



Herd movements

The exchange of
livestock breeds and genes
between North and South

Evelyn Mathias
and Paul Mundy

League for Pastoral Peoples
and Endogenous Livestock Development



LEAGUE FOR
PASTORAL PEOPLES
AND ENDOGENOUS
LIVESTOCK
DEVELOPMENT

Herd movements

The exchange of
livestock breeds and genes
between North and South

Evelyn Mathias
and Paul Mundy

League for Pastoral Peoples
and Endogenous Livestock Development

2005

Published 2005 by the League for Pastoral Peoples and Endogenous Livestock Development



LEAGUE FOR
PASTORAL PEOPLES
AND ENDOGENOUS
LIVESTOCK
DEVELOPMENT

The League for Pastoral Peoples and Endogenous Livestock Development (LPP) is a non-profit organization devoted to advocacy and technical support to marginal livestock keepers, in particular pastoralists. It was founded in 1992 in Germany. Activities focus on research, training, capacity building and networking in co-operation with partner organizations. LPP promotes the concept of endogenous livestock development utilizing indigenous animal genetic resources and building on local institutions. For further information, contact:

League for Pastoral Peoples, Prugelatostrasse 20, 64372 Ober-Ramstadt, Germany. www.pastoralpeoples.org, email info@pastoralpeoples.org

This study was compiled and printed with the support of:



Misereor, Mozartstraße 9, 52064 Aachen, Germany, www.misereor.org

Misereor is a Catholic development organization that helps people in Germany contribute to justice and solidarity with the poor and oppressed in Africa, Asia and Latin America. The projects support and promote local initiatives, irrespective of nationality, religion or gender.

The opinions expressed in this book do not necessarily reflect those of Misereor.

We encourage organizations and individuals to photocopy and distribute this publication. Please credit the League for Pastoral Peoples if you do so.

Correct citation Mathias, Evelyn, and Paul Mundy. 2005. *Herd movements: The exchange of livestock breeds and genes between North and South*. League for Pastoral Peoples and Endogenous Livestock Development, Ober-Ramstadt, Germany.

Cover photos (from top to bottom)

- Farmer with exotic x local crossbred cow in Rajasthan, India (photo: Evelyn Mathias)
- Priangan sheep, Garut, West Java, Indonesia (photo: Paul Mundy)
- German Holstein dairy cow, Germany (photo: Paul Mundy)

Design and layout: Paul Mundy

Printed by ICS, Bergisch Gladbach, Germany

Contents

Figures	vi
Tables	vi
Boxes	vii
Abbreviations	viii
Summary	ix
Acknowledgements	x
1 Introduction	1
Study questions and methods	1
Key definitions	2
2 Why and how do livestock genes flow?	3
Why genes flow	3
How genes flow	4
Live animals	4
Eggs	6
Semen	6
Embryos	8
Other biotechnology techniques	9
Measuring gene flows	9
3 Gene flows from South to North	10
From ancient times to the Middle Ages	10
The development of modern breeding	10
Breeding for production	11
Gene flows from the South to Germany	12
Cattle	12
Sheep	13
Goats	14
Pigs	14
Poultry	15
Summary	16
Gene flows from the South to other countries in the North	17
Differences between Germany and other countries	18
Value of Southern breeds to the Northern livestock industry	19

Herd Movements

4	Gene flows to the South	21
	Gene flows from Germany to the South	21
	Cattle	22
	Sheep and goats	26
	Pigs	26
	Poultry	27
	Summary	28
	Costs and benefits to Germany	28
	Gene flows from other Northern countries to the South	29
	South–South gene flows	30
	Costs and benefits to the exporting countries	31
5	Driving forces of gene flows to the South	32
	Players in international livestock development	32
	Development paradigms in livestock breeding	34
	Breed substitution	34
	Crossbreeding – a shortcut to higher yields	35
	Recognizing the value of local breeds	35
	Government regulations and incentives	35
	Commercialization in the South	36
6	Impact of global gene flows in the South	38
	Breed numbers	38
	Risk factors	39
	Market competition as a threat to local breeds	41
	Genetic diversity	41
	National livestock populations	42
	Animal productivity and production	44
	Dairy production	44
	Socio-economic benefits	46
	Gender	47
	Factors influencing the outcome of gene flows and breed improvement programmes	47
	External conditions and the fit of the breed	48
	Programme design and implementation	48
	Livestock keepers’ needs and participation	49
	Institutional support, policies and other factors	50
7	Factors shaping the future	52
	Advances in biotechnology and genetics	52
	Cloning	52
	Genomics	53
	Genetic engineering	53

International agreements affecting gene livestock production	54
World Trade Organization	54
Trade Related Aspects of Intellectual Property Rights	55
Codex Alimentarius Commission	57
SPS Agreement	57
Convention on Biological Diversity	58
Biosafety protocol to the CBD	58
Implications for gene flows	58
Biopiracy, patents and benefits	59
8 Comparing Northbound and Southbound gene flows	62
9 Conclusions and recommendations	64
Gene flows need to remain unrestricted	64
Livestock keepers need to stay involved in breeding decisions	64
The South needs to find its own path to breed development and conservation	65
Appendix	66
Records of trade in breeding stock and semen in Germany	66
Breed societies	66
Customs Office in Hamburg	67
European Association for Animal Production	67
Eurostat	67
Federal Statistical Office	67
HI-Tier database	67
Glossary	69
References	70

Figures

Figure 1	World exports of live animals, 1961–2003	5
Figure 2	Major exporters of live cattle, 2002	22
Figure 3	Cattle exported from Germany, 1958–2002	23
Figure 4	Exports of live cattle and semen from Germany, 1987–2001	24
Figure 5	Export of cattle semen from Germany, 1987–2001	25
Figure 6	Destination of cattle semen exports from Germany, 1987–2001	25
Figure 7	Major exporters of live pigs, 2002	27
Figure 8	Major exporters of live chickens, 2002	29

Tables

Table 1	World exports of live animals, 2002	6
Table 2	Cattle (with genes) of southern breeds registered in Germany	13
Table 3	Sheep (with genes) of southern breeds registered in Germany	14
Table 4	Goats (with genes) of southern breeds registered in Germany	14
Table 5	Proportion of cattle, sheep and goat breeds in Germany with genes from the South	16
Table 6	Number of breeds of domestic livestock (mammals and poultry) recorded as extinct in the South	39
Table 7	Main causes of threat to African cattle breeds	40
Table 8	Percentage of crossbreeds with indigenous cattle in Asian countries	43
Table 9	Sources of change in cows' milk production in sub-Saharan Africa, 1985–98	45
Table 10	Distribution of milking animals in rural households by land holding category, India, 1992	47

Boxes

Box 1	Activities and circumstances leading to livestock gene flows	3
Box 2	Alive or dead?	7
Box 3	Usefulness of artificial insemination as a breeding tool in the South	8
Box 4	The Booroola gene in sheep	18
Box 5	The Australian Awassi Joint Venture	19
Box 6	Development organizations involved in animal breeding in the South	33
Box 7	Examples of livestock breeds endangered through crossbreeding	40
Box 8	The “White Revolution” in India	45
Box 9	Goat upgrading programme in East Java, Indonesia	49
Box 10	Chinese patent on “Method of improving cattle”	56
Box 11	Tuli cattle from Zimbabwe	60

Abbreviations

ADR	Arbeitsgemeinschaft deutscher Rinderzüchter (Umbrella Association of German Cattle Breeders' Associations)
ADT	Arbeitsgemeinschaft deutscher Tierzüchter (Umbrella Association of German Breeders' Associations)
BAIF	Indian Development Research Foundation
BSE	Bovine spongiform encephalopathy ("mad cow disease")
CAST	Council for Agriculture Science and Technology
CBD	Convention on Biological Diversity
DAD-IS	Domestic Animal Diversity Information System
DAGRIS	Domestic Animal Genetic Resources Information System
DNA	Deoxyribonucleic acid
EAAP	European Association of Animal Production
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAL	Bundesforschungsanstalt für Landwirtschaft (Federal Agricultural Research Centre)
GEH	Gesellschaft zur Erhaltung alter und gefährdeter Haustierrassen (Association for the Conservation of Local and Endangered Breeds)
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Cooperation)
HPI	Heifer Project International
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
NGO	Non-governmental organization
OSU	Oklahoma State University
SPS	Sanitary and Phytosanitary Measures
TRIPS	Trade-related aspects of intellectual property rights
UNDP	United Nations Development Programme
USAID	US Agency for International Development
WTO	World Trade Organization
ZADI	Zentralstelle für Agrardokumentation und -information (Centre for Agricultural Documentation and Information)

Summary

THIS REPORT focuses on the exchanges of livestock and poultry breeds and their genetic materials between developed countries (“the North”), especially Germany, and the developing world (“the South”). Particular focus is given to smallholder keepers in the South because they have been crucial to breed development in non-temperate climatic zones, and millions of them depend on livestock for their livelihoods.

Data were collected through literature and internet searches, the analysis of statistical information, and informal interviews.

In the last 100 years, gene flows from South to North have been dwarfed by flows in the opposite direction, from North to South. Large numbers of animals, semen, embryos and eggs are shipped to developing countries, and Northern breeds (particularly of pigs, poultry and dairy cattle) have become firmly established in various countries. Despite this, the impact on the South has been limited, and any benefits of Northern breeds have mostly bypassed pastoralists and poor livestock keepers.

The North has often subsidized livestock exports, while the South has furthered the import of exotic genetic materials, for example by offering livestock keepers credit, services, and subsidized feed. Southern governments tend to favour livestock industrialization at the expense of smallholder producers.

Experience in the North shows that it does not take a large amount of genetic materials to establish a successful breed in a new country if there is a functioning infrastructure in place. Additional factors that determine the outcome of a breeding programme include how it is planned and implemented; whether a breed is suited for the new environment and fits in with the goals and strategies of the producers; and whether a country offers institutional and legal support to its producers.

International agreements regulating agricultural trade are likely to enhance the intensification of livestock production and increase gene flows to the South. Breeding decisions are increasingly taken out of the hands of farmers and herders. While relatively few Southern breeds have so far disappeared, these trends are likely to push more to the brink of extinction.

Southern breeds are a valuable pool of genetic diversity. Pastoralists and small-scale livestock keepers are crucial for the maintenance of these breeds. Southern governments need to recognize their contribution to breed development and secure their access to grazing and water, services and education. Governments must also ensure that the access and exchange of genetic materials are not restricted by patents on animals or genes, and do not grant patents that infringe on indigenous knowledge.

Acknowledgements

WE WOULD like to thank the many individuals and organizations who have helped in compiling this study.

- **Ilse Köhler-Rollefson** provided numerous reference materials and contributed comments and inputs to the text.
- **Evelyn Barth** assisted in typing and proofreading the *References*.
- **ADT** (Arbeitsgemeinschaft Deutscher Tierzüchter) kindly allowed me to use their office and reports.
- **Misereor** provided funding for this report in particular, as well as for several other projects that made it possible for the League of Pastoral Peoples to gain long-standing first-hand insights into the problems of pastoralists and smallholder producers.
- The following provided valuable information during personal meetings or per email, or contributed materials: **Wolfgang Bayer**, Agrecol; **Joerg Bremond**, ZADI; **Tadelle Des-sie**, then PhD student in Berlin, now ILRI; **Otto Distl**, Tierärztliche Hochschule Hannover; **Antje Feldmann**, GEH; **Ulrike Funke**, Humboldt University Berlin; **Anita Gruenbacher**, Statistisches Bundesamt; **Irene Hoffmann**, FAO; **Anita Idel**, Agrobiodiversity; **Alfred Kretzschmar**, Statistisches Bundesamt; **Klaus Meyn**, former director of ADR; **Thomas Schmidt**, FAL Mariensee; **Marianna Siegmund-Schultze**, University of Hohenheim; **Ruth Tippe**, Kein Patent auf Leben; **Rita Weber**, formerly Tierärzte ohne Grenzen; **Steffen Weigend**, FAL Mariensee; **Andrea Wienecke**, HIT Datenbank and **Birgit Zumbach**, Humboldt University Berlin.
- In addition, the study benefited from the discussions of the steering committee of a study on livestock gene flows conducted by the **University of Hohenheim** for GTZ and FAO (see footnote 4 on page 1).

