Rights Act was obvious in a rapid reduction in genetic diversity. A crop that is a single genotype is more amenable to modern agronomy giving economically worthwhile responses to high inputs but is also vulnerable to damage by pests etc. This may require intervention with pesticides that have unwanted side effects for species that are important for birds. Experimentation with cultivar mixtures indicates that mixing even a few genotypes improves performance under disease pressure (Newton et al, 1999).. The potential for landraces, whether natural or recreated, to improve overall biodiversity has not been tested so it is not possible to precisely estimate the effect of the reduction in use of Scots Bere.

CHAPTER FOURTEEN: A DETAILED REVIEW OF THE CONTRIBUTION MADE TO BIODIVERSITY BY SCOTS BERE

14.1 The importance of the historical role of Scots Bere in Scottish agriculture is indicated by the fact that until 1960 the Scottish Agricultural statistics recorded barley and bere together. Scots Bere is a six-row barley and an example of a traditional variety with specific adaptation to soils that are of low pH. According to Jarman (1996) Scots Bere was still grown in Orkney and Caithness, in the late 1990s, as a spring crop, although only 5-15 ha was grown annually. It is susceptible to frost, but grows very rapidly, especially in long summer days such as experienced in Northern Scotland. Because of its very rapid growth it is sown late but is often the first to be harvested and is known locally as the '90-day' barley. Scots Bere is weak strawed and susceptible to foliar disease, especially mildew and is milled to make traditional 'bere bannocks'.

PERFORMANCE OF SCOTS BERE

14.2 Experimental results at the Scottish Plant Breeding Station showed that Scots Bere was well adapted to the Midlothian environment. In a hand-planted experiment the relative yield of Scots Bere was the highest (Riggs and Hayter, 1975) of the parents under test and this was coupled with early flowering (Riggs and Hayter, 1973). The study was completed with the publication in 1978 of estimates of diastatic power and alpha-amylase showing that Scots Bere had the highest diastatic power (Hayter and Riggs, 1978). A comparison between Scots Bere and cultivars considered to be sources of high diastatic power (Olli, Pirkka) and highly commercial cultivars (Ymer, Golden Promise, Midas) is given in Figure 14.1 as the difference between the scores for Scots Bere and the other cultivars. This plot clearly indicates that yield potential is higher in Scots Bere because it had more ears, a larger number of grain per ear and the grains were larger than many of the other cultivars.

14.3 These data appear to be at odds with the traditional view that Scots Bere is low yielding and this could be for a number of reasons. If grown with lower levels of, or even no lime, Scots Bere will not be as high yielding as barley on the same soil after liming to modern standards. The experimental design used to assess the diallel cross was the most precise (with single plant randomisation) available but lacked flexibility. The wide segregation, due to the deliberate use of diverse parents, for height and heading date resulted in interplant competition that favoured early, tall over short, late lines. A truer estimate of the potential for barley with improved tolerance to low soil pH, to the same level as wheat, would be obtained from a study of random inbred lines from a cross with current dwarf, mildew resistant lines.

IMPLICATIONS FOR WIDER BIODIVERSITY

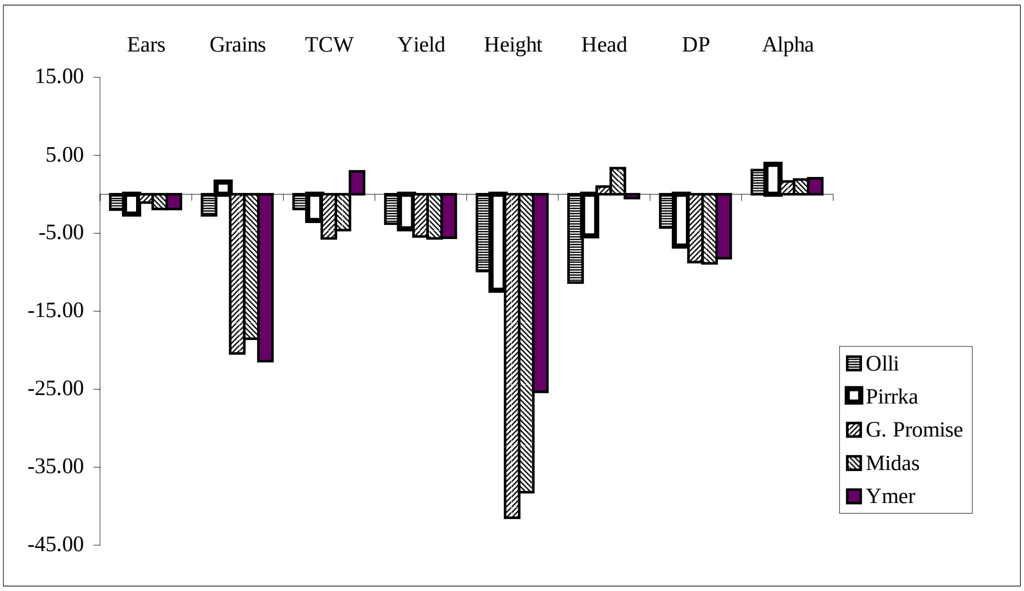
14.4 The key characteristics of Scots Bere, earliness, height and weakness of straw allow an estimation of a past contribution to biodiversity. In a system based on non-intensive practises rapid early growth would provide cover in early spring for birds and harbour invertebrates essential for young chicks. Relatively early harvest and natural drying in the field would provide seed for adult birds in the autumn. This contrasts with crops of uniform spring barley that mature later than Scots Bere, although spring barley is more benign than autumn sown crops. Research has been carried out on the amelioration of the effects of intensive cropping with the development of the concepts of "beetle banks" (Boatman, 1999).

