Gene Flow in Animal Genetic Resources – A Study on Status, Impacts, Trends from Exchange of Breeding Animals

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Abstract

Data on exchange of livestock genetic resources were compiled to create an information basis for future national, regional and global negotiations on trade agreements for breeding stock. The report comprises of a global study and case studies for cattle, sheep, goats and pigs. Human migration and exchange of stock led to breed diversity through domestication and breed formation. Advanced mobility, reproduction biotechnology and modern breeding methods enhanced gene flows since the 20th century. Concentration on a few successful breeds led to their worldwide expansion at the expense of local breeds, resulting in loss of biodiversity. However, transfer of breeds suitable for respective production systems benefited farmers economically. Veterinary regulations increasingly restricted transfer of breeding stock. While in more sophisticated breeding systems after sales benefit sharing was increasingly practised, a single and final payment was still the rule in most circumstances. Movements of breeding animals were best documented in cattle due to early establishment of breeding organisations. Main directions of cattle transfers were initially east to west and north to south but more recently west to east as well as south to south movements gained importance. Sheep and goat gene flows were relatively small in number and extent. Transfers were mainly conducted by private initiatives of single breeders, but breeding organisations with data on movements were rare. Data on recent transfer of breeding pigs were difficult to obtain because of the structure of modern pig breeding with main emphasis on hybrids and the leading role of few breeding companies in worldwide distribution of pigs.

1. Introduction

Animal migration and exchange has always taken place, but in the beginning 20th century development of modern breeding methods, advances in trade, transportation, communication and a trend to uniformity of breeding goals increasingly fostered the exchange of breeding animals and material. Quantitative data on the exchange of livestock genetic resources between the various regions of the world is lacking. The advantages and disadvantages of gene flow for stakeholders has not yet been assessed, although some stakeholders complained that animal genetic resources were being used without sharing of benefits (Maier et al., 2002). Additionally, it was argued that gene flow from industrialised countries have done more harm than good. In other studies concerning loss of genetic resources, losses in developing countries could not be proven (Ashley et al., 2002). The knowledge level was not a profound basis for debates regarding advantages and disadvantages of gene flow. An overview of the current status of exchange of genetic material was required to draft policies and programmes at national, regional or global level.

Direct beneficiaries of such a study should be political decision-makers, particularly in developing countries, and relevant international bodies and donor institutions. Intermediate beneficiaries should be farmers, pastoralists and breeders in developing countries, whose interests have to be considered in the beginning international discussion on the regulation of access to genetic resources and the connected benefit sharing. The study at hand will be incorporated into the “First Report on the State of the World’s Animal Genetic Resources” of the Food and

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Agriculture Organisation (FAO) as one of the thematic studies. It will be a contribution to the development of the “Global Strategy for the Management of Animal Genetic Resources” by FAO.

2. Material and Methods

The study was implemented by the Institute of Animal Production in the Tropics and Subtropics of the University of Hohenheim and commissioned by the Federal Ministry for Economic Cooperation and Development (BMZ) and German Technical Cooperation (GTZ). The Food and Agriculture Organisation (FAO) acted as a support agency. An advisory panel composed of international scientists, representatives of donor and development agencies, the private sector and Non-Governmental Organisations (NGOs) closely accompanied the study. Feedback took place through meetings in the beginning, mid and end of the study, as well as through reporting and advice by e-mail.

2.1. Global study

In the global study (Valle Zárate et al., forthcoming) the historical development and the current status of breeding animal transfer were described for cattle, sheep, goats and pigs. Model breeds and breed groups were chosen according to the amount of exchange and the access to information (Table 1). National and international statistical data were analysed and literature reviews were conducted. For specific information on breeds breeding organisations were consulted. The intermediate analysis results were used as a basis for national and international expert interviews. Further prepared excerpts of gene flow relevant contents of 114 FAO country reports on animal genetic resources were incorporated into the study.

2.2. Case studies

In four selected case studies (Homann et al., 2005, Huyen et al. 2005, Rummel et al., 2005, Stemmer et al., forthcoming) in-depth analyses of typical aspects and effects of gene flow were conducted. The selection of case studies took place according to the usefulness to show certain aspects of effects and the regional access to information (Table 1). The independent case studies were conducted from the perspective of tropical and subtropical countries.

Table 1: Model breeds and breed groups

<table>
<thead>
<tr>
<th>Model breeds and breed groups of</th>
<th>Cattle</th>
<th>Sheep</th>
<th>Goats</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global study</td>
<td>Simmental/Holstein/Brahman</td>
<td>Merino/Hair Sheep</td>
<td>Boer/Angora</td>
<td>Large White/Duroc</td>
</tr>
<tr>
<td>Case studies</td>
<td>Boran/Tuli, Eastern Africa</td>
<td>Awassi, Israel</td>
<td>Anglo-Nubian, Bolivia</td>
<td>Vietnamese local breeds</td>
</tr>
</tbody>
</table>

3. Results and Discussion

Historically, human migration was one of the most important causes for gene flow. It led to enhanced breed diversity through domestication. Exchange of stock was an important tool in breed formation and development. Advanced mobility, reproduction biotechnology and modern breeding methods enhanced gene flow further in the 20th century. Especially in cattle, gene flow was stimulated by the development of artificial insemination and embryo transfer. The ease and cost efficiency of transportation, storage and veterinary control of these media led to increased exchange. The concentration on a few successful breeds in the second half of the 20th century led to their worldwide expansion, often at the expense of local breeds. Although this trend resulted in loss of biodiversity, transfer of breeds that are suitable for respective production systems benefit farmers economically. On the other side, veterinary regulations increasingly restricted transfer of breeding stock. While in more sophisticated breeding systems after sales benefit sharing is
increasingly practised, a single and final payment was still the rule in most circumstances. In most developing countries influence of breeding organisations and governments on animal trade was limited. The available and accessible data on exchange of breeding animals differs strongly between the different animal species.