1 Introduction

SINCE EARLY times of domestication, movements of livestock and their genes have been at the heart of livestock development. When people migrated, they brought along the animals they relied on for food, clothing and transport. Examples are legion: domesticated cattle and sheep arrived in Europe this way in the Neolithic. Europeans in turn took with them their horses, cattle, sheep, goats and pigs when they settled the Americas and Australasia. Thus, over time, the combined influence of human selection and ecological factors shaped a great variety of breeds, enabling people to exploit a wide spectrum of different climatic zones including areas with harsh ecological conditions. An example are the world's steppes and deserts where survival without animals would be difficult – perhaps one of the reasons for the large number of breeds found in such drylands despite the few people (often pastoralists) living there.¹

Also livestock trade and crossbreeding have been known for centuries.² However, new are the high and increasing speed and the means with which livestock movements and breed development are nowadays driven. Since the establishment of the first cattle herd book in England in 1822,³ transportation, infrastructure and breeding techniques have substantially advanced, facilitating extensive global exchanges in short periods.

During the 20th century, substantial amounts of animals, embryos, eggs and semen were shipped around the globe. A large part of the gene flows went to the South to improve livestock production and living standards in developing countries. But also breeds from the South made their way into the North.

What have been the extent and characteristics of the gene flows between North and South, what their outcomes? Drawing especially on data about Germany, the study describes the exchanges of livestock and poultry breeds and their genetic materials between the North and the South, and discusses impacts and implications. Particular focus is given to smallholder livestock keepers in the South because they have been crucial to breed development in non-temperate climatic zones and millions of them depend on livestock for their livelihoods.⁴

Study questions and methods

This study investigated the following questions:

- Why and how are live animals and their genetic materials exchanged?
- How has modern breeding in the North evolved?
- What gene flows have occurred from the South to Germany (and other countries in the North) since the development of modern breeding some 200 years ago? What has been their impact?
- What gene flows have occurred from Germany and elsewhere into the South, especially during the 20th century? What have been the driving forces; who are the players?

1 Hall and Ruane 1993; Köhler-Rollefson 2005.

2 See Freeden and Schnurbein 2002 and Menghin and Planck 2002.

3 The first herd book was opened for Shorthorn cattle bred by the Colling Brothers in the UK in the 18th century. See Sambras 2001:76.

4 This study was conducted parallel to another much larger study conducted by the University of Hohenheim (Musavaya and Valle Zárate forthcoming). As the body of the text was already completed when the first parts of the Hohenheim study became available, it was not possible to consider the findings in this report.

Herd Movements

- What are the implications of gene flows into and within the South? How have they affected pastoralists and smallholder livestock keepers in marginal areas?
- What can we expect for the future?

Data were collected between October 2002 and January 2005. Methods included:

- Searches in libraries and on the Internet.
- Analysis of information from the annual reports of the Umbrella Association of German Cattle Breeders' Associations (Arbeitsgemeinschaft Deutscher Rinderzüchter, ADR),⁵ data of the Food and Agriculture Organization of the United Nations (FAO) and breed databases available on the Internet.
- Informal interviews with individuals and organizations. The respondents were selected because they were well-known specialists or recommended during the interviews.

In addition, the report benefits from the first-hand experience and documents that the first author and League for Pastoral Peoples have been collecting in Europe and overseas since 1978.

Species covered are cattle, sheep and goats, swine and poultry (mostly chickens), which are the main species for agricultural production in Europe. From the very beginning, we were aware that the objectives of this study were ambitious and it would be impossible to come up with a comprehensive analysis of the ongoing global gene flows. Therefore the above-mentioned focus on Germany. However, during data collection it became obvious that a lot of activities affecting the animals of southern livestock keepers are happening elsewhere. Therefore we also included data from other countries that we came across during data collection.

Key definitions

Gene flows Originally used in the context of plants, the term refers to the transport of plant genetic materials over distance. Recently livestock professionals started applying this term also to animals,⁶ not necessarily restricting its meaning to genes but including also the movements of live animals.

Breed The definition of breed is controversial. In the North, it is understood as, "a group of animals with definable and identifiable external characteristics that distinguish it from other groups within the same species". In the South, it refers to a group of animals belonging to the same species that is kept by a particular community in a specific environment and subjected to the same utilization pattern.

North and South The terms "North" and "South" are used in development jargon to refer to developed and developing countries. The "North" includes the northern-hemisphere countries of western Europe, the USA, Canada and Japan, plus Australia and New Zealand. The South is used to cover the developing world. As the study will show, with regard to gene flow patterns some of countries in the South have some commonalities with their northern counterparts.

Some further technical terms are explained in the *Glossary*.

⁵ Translation based on DAD-IS 2004.

⁶ See, for example, Kaal-Lansbergen and Hiemstra 2003, Musavaya and Valle Zárate forthcoming.

2 Why and how do livestock genes flow?

BEFORE LOOKING at the flows of breeds and genes around the world, the report discusses first the human activities and circumstances that can lead to the introduction of animals into new areas. It then turns to how animals and their genetic materials flow and the form in which they are transported.

Why genes flow

As mentioned above human migration has often gone hand-in-hand with the flow of livestock and their genes. But other human activities and circumstances also lead to gene flows (Box 1).

Commerce and trade have been an important conduit for the movement of breeds since early history. Indian Zebu cattle, for example, likely came to Africa by sea with traders, perhaps as early as the second millennium BC.¹ Governments, private companies and stockholder associations purchase breeding stock from abroad to establish new herds or enrich existing bloodlines.

Large numbers of animals are also exported and imported for slaughter. It is possible that some of these animals are in fact spared and are used for breeding.

Research Universities and research institutes are often behind the initial introduction of new animal types into a country. This genetic material is often made available for free, or as part of an exchange programme involving training and collaborative research. An example of such an introduction is the Dorper sheep that was introduced into Germany by the University of Göttingen² (see also page 13).

Box 1 Activities and circumstances leading to livestock gene flows

- Human migration
- Trade
- Research
- Traditional exchange mechanisms
- Raiding and warfare
- Development aid
- Travellers' (often illegal) "souvenirs"
- Accidental introduction and deliberate release.

1 Hannotte et al. 2002; Bradley 2003.

2 www.dorper.de/dorperschaf.htm (accessed 10 June 2004).

Herd Movements

Traditional exchange mechanisms Pastoralist and other livestock-keeping groups have various traditional methods of exchanging animals contributing to gene flows. These include lending animals to (often poorer) relatives to care for (this reduces the risk that the owner's herd will be completely wiped out by disease, or stolen in a raid), providing animals as a dowry, and trading animals for grain or goods.³

Warfare and raiding Some groups of pastoralists traditionally raid each other (or settled communities nearby) to steal cattle, camels and other animals. Horses and cattle spread in North America not only through peaceful trade, but also by rustling – as depicted in countless westerns. Conflict also forces people to flee, and they naturally try to take their most valuable animals with them. Indeed, because animals can walk and carry a load, they are often among the only possessions a refugee can keep. Such warfare and raiding are confined to certain regions or societies; they play a limited role in international movements of livestock.

Development aid, on the other hand, has been an important driving force, mostly for flows towards the South. Development agencies facilitated the introduction of many new breeds into the South (see Box 6, page 33).

Accidental introduction and deliberate release Wild plants, animals, birds and insects may be introduced by accident to new areas on ships and planes. This is not an issue with larger livestock. It is more common for them to escape from confinement, or to be released into the wild. Goats and pigs, originally introduced for farming, are now seen as pests in small islands, such as the Galapagos, because they destroy the fragile ecosystem. Similarly, camels that were brought to Australia as a means of transport and released when no longer needed are nowadays regarded as a threat to the ecosystem of the Outback.⁴

How genes flow

Live animals

Until recently, almost the only way a species or breed could be moved from one place to another was as live animals, either by foot or on boats. The advent of motorized transport in the 19th century meant that more animals could be moved faster and further. Despite these advances, transporting live animals is cumbersome and costly, and suffers from numerous problems, especially if the animals are later intended for use as breeding stock. Repeated loading and unloading animals causes stress, as do confinement with other animals and the process of transportation itself. Conditions are often poor, and it is difficult to maintain adequate levels feed, water, ventilation and hygiene. The change to a new environment at the end of the journey causes additional stress. The animals may fight, be injured or fall ill during transport, or may contract diseases shortly afterwards.⁵

Another drawback of the trade with live animal is the danger of introducing diseases. An infamous example is the case of rinderpest that came to northeastern Africa with a shipload of Italian cattle imported by Italian priests in 1887.⁶

³ LPPS and Köhler-Rollefson 2005.

⁴ www.guardian.co.uk/worldlatest/story/0,1280,-4964176,00.html (accessed 30 April 2005).

⁵ European Commission 2002.

⁶ See the description of Sanga cattle in the DAGRIS database at <http://dagrils.ilri.cgiar.org/dagrils/> (accessed 18 February 2005).

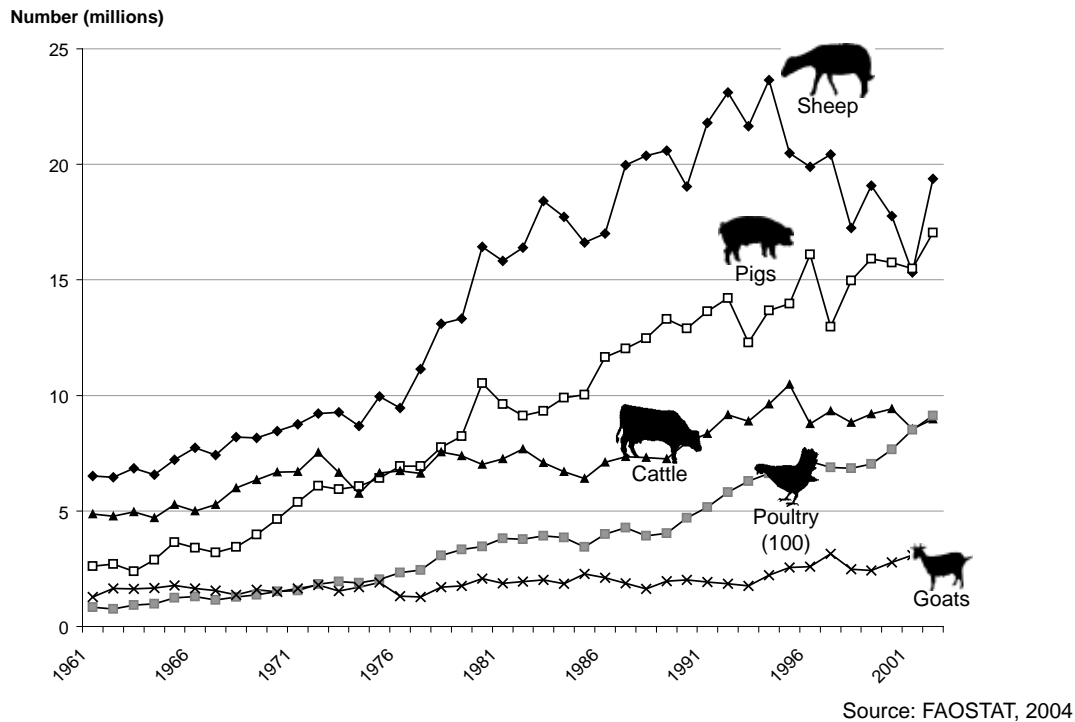


Figure 1 World exports of live animals, 1961–2003

Despite these difficulties, large numbers of live animals are carried across international borders each year (Figure 1). In terms of numbers, the most traded mammal species is sheep: more than 19 million animals were shipped across international borders in 2002, compared with 17 million pigs, 9 million cattle and 3 million goats. In the same year, 900 million live chickens and other poultry were exported worldwide,⁷ almost all as day-old chicks.⁸

In terms of total value, cattle were the most valuable animals exported, followed by horses, pigs and sheep (Table 1). It is interesting that horses are so valuable: the 243,000 horses exported in 2002 were worth \$1.36 billion, or an average of \$5600 each.

The numbers of animals traded has tripled over the last 40 years, from about 16 million mammals in 1961 to 49 million in 2002. The number of chickens has risen more than 10-fold, from 84 million in 1961 to over 900 million in 2002.

To put these figures in perspective: 5% of the world’s chicken population is exported each year. Slightly less than 2% of the world’s pigs and sheep change their nationality each year, as do a little less than 1% of the world’s cattle. By contrast, only about 1.5 million people (0.2% of the world’s human population) emigrate permanently each year.⁹ Nevertheless, the trade in live animals is much smaller than the trade in dead ones (Box 2).

It is impossible to tell how many of the live animals traded were intended for breeding in their new homes, as the data (from FAO) are not broken down by the purpose of export. But it is likely that the vast majority are intended for fattening and slaughter. Relatively few are earmarked for breeding, or end up mating with local animals. However, as noted above, it is possible that












7 All data in this section are based on FAOSTAT 2004.

8 Anonymous personal communication 2005.

9 *The Economist* 1997.