More recent research has highlighted the interdependence of bird species and particular crops and has resulted in the concept of conservation seed mixtures.

14.5 Effects of crops on birds and insect may be highly visible but it is as likely that "invisible" effects may have even greater consequences. Barley crops tolerant of low soil pH would allow an overall reduction of lime use in arable rotations. As well as reducing the level of inputs the reduction of lime use will also have consequences for soil organisms such as earthworms (Robinson et al, 1992). More research is required into the consequences of changing liming regimes for soil bacteria, fungi and invertebrates.

14.6 Plant nitrogen metabolism is a major area of research that is vital to the future of world-wide farming (Raun & Johnson, 1999) as much applied fertiliser is wasted. Global nitrogen use efficiency (NUE) for cereal production is only 33%, a loss equivalent to about $16 billion annually. It is already known that there are genetic differences between cereal cultivars in nitrogen uptake (Sylvester-Bradley et al, 2002) and retention. Scots Bere represents potential germplasm for the investigation of the genetic control of nitrogen metabolism and this opportunity must not be lost.

Figure 14.1 Characteristics of cultivars relative to the performance of Scots Bere in hand sown experiments grown at the Scottish Plant Breeding Station in 1970/71.



CHAPTER FIFTEEN: RECOMMENDATIONS FOR FURTHER WORK, IDENTIFICATION OF RESEARCH REQUIREMENTS AND PRACTICAL DEVELOPMENTS AND OPPORTUNITIES FOR PROMOTION OF TRADITIONAL CROPS

POTENTIAL FURTHER WORK

15.1 A distinct programme of development of new varieties for low input sustainable agriculture has advantages for both high and low input farming. In the case of high input farming many aspects of the current SCRI programme can be used to address these issues.

15.2 The identification of distinctive traits, e.g. if in Scots Bere there is a particularly well-developed antiporter system to sequester toxic ions in the vacuole or exudates to immobilise Al^{+++} in the soil, then it would be possible to identify and transfer the genes efficiently from traditional to novel germplasm by marker assisted selection. ***A survey of genetic variation related to the tolerance of Scots Bere to acid soils should be undertaken.***

15.3 Traditional varieties may have traits of value in modern commerce such as an improvement in nitrogen use efficiency. ***A study of genetic variation for nitrogen use efficiency in Scots Bere compared to other varieties should be undertaken.***

15.4 In the broadest sense processing quality in barley can be considered to relate to animal fodder, human food (Bhatty, 1996) and malting. Much research relates to malting, brewing and distilling with less attention paid to food uses of barley in the UK although waxy, naked barley has been developed as a “new crop” in Canada (Bhatty, 1996). This is essentially because other cereals, when they can be cultivated, such as maize, sorghum, wheat and oats are preferred to barley for food. Scots Bere has been used to produce Bere Bannocks and in view of its high diastase levels in the Pentlandfield diallel experiment it may have use as a high lysine barley for animal or human food. ***A survey of the nutrient value of Scots Bere should be undertaken.***

15.5 In the case of low input systems in crofting the use of composite cross techniques in tandem with modern genetics appear to have many attractions:-

1) Distinctive traits of traditional varieties can be efficiently maintained by natural selection.
2) Farmers can be involved directly in the “breeding process”.
3) Simple crop handling techniques can be applied. ***The practicality of implementing such participatory breeding schemes for low input cropping should be examined.***

15.6 ***Research should be conducted on development of a Scottish Seed Conservation mix to encourage farmland birds.***

RESEARCH REQUIREMENTS

15.6 ***There is a need for further research into the effect that traditional barley and oat cultivars have on the biodiversity of the environments in which they are grown.*** There has been limited research in this area, and its results along with the body of anecdotal evidence suggests that these cereals have a major role to play in the management of the countryside.

Cereal crops and potentially "conservation plots", that remain unharvested, are of great significance to insect, mammal and bird life and may have a particular role in crofting.

15.7 ***There needs to be a quantification of the traits traditional cultivars exhibit in relation to biodiversity***, for example in adaptation to the climate and local soil types. Examples include oats tolerant of high manganese levels on alkaline soils or barleys tolerant of acidic soils.

