

Geographical Isolation of Commercially Farmed Native Sheep Breeds in the UK – evidence of endemism as a risk factor to their genetic resources

5 A final report to the UK National Standing Committee on Farm Animal Genetic Resources from The Sheep Trust on research supported by a Defra-funded project grant.

Context

10 Arising from the Foot and Mouth disease (FMD) epidemic in 2001, there was an increased awareness of the threat to farm animal genetic resources (FAnGR) from geographical concentration of breeds relative to sites of disease outbreak. In particular, there was considerable anecdotal evidence that three sheep breeds concentrated in the North of
15 England and Scottish borders suffered disproportionate losses to FMD and the control measures employed. This threat was recognised by Heritage GeneBank (HGB) which undertook crisis collections of germplasm as an *ex situ* conservation action.

20 Following the FMD outbreak, The Sheep Trust was established to continue the work of HGB [www.thesheeptrust.org]. The Trust contributed to the National Steering Committee on FAnGR at which it was agreed that Heritage Sheep Breeds represented a new category of breeds at risk. The risk facing these breeds, exemplified by the FMD epidemic, arises from their regional concentration and not from numerical scarcity.

25 Indeed Heritage Sheep Breeds (HSBs) are commercially farmed, can exist in large numbers and contribute to the economic and environmental sustainability of their regions, as well as to cultural heritage. Significantly, this category is completely distinct from rare breeds that are at risk specifically from their numerical scarcity.

30 Recognition of HSBs was confirmed formally in the UK National Action Plan for FAnGR. The European Regional Focal Point (ERFP) commissioned The Sheep Trust to undertake a scoping study to investigate the existence of HSBs throughout Europe. The results of this scoping study have been published and confirm the significance of regional native sheep breeds to local culture, economies and environments in member states across the EU.

35 More detailed analysis of HSBs in five member states (UK, France, Greece, The Netherlands and Slovenia) is currently underway, funded by a DG Agri, GENRES programme coordinated by The Sheep Trust [www.heritagesheep.eu].

The Endemism Project

40 Heritage Sheep Breeds are recognised to be regional. However the extent of their spatial distribution is unknown. The absence of this information for livestock is recognised in the
45 FAO State of the World Farm Animal Genetic Resources and presents a real problem for breed characterisation and conservation prioritisation.

50 Within the UK, there is the added policy issue of the existing Breeds at Risk Register since many HSBs are excluded and the Register continues to focus on numerically scarce rare breeds. This anomaly continues despite the clear example of HSBs suffering disproportionate losses to their genetic resources from the disease threat during 2001.

55 As a means of establishing a new robust evidence-base for the extent of geographical concentration of HSBs, Defra commissioned The Sheep Trust to undertake an endemism project. It was considered that the results of such a project would contribute new, essential

information on the spatial distributions of the breeds to clarify the extent of their risk status from endemism. The study would thereby underpin future policy decisions and potential revisions of the national Breeds at Risk Register.

60 This report provides an Executive Summary of the project results and recommendations from these results for consideration by the National Standing Committee of FAnGR. Data from 12 breeds that are analysed together with the detailed methodology used for the analysis are described in Annex 1, a publication *in press* in the international peer-reviewed journal, *Livestock Science* [DOI: 10.1016/j.livsci. 2008.11:026] and available on-line at Science Direct:

"Geographical isolation of native sheep breeds in the UK – Evidence of endemism as a risk factor to genetic resources" (2009) A. Carson¹, M. Elliott², J. Groom², A. Winter³, D. Bowles^{1,4}

70 ¹The Sheep Trust, ²Defra, Economics and Statistics Programme, ³University of Liverpool, ⁴University of York

Annex 2 provides large-scale versions of Figures 1 and 2 from the publication; Annex 3 provides data on four breeds that were analysed in the study but not included in the *Livestock Science* publication; Annex 4 provides details of the resources and procedures adopted by the breed societies with whom the study collaborated.

80 The endemism project is a collaboration with national sheep breed societies and their memberships and provides new information on the population size and structure of 16 native sheep breeds that are commercially farmed in the UK, together with the spatial distribution of flocks within each of those breeds. The study demonstrates that 13 of the breeds can be defined as geographically isolated with up to 95% of their numbers clustered within a 65km radius of the breeds' mean centre. The data highlight that the genetic resources of commercially farmed sheep breeds existing in significant numbers can be endangered through their geographical isolation. Importantly, the new data arising from the endemism project also fundamentally question the accuracy of information that has been used to compile the current Breeds at Risk Register.