Herd Movements

Table 1 World exports of live animals, 2002

		Numbers (1000)	Value (\$ million)
Cattle		8,986	4,263
Horses		243	1,360
Pigs		17,052	1,347
Sheep		19,210	1,055
Goats		2,835	105
Camels		62	13
Buffaloes		47	6
Chickens		836,910	868
Turkeys		58,757	112
Ducks		16,157	36
Geese		538	2
Total			9,169

Source: Calculated from FAOSTAT 2004, Trade in live animals, <http://faostat.fao.org/faostat/form?collection=Trade.LiveAnimals&Domain=Trade&servlet=1&hasbulk=&version=ext&language=EN> (accessed on 8 Aug 2005)

some animals destined for the slaughterhouse do in fact end up sharing their genes with the national herd.

One way to reduce costs of transporting live animals intended for breeding is to import pregnant females. In this way, at least two animals (the mother and offspring) can be imported for the cost of one.

Eggs

Poultry used to be the only type of livestock could be transported without having to move live animals. Fertilized eggs are easy to carry. Egyptian Fayoumi chickens came to the USA this way in the 1940s – carried by Iowa State University's Dean of Agriculture, R.E. Buchanan.¹⁰

Semen

It was not until the middle of the twentieth century that transporting mammals became nearly as easy as carrying a basket of eggs. The development of artificial insemination and the discovery that semen mixed with glycerol could be deep-frozen safely¹¹ made it possible to store semen almost indefinitely and transport it over long distances.

¹⁰ Meyer 1997.

¹¹ Foote 2002.

Box 2 Alive or dead?

A country can fulfil its need for livestock products in many ways: by importing live animals for fattening and slaughter, by importing breeding animals, or by bringing in genetic materials such as semen and embryos. It can also import dead animals (meat) or animal products (eggs, milk), or processed items such as butter, sausages and pies. World trade in livestock products in 2003 was worth over US\$ 36,539 million in 2003 – about four times the \$9,672 million trade in live animals – and this does not include trade in processed products.¹ Transporting dead animals around the globe is a lot easier and cheaper than moving live ones.

This trade affects gene flows because of competition: local livestock raisers compete indirectly with meat importers. If imports of live animals or breeding materials are too expensive or restrictive, imports of meat and other livestock products are likely to rise.

¹ FAOSTAT, accessed August 2005

Furthermore, artificial insemination enables a male to father a hitherto impossible number of offspring. One of the proudest fathers in this respect must be the Holstein Friesian bull Starbuck in Canada, which has sired more than 200,000 daughters around the world. His owners have sold 685,000 doses of his semen in 45 countries.¹² Germany's top Holstein bull reached 50,373 first inseminations in 2003.¹³

Transporting semen rather than male animals has other advantages besides cost. It is a fairly safe and reliable way to transport genetic information. Stud animals can be strictly monitored for disease, and the hygiene of semen production can be assured. Antibiotics can be added to the semen "extender". All this means that the risk of disease transmission is greatly reduced compared to gene flows in form of live animals.

Large numbers of batches of semen, deep frozen with liquid nitrogen, are now routinely transported around the globe. The semen is used to inseminate females in the importing country, resulting in a crossbred offspring if the dam (mother) and sire (father) are of different breeds.

Using artificial insemination to improve a herd's characteristics relies on "progeny testing". This is an expensive and time-consuming procedure: the best young bulls are first selected from a herd. Their semen is then used to breed a small number of calves. The young "test bulls" must then wait until their offspring can be tested for milk production and other desirable traits. During this period the bulls in Germany are known as "waiting bulls". Only then are the very best bulls reclassified as "tested sires", and their semen can be used more widely, in the confidence that their offspring will inherit their desirable traits.

Progeny testing is widely used in the developed world, but is less common in the South. This and other reasons have meant that artificial insemination has not been as successful and widely used in the South as had been expected¹⁴ (Box 3).

¹² www.ciaq.com/Estarb2.htm#ancre1 (accessed 25 May 2005).

¹³ ADR Aktuelles: *Bulleneinsatz 2003* (posted 10.3.2004, accessed at www.adr-web.de on 26 July 2004; see www.adr-web.de/download.php/752/leitartikel_2404.pdf for full information).

¹⁴ Chupin and Schuh 1992.

Box 3 Usefulness of artificial insemination as a breeding tool in the South

The potential of artificial insemination for enhancing performance of livestock populations can only be realized when it is combined with systematic performance testing and careful bull selection. Because developing countries rarely have the sophisticated management systems and computing facilities needed, the usefulness of artificial insemination for breed improvement in the South has remained confined to high-potential areas. In India, for example, these were Kerala and some milk unions in Gujarat. Apart from these the entire artificial insemination system in India has depended on unevaluated bulls. This is why it has not resulted in genetically superior progeny.¹

Other constraints that hamper the spread and usefulness of artificial insemination in the South include:

- The lack of communications infrastructure (though mobile phones may help overcome some of this problem).
- Uncastrated bulls: they are faster and more reliable than inseminators!
- The irregular supply of high-quality semen and freezing agent.
- The low success rates after insemination.

For example, the Mewat Area Development Project, some 120 km south of New Delhi in India, achieved calving rates of 26% in cattle and 32% in buffalo after inseminating nearly 19,000 cows and 20,000 buffaloes between 1997 and 2000.² This is much lower than the results in other countries. In Germany, for example, between 50 and 75% of the cows become pregnant after the first insemination;³ actual calving rates are slightly lower.

1 Kurup 2002.

2 www.ifad.org/lrkm/region/pi/in_375.htm (accessed 14 August 2004).

3 ADR 2002.

Embryos

Transporting semen enables male animals to sire large numbers of offspring. The equivalent for females became possible in the 1970s, with the development of embryo transfer. With a fairly complex set of techniques, multiple embryos are collected from valuable female animals. The embryos can be transported “fresh” or frozen. On arrival at their destination, they are implanted into surrogate mothers, which eventually give birth to the offspring. This way it is possible to produce up to 100 offspring per donor cow per year.¹⁵ The young animals inherit the genes from the donor mother and the father whose semen was used to inseminate her, so they do not have any genetic relationship with their surrogate mothers.

Embryo transfer was developed in cattle and pigs in Britain in the 1950s, and was introduced to Germany in the 1970s. By 1998, some 440,000 embryo transfers were recorded in cattle worldwide.¹⁶ But overall, this technique has not become as important as a breeding tool as many expected, in part because of the high cost per animal.¹⁷ In Germany the number of embryo transfers decreased from about 22,000 in 2000 to 17,000 in 2001 – a fall of nearly a quarter.¹⁸

15 Greising 1998.

16 FAO News Room *Animals: unexpected products?* www.fao.org/english/newsroom/focus/2003/gmo4.htm (accessed 25 May 2005).

17 Kalm 2000.

18 ADR 2002.

In 2002 the number had fallen further to 10,000,¹⁹ likely because of the prohibition of the egg-stimulating hormone FSH.

Nevertheless, embryo transfer has its role in international gene exchanges. Australia has imported a number of southern breeds as frozen embryos to build up its own breeding industries for these breeds (see page 17). One of these is the Damara sheep.²⁰ Also the Dorper sheep (page 13) entered Germany as frozen embryos.

Other biotechnology techniques

In the future, other cell and gene materials are likely to play a role in livestock agriculture, and thus to the international flows of livestock genes (see page 52). However, these techniques are still new, and it is difficult to predict the type and scale of impact they will have.

Measuring gene flows

While for many countries in the North export and import statistics exist, they all have limitations, making it difficult to trace the movements of breeding animals (see the *Appendix*). Reliable statistics from the South are even harder to find.

Another option is taking the amount of animals, semen batches and so on that are exported as an indicator of gene flows. However, the numbers exported are not necessarily equivalent to the numbers that arrive or that are used at their destination. Shipping pregnant heifers means more animals (mother and calf) are actually transferred. Breeding males can be used to produce large amounts of sperm for artificial insemination.

But other factors reduce the numbers. Animals may die during transport or soon after they arrive. They may fail to produce, or to reproduce, and they may end up on the slaughter block sooner rather than later. Not all semen portions have the same degree of fertility, and local conditions may make it impossible to distribute and use them. A cow may be inseminated several times while she is in heat, and even then, only about half or even less of the females inseminated in any one heat period may become pregnant. In addition, batches of semen may spoil if they are not kept frozen, or they may be accidentally damaged.

So export figures are only a very vague measure of the actual flows of breeds and genetic resources. But in the absence of better evidence, we use them as an indication of the levels of gene flows around the world.

Another approach is to follow up on the history of the different breeds found in a country. The presence of foreign breeds, or breeds that include foreign genes, is an indication of gene flows into that country.

19 ADR Aktuelles *Embryotransfer weiter rückläufig*, posted 17.7. 2003 at www.adr-web.de/ (accessed 26 July 2004).

20 Hills and Young 1999:6.

3 Gene flows from South to North

From ancient times to the Middle Ages

LIVESTOCK DEVELOPMENT in Central Europe began with extensive gene flows from South to North. The earliest domestication of plants and livestock occurred in the Near East some 2000 years before agriculture developed in Europe. Domesticated animals were introduced when “linear pottery” (Bandkeramik) and La Hoguette agriculturalists moved into Central Europe from the East and the West during Neolithic times (around 5500 BC), bringing their cattle, sheep, goats and pigs with them.¹

The ancestors of chickens were domesticated in India during early Bronze Age. Chickens arrived north of the Alps during the 7th century BC, and were spread further northwards later through the Romans.² The Romans also introduced superior bulls into what is now Germany, crossing them with the relatively small cattle of the Celts to enhance meat supplies for the Romans living there.³

With the decline of the Roman Empire, their breeds and breeding methods disappeared, and there seem to have been few targeted breeding efforts in central Europe during the Middle Ages.

The development of modern breeding⁴

This situation changed during the 17th century, as new breeds of horses were imported into Europe. Arab horses became popular, especially in Britain, where breeders also adopted Arab pastoralists’ practices of careful parent selection and maintaining pure lines. They then used these principles in breeding cattle and other farm animals. The same principles were important for progress in animal breeding in the following centuries.

Unlike the Arabs, however, British breeders kept written records on their animals’ pedigrees. This was a precondition for the foundation of herd books and breeding societies in the 19th century. Longhorn and Shorthorn cattle were among the first breeds of international importance to be developed. Holstein Friesians are descended from the latter.⁵ Herd-book societies and other registry associations are active in a growing number of countries around the globe. They are still a driving force in breed improvement today.

In the early 19th century, British breeding approaches were introduced into Germany. Whereas in Britain, breed development was largely the result of practical experience and focused on form and production, breeding in Germany was for a long time dominated by disputes about inbreeding⁶ – probably one of the reasons that German registry associations for cattle and swine started

1 Baldia 2000.

2 Weigend 2000.

3 Freeden and Schnurbein 2002:266-7.

4 This section is based on Berge 1959.

5 Augsten 2001. See also www.primholstein.com/anglais/_private/race/presentation.asp (accessed 25 May 2005).

6 Berge 1959:13-14

forming only in the second half of the 19th century. At this time, too, the basis was laid for the legal and institutional framework that regulates animal breeding in Germany up to the present date. These officially recognized herd-book societies – which act as non-profit farmer organizations – guide, oversee and implement the breeding of individual breeds, in close collaboration with organizations specializing in recording, testing and insemination. In 2001, there were 40 breed societies for cattle (down from 80 in 1965).⁷ In accordance with the Animal Breeding Act (*Reichstierzuchtgesetz* of 1936, replaced by the *Tierzuchtgesetz* of 1949), only licensed bulls and boars are allowed to breed.⁸

At first, the herd-book societies were accredited by the German Agricultural Association (Deutsche Landwirtschafts-Gesellschaft, DLG), but this role has now been taken over by the State. German laws and regulations on the agricultural sector must also comply with European law.⁹

Breeding for production

With the improvement of fodder plants, animal feeds and management conditions, breeds adapted to local conditions became less relevant. The systematic selection for production traits pursued during the 20th century greatly enhanced the output per animal. The average milk production of dairy cows in Germany, for example, rose from about 2600 kg in 1950 to about 6300 kg in 2001. German Holsteins, the dominant dairy breed, produced 7988 kg.¹⁰ In the USA, the average production of Holstein Friesian cattle was even higher, at 10,584 kg in 1999.¹¹ Hybrid hens nowadays lay 300 and more eggs a year,¹² more than twice as many as indigenous breeds. As a result, the overall production of meat, milk and eggs greatly increased in the North, making animal products widely available, accessible and affordable, while the land area necessary to obtain these outputs has steadily declined.