15.8 Research in England has established the usefulness of growing cereal plots that are left un-harvested to encourage particular species of birds. In Scotland a spring sown crop could be more appropriate than winter sown mixtures. This is important if cropping continues to decline in crofting areas as a sown and left seed crop will support insect, mammal and birdlife. **There is a need for research on the varieties or mixtures suited to this purpose.**

15.9 ***Research needs to be carried out on how best to manage cereals, particularly diploid oats for grazing and silage, to maximise biodiversity.***

15.10 ***Investigations need to be carried out on the susceptibility of traditional barley and oat cultivars to diseases such as mildew and smut.*** It may be necessary to identify resistances and carry out backcrossing programmes to improve traditional cultivars.

15.11 ***There needs to be a general review of plant breeding programmes in relation to genetic diversity.*** It appears that selection for traits of use to modern systems have led to the loss of important characteristics found in traditional cultivars e.g. acid soil tolerance in barley.

15.12 The loss of the particular characteristics of traditional varieties was accelerated by the development of very dwarf types, between 1960s and 1980s that were well adapted to combine harvesting. Since that period the development of new genetical and tissue culture techniques have transformed the practice of barley improvement. ***Consideration should be given to using these techniques to move traits from tall, six-row ear types to the shorter two-row ear types, widely used in Scotland.***

PRACTICAL DEVELOPMENTS

15.13 ***Encouragement needs to be given to farmers to co-operate with each other on seed production and the development of new cultivars***. For example, the use of composite cross breeding for oats at the Scottish Plant Breeding Station demonstrated the potential of this technique and its simplicity means that it can be directly used by crofters given F_1 seed.

15.14 ***Further work is needed to look at objective techniques of prioritisation of seed conservation.*** There is no cereal genebank in Scotland and this does hamper cereal research.

OPPORTUNITIES FOR PROMOTION OF TRADITIONAL CROPS.

15.15 Bere bannocks and whisky are examples, respectively, of a niche product and main-stream product that rely on the "purity" of the Scottish environment. However the success of the whisky industry, where the major component, grain whisky, comes from “industrial distillation” rather than “Highland Streams”, highlights the success of modern advertising. ***There is an opportunity for greater promotion of local cereal-based products based on traditional varieties.***

15.16 There are opportunities to market the products of traditional cultivars by modern methods. For example the internet can be used to bring together customers and suppliers to develop more efficient distribution systems. ***The success of food supermarket groups in this area should be exploited by developing sponsorship schemes.***

15.17 There is little recent information on some aspects of the performance of traditional cultivars. ***Such information needs to be made available to allow their market niches to be exploited.***

REFERENCES (LIVESTOCK BREEDS COMPONENT)

Armstrong, R.H. Grant, S.A. Common, T.G. and Beattie, M.M. (1997) *Controlled grazing studies on Nardus grassland: Effects of between tussock sward height and species of grazer on diet selection and intake.* Grass and Forage Science (1997) Volume 52, 219-231.

Bailey, J.F., Richards, M.B., Macaulay, V.A., Colson, I.B., James, I.T., Bradley, D.G., Hedges, R.E.M. and Sykes, B.C. (1996) *Ancient DNA suggests a recent expansion of European cattle from a diverse wild progenitor species.* Proceedings of the Royal Society of London Series B, 263, 1467-1473.

Bignal, E., McCracken, D. and Makay, A. (1999) *The economics and ecology of extensively reared Highland Cattle in the Scottish LFAs: an example of a self sustaining livestock system. Livestock Production in the European Less Favoured Areas.* Proceedings of the 2nd International Conference of the Livestock Systems in Integrated Rural Development Network. Macaulay Land Use Research Institute publication pp 145-154

Blott, S. C., Williams, J. L., and Haley, C. S. (1998). *Genetic relationships among European cattle breeds.* Animal Genetics, 29**,** 273-282.

Common, T.G., Wright, I.A. and Grant, S.A. (1998) *The effect of grazing by cattle on animal performance and floristic composition in Nardus-dominated swards.* Grass and Forage Science, 53, 260-269.

Conington, J., Bishop, S. C., Waterhouse, A. and Simm, G. (1998). *A comparison of growth and carcass traits in Scottish Blackface lambs sired by genetically lean or fat rams.* Animal Science, 67**,** 299-309.

Dennis, P., Young, M.R. Howard, C.L. and Gordon, I.J. (1997) *The response of epigeal beetles (Col.: Carabidea, Staphlinidea) to varied grazing regimes on upland Nardus stricta grasslands.* Journal of Applied Ecology, 1997. 34, 433-443.

Dunn, T.G., Ingalls, J.E., Zimmerman, D.R. and Wiltbank J.N. (1969) *Reproductive performance of 2 year old Hereford and Angus heifers as influenced by pre and post calving energy intake.* Journal of Animal Science, 29, 719-726.

Dwyer, C.M. and Lawrence, A.B. (1997) *The effect of ewe genotype on the behaviour of their lambs in two breeds of sheep*. Proceedings of the British Society of Animal Science, p18.