90 **Methodology**

Sixteen native sheep breeds were selected to represent regions of the British Isles: North of England hill breeds (Herdwick, Rough Fell, Lonk, Dalesbred, Derbyshire Gritstone), South of England breeds (Southdown, Romney, Devon Closewool, Exmoor Horn), Scottish breeds (Shetland, South Country Cheviot, North Country Cheviot (Caithness type)) and Welsh/Welsh border breeds (Welsh Hill Speckled Face, South Wales Mountain (Nelson), Brecknock Hill Cheviot, Clun Forest).

100 For each breed, numerical data were collected from flock keepers and analysed in terms of population size and structure together with the extent of their geographical range. This was made possible by the close working collaboration with breed societies and their agreement that questionnaires could be sent out to their memberships enabling direct interactions during the project with the breeders/flock keepers. Annex 4 describes the resources held by the breed societies and their individual processes for information gathering and when used, registration. The very considerable variation between breed societies emphasised the absolute need for direct communication with flock keepers to gain accurate census data.

110 The questionnaire for data gathering from the flock keepers was externally reviewed and approved by the Survey Control Liaison Unit at Defra prior to UK Ministerial approval and distribution. A total of 1653 surveys were sent out to the members of the sixteen breed

societies and the average return rate was 72% with twelve of the sixteen breed society members returning above 70%.

115 The data from the questionnaires were transferred into a database showing the grid reference number for the agricultural holding, flock size, flock composition and number of purebred sheep divided into further categories (females used for breeding purebred replacements, females under 1 year, total number of females, number of rams, total number of purebred sheep, numbers of females and rams of other breeds by breeds, grand total of all sheep on the holding).

120 The grid reference number together with the total number of sheep per flock for each breed was used to display geographical distribution using ESRI ArcGIS (version 9.2) mapping software and Microsoft Access. For each flock of every breed studied, a map reference was identified and together with the individual flock sizes was used to produce the detailed georeferenced information described in the publication and in the annexes.

Results

130 Accuracy of data collection

The helpful input of the breed societies during the study revealed that each society acts very independently and their procedures are not standardised - some societies register females but many do not, few societies keep written pedigree records, and some societies keep no written records at all [procedures are summarised in Annex 4]. The societies fully accepted that they could only estimate numbers and welcomed the data gathering undertaken by The Sheep Trust to provide an accurate update on previously estimated numbers, such as those that are currently underpinning national policy documents.

140 It should be emphasised that the study indicated that any attempt to compare numbers of registered females across breeds is meaningless when the process of registration is not standardised. Many of the breed societies of commercially farmed HSBs do not keep records of registered females – a significant difference from those of the rare breeds and indicating that processes for auditing numerically scarce breeds cannot be applied to other sheep breeds, since 'registration' is NOT used as a sign of provenance.

150 The members of each breed society in the study were asked clearly how many animals of the breed they farmed. It was made completely clear that purebred animals were those that should be recorded in their returns. Note that flock keepers were also asked which additional breeds and numbers of sheep they kept. The study relied on the individual breeders to provide information based on their knowledge of accepted breed standards.

155 The average response rate to the questionnaire was >70%. This response rate compares well with previous exemplars such as the Pollit Report - note that report was a single page postal questionnaire sent to 60% of sheep producers registered with the British Wool Marketing Board. Only 34% of forms were returned and many of the conclusions were questioned at the time by breed societies. The average reply rate from the 12 breeds included in the Livestock Science publication is 74%. For the total 16 breeds studied, it was 72%.

160 Of those breed society members who replied, it was discovered that many members remained registered with societies but no longer kept sheep - the data in supplementary table 1 and the description of methods in the publication makes explicit the information used for the analyses.

165

Breeds with the two lowest replies to the questionnaire were the Derbyshire Gritstone and Brecknock Hill Cheviot (50% and 51% respectively): these breeds were omitted from the publication and their analyses are included in Annex 3. A method suggested by Professor Woolliams was used to investigate the potential impact of lower response rates on the geographical concentration of breeds. As shown in supplementary table 2 of the publication there is very little impact from non-responders on the geographical concentration analyses.

Number of purebred sheep by breed

Whilst there were some examples in which numbers of purebred sheep identified by the questionnaire and those estimated by the corresponding breed society correlated closely, there were many other instances for which there was no correlation. These differences highlight the lack of factual information on which breed societies make estimates of their numbers. In turn, this emphasises the importance of data collection from individual flock keepers to gain an accurate census.