The trend towards intensive production has been paralleled by a fall in the number of farms and a rise in the number of animals on each farm.¹³ This trend has been less marked in Germany than elsewhere: in 1999/2000 the average British farm had 68 dairy cows, compared to 28 in Germany.¹⁴

Parallel to the developments in animal breeding, there has been a growing commercialization of the production process, and a progressive concentration of players. This trend has been most marked in poultry production, which is now largely in the hands of commercial companies, and breeding societies are relegated to the hobby sector. Pig production in Denmark and the Netherlands has also been organized into vertically integrated firms, with commercial pig companies conquering a substantial share of the crossbred market.^{15,16} In Germany, though, pure breeding of swine is still largely in the hands of breeding societies.

Because they need large amounts of roughage, ruminant species – cattle, sheep and goats – depend much more on their environment than do pigs and poultry. That makes ruminant produc-

7 ADR 2002:27.

8 ADT 1961.

9 Kräußlich 1994:432-436.

10 ADR 2002:22, 30.

11 Augsten 2001.

12 Weigend and Bremond 2004.

13 Boehncke and Krutzinna 2001; Statistisches Bundesamt 2004a.

14 BMVEL 2001:39.

15 Kräußlich 1994:437; Nischwitz, Bartelt, Kaczmarek and Steuerer undated.

16 Vertical integration is the expansion of activities of a firm until it controls its raw materials at one end and its markets at the other (ILRI 1995).

Herd Movements

tion less suitable for industrialization, so they are still mostly in the farmers' domain. However, in cattle the heavy emphasis on testing and selecting for performance raises the question how far breeding decisions are still informed by practical field experience.

While the intensification and industrialization of livestock breeding and production have undoubtedly led to higher production levels and cheaper food, their negative effects on animal welfare, public health, and the environment are of growing concern.¹⁷ Another drawback is their negative impact on breed and genetic diversity. For example, Holstein cattle account for 60% of European and 90% of North American dairy cattle. By 2015, it is projected that in the USA, the genetic diversity within this breed will correspond to that of only 66 animals.¹⁸

With progressing reduction of the genetic base, traits may get lost – and with them the ability of breeders to adapt their breeds to climate change, new diseases or shifts in consumer preferences. If a breed is genetically uniform, many animals may succumb to a disease if they share susceptibility to the disease.

Gene flows from the South to Germany¹⁹

Cattle

In Germany during the 19th century, numerous landraces developed.²⁰ Many of these have since disappeared, while new ones emerged and others were introduced. In March 2004, a database maintained by the European Association for Animal Production (EAAP) listed 64 cattle breeds in Germany.²¹ Few originated outside Europe, and only four come from (or carry genes from) the South: Brahman, Brangus, Piedmont and the Dwarf Zebu (*Zwerg-Zebu*) (Table 2). All four are beef animals. Because the EAAP database gives details only for the 2.6 million cattle registered in herd books, it does not allow us to estimate the actual proportion of these breeds among Germany's 2001 population of 14.5 million cattle.²²

In 2001, about 96% of all herd-book cattle fell into the category “dairy and dual-purpose”. About 60% of this category was made up of the German Holstein breed.²³ Over the last decades, breeding efforts in dairy cattle have centred largely on improving milk yield through intense selection within certain breeds, rather than through crossbreeding.²⁴ We can therefore suppose that there has been very little influence on this category from southern breeds.

Crossbreeding is more common in the beef sector. But here also, influences from the South are limited. The most important southern breeds are Piedmont and Dwarf Zebu. Piedmont is actually an Italian breed, but it is said to be the only European breed to have zebu blood.²⁵

17 Geerlings et al. 2002.

18 De Haan et al. Undated (1999?):72-73. See also Weigend 2002 for the situation in poultry.

19 Because of data limitations (see Appendix), this discussion is based on an analysis of the breeds registered in the EAAP Animal Genetic Data Bank, annual reports of German breeding associations, and secondary literature.

20 Sambras 1999:13-14. A “landrace” is a breed produced and maintained by farmers, so adapted to the local environment.

21 EAAP database www.tiho-hannover.de/einricht/zucht/eaap/crosstot.htm (accessed on 17 March 2004).

22 See ADR 2002.

23 ADR 2002:29.

24 Campbell and Lasley 1985:47.

25 Sambras 2001: 60.

Table 2 Cattle (with genes) of southern breeds registered in Germany

Breed	No. males in herd book 2002	No. females in herd book 2002	Trend compared to 2001
Piedmont	87	233	Rising
Dwarf Zebu	36	286	Falling
Brahman	2	2	Falling
Brangus	1	Missing information	Disappeared/ extinct

Source: EAAP database, 17 March 2004

Since 1979, the Dwarf Zebu has been used for landscape maintenance and beef production in Germany. The breed is reported to stem from Sri Lanka and the Caucasus. The first herd book in Germany for this breed was established in 1992. According to one of the largest Zebu breeders in Germany, Dwarf Zebras are now the sixth most numerous beef breed in Baden-Württemberg, a province in southern Germany.²⁶ There are around 320 herd-book animals of this breed.

In 1980, Brahman cattle came to Germany in the form of semen from South Africa; it was used to inseminate Black and Red German Holstein cows, among other breeds. In 1985 a Brahman breeders' society was formed in Germany.²⁷ But by 2002 only four Brahman herd book animals were left. As there are no easily accessible data on semen imports, it is difficult to judge whether imports of Brahman semen still occur.

Synthetic breeds like Beefmaster (a mix of Hereford, Shorthorn and Brahman) and Santa Gertrudis (Brahman x British Shorthorn)²⁸ that have conquered sizeable market shares in Australia and the USA, hardly play a role in Germany. The EAAP database lists Brangus (Brahman x Angus) as "disappeared/extinct".

Sheep

Sheep and goats are a lot less important than cattle, pigs and poultry in German agriculture, but they are covered here because of their importance in developing countries. In 2003, Germany had about 2.6 million sheep²⁹ belonging to 60 different breeds.³⁰ Exotic breeds form a small percentage of the sheep population (Table 3).

Dorper sheep are a promising recent introduction. This hardy meat breed which does not require shearing is a cross between the English Dorset Horn and the Somali Blackhead Persian. They were imported as frozen embryos by the University of Göttingen in 1995.³¹ Trials showed that under intensive feeding regimes in Germany the lambs put on too much fat. In Baden-Württemberg, Dorper are increasingly used as bucks in Merino herds.³²

26 www.zebusvombirkenhof.de/?content=zebuinfo&zeigen=2&language=german and www.zwergzebu.de/ (accessed 28 March 2004).

27 Sambras 2001:89.

28 Campbell and Lasley 1985:46.

29 Statistisches Bundesamt 2004b.

30 EAAP database www.tiho-hannover.de/einricht/zucht/eaap/crosstot.htm (accessed on 17 March 2004).

31 www.dorper.de/dorperschaf.htm (accessed 10 June 2004).

32 Jilg 2003.

Herd Movements

Table 3 Sheep (with genes) of southern breeds registered in Germany

Breed	No. males in herd book 2002	No. females in herd book 2002	Trend compared to 2001
Cameroon Sheep	41	516	Stable
Dorper	14	221	Rising
Karakul	14	111	Stable
Booroola	Missing information	8	Falling

Source: EAAP database, 17 March 2004

Table 4 Goats (with genes) of southern breeds registered in Germany

Breed	No. males in herd book 2002	No. females in herd book 2002	Trend compared to 2001
Boer	271	2110	Rising
Anglo-Nubian	35	163	Rising
Dwarf Goat	21	118	Rising
Angora	14	82	Falling
Owambo	12	42	Rising
Kashmiri	1	8	Falling

Source: EAAP database, 17 March 2004

Goats

In 2000, there were about 163,000 goats³³ belonging to 27 breeds³⁴ in Germany. The most important southern breed is the Boer (Table 4). This South African breed³⁵ is gaining some importance for meat production. Dwarf goats are probably more numerous than Table 4 indicates because they are often kept by zoos and hobby keepers, and are not necessarily registered in herd books.

Pigs

There are currently about 26.5 million pigs in Germany.³⁶ At the end of the 1950s, there were 35 pig herd-book societies,³⁷ but the number has shrunk since; nowadays there are only recognized 17 breeds,³⁸ 14 breeders' societies, and 10 commercially oriented breeding enterprises.³⁹ Just four breeds (German Landrace, Pietrain, German Large White and Leicoma) make up 98% of

33 DAD-IS 2004:12.

34 EAAP database www.tiho-hannover.de/einricht/zucht/eaap/crosstot.htm (accessed on 17 March 2004).

35 Sambras 2001.

36 Statistisches Bundesamt 2004b.

37 ADT 1961:69.

38 EAAP database www.tiho-hannover.de/einricht/zucht/eaap/crosstot.htm (accessed on 17 March 2004).

39 Website of *Zentralverband der Deutschen Schweineproduktion* (= Union of German pig producers) www.zds-bonn.de/ (accessed 27 May 2004).

all herd-book animals.⁴⁰ Together with a few other breeds they form the basis for hybrid production, which uses crosses between specialized sire and dam lines that have been developed through intense within-line selection.⁴¹

No purebreds from the South are listed among the 17 breeds in the EAAP database. However, with one exception (the “German Weideschwein”, which died out at the end of the 1970s), all breeds developed in Germany during the last two centuries carry genetic material from Chinese pigs.⁴² These were introduced to England beginning in 1816,⁴³ and later were crossed into European breeds. Their properties are still manifest in some highly productive breeds, such as the Middle and Large White. The Chinese swine were very fertile, had good mothering qualities, were less susceptible to stress than local breeds, and produced good quality pork.⁴⁴

More recent crosses with Asian pigs are the miniature pig breeds. The Göttinger Mini-pig is a cross of Minnesota mini-pig with the Vietnamese potbellied pig.⁴⁵ Mini-pigs play an important role in medical research, but it is not clear what percentage they make of the nearly 12,000 pigs used for research in Germany in 2001.⁴⁶

Poultry

As with pigs, many of our present-day poultry breeds carry genetic material introduced from Asia to northwestern Europe in the 19th century. For example, Cochin and Malayan chickens formed the basis for the Plymouth Rock and other breeds.⁴⁷ After 1900, hobby breeds started to separate from the commercial sector. Poultry breeding remained in the hands of breeding associations until the middle of the 20th century. But beginning in the 1950s, hybrid chickens were imported from the USA, replacing the local breeds, and the poultry industry started to become highly specialized.

Chickens that lay brown eggs are of Asian origin, while white-egg layers hail from the Mediterranean.⁴⁸ Nowadays more than 80% of the world’s layers are supplied by three major firms, which produce hybrid chickens from very few, highly specialized parent lines.⁴⁹ The parent lines are then mated using artificial insemination to produce hybrid birds that lay the eggs we eat.

There is still wide diversity in the hobby sector. In 2002 the Union of German Poultry Breeders (Bund Deutscher Rassegeflügelzüchter) counted 95 chicken breeds, not including dwarf breeds.⁵⁰ But these breeds have no economic importance, and commercial breeders do not tap into this resource.⁵¹ Hobby breeds are often bred for specific external characteristics; despite their different appearances, they may have quite similar genetic makeups. This means that the high breed diversity in poultry does not necessarily correspond to high genetic diversity.⁵²

40 ZDS 2002.

41 Flock and Preisinger 2002.

42 Sambras 1999:348.

43 Bühler 1998.

44 Horst 1989.

45 Sambras 2001:297.

46 Bundesregierung 2003.

47 Weigend 2000.

48 Weigend and Bremond 2004.

49 Flock and Preisinger 2002, Weigend 2002.

50 Cited in Weigend 2002:35.

51 See Arik et al. 1996, Hoffmann et al. 2004 and Weigend 2002.

52 Hoffman et al. 2004.

Herd Movements

Summary

There appears to have been a very limited inflow of livestock genes from the South into Germany, and the few animals that have been brought here have had little impact. In ruminants, this is especially true of cattle and sheep, where southern introductions make up a very small proportion of the breeds, and an even smaller part of the total population (Table 5).

In cattle, southern blood is confined solely to beef and multipurpose sectors, which are minor compared to the dairy sector. Only Piedmont and Dwarf Zebu have gained limited importance and are likely to expand in the future. In sheep, the decreasing demand for wool and growing needs for landscape maintenance may encourage the spread of Dorper and Cameroon – both hair sheep.

