GENETIC RESOURCE REQUIREMENTS UNDER FAVOURABLE PRODUCTION MARKETING SYSTEMS: PRIORITIES AND ORGANISATION

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SUMMARY

Conservation of animal genetic resources has often been discussed as an aid to the improvement of animal populations used in sophisticated agricultural systems. Cumulative mutation and molecular manipulation are however likely to ensure the continuous opportunity to change the biological characteristics of animals by genetic selection. Moreover, market forces are likely to maintain and create sufficient diversity for most future requirements. Even if populations were conserved, it is unlikely that adequate resources would be provided for their evaluation. The logical case for conservation in circumstances where the production and marketing systems are favourable is therefore difficult to perceive. By contrast, the emotive case is clear. There is then the opportunity to harness the emotive case and establish populations selected for particular purposes and possible future requirements. As populations under selection their characteristics will be known and the requirements for testing will be few.

INTRODUCTION

The main genetic resource requirements of a developed agriculture are the populations which are used to meet current markets. The question is then whether these populations are in themselves likely to be sufficient, or whether additional populations should be kept to better meet the requirements of future markets.

The specific conservation of animal populations has been considered frequently in the past decade and much has been written on the subject. The Food and Agriculture Organisation of the United Nations (FAO) and the United Nations Environmental Programme (UNEP) set up an Expert Panel to advise on animal genetic resources (FAO and UNEP, 1984). The EAAP established a working party to assess animal genetic resource conservation and their findings were published in Livestock Production Science (Maijala et al, 1984). The predecessor to the present Congress in Madrid also included a roundtable assessment of breed conservation (Lauvergne, 1982). There are two reasons why a topic should receive so much attention: one is that it is a fast moving subject of overriding importance where scientists are concerned to keep abreast of developments; the other is that it is a scientifically trivial but emotive issue which scientists do not have the confidence to put to one side. It is perhaps appropriate to consider the options, priorities and organisation of genetic resource requirements against the background of the three reviews.

THE CASE FOR CONSERVATION

'Genetic variability is the basis for future genetic changes in any given species. It is imperative, therefore, that variability is maintained so that future generations of mankind will be in a position to adapt their livestock to the many unknown future demands and requirements which will be put on them.' Rendel (1982) used these sentences as part of his introduction of the topic at Madrid; they are still apposite and in essence summarise the arguments for the conservation of populations which would otherwise be lost by market forces. By and large the roundtable papers at Madrid in 1982 took the need for conservation for granted and concentrated on how it might be achieved.

More recently, the EAAP working party assessed the case for conservation and for the first time included an economic appraisal of the cost benefits of conservation (Smith, 1984). The appraisal showed that the costs were so small relative to the potential benefits that conservation could be justified with even a very low probability of any benefit at all - so long as the benefits are assessed on a national scale. Maijala et al (1984) give the avoidance of loss of genetic material as the most important reason for conserving animal genetic resources. Simon (1984) adds the better understanding of biological variation and cultural or emotional reasons.

It is not appropriate to rehearse or relist the arguments for and the approaches to conservation for they are well known, but rather to ask why, if the case is so good as has been assumed, conservation is not underway and why the topic is raised once more for discussion. Perhaps the case is not as good as has been assumed and needs to be re-examined. In particular, the fundamental assumption that conservation will directly contribute to genetic improvement needs to be examined. There can indeed be no change without variation, but how much is required and of what nature? Are there likely to be sufficient sources without active conservation? If variation is conserved, how might it be used?

Economic Forces and the Generation of Diversity.

As a first step to answer these questions it is necessary to consider what actually happens as animal breeders adopt objective criteria for selection. The dairy cattle and pig industries indicate how commercial production becomes dominated by a small number of breeds and the trends in these industries have been used to support the case for conservation. It is however important to consider what has actually happened.

'Black and white' dairy cattle now dominate milk production in most favourable agricultural systems. The present types originated from the same source but they have been subject to different selection criteria in their adopted countries and quite new diversity has been created. In the UK, for example, Friesian cattle could be considered as a breed under 'enlightened conservation'. There has been some selection for objective criteria but this has been diluted by what are, in essence, conservation constraints - subjective conservatism. By contrast, in North America, objective criteria were applied more rigorously and Holstein cattle have been shown to fill a niche in the UK market. At the same time some representatives of some of the 'pre black and white' breeds remain. What has actually happened is that 'new types' have been introduced and 'old types' have declined. The mean of the population as a whole has changed, some genotypes have been lost but there is still considerable (and in the case of dairy cattle probably as much) genetic variation about the new mean. Chance variation in selection procedures has actually created new diversity which becomes available for utilisation by others.