3.1. Cattle

Movements were best documented in cattle due to early establishment of breeding organisations. Main directions of cattle transfers were initially east to west and north to south but more recently west to east as well as south to south movements gained importance. The Boran of East Africa and the Tuli of Southern Africa both represent locally developed, adapted and high yielding breeds that stirred interest in industrialised countries. Here it was shown that breeding associations can be a step stone to improvement and development of local breeds and to their global marketing and distribution. However, their transfer to North America and Australia, from Kenya and Zambia, had given rise to access and benefit sharing claims from the countries of origin.

Simmental cattle served as a well documented example for breed formation and subsequent worldwide spread. Reports of Simmental movements ranged back to the 15th century. Their spread as a dual-purpose breed began in Europe in the 15th century and reached Asia and Africa in the second half of the 19th century. The success in Southwest Africa led to further spread to Latin America, North America and finally also Oceania since the early 20th century. In the New World the Simmental has been mainly developed for beef production.

3.2. Small ruminants

Sheep and goat gene flows were relatively small in number and extent. Transfers were mainly conducted by private initiatives of single breeders, but breeding organisations with data on movements were rare. The Awassi sheep of Israel were an exceptional case, in which details on movements could be reconstructed. The Awassi case study showed the success of developing a local breed and its importance for other countries. Flows occurred from south to north, as well as from north to south and from south to south, where the main emphasis was on the south to north movement. Today the majority of Improved Awassi and Assaf stocks are kept in European countries, north of Israel. Farmers of the countries of the Iberian peninsula, where the Assaf became the dominating milk sheep, had the highest benefit from the past gene flow of Awassi and Assaf breeding material. While the south to north movement was dominated by the Assaf breed, in the movement to the South (Australia and some developing countries) the Improved Awassi played the major role.

Anglo Nubian goats, which were e.g. imported to Bolivia, were only successful in intensive management conditions. In extensive, smallholder conditions the breed was abandoned by farmers. This way the impact on local goat genetic resources or economic loss to farmers was insignificant in the Bolivian context, however funding directed towards introduction of Anglo Nubians was lost for the development of the local breeds.

3.3. Pigs

Data on recent transfer of breeding pigs were difficult to obtain because of the structure of modern pig breeding: The main emphasis is on hybrid pigs, and few breeding companies have a leading role in the worldwide distribution of pigs. The wide information gaps and inaccessibility of information due to company secrecy largely prevented quantification of global movements. The case study on exotic breed influx to Vietnam showed a strong governmentally driven promotion of exotic pig breeds. Information on pig gene flow to and within Vietnam was limited due to restricted information policy of both international breeding companies and Vietnamese official sources, but also due to the decentralised nature of pig breed import and distribution. Nevertheless, it was observed that the influx of exotic breeds had positively influenced output
and efficiency of pork production in Vietnam. At the same time the local pig populations had been affected in a negative way.

4. Conclusions

Generally the study showed that, in most cases, gene flow is characterised by free animal movements, based on commercial interests on the side of the importer. Development projects and emergency aid played a role in some instances. However it was observed that where gene flow was initiated by private persons, breeders or companies the impact was more sustainable than when initiated by governmental or non-governmental projects. The success and failure of animal transfers depended largely on the fit of the breed to the prevailing production conditions. Where it faced a better fit than local animal genetic resources, it led to loss of local resources and spread for the economic benefit of the farmers. Changes in the production system, e.g. in the peri-urban context, and the development towards commercial, controlled and input oriented production systems led to a higher demand for high performance breeds to enable the best utilisation of resources.

The most limiting factor of the study was the information basis of current gene flow. It became evident that with the increase of global mobility and the potential use of biotechnologies gene flow had increased and had become more complicated and even more difficult to follow up. This put severe limitations to the study, especially in the global part. The Awassi case study showed in an illustrative example how this limitation was overcome through the help of case studies and what effort it took to collect the necessary information to assemble a nearly complete picture of gene flow for one particular breed. The study as a whole therefore had to restrain from quantifying gene flow on a global scope. A first step to overcome this limitation is to install documentation systems on a certain minimum standard. As it was shown with the results of the study, the current information situation allows conclusions only to be made for certain aspects in well-chosen and investigateable case studies in which generalisation was not possible or only possible to a very limited extent.

The study analysed possible aspects of gene flow on the basis of available information. It was meant to provide scientifically founded information for decision makers in the ongoing discussion on global gene flow and its impacts. However, the study is not suitable to finalise this discussion and cannot take over responsibility for political decision in one or the other direction.

5. References