The situation in goats is somewhat different. Here breeds from the South make up 22% of the breed spectrum. There might be several reasons for this. Goats are unimportant in German agriculture, and there are few goat breeds, and even fewer originate from Germany. In 1927, the shortage of breeding stock led to several local breeds being combined into just two breeds, namely *Weißer Deutsche Edelziege* and *Bunte Deutsche Edelziege* in an attempt to increase the number of animals available for breeding.⁵³

Southern influences on German pigs and poultry are mostly historical. The pig industry, and a large part of poultry production too, build on animals that were crosses with Asian breeds in previous centuries. It is impossible to judge how present-day pig and poultry production would differ without these influences, or indeed whether this heritage makes an economic difference.

Table 5 Proportion of cattle, sheep and goat breeds in Germany with genes from the South

	Cattle	Sheep	Goats
Breeds^a			
No. of breeds	64	60	27
No. of breeds with genes from South	4	4	6
% of breeds from South	6%	7%	22%
Animals			
Total population ^b	14,500,000	2,600,000	163,000
No. of herd book animals ^b	2,600,000	?	?
No. of herd book animals with genes from South ^a	647	925	2877

^a Registered in EAAP database (2002).

^b See text for sources.

53 GEH undated:60, Sambraus 1999:330, Sambraus 2001:166-167.

Gene flows from the South to other countries in the North

Exotic breeds have had a big impact elsewhere in the North. In some countries, southern breeds have themselves conquered large market shares, or they have been crossed to produce important new breeds.

In the **USA**, the number of beef cattle breeds rose markedly in the 20th century, both through imports and through crossbreeding to develop composite breeds. Southern breeds played a role in this.⁵⁴ In 1984, the Council for Agricultural Science and Technology (CAST) noted that recent imports of *Bos indicus* (zebu-type cattle having their origin in India) and *Bos taurus* (non-zebu types) breeds had “contributed needed genetic variability in size, milk production, body composition, and adaptation to various climates” for beef production.⁵⁵ An example of a southern-influenced addition is the Senepol, which farmers developed after 1918 by crossing Red Poll from England with N’Dama from Senegal.⁵⁶

Other examples, and perhaps of greater economic importance, are the Brahman and some of its crosses (Beefmaster, St. Gertrudis).⁵⁷ The progenitors of the Brahman include Guzerat, Nelore and Gir cattle. These were originally developed in India and were imported to the USA via Brazil (see also page 30).⁵⁸ Nearly 30% of the cattle in the USA are estimated to have some Brahman blood. The widespread use of Brahman-descended stock throughout the southern USA reflects the value commercial breeders placed on its tolerance to heat, humidity, diseases and parasites.⁵⁹

Southern breeds have also made a substantial contribution to **Australian** livestock production. A total investment of about \$340 million in Australia’s beef cattle genetics since 1970 yielded a 28-fold return (\$9.4 billion) by 2000.⁶⁰ The biggest contribution came from better-adapted *Bos indicus* animals in northern areas of the country.

The Australian sheep industry has also benefited from southern genes. In the 1800s, the Garole sheep, a prolific breeder from West Bengal, India, enabled the Australia’s wool industry to grow rapidly and become a major contributor to the young colony. The Booroola gene, responsible for the animals’ prolificacy (Box 4), can be traced back to an early Australian flock containing Bengal sheep. Over 100 of these animals were imported from Calcutta in 1792/3.⁶¹

More recently, the Australian Department of Agriculture has systematically introduced fat-tail sheep breeds from Africa and the Middle East. Its reasons for doing so include the desire to boost Australia’s export potential and to serve the growing market for fat-tail meat in the Middle East.⁶²

The story of the Awassi sheep illustrates how a systematic breeding and multiplication scheme can turn a small number of embryos into to a substantial population within a relatively short pe-

54 CAST 1984 and www.glenroseffa.org/COMMON%20BEEF%20BREEDSpowerpoint.ppt (accessed 10 June 2004).

55 CAST 1984:1.

56 Oklahoma State University (OSU) breed database www.ansi.okstate.edu/breeds/cattle/senepol/index.htm (accessed 23 June 2004).

57 www.glenroseffa.org/COMMON%20BEEF%20BREEDSpowerpoint.ppt (accessed 10 June 04).

58 CAST 1984: 23.

59 ARS 2003.

60 Griffith et al. 2003. This study uses a discount rate of 7%. The figures are presumed to be Australian dollars (though the source does not specify this). In June 2004, Aus\$ 1 = € 0.58.

61 Nimbkar 2002:33.

62 Sunderman and Johns 1994:1.

Box 4 The Booroola gene in sheep

The Booroola gene is one of several prolificacy genes identified by AgResearch, a bio-tech firm in New Zealand. The firm claims the gene has a large influence on the litter size of sheep: "it is additive, so one copy of the gene means an extra 100 lambs born per 100 ewes lambing, and two copies inherited from both parents means an extra 150 lambs born per 100 ewes lambing."¹ In 1993, the discovery of a genetic marker for the Booroola gene made it possible to identify carriers of this gene.

Research in Israel has confirmed the gene's economic potential. Between 1996 and 2000, the Department of Animal Production of Israel's Agricultural Research Organization introduced the Booroola gene into Awassi, Assaf and German Mutton Merino sheep. The experiments produced a new Awassi strain called "Afec". Ewes produce an average of 2.0 lambs in each lambing.² Department scientists thought that introducing the Afec into Awassi flocks managed under semi-intensive conditions would be profitable.³

Recently the gene has been found to occur in sheep elsewhere in Asia.⁴ In 2003, researchers from New Zealand and Australia obtained a patent for the marker and the Booroola gene. This patent is registered in the USA under application no. 10/169,051. Genetically modified animals having received the Booroola gene constructs would also be covered by the patent, but this also varies depending on national patent regulations.

1 www.agresearch.cri.nz/agr/media/press/15_press.htm (accessed 18 Nov 2002). The website of this firm has been moved since to www.agresearch.co.nz/ ((18 June 2004) and the above cited page has been removed.

2 www.agri.gov.il/AnimalScience/Reproduction/Reproduction.html (accessed 18 June 2004).

3 Spharim and Gootwine undated.

4 Ella Martinyuk personal communication 2004.

riod (Box 5). Other fat-tails introduced to Australia include the Damara, Dorper and Van Rooy all of which were imported as frozen embryos from South Africa in the mid-1990s.⁶³

Differences between Germany and other countries

Why do breeds from the South play a role in some regions, but not in Germany? The obvious reason is the difference in climate: unlike the USA and Australia, Germany has no tropical or subtropical regions. Breeds adapted to hot and humid climates do not have a comparative advantage over local German breeds.

However, there may be additional reasons, such as differences in regulations governing breeding and in the organization of the breeding sector. An investigation of such influences on a country's breed spectrum might provide insights whether, and how, the legal and organizational framework can contribute to biodiversity.

63 Hills and Young 1999 and www.lm.net.au/~saltbush/svrooy.htm and www.lm.net.au/~saltbush/sdorper.htm (accessed 18 June 2004).

Box 5 The Australian Awassi Joint Venture

“The name [Awassi] is attributed to the El-Awas tribe from the area between the Tigris and Euphrates rivers in present day Iraq. In most physical characteristics the Awassi is very close to the original sheep from which the various fat tailed breeds were derived. These sheep have been bred for at least 5000 years in southwest Asia where stock with fat deposits in their tails were selected by the nomadic herdsmen for survival under steppe and desert conditions. In more recent times, the Awassi has been selected and bred to produce different strains suitable for meat, milk, or carpet wool production”.¹

Through intensive selection, Israel was able to double the milk production of its strain compared to Awassi sheep in Syria which produced 200–300 kg milk per year.² Presently there are more than 80 million Awassi and Awassi-related sheep in the Middle East.³

In 1987, 311 frozen Awassi embryos were flown to the Australian quarantine station on Cocos Island. The embryos stemmed from a flock in Cyprus which had been built up from Israel’s two best Awassi dairy flocks and subjected to intensive dairy selection for many years in a closed herd.⁴ Of the 311 embryos, 51 lambs were born and 41 survived. They became the starting point for a systematic multiplication programme under the Australian Awassi Sheep Joint Venture set up to produce large numbers of the animals quickly, and to supply semen and purebreds to farmers.⁵

In the 1990s the Joint Venture sold most of its shares to an Australian firm owned by a Kuwaiti businessman who had experience in the Middle East live sheep trade and funded most of the subsequent operation costs. By offering forward contracts to graziers a flock of 250,000 pure and cross-bred Awassi was built up. In November 2004 Livecorp reported the “one-millionth Awassi sheep exported to the Middle East.”⁶

1 Sunderman and Johns 1994:2. <http://agspsrv34.agric.wa.gov.au/agency/pubns/journalofag/v35/awassiFat-Tails.htm> (accessed 18 June 2004).

2 Horst and Grell, 1973:84.

3 www.agri.gov.il/Units/Kidum/gootwine.html (accessed 23 April 2005).

4 Sunderman and Johns 1994:1

5 Sunderman and Johns 1994:2.

6 See the news section at www.livecorp.com.au (accessed 12 April 2005). Livecorp is a not-for-profit industry body of livestock exporters.

Value of Southern breeds to the Northern livestock industry

Because of their exposure to different climates and environments, the various purposes they are kept for and the centuries of careful breeding and selection through their keepers, southern breeds have characteristics that animals bred for intensive production have lost. Examples are the resistance to certain diseases observed in a number of local breeds⁶⁴ and the high fertility of some Chinese pig breeds.⁶⁵ CAST identified the importance of southern genetic material in 1984: “reasonable free access to animal germplasm from other parts of the world is important for the future of US animal production”, and “the national interest will be served by preserving representative samples of promising germplasm from all food and fibre animal species of the world.”⁶⁶

64 See Gibson 2002:10-12 for a list of genetically controlled resistance to livestock diseases in southern breeds.

65 Horst 1989.

66 CAST 1984:1.

Herd Movements

In response to such concerns, the US Department of Agriculture founded the National Animal Germplasm Program in 1999 at the National Center for Genetic Resources Preservation in Fort Collins, Colorado. This programme coordinates the availability, conservation and utilization of animal genetic resources.⁶⁷

Interest in southern breeds is rising, and research on certain breeds has is under way. Examples include the Meishan (a strain of Taihu pig from China), Fayoumi chickens from Egypt,⁶⁸ and Red Maasai sheep from Kenya (see page 61). How such breeds and their genes will be used depends on future technology developments, plus other factors such as the compatibility between the breeds to be combined. For example, an attempt to introduce the high fertility of Meishan pigs into commercial breeding lines failed, as the reproductive organs of the pregnant sows could not cope with a high number of offspring.⁶⁹

⁶⁷ Blackburn 2002; see also www.ars-grin.gov/nag/ (accessed 23 October 2004).

⁶⁸ Meyer 1997.

⁶⁹ Kor Oldenbroek personal communication June 2005.

4 Gene flows to the South

IT WAS not just European livestock history that started with extensive breed movements. Genetic studies show that African cattle were first domesticated in northeastern Africa, and cattle pastoralism spread from the Great Lakes region southwards on the eastern side of Africa with migrating pastoralist or crop–livestock farmers. Another movement was the introduction of zebu-type cattle originating in India that gradually mixed with the African cattle.¹ European breeds were latecomers to southern Africa, first arriving with the Dutch in the 17th century.

In the Americas, there were no cattle at all before Columbus introduced the first animals in 1493.² Most other domestic livestock in the Americas have their origin in other continents. North American Indians kept only turkeys, ducks and bees, while the Incas also raised camelids. Also Australia originally lacked the common livestock species.

Like in Europe, livestock keepers in the South were crucial to breed development. Pastoral societies especially have a reputation as careful breeders. They keep pedigrees, test offspring, select the best males for breeding, and prevent less valuable males from breeding by castrating them, tying on aprons, subdividing the herd, and other methods.³

Pastoralists often keep a mix of breeds able to cope with different challenges, so as to be optimally prepared for all eventualities. Some Raika (a pastoralist group in India), for example, are known to differentiate three and possibly more different breeds of sheep in their herd – breeds with high production for good times and ones that do not produce as well but better cope with droughts.⁴ Farming societies have also developed specific breeds, such as Bali and Madura cattle and Garut sheep in Indonesia.