So where does this leave the case for conservation? The circumstances of dairy cattle could be regarded as the early stages of the reduction of genetic variation. Reduction of variation is not however in itself a hindrance to improvement. To argue for conservation one has to argue either that the present chance system is unlikely to continue to maintain appropriate variation, or that genetic variation is likely to be exhausted.

When might the chance provision of superior genotypes break down? One might consider that economic circumstances might become uniform or that the interactions between genotype and environment might be such that populations become genetically uniform. For this to happen one has to envisage the establishment of complete uniformity of selection objectives across all countries followed by rapid change in commercial requirements in a significant number of those countries. If the change occurs first in one country, then that country will adapt its selection criteria first and so produce the new superior lines. By analogy with the analysis of variance, one has to envisage variation within countries without variation amongst them - an F value of close to nought!

The chance of such a coincidence is remote. Further, the division of the topic of conservation into systems with favourable and systems with limited marketing systems, though useful, is artificial in the sense that there would both be movement of countries between groups and one group would act as a 'genetic reserve' for the other. (It is utopian to imagine genetic uniformity across all countries).

A period of world uniformity followed by drastic, sudden and uniform changes in circumstances is perhaps the only situation in which conserved populations might be required by countries where production and marketing systems are presently favourable. The very utilisation of conserved populations would take many years and is incompatible with cataclasm. Minor variation in economic circumstances among countries and in the perception of these circumstances by breeders within countries are therefore likely to be the most effective generators of populations with defined genetic diversity about currently perceived selection objectives.

The Continuous Supply of Genetic Variation.

The worst of all conservation options would be a single population of animals which had been selected to meet well defined requirements. Even if we forget the argument that this is unlikely, it could still be argued that genetic variation would become exhausted, the rate of genetic improvement would progressively fall below the 2% or so per year which can currently be achieved, conservation would then be required to introduce 'new' genetic variation and so enable progress to continue. Surprisingly this argument has often been used, yet it has not been substantiated. Evidence from laboratory animals and poultry shows that responses can be sustained over tens of generations even in relatively small populations. There is now evidence to suggest that mutation has a progressively important role to play in the maintainance of responses and not surprisingly it has been shown that the larger the population the greater the opportunity for mutation. The case for conservation stems from the argument that populations become uniform but this in itself defeats the case because that population would itself then be so large that mutation would sustain the response.

The molecular transfer of genes from conserved to commercial populations is also used to support the conservation of unimproved populations. The identification of useful genes will be a difficult task and with limited resources one might expect any such research to concentrate on commercial populations where, by definition, useful alleles are most likely to be found. Even in commercial populations it might well be a question of turning genes off rather than adding them. It is difficult to suggest genes to add but knowledge of the feedback control of the biological components of commercial traits is likely to readily indicate which genes to turn off. Further, by extrapolation from the work of Kacser and Burns (1979), knowledge of control systems shows that the reduction of the activity of individual enzymes in biochemical pathways is likely to have a much greater effect on the flux than would an increase in activity.

One could for example consider the genetic twinning of cattle by turning off, or at least turning down the expression of the genes controlling the production of hormones which have a feedback effect on gonadotrophin release. The antisense principle and the possibility of oligonucleotide mutagenesis now make this possible. It is therefore more likely that knowledge of the physiological and biochemical basis of variation in the biological components of the performance of commercial animals will lead to the directed introduction of new genetic variation than will the conservation of previously 'uncommercial' stock. Genetic variation is not under threat.

The Futility of Conserved Populations.

The case for conservation partly stems from a combination of the assumption that there are some present populations which are not economically viable, that they will therefore be lost, but that they would have a role to play in the future if they were kept. The subjective assessment of value by those that presently maintain uneconomic populations has itself led to their retention, for by definition they cannot be both uneconomic and retained in an agriculture where all decisions are objective. Furthermore, the commercial forces in animal breeding are such that fads or fashion as well as objective assessment influence selection decisions. Populations may therefore even be introduced for biologically subjective yet, to the individual concerned, financially objective reasons.