Farid, A., O'Reilly, E., Dollard, C. and Kelsey, C. R. (2000). *Genetic analysis of ten sheep breeds using microsatellite markers.* Canadian Journal of Animal Science, 80, 9-17.

Gardner, S.M., Hartley, S.E., Davis A. and Palmer, S.C.F. (1996) *Carabid communities on heather moorland in Northeast Scotland: The consequences of grazing pressure for community diversity. Biological Conservation,* 81, 275-286

Gordon, I.J. and Iason, G.R. (1989) *Foraging strategy of ruminants: its significance to vegetation utilization and management.* MLURI Annual Report 1988-89, pp34-41.

Grant, S.A., Milne, J.A., Barthram, G.T. and Soutar, W.G. (1982) *Effects of season and level of utilization of heather by sheep. 3. Longer term responses.* Grass and Forage Science Volume 37, 311-320.

Grant S.A., Torvell L., Common,T.G., Sim, E.M. and Small, J.L. (1996a) *Controlled grazing studies on Molinia grassland: effects of different seasonal patterns and levels of defoliation on Molinia growth and responses of swards to controlled grazing by cattle.* Journal of Applied Ecology, 33, 1267-1280.

Grant, S.A., Torvell, L., Sim, E.J., Small, J.L. and Armstrong, R.H. (1996b) *Controlled grazing studies on Nardus grassland: Effects of between-tussock sward height and species of grazer on Nardus utilization and floristic compostition in two fields in Scotland.* Journal of Applied Ecology 1996. pp 1053-1064

Graves, C. (1997) *Galloways, The Society and the Cattle.* Published by the Galloway Cattle Society.

Hall, S. J. G. (1986) *Genetic conservation of rare British sheep: the Portland, Manx Loghtan and Hebridean breeds.* Journal of Agricultural Science, Cambridge, 107, 133-144.

Hall, S. J. G. (1989) *Conserving and developing minority British breeds of sheep: the example of the Southdown.* Journal of Agricultural Science, Cambridge, 112, 39-45.

Hansen, P.J., Baik, D.H., Rutledge, J.J. and Hauser E.R. (1982) *Genotype x environmental interactions on reproductive traits of bovine females. Postpartum reproduction as influenced by genotype, dietary regimen, level of milk production and parity*. Journal of Animal Science, 55, 1458-1472

Hart, E. (1999) *Traditional Aberdeen Angus. Ark* 27, 110-111.

Hester, A.J. and Ballie, G.J. (1998) *Spatial and temporal patterns of heather use by sheep and red deer within natural heather/grass mosaics.* Journal of Applied Ecology, 35, 772-784.

Hodgson, J., Peart, J.N., Russel, A.J.F., Whitelaw, A. and Macdonald, A.J. (1980) *The influence of nutrition in early lactation on the performance of spring-calving suckler cows and their calves.* Animal Production, 30, 315-325.

Hoekstra, J., van der Lugt, A. W., van der Werf, J. H. J. and Ouweltjes, W. (1994) *Genetic and phenotypic parameters for milk production and fertility traits in upgraded dairy cattle.* Livestock Production Science, 40, 225-232.

Jamieson, A (1966). *The distribution of transferrin genes in cattle.* Heredity, 21, 191-218.

Kantanen, J., Olsaker, I., Holm, L.-E., Lien, S., Vilkki, J., Brusgaard, K., Eythorsdottir, E., Danell, B. and Adalsteinsson, S. (2000) *Genetic diversity and population structure of 20 north European cattle breeds.* Journal of Heredity, 91, 446-457.

Lidauer, M. and Mantysaari, E. (1996) *Genetic constitution of the Finnish black and white cattle population and the influence of Holsteinization on protein yield, days open and somatic cell count.* Acta Agriculturae Scandinavica, 46, 193-200.

Marriott, C., Bolton, G.R., Barthram. G.T., Fisher, J.M. and Hood, K. *Early changes in species composition of upland sown grassland under extensive grazing management.* Applied Vegetation Science 2002 (in Press).

Mercer, J.T., Lewis, R.M. and Alderson, G.L.H. (1997) *The Adaptation of Rare Breeds of British Livestock to Different Environments : A Review.* A literature review on behalf of the Ministry of Agriculture, Fisheries and Food.

McDougal, J.D. (1978) *Blue-Greys as suckler cows and the role of the Whitebred Shorthorn.* ADAS Quarterly review. No 30, 153-158.

Nee, S. and May, R.M. (1997) *Extinction and the loss of evolutionary history. Science*, 278, 692-695.

Newborn, D. (2000) *The value of Hebridean sheep in controlling invasive purple moor grass.* Aspects of Applied Biology, 58, 191-196.

Nicholas, F.W. (1987) *Veterinary Genetics*. Clarendon Press, Oxford.