In both smallholder farming and pastoral systems, livestock fulfil multiple functions, and breed development is influenced by social mechanisms such as taboos on selling female animals, and the exchange of animals through dowry, bride wealth or as gifts at births, circumcisions and funerals.⁵

Gene flows from Germany to the South

German influence on southern livestock probably began when German settlers started migrating overseas during the 17th century. However, tracing such early influences is beyond the scope of this study. This section focuses on the 20th century.⁶

1 Hanotte et al. 2002.

2 Williamson and Payne 1978:208.

3 Köhler-Rollefson 2000, 2003.

4 Geerlings 2001.

5 LPPS and Köhler-Rollefson 2005.

6 There is little information available on the destinations of livestock exports, the reasons for the export (breeding, fattening, slaughter, etc.), or who does the exporting (development organizations, commercial firms, etc.). The information in this section is drawn primarily from annual reports of the Umbrella Association of German Cattle Breeders' Associations (ADR, see page 66) and FAO livestock trade statistics, along with secondary literature and interviews.

Herd Movements

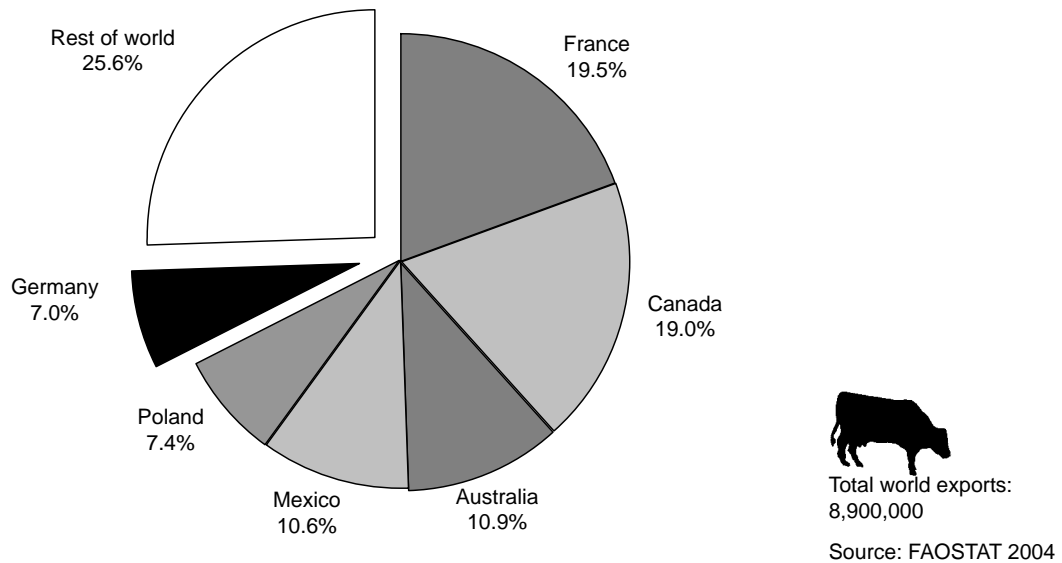


Figure 2 Major exporters of live cattle, 2002

Cattle

Exports of live cattle Before 1900, Germany exported breeding cattle to the Baltic States, Russia, North and South America. By the 1960s, export destinations had expanded to include Algeria, Argentina, Brazil, Chile, Kenya, South Africa, Peru, Tunisia, Turkey and Uruguay.⁷ Exports were mostly of German Holstein and German Simmental (spotted mountain cattle). As demand for high-class breeding stock within Germany was good, the Arbeitsgemeinschaft deutscher Tierzüchter (ADT, Umbrella Association of German Livestock Breeders' Associations) saw no reason "to go in for export at any price".⁸ Nevertheless, brochures in several languages and a film on Simmental cattle in Afrikaans were produced to advertise German cattle at fairs in Europe and overseas.⁹ One leaflet produced by the German Holstein Breeders' Association states that the number of Holstein cattle exported increased from 2,161 animals in 1961 to 6,553 (132 bulls and 6,401 females) in 1968.¹⁰

Germany is now the world's sixth largest exporter of live cattle: with over 600,000 animals exported in 2002, or 7% of the world total (Figure 2). Of these animals, about 10% (between 50,000 and 90,000 a year) are exported for breeding purposes. The vast majority of the breeding animals are females: less than 1000 bulls are exported each year – presumably because their semen is exported instead (see page 23). The remainder are for fattening and slaughter (Figure 3).

Unfortunately the ADR annual reports provide limited data on where these cattle were shipped to. Of the nearly 500,000 breeding cattle exported between 1971 and 1990, 57% went outside the European Union.¹¹ But this designation covers the whole of the rest of the world, so it is not possible to say how many animals were sent to the South. Eastern Europe and the Soviet Union may have been the destination for the bulk of the exports.

⁷ ADT 1961.

⁸ ADT 1961:54.

⁹ See ADR 1959a:40-42 and ADR undated (1960?):64-65.

¹⁰ Verband Deutscher Schwarzbuntzüchter undated.

¹¹ ADR annual reports.

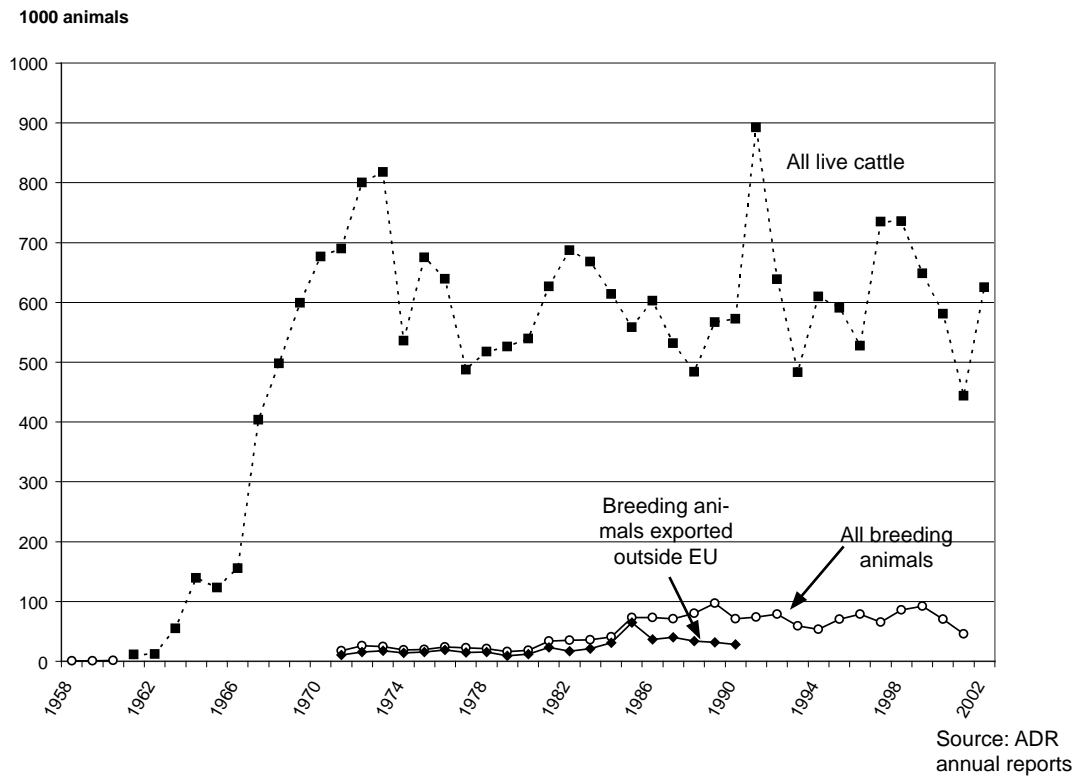


Figure 3 Cattle exported from Germany, 1958-2002

A significant boost to exports of breeding stock occurred in 1985, when nearly 73,000 breeding animals were exported – 30,000 more than the previous year. Numbers sent outside the EU more than doubled (to 65,000) in 1985, but subsequently returned to levels only slightly higher than before the peak. This export peak may be due to the introduction of an EU-wide milk quota in 1984 to curb overproduction. As a consequence many farmers were forced to sell their stock.

According to the former chairman of ADR, Germany was the world’s largest exporter of live breeding cattle before the BSE crisis.¹² Turkey, North Africa and Central Asia were the main developing country markets. For example, some 15–20,000 breeding cattle were sent to Algeria and Morocco. Exports to other southern countries were much smaller: for example, in the late 1980s some 250 cattle went to Kenya, and around 3000 to China. Some 1000 heifers were exported to India.¹³

Export of cattle semen Germany started to export cattle semen in the 1950s in response to requests from abroad. For example South Africa wanted Simmental semen for crossbreeding with its zebu.¹⁴ Before 1980, Rinderproduktion Niedersachsen, a cattle breeding organization in northern Germany, was exporting cattle semen to a long list of countries, including Algeria, Angola, Argentina, Bangladesh, Bolivia, Brazil, Chile, China, Ethiopia, Ghana, India, Jordan, Kenya, Korea, Pakistan, Peru, Philippines, South Africa, Thailand, Tunisia and Uganda.¹⁵

12 BSE stands for bovine spongiform encephalopathy; Germany announced its first case in a native-born cow on 24 November 2000 (CEI 2000).

13 Klaus Meyn personal communication December 2003.

14 ADR 1955.

15 Verband Deutscher Schwarzbuntzüchter undated.

Herd Movements

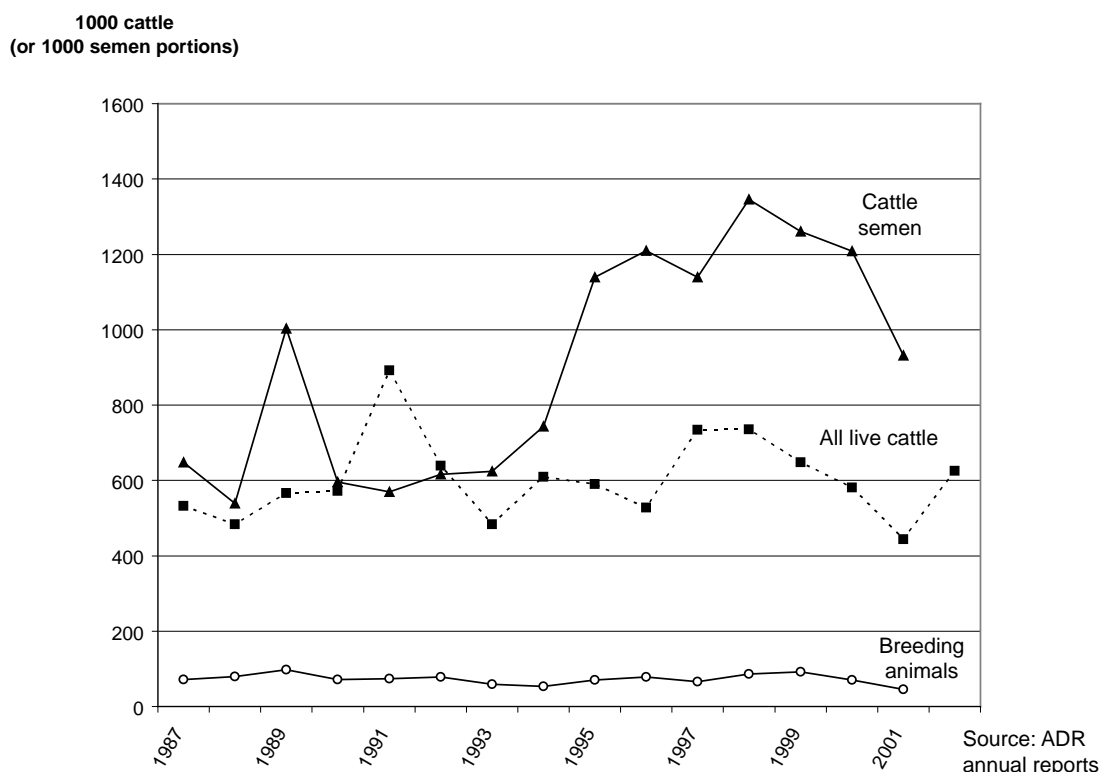


Figure 4 Exports of live cattle and semen from Germany, 1987-2001

Up to 1986, the ADR annual reports provide only sporadic information on semen exports. In 1973 some 213,544 portions were exported to 36 countries; 94% went outside the EU.¹⁶ In 1983 and 1984 a total of about 800,000 portions were shipped: German Holstein to Arab countries and Africa, Simmental to Africa, and German Yellow to Brazil and Paraguay.¹⁷

During the period 1987–2001, Germany exported nearly 13.6 million portions of semen (Figure 4). Semen exports finally overtook exports of live animals in 1993; now about a million semen portions a year are exported: about twice as many as all live cattle.

There are no data on the numbers of calves born outside Germany as a result of insemination using this semen. However, even allowing for the need for multiple inseminations and for wastage, semen exports are likely to produce far more calves each year than the 50–90,000 breeding animals that are exported live each year.^{18,19}

Of the 13.6 million semen portions exported between 1987 and 2001, about two-thirds went to the developed world (Figure 6). Of the remainder, 6% were shipped to the Mediterranean and Middle East, another 6% to Central and South America, and only 2% each to Asia and Africa. As a result, a large number of calves born in the developing world in this period have been able to claim a German bull as their father.