If market forces, mutation (natural or artificial) and the perversity of man all failed to create and maintain genetic diversity, is it even realistic that conserved populations might be used objectively? Total objectivity is a precondition for uniformity. Objectivity would equally demand that conserved populations are assessed correctly and at present there does not seem to be even the remotest chance of that happening. Conserved breeds would have to be assessed rigorously in a comparable way to the assessment of new cereal varieties. Populations would have to be properly represented and assessed in a series of physical and husbandry environments. The cost would be very great and the source of funding is not clear. Cost benefit analyses show such evaluation to be in the national interest but this has not sufficiently influenced the allocation of national resources. This would only be overcome if total objectivity in the choice of populations in commerce was accompanied by equal objectivity in the allocation of resources by national governments.

Conclusion.

The premise that populations must be conserved to maintain genetic diversity and the option for future change is false. Furthermore, even if populations were conserved, it is unlikely that they could be used effectively.

A CONSTRUCTIVE ALTERNATIVE

It can be argued that there is no objective case for conservation. There are however sociological and emotional reasons for conservation (Simon 1984). It is paradoxical that the same factors which prevent objectivity, ensure diversity and so negate the argument for the need for conservation, are equally the factors which will probably have more influence than any other on whether conservation actually takes place. The question then is whether sociological and emotive forces can be harnessed to develop a form of constructive conservation. One can readily see regional support systems ensuring the preservation of some aspects of rural society and this might be expected to include regional stock. Without the opportunities for either selection or appropriate testing however these are likely to become 'relic populations' and lost to mainstream genetic improvement.

There is perhaps an intermediate scenario whereby populations would be selective for characteristics which deviate from those presently perceived to be required. Smith (1985) showed that in an economic evaluation 'reserve populations' are a sound investment. If they are maintained under selection, their characteristics will be known and the difficulty of comprehensive testing will be largely eliminated. If such a strategy were to be adopted, the whole issue of conservation in countries with favourable agricultural production marketing systems is reduced to two questions: who pays and which traits?

Funding will depend on the wishes of society in the allocation of resources. It would however be the responsibility of the animal breeder to consider the choice of traits. As an example, while one might expect all dairy cattle to be selected for efficiency, some populations might be selected on different management systems to those used in practice, others might be selected for the efficient production of particular components of milk. Pigs might be selected for efficiency on different diets, sheep for lean tissue growth to a variety of weights.

Finally, perhaps one should emphasise the contribution of the study of diverse genetic types to the understanding of biological function. While it would seem unlikely that genes will be taken from conserved to commercial stock by crossing or by molecular manipulation, this might indicate the loci of commercial stock for manipulation. The identification of loci for molecular manipulation is one of the key challenges for animal genetic research, but that is another story.

REFERENCES

FAO Animal Production and Health. 1984. 44/1: Animal genetic resources: conservation by management, data banks and training. Food and Agriculture Organisation, Rome.

FAO Animal Production and Health. 1984. 44/2: cryogenic storage of germplasm and molecular engineering. Food and Agriculture Organisation, Rome.

FAO Animal Genetic Resources Information (4). 1985. Food and Agricultural Organisation , Rome.

KACSER, H. and BURNS, J.A. 1979. Molecular democracy - who shares the controls? Biochem. Soc. Trans. 7, 1149-1160.

LAND, R.B. 1985. Knowledge for animal breeding. Phil. Trans. R. Soc. Lond. B 310, 243-289.

LAUVERGNE, J.J. 1982. Breed Conservation - Introduction. Proc. 2nd Wld. Congr. Genet. Appl. Livestock Prodn., Vol. VI, 73-76.

MAIJALA, K., CHEREKAEV, A.V., DEVILLARD, J.-M., REKLEWSKI, Z., ROGNONI, G., SIMON, D.L. and STEANE, D.E. 1984. Conservation of animal genetic resources in Europe. Final report of an E.A.A.P. Working Party. Livest. Prodn. Sci. 11: 3-22.

SIMON, D.L. 1984. Conservation of animal genetic resources - a review. Livest. Prod. Sci 11: 23-36.

SMITH, C. 1984. Estimated costs of genetic conservation in farm animals. Animal genetic resources: 44/1, conservation by management, data banks and training. Food and Agriculture Organisation, Rome (1984), 21-30.

SMITH, C. 1985. Scope for selecting many breeding stocks of possible economic value in the future. Anim. Prod. (In press).