Osoro, K. and Wright, I.A. (1992) *The effect of body condition, live weight, breed, age calf performance and calving date on reproductive performance of spring-calving beef cows.* Journal of Animal Science. 70, 1661-1666.

Pollock, C.J. (2000) *Farming for the Future: Biotechnology and Engineering in Perfect Harmony?* Journal of Agricultural Engineering Research 76, 219-255

Royal, M. D., Darwash, A. O., Flint, A. P. F., Webb, R., Woolliams, J. A. and Lamming, G. E. (2000) *Declining fertility in dairy cattle: changes in traditional and endocrine parameters of fertility.* Animal Science, 70, 487-501.

Ruane, J. (2000) *A framework for prioritizing domestic animal breeds for conservation purposes at the national level: a Norwegian case study.* Conservation Biology, 14, 1385-1393.

Ruane, J., Klemetsdal, G., Heringstad, B., Jorjani, H., Madsen, P. and Poso, J. (1999). *A note on genetic exchange in the Nordic dairy cattle population.* Acta Agriculturae Scandinavica 49, 221-224.

Rutter, L.M. and Randel, R.D. (1984) *Postpartum nutrient intake and body condition: effect on pituitary function and onset of oestrus in beef cattle.* Journal of Animal Science, 58, 265-274.

Ryder, M.L. (1968) *The evolution of Scottish breeds of sheep.* Scottish Studies 12, 137-167.

Scottish Executive. (2001) *Economic Report on Scottish Agriculture,* 2001 Edition
At http://www.scotland.gov.uk/library3/agric/ersa01-00.asp

Southgate, J.R., Cook, G.L. and Kempster, A.J. (1982) *A comparison of different breeds and crosses from the suckler herd. 1. Live-weight growth and efficiency of food utilization.* Animal Production, 35, 87-98.

Strong, L. and Wall, R. (1994) *Effects of ivermectin and moxidectin on the insects of cattle dung.* Bulletin of Entomological Research, 84, 403-409

Thorhallsdottir, A.G., Provenza, F.D. and Balph, D.F. (1990) *Ability of lambs to learn about novel foods while observing or participating with social models.* Applied Animal Behaviour Science, 25, 25-33.

Toulmin, D. (1992) *I widn'a be a loon again.* In Collected Short Stories. Gordon Wright Publishing, Edinburgh.

Waterhouse, A. and Evans, R.G. (1995) *The development of tourist sites interpreting livestock production in Scotland.* In: Animal production and rural tourism in Mediterranean regions. Proceedings of the International Symposium on Animal Production and Rural Tourism in Mediterranean Region organized by EAAP, FAO, CIHEAM and SNFEZ of Portugal, Evora, Evora, Portugal, 10-13 October 1993. Wageningen Press, Wageningen Netherland pp. 257-261.

Wilkins, R.J. (1994). *Future directions for grassland farming - a research scientist's view.* Journal of the Agricultural Society – University of Wales, 74, 53-64.

Wiltbank, J.N., Rowden, W.W., Ingalls, J.E. and Zimmerman, D.R. (1964) *The influence of post-partum energy level on reproductive performance of Hereford cows restricted in energy intake prior to calving.* Journal of Animal Science, 23, 1049- 1053.

Wright, I.A. and Russel, A.J.F. (1987) *The effect of sward height on beef cow performance and on the relationship between calf milk and herbage intakes.* Animal Production, 44, 363-370.

Wright, I.A., Rhind, S.M., Whyte, T.K. and Smith, A.J. (1992) *Effects of body condition at calving and feeding level after calving on LH profiles and the duration of post-partum anoestrous in beef cows.* Animal Production, 55, 41- 46.

Wright, I.A., Davies, D.A. and Vale, J.E. *Grazing of permanent pasture and Molinia-dominated pasture by different Genotypes of Cattle.* Grazing Management: British Grassland Society occasional symposium No 34.

Sources of Information for Tables 2.7 and 2.8

Alderson, G.L.H. (1977) *Comparative performance standards for some minority breeds of sheep.* The Ark 4, 227-232.

Alderson, G.L.H. and Hindson, J.C. (1993) *Invaluable source of information – rare breeds of sheep at Ash Farm.* The Ark 3, 91-93.

Anon (1991b) *Summary of Combined Flock Book Returns,* 1989/90. The Ark 18 (6) 200-201.

Anon (1994) *The Combined Flock Book Volume XX.* The Ark 21, 277-278.

Castlemilk Moorit Breed Society (-) *Castlemilk moorit – breed description.* Castlemilk Moorit Breed Society leaflet.

Hall, S.J.G. and Clutton Brock, J. (1989) *Two Hundred Years of British Farm Livestock.* British Museum (Natural History), London.

Kilkenny, J.B. (1981) *MLC Beef Improvement Services Pedigree Beef Cattle Averages,* 1979-81. MLC Beef Improvement Services Data Sheet 81/7.