¹⁶ ADR 1974.

¹⁷ ADR 1985.

¹⁸ Kaziboni et al. 2004 report 35-71% insemination success rates in the literature, and 1.64 inseminations needed per cow by newly trained, inexperienced inseminators in Zimbabwe. See also Box 3.

¹⁹ The picture might look different if we were to consider the number of offspring that the breeding bulls produce in the importing countries. But again, no data on this are available.

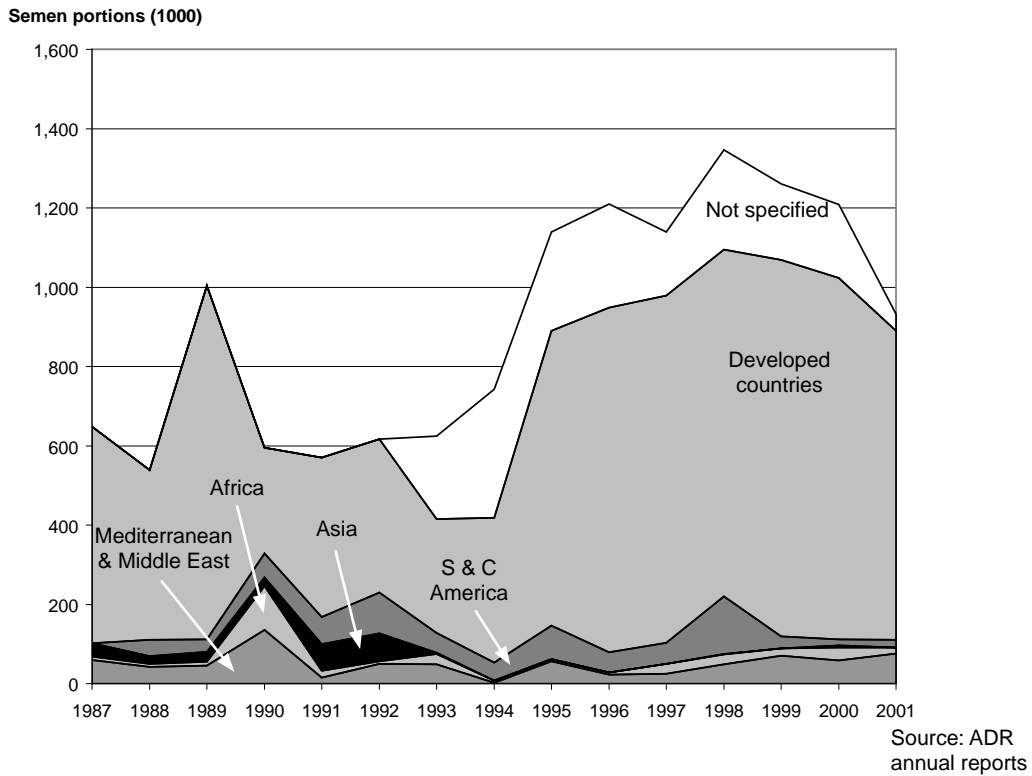
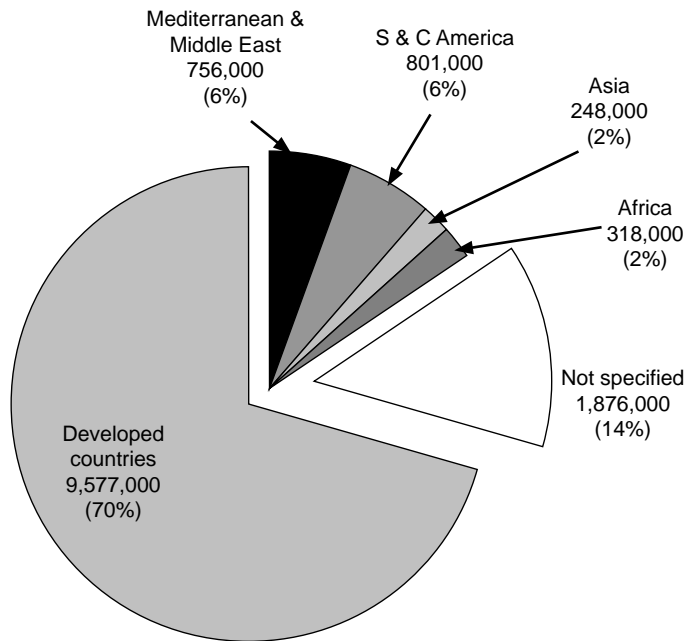


Figure 5 Export of cattle semen from Germany, 1987–2001



Figures are number of semen portions exported

Total = 13,575,000 semen portions

Source: ADR annual reports.

Figure 6 Destination of cattle semen exports from Germany, 1987–2001

Herd Movements

Sheep and goats

Compared with cattle, there is far less information available about German exports of sheep and goats, which are relatively unimportant in German agriculture. Germany is only a minor exporter of live sheep and goats. Only about 70,000 animals (almost all sheep) are exported a year – less than 1% of world trade in these species.²⁰ This figure includes both breeding and meat animals.

In 1932, the German Mutton Merino was introduced into South Africa, where it was used to develop the South African Mutton Merino, as well as the composite breeds Dohne Merino and Dormer.²¹ A German Merino ram was also used in South Africa's Vandor breeding programme to improve the Vandor's wool and mutton qualities.²² Furthermore, the German Mutton Merino was exported to Egypt with the aim of building up the production of fine wool in that country. The animals were probably introduced in the early 1960s, and they seem to have had problems getting used to the local climate.²³

In 1961, ADT reported a rising demand for German breeding sheep abroad. Among the countries receiving animals from Germany were Argentina, Chile, Congo, South Africa and Turkey. In 1960, some 4000 breeding animals were exported, but there is no information about their destination.²⁴

German goat exports to the South around 1960 seemed to go mainly to South Africa.²⁵

Starting in 1980, however, Humboldt University in Germany helped the University of Malaya to create and test a dual-purpose breed by crossing Kambing Katjang with German Fawn.²⁶ Unfortunately there is no information on how widely this breed has been adopted.

Pigs

Pigs are a far more important export for Germany. The country is the world's sixth-largest exporter, accounting for 6.6% of the total trade (Figure 7).

Despite this, little information is available on the export of breeding pigs or their semen. The annual reports of the Union of German Pig Producers for 2001 and 2002 do not give export data for breeding stock. The data of the Federal Statistical Office and Eurostat provide export information only on pure breeds.

Unlike the case with other livestock, there seem to have been few pig-breeding projects in the developing world with German involvement. A German specialist was reportedly involved in a project developing intensive pig farms in Singapore that started in the 1970s.²⁷ However, this project phased out by 1987 (about 8 years earlier than planned) because of the limited land and water available in Singapore and local residents' objections to the smell.²⁸

20 CEI 2000.

21 Ramsay et al. undated:78, 80 and 84.

22 Ramsay et al. undated:86.

23 Grell 1973:82.

24 ADT 1961:88.

25 ADT 1961:88.

26 Hirooka et al. 1997.

27 Maria Ng personal communication September 1992.

28 Chark 1998.

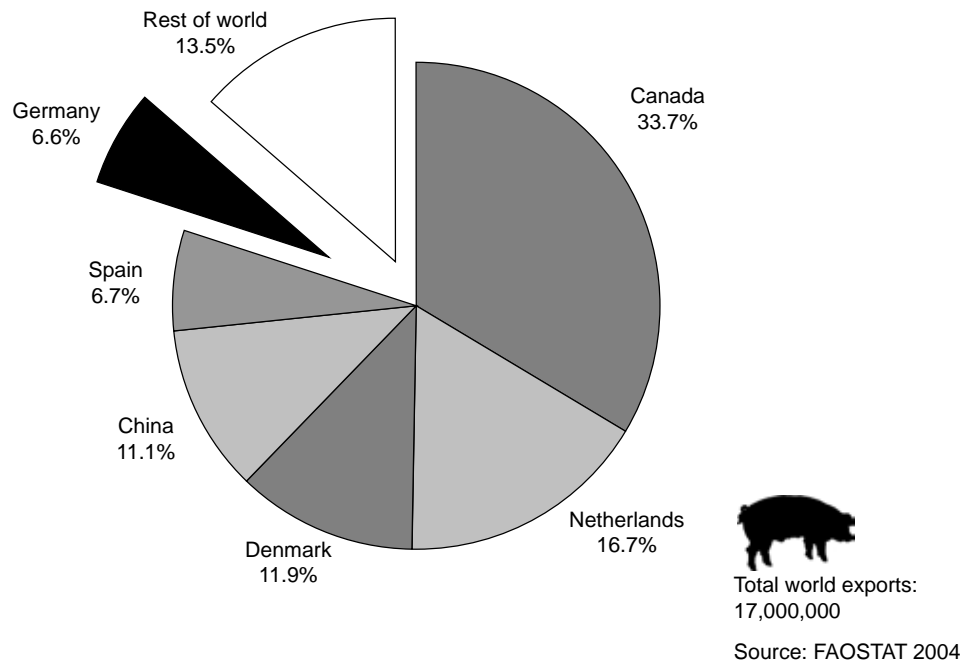


Figure 7 Major exporters of live pigs, 2002

Poultry

Germany is also a major player in world poultry trade. In 2002 it shipped nearly 850 million chickens abroad, 14% of the world total, and second only to the Netherlands (Figure 8). These data (from FAO) presumably cover mainly day-old chicks, plus perhaps a few mature birds, but not fertilized eggs. There is, however, little information available on poultry exports related to development projects.

Patents do not yet play a role in the poultry industry.²⁹ Instead, poultry firms guard their breeding stock jealously by signing contracts with growers who raise the birds. A firm may keep its purebred “grandparent” or “great-grandparent” lines (breeds) closely guarded, and export only the “parent lines” (the offspring of the grandparents). The importing firms then breed from these birds to produce eggs and broilers for sale to consumers. It would be very costly for a firm in the South to develop its own purebred lines: it would have to invest a large amount in research and breeding effort, so would not be able to compete with imports of meat and eggs (see Box 2). It is cheaper to rely on Northern breeders for a supply of breeding stock. The Northern firms, on the other hand, lack the local presence and expertise to penetrate a Southern market, so often license Southern firms to act as distributors of their breeding stock to outgrowers.³⁰

Modern poultry production is a highly intensive industry. The birds are raised indoors under controlled conditions, are fed on manufactured feed, are kept isolated from sources of disease, and are under intensive veterinary care. Conditions in a poultry house in the North are not very different from those in a commercial unit in the South. This makes it possible to transfer whole production systems from North to South, including the breeds that inhabit them. (The same is true of pig production, but is not the case for cattle.)

29 Hoffmann et al. 2004.

30 Anonymous personal communication 2005.

Herd Movements

This has enabled poultry firms to expand rapidly in southern markets. For example, a farm in Malaysia that produces more than a million eggs a day imports Lohmann Brown Layers as their parent stock.³¹ In 1999, Lohmann LSL (a strain of layer chickens that produce white eggs) accounted for 70% of the market in Saudi Arabia and 50% in the Gulf States and Yemen. At first, day-old chicks were imported from Europe, but now most are distributed by Arab Poultry Breeders Co.³²

Summary

Germany has exported significant numbers of breeding cattle, the vast majority of them females. It exports few live bulls, but it ships large quantities of semen to the developing world, mainly to the Mediterranean, the Middle East, and South and Central America. Assuming that the exported bulls have produced additional numbers of offspring through artificial insemination, all-in-all substantial quantities of German cattle genes were introduced into the South during the 20th century.

Germany is a major exporter of pigs and chickens, but there is not enough information to draw any conclusions about the influence of German pig and chicken breeds in the South.

Germany is a minor exporter of sheep and goats, and with the exception of the German Merino, German breeds have had little impact in the developing world.