Population structure

The number of flocks comprising a breed was found to vary immensely. For example, the Romney and Rough Fell breeds have similar total numbers of purebred sheep yet the Romney breed comprises 29 flocks and the Rough Fell 121 flocks. Moreover, data in the questionnaire provided information on the size of individual flocks within each sheep breed enabling rapid assessment of the numbers of flocks per size range and how these differed for each breed. Again, the data demonstrate that no generalisations can be made. For some breeds there are large numbers of small flocks and for other breeds a relatively small number of flocks containing large numbers of purebred sheep. For example the Southdown have 150 flocks with less than 50 sheep per flock. In contrast, the South Country Cheviot have 57 flocks with >500 sheep per flock. These data demonstrate that it is impossible to gain any insights into the average flock size from the total number of sheep in a breed and indeed any estimates could be highly misleading. Equally, sampling only a small number of flocks per breed is inappropriate.

Spatial distribution

Statistical methods were developed to demonstrate the extent of concentration of flocks and sheep numbers and plotted using GIS computer technology. The data clearly show that there is statistically significant geographical isolation. For ten of the twelve breeds described in the Livestock Science publication, up to 95% of each breed's numbers lie within a radial distance of less than 65Km from the mean centre of the breed. It is noteworthy that from the survey of sixteen breeds, eight of the breeds have up to 95% of their numbers within a radius less than 50Km and four of those eight breeds, the Brecknock Cheviot, Exmoor Horn, Herdwick and the South Wales Mountain breeds have up to 95% of their numbers concentrated within a radius of less than 30Km. Of the two breeds described in the publication with a more dispersed population, up to 95% of the Clun Forest are distributed within 131Km from the breed's mean centre and for the Southdown breed, up to 95% of numbers are even more dispersed, greater than 230Km from their mean centres. In addition, 95% of the population of Derbyshire Gritstone are distributed within 231Km from the breed mean centre.

Conclusions

225 The new findings fundamentally question the assumption previously made in FAnGR policy documents that the number of 'breeding units' - flocks within a breed - can be disregarded in calculations of endangerment. The total number of animals in a breed does not provide sufficient stand-alone information for understanding the likely extent of within-breed genetic diversity. This is illustrated by data from the study on population structures in which number of flocks per breed proved to be highly variable. For example, some 26,226 South Wales Mountain sheep are managed in only 32 flocks. In contrast 6,711 Southdown sheep are managed in 186 flocks.

230 In addition, the data indicate that accurate estimates of an average flock size for a breed cannot be made from total breed numbers. This is illustrated by the 186 Southdown flocks comprising only 13 flocks with >100 sheep and 150 flocks with < 50 animals, compared with the distribution of the Romney breed numbers showing that one flock contained almost half of the total breed numbers.

235 Thus, it is essential to gain accurate information on numbers from individual flock keepers to carry out valid surveys of population structure. Estimates and generalisations will be highly misleading if used to determine thresholds for endangerment of a breed.

240 The study reveals a number of issues concerning the role and potential contribution of sheep breed societies in breed conservation. Many of the societies contacted kept no written records of breed numbers, populations or structure. In FAnGR policy discussions, registered female numbers have been typically highlighted as the indicator to calculate degree of endangerment of a sheep breed. However, out of the sixteen breeds analysed in the study, 245 only nine societies registered females and of those, three societies registered only a proportion of the females. Significantly, even for those societies that carried out registration, requirements for the registration were not standardised across breeds.

250 These data strongly question the validity and usefulness of using breed society registered female numbers for endangerment analyses, and show that procedures used for rare breeds cannot be extrapolated to other sheep breeds.

255 The analyses involving two dimensions, the size of population of each breed in terms of individual flocks and the extent of their spatial distribution provides factual evidence for geographical isolation of native sheep breeds in the UK. The breed maps highlight the degree to which each breed can be geo-referenced. The numbers of sheep involved confirm that the HSBs are commercially farmed livestock, yet must be considered to have a high risk status through their geographical isolation.

260

Recommendations

265 To gain an accurate census for conservation and prioritisation purposes it is essential that information is gained from individual breeders/flock keepers of sheep: many breed society records provide only estimates.

Standardisation of record keeping across sheep breed societies should be strongly encouraged and aided by a national set of guidelines of best practice.

270 Both the number and the individual size of 'breeding units'/flocks for each breed of sheep should contribute to the estimation of risk of endangerment, whether the breeds are numerically scarce or exist in large numbers and are commercially farmed.

275 Geographical isolation of commercially farmed native sheep breeds can present a high risk
status that should be recognised in conservation/prioritisation programmes with
georeferencing data of each breed underpinning legislation.

280 Since the accuracy of data used to compile the current national Breeds at Risk Register is
questionable and the Register does not include those breeds facing considerable
endangerment through endemism, a new framework and process for inclusion of sheep
breeds to be prioritised in the event of a disease outbreak should be urgently initiated.

285 The Sheep Trsut
5th February 2009