Lewis, W.H.E. (1978) *Beef records and the interpretation of performance test results.* Proceedings of a Conference on Minority Breeds in Commercial Systems – NAC Stoneleigh, UK, December 1978.

MLC (1991) *MLC Beef Yearbook.* MLC Publications, Milton Keynes, UK.

MLC (1995) *MLC Beef Yearbook 1995* Appendix B Genetic Performance. MLC Publications, Milton Keynes, UK.

Porter, V. (1992) *Cattle – A Handbook to the breeds of the world.* Helm Information, England.

RBST (1994) *Rare Breeds Facts and Figures.* Rare Breeds Survival Trust Publication.

RBST (1989a) *Hebridean : Mule productivity comparison 1988-89; summary of results.* Rare Breeds Survival Trust report.

Ryder, M.L. (1968) *Orkney Sheep.* Scottish Studies. 12, 137-167.

Schwabe, A.E. and Hall, S.J.G. (1989) *Dystocia in nine British breeds of cattle and its relationship to the dimensions of the dam and calf.* Veterinary Record. 125, 6363-639.

Silva, J.R. (1984) *RBST Study: Ease of parturition in rare breeds of sheep.* Rare Breeds Survival Trust Report.

Simon, D.L. and Buchenauer, D. (1993) *Genetic diversity of European livestock breeds.* EAAP Publication No. 66, Wageningen Press.

REFERENCES (CROP VARIETIES COMPONENT)

Badr, A., Muller, K.and Schafer-Pregl, R. et al (2000) *On the origin and domestication history of barley (Hordeum vulgare).* Molecular Biology and Evolution. 17, 499-510.

Bezant, J., Laurie, D., Pratchett, N., Chojecki, J. and Kearsey, M. (1996) *Marker regression mapping of QTL controlling flowering time and plant height in a spring barley cross (Hordeum vulgare L.).* Heredity. 77, 64-73.

Bhatty, R.S. (1996*) Production of food malt from hull-less barley*. Cereal Chemistry. 73, 75-80.

Boatman, N. (1999) *Marginal benefits? How field edges and beetle banks contribute to game and wildlife conservation.* Game Conservancy Trust Review 1999, 61-67.

Britton, D.K. (1969) *Cereals in the United Kingdom. Production, marketing and utilisation*. Pergamon Press, London and New York.

Cameron, D. and Phillips, M.S. (1974) *Oat Breeding***.** Annual Report of the Scottish Plant Breeding Station. 1973-4 p11.

Cameron, D. and Phillips, M.S. (1975) *Oat Breeding*. Annual Report of the Scottish Plant Breeding Station. 1974-5 p12.

Coppack, J.T. (1976) *An agricultural atlas of Scotland.* John Donald Ltd, Edinburgh.

Davidson, P. (1982) *Bere barley – past and present*. Orkney Field Club Bulletin, 7.

Ellis, R.P. and Kirby, E.J.M. (1980) *A comparison of spring barley grown in England and Scotland. 2. Yield and its components*. Journal of agricultural Science, Cambridge 95, 111-115.

Ellis, R.P. (1986) *Spring barley cultivars bred at the Scottish Crop Research Institute.* Crop Research (Hort. Res.) 26, 57-77.

Ellis, R.P., McNicol, J.W., Baird, E., Booth, A., Lawrence, P., Thomas, W.T.B. and Powell W (1997) *The use of AFLPs to examine genetic relatedness in barley.* Molecular Breeding 3, 359-369.

Ellis, R.P. and Russell, G. (1984) *Plant development and grain yield in spring and winter barley*. Journal of Agricultural Science, Cambridge 102, 85-95.

Ellis, R.P. and Schmuetz, W. (1981) *Collaborative spring barley trials in Europe.* Barley Genetics IV, Proceedings of the Fourth International Barley Genetics Symposium, Edinburgh, pp163-166.

Food from Britain. (1983) *Cereals in the United Kingdom*.

Gass, T., Frese, F., Begemann, F. and Lipman, E. (1999) *Implementation of the global plan of action in Europe – conservation and sustainable utilization of plant genetic resources for* *food and agriculture*. Proceedings of the European Symposium, Braunschweig, Germany. International Plant genetic Resources Institute, Rome

Graham, J., Squire, G.R., Marshall, B. and Harrison, R.E. (1997) *Spatially dependent genetic diversity within and between colonies of wild raspberry* Rubus idaeus *detected using RAPD markers.* Molecular Ecology 6, 1001-1008.

Harlan, J.R. (1995) *Barley*. In: Evolution of Crop Plants, ed. Smartt, J. and Simmonds, N.W., Longman, London.

Hayter, A.M. and Riggs, T.J. (1978) *The inheritance of diastatic power and alpha amylase content in spring barley*. Theoretical and Applied Genetics 52, 251-256.

Heun, M., Schafer-Pregl, R., Klawan, D., et al (2000) *Site of einkorn wheat domestication identified by DNA fingerprinting*. Science 278, 1312-1314.

Hoekstra, R., Maggioni, L., Lipman, E., and compilers (2001) *Report of a working group on potato. First meeting Wageningen, The Netherlands*. International Board for Plant Genetic Resources, Rome.

IBPGR (1991) *A guide to the European Forage Databases. European Cooperative Programme for Crop Genetic Resources Networks*. International Board for Plant Genetic Resources, Rome.

Jarman, R.J. (1996) *Bere barley - a living link with 8th Century?* Plant Varieties and Seeds 9, 191-196.

Kehoe, H.W. (1986) *Inventory of potato variety collections in EC countries.* Balkema, Rotterdam and Boston.

Kidd, P.S., Llugany, M., Poschenrieder, C., Gunsé, B. and Barceló, J. (2001) *The role of root exudates in aluminium resistance and silicon-induced amelioration of aluminium toxicity in three varieties of maize (*Zea mays L.*).* Journal of Experimental Botany 52, 1339-1352.

Kirby, E.J.M., Ellis, R.P. (1980) *A comparison of spring barley grown in England and Scotland. 1. Shoot apex development.* Journal of agricultural Science, Cambridge 95, 101-110.

Laliberté, B., Maggioni, L., Maxted, N., Negri, V. and compilers (2000) *ECP/GR in situ and on farm conservation network. Report of a joint meeting of a task force on wild species conservation in genetic reserves and a task force on on-farm conservation and management, Isola Polvese, Italy.* International Board for Plant Genetic Resources, Rome.

Laurie, D.A. (1997) *Comparative genetics of flowering time.* Plant Molecular Biology 35, 167-177.

Laurie, D.A., Pratchett, N., Bezant, J.H. and Snape J.W. (1995) *RFLP mapping of five major genes and eight QTL controlling flowering time in a winter x spring barley* (Hordeum vulgare L.) *cross.* Genome 38, 575-585.

Maggioni, L., Leggett, M., Bücken, S., Lipman, E. (1998) ECP/GR *Report of a Working Group on Avena.* Fifth Meeting, 7-9 May 1998, Vilnius, Lithuania. International Plant Genetic Resources Institute, Rome.

Maggioni, L., Knüpffer, von Bothmer, R., Ambrose, M., Hammer, K., Lipman, E. (1999) *Report of a working party on barley.* International Plant Genetic Resources Institute, Rome

Maggioni, L., Marum, P., Sackville Hamilton, N.R., Hulden, M., Lipman, E. and compilers (2000) *Report of a working group on forages, seventh meeting, Elvas, Portugal*. International Board for Plant Genetic Resources, Rome.

Maggioni, L. and Spellman, O. (2001) *Report of a network coordinating group on cereals.* Ad Hoc meeting Radzików, Poland. International Plant Genetic Resources Institute, Rome

McConnell, P. (1904) *The Agricultural Note-Book.* Crosby Lockwood & Son.

Newton, A.C., Guy, D.C., Ellis, R.P. and Swanston, J.S. (1999) *The effect of cultivar disease resistance and malting quality characteristics on their performance in mixtures*. Proceedings Crop Protection in Northern Britain.

Plarre, W. and Hoffman, W. (1963) *The development of barley growing and breeding in Europe*. 1st International Barley Genetics Symposium, Wageningen, 7-57.

Raun, W.R. and Johnson, G.V. (1999) *Improving nitrogen use efficiency for cereal production.* Agronomy Journal 91, 357-63.

Riggs, T.J. and Hayter A.M. (1973) *Diallel analysis of the time to heading in spring barley.* Heredity 29, 341-357.

Riggs, T.J. and Hayter A.M. (1975) *A study of the inheritance and inter-relationships of some agronomically important characters n spring barley*. Theoretical & Applied Genetics 46, 257-264.

Robinson, C.H., Ineson, P., Piearce, T.G. and Rowland, A.P. (1992) *Nitrogen mobilization by earth worms in limes peat soils under* Picea sitchensis. Journal of Applied Ecology 29, 226-237.

Robinson, D.L., Kershaw, C.D. and Ellis, R.P. (1988) *An investigation of two-dimensional yield variability in breeders' small plot trials.* Journal of agricultural Science, Cambridge 111, 419-426.

Russell, G. and Ellis, R.P. (1988) *The relationship between leaf canopy development and yield of barley.* Annals of applied Biology 113, 357-374.

Russell, J.R., Ellis, R.P., Thomas, W.T.B., Waugh, R., Provan, J., Booth, A., Fuller, J., Lawrence, P., Young, G. and Powell, W. (2000) *A retrospective analysis of spring barley germplasm development from 'foundation genotypes' to currently successful cultivars.* Molecular Breeding 6, 553-568.

Simmonds, N.W. (1970) *Oat Breeding*. Annual report of the Scottish Plant Breeding Station. 1969-70 p13.

Stølen, O. and Andersen, S. (1978) *Inheritance of tolerance to low soil pH in barley*. Hereditas 88, 101-105.

Sylvster-Bradley, R., Lunn, G., Foulkes, J., Shearman, V., Spink, J. and Ingram J. (2002) *Management strategies for high yield of cereals and oilseed rape*. HGCA R&D Conference 2002, pp 8.1-8.17.

Swanston, J.S., Ellis, R.P., Perez-Vendrell, A., Voltas, J., Molina-Cano, J.L. (1997) *Patterns of barley grain development in Spain and Scotland and their implications for malting quality.* Cereal Chemistry 74, 456-461.

Symon, J.A. (1959) *Scottish farming past and present.* Oliver & Boyd, Edinburgh & London. (In the library at SCRI.)

Talbot, M. and England, F.J.W. (1984) *A comparison of cereal variety performance in National List and Plant Breeders' trials.* Journal of the National Institute of Agricultural Botany 16, 499-505.

The New Statistical Account of Scotland by the Ministers of the respective parishes under the superintendence of a committee of the Society for the Benefit of the Sons and Daughters of the Clergy. William Blackwood and Sons, Edinburgh and London. Access via :- :- http://edina.ac.uk/cgi/StatAcc/

Thomas, H. (1995) *Oats*. In: Evolution of Crop Plants, ed. Smartt, J. and Simmonds, N.W., Longman, London

Thomas, W.T.B., Baird, E., Fuller, J.D., Lawrence, P., Young, G., Russell, J.R., Ramsay, L., Waugh, R. and Powell, W. (1998) *Identification of a QTL decreasing yield in barley linked to* Mlo *powdery mildew resistance.* Molecular Breeding 4, 381-93.

Van Essen, A., Dantuma, G. (1962) *Tolerance to acid soil conditions in barley*. Euphytica 11, 282-286.

Van Oosterom, E.J. and Acevedo, E. (1992) *Adaptation of barley (Hordeum vulgare L) to harsh Mediterranean environments. III Plant ideotype and grain yield.* Euphytica 62, 29-38.

APPENDIX ONE: WORKSHOP OBJECTIVES

A workshop was held at The Scottish Crop Research Institute on 28th November 2001. The objectives of the workshop were as follows.

Firstly, to explore how rare and traditional breeds of cattle and sheep and varieties of crops fit into farming systems. In particular what these breeds and varieties can deliver in terms of enhanced biodiversity. Also the management implications and how current systems would have to change to accommodate these breeds and varieties.

Secondly, to explore the concept of more mixed farming systems, especially those which involve the use of traditional breeds and varieties. How are these systems managed, and what are the implications for biodiversity.

Thirdly, to discuss the conservation and promotion of rare and traditional breeds of livestock and varieties of crops. This included not only genetic conservation, but the promotion of the produce from these breeds and varieties and marketing initiatives.

APPENDIX TWO WORKSHOP ATTENDEES

Mr Robert Anderson, The Aberdeen Angus Cattle Society.

Mr Donald Bailey, Scottish Executive Environment and Rural Affairs Department.

Mrs D Lenice Bell, Shetland Sheep Breeders Group.

Ms Morag Boyd, Scottish Wildlife Trust.

Mrs Elizabeth Brown, Shetland Sheep Breeders Group.

Mr W.J.Christie OBE, Whitebred Shorthorn Association.

Mr Carey Coombs, Beef Shorthorn Cattle Society.

Mr Andrew Dalziel, Macaulay Land Use Research Institute.

Dr Roger Ellis, Scottish Crop Research Institute.

Mr John Fawcett, Luing Cattle Society.

Mr Niall Green, Scottish Agricultural Science Agency.

Professor Stephen Hall, Lincolnshire School of Agriculture.

Mr Mark Hancock, Royal Society for the Protection of Birds.

Mr Roy Harris MBE, European Forum for Nature Conservation and Pastoralism.

Mr Peter Harrison, Forestry Commission.

Mr John Henderson, Scottish Executive Environment and Rural Affairs Department.

Dr S Hoad, Scottish Agricultural College, Crop Science Division.

Mr Gordon Jubb, Scottish Landowners Federation.

Mr Jerry Laker, Macaulay Land Use Research Institute.

Mr George Lawrie, National Farmers Union of Scotland.

Mrs Aileen McFadzean, Blackface Sheep Breeders Association.

Mrs J.M. McGowan, Luing Cattle Society.

Mr Gilbert Meikle, Shetland Sheep Breeders Group.

Mrs Marian Miller, Border Leicester Sheep Society.

Mr David Nelson, Macaulay Land Use Research Institute.

Professor Wayne Powell, Scottish Crop Research Institute.

Dr Joanne Russell, Scottish Crop Research Institute.

Ms Fiona Sloan, Bluefaced Leicester Sheep Society.

Mr David Soutar, The Highland Cattle Society.

Dr Geoff Squire, Scottish Crop Research Institute.

Dr Saffron Townsend, Rare Breeds Survival Trust.

Dr Iain Wright, Macaulay Land Use Research Institute.

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