Costs and benefits to Germany

Looking at the exporters' side, German farmers benefited from cattle exports in two ways: not only could they sell their animals; they also received an additional sum through export subsidies. Until 2003, subsidies for breeding cattle shipped outside the Union were paid by kg live weight and could sum up to several hundred euros per animal. So German (and other European) taxpayers shouldered part of the costs of the export. There seems to be no difference whether the animals were exported by a commercial firm or a donor organization – except that in the latter case, the taxpayer also paid for the development project if it was financed by the EU or the government. However, development aid seems to have played only a minor role behind the German exports of live breeding cattle.³³

The German economy as a whole gains as the exports open new markets. Europe's exports of several hundred thousand pregnant heifers to Turkey in the mid1990s – subsidized by the EU – were reportedly highly lucrative for both the European export companies and the importing companies in Turkey.³⁴

For semen, foreign markets offered German insemination organizations not only a business outlet but also an opportunity to utilize the sperm of “waiting bulls” (animals whose progeny had not yet been tested – see page 7) that otherwise could not be sold in Germany. In 1980, *Rinderproduktion Niedersachsen* had about 6 million portions of semen from 150 waiting bulls available, and provided some of this (there is no record of how much) to developing countries.³⁵

31 Lohmann Tierzucht 2002. Lohmann is a German firm but the sources do not say whether the layers originated from Germany or other European countries.

32 Lohmann Tierzucht 1999.

33 Klaus Meyn personal communication December 2002.

34 Barwinek and Gürer 1997.

35 RPN 1980:42-44.

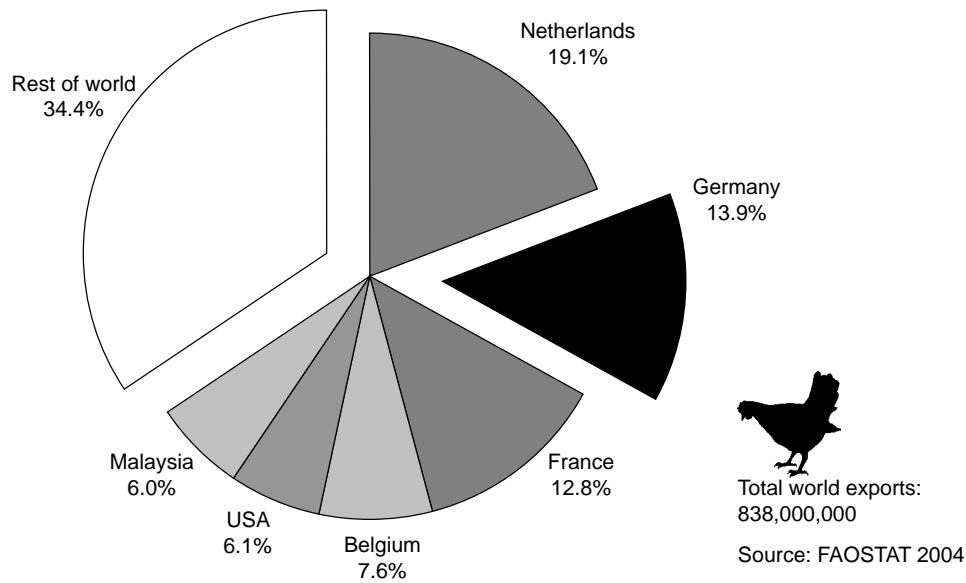


Figure 8 Major exporters of live chickens, 2002

Gene flows from other Northern countries to the South

Germany has been only one among several players – and not the largest, as the examples of cattle semen and breeding pigs show.

Large exporters of cattle semen in the North include other European countries, the USA, Canada, Australia, and New Zealand. For example, in 1995–96, New Zealand, Australia, Canada and the Netherlands supplied some 140,000 doses of deep-frozen semen to Sri Lanka (46,000 Holstein Friesian, 88,000 Jersey and 6,000 Australian Milking Zebu).³⁶ In 1985–93, semen suppliers to Nepal included Canada, Denmark, Finland, France, Germany, Italy, New Zealand and the USA,³⁷ with the USA and New Zealand probably the most important. Further examples can be found in chapter 5 (pages 32 ff).

For pigs, the UK was the largest global exporter of pure-bred breeding animals until the 2001 foot-and-mouth disease epidemic. It was followed by the USA and France.³⁸ Other large exporters are Canada and Denmark. For example, the Canadian firm Hypor announced that in 2003 it had flown more than 600 Canadian pigs to China. This one shipment accounted for more than 70% of the total import of breeding pigs to China in 2003.³⁹ The Danish firm Danbred supplies breeding pigs to China, Vietnam, Thailand and Malaysia.⁴⁰ However, the biggest commercial supplier of breeding pigs is the UK-based PIC International Group, which operates in 30

36 Schrage et al. 1997:185-86.

37 Shrest and Sherchand 1997:106.

38 Meredith 2002.

39 See "Canadian pigs fly first class" www.beijing.gc.ca/beijing/en/navmain/media/partnerships/1054.htm (accessed 20 April 2005).

40 See www.danbred.dk/smcms/DanBred/news/news_2/3924/3933/Index.htm?ID=3933 (accessed 20 April 2005).

Herd Movements

countries and is currently expanding into Asia.⁴¹ Another large supplier of breeding materials is Topigs, a firm group that has its origin in the Netherlands.⁴²

South–South gene flows

Some southern countries have been remarkably successful in using breeds from other countries in the South. The Nelore is illustrative. This cattle breed originates from Indian zebu-type Ongole cattle that Brazil started buying from India in the early 1900s.⁴³ In Brazil it was called Nelore, after a district in India in present-day Andhra Pradesh. The breed thrived in South America, and in the 1950s Argentina started its own breeding programme for the “Nelore Argentino”.⁴⁴ The Nelore later was exported to the USA and there became one of the Brahman progenitors (see above). In 1995, the breed made up more than 60% of Brazil’s 160 million cattle⁴⁵ and in 2005 some 85% of Brazil 190 million cattle had Nelore blood.⁴⁶

Ironically, while the Ongole has been successfully established in a number of countries in North and South America, the West Indies, Southeast Asia, and Australia,⁴⁷ its population has greatly declined in its original range in coastal Andhra Pradesh, and it is qualitatively inferior to the Ongole population in Brazil.⁴⁸

Another country that has successfully developed breeds with stock introduced from other southern countries is South Africa. Examples include the Damara sheep originating from neighbouring Namibia and the Dorper, a cross between the Somali Persian Blackhead and Dorset Horn sheep.⁴⁹

The N’Dama cattle from West Africa, which tolerates trypanosomosis, a debilitating disease transmitted by tsetse flies, has been successfully introduced to Gabon, Congo-Brazzaville, the Democratic Republic of Congo, and the Central African Republic.⁵⁰

In some instances, South–South exchanges have been facilitated by development aid. Such exchanges have taken place in form of both live animals and semen. For example, German projects introduced Sahiwal cattle from Pakistan to Kenya to improve milk production, and semen from Kenya to Zaire for a beef project.⁵¹

41 See www.pic.com/about_us/ (accessed 20 April 2005). PIC stands for ‘Pig Improvement Company’.

42 See www.topigs.com/ (accessed 20 April 2005).

43 Khurana 1997:35. Incidentally, zebus that were on their way from India to Brazil stopped over in the port of Antwerp in 1920, triggering a rinderpest outbreak in Belgium. This led to the establishment of the World Organization for Animal Health (OIE) four years later (www.oie.int/eng/OIE/en_histoire.htm accessed 7 August 2004).

44 Beck 1983:8.

45 OSU breed database www.ansi.okstate.edu/breeds/cattle/nelore/ (accessed 25 May 2005).

46 See www.findarticles.com/p/articles/mi_m0HDV/is_1_47/ai_n11839930 (accessed 25 May 2005).

47 see Nath 1993 and www.fao.org/ag/AGa/AGAP/FRG/FEEDback/War/v0600b/v0600b00.gif (accessed 16 June 2004).

48 Beck 1983:8.

49 Ramsay et al. undated.

50 OSU breed database www.ansi.okstate.edu/breeds/cattle/ndama/ (accessed 27 October 2004).

51 GTZ 1976:29.

Costs and benefits to the exporting countries

It is difficult to estimate the costs versus benefits of the exports of live animals and their genetic materials for the exporting countries involved. With regard to breeding animals transferred as part of development agreements, it can be assumed that donor countries gained (back) a substantial proportion of the money invested in breeding programmes in the South, as large parts of international aid are tied to the purchase of goods and services from the donor country.⁵² Live-stock projects have been no exception. For example, in the 1990s the Canadian-supported Lean Swine Project in China imported the project's 827 pigs... from Canada.⁵³

52 Greenhill and Watt 2005.

53 See www.ccag.com.cn/english/projects/prj_swine_eng.htm (accessed 20 April 2005).

5 Driving forces of gene flows to the South

HISTORICALLY, COLONIZATION and trade have been important vehicles for gene flows from North to South. In the 20th century, development aid became another major force. It is hard to say how many of the animals and breeding materials have been shipped by development organizations, and how many were transported for commercial reasons. Reports from seven countries in Asia indicate that in the mid-1990s the promotion of exotic genetic materials of cattle, sheep and goats still was mostly in the hands of governments,¹ which often received development aid to support such activities. In Sri Lanka, on the other hand, at least 90% of all purchased breeding animals were thought to be bought on a private basis² – an indication that here at least, development aid played only a minor role. This is probably true especially in pigs and poultry, because of the early intensification of this sector. Still, national and global trade regulations set the stage for such developments.

Players in international livestock development

Many **development organizations** have been active in the field of animal breeding especially from the 1960s to 1990s (see Box 6 for an overview). Their involvement seems to have been quite substantial. An overview by one of the German insemination stations found that at the end of the 1980s some 5 million doses of semen were traded around the globe – mostly of cattle, but also limited amounts from horses, pigs, goats and dogs. According to this review, “...the majority of Third World countries are supplied with frozen semen by donor organizations (FAO, World Bank, GTZ and others)”.³

Universities and research institutions have also been involved in introducing foreign breeds into the South. However, these institutions seemed to play mostly a supportive and facilitating role, testing breed combinations and evaluating crossbreeding programmes rather than introducing large quantities of exotic genetic materials.⁴

Commercial players have become more important in recent years, especially in the swine and poultry sectors, and also for dairy development.

The activities of development organizations and commercial firms have always been connected to a certain extent. For example, in Germany all exports of live animals have to be implemented through specific, licensed export firms whether the animals are exported for commercial or development aid reasons. The collaboration of the aid and commercial sectors is likely to rise further as public–private partnerships become a more important development approach.

An example of such a partnership is a dairy development project in Tanzania, run by Land O’Lakes (a US-based dairy cooperative) with USAID support. The project plans “to bring WorldWide Sires (WWS) into a range of project activities and introduce them to the artificial insemination market in Tanzania. WWS will, in turn, assist entrepreneurs to develop business

1 Gall 1997:210 ff.

2 Schrage et al. 1997:183.

3 Höfer et al. 1982:78.

4 See, for example, Pirchner 1982, Djimde and Weniger 1986.

Box 6 Development organizations involved in animal breeding in the South

International agencies Perhaps the most important international agencies with regard to gene flows are the World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD).

Some examples:

- World Bank projects provided breeding stock and supported artificial insemination in countries such as China, India, Morocco, Nigeria, Tunisia and Vietnam.¹
- FAO and UNDP were involved in breeding programmes in Kenya and Vietnam,² as well as the pig project in Singapore mentioned on page 26.
- Under an IFAD-sponsored restocking programme, 16 projects covering 13 developing countries focused on genetic improvement.³

Other agencies playing a role on the livestock sector have been the Asian and African Development Banks, and the European Union.

Bilateral donors A number of governments have funded projects that have included the spread of livestock breeding material. In East Africa, for example, projects funded by Sweden and the Netherlands provided Kenya with cattle semen, while Danish aid did the same for Tanzania.⁴ GTZ helped various countries, including Bangladesh, Columbia, India, Malaysia, Morocco and Zaire to establish artificial insemination centres.⁵ The Swiss Development Cooperation (SDC) has been an important donor for the livestock sector, for example supporting comprehensive dairying and goat crossbreeding projects in India.⁶ Dairy development in Thailand has been supported by the governments of Denmark and Germany.⁷

Universities and university-based consortia Many universities from the North have collaborated with their counterparts in the South to develop breeding programmes and test crossbreds and local breeds. For example, the USAID-funded Small Ruminant Collaborative Research Support Program (SR-CRSP) conducted breed-related livestock research in Bolivia, Brazil, Indonesia, Kenya, Morocco and Peru between 1980 and 1997⁸ and supported the development of dual-purpose goats in Kenya and prolific sheep in Indonesia.⁹

Non-government organizations (NGOs) Various international NGOs have been involved in livestock breeding, distribution and multiplication programmes. They include Heifer Project International (HPI), FARMAfrica, Land O'Lakes, Vétérinaires Sans Frontières and Winrock International. National NGOs are also among the players in animal breeding. In India, the NGO BAIF has set up artificial insemination projects in several states.¹⁰

1 De Haan 2003.

2 See, for example, www.fao.org.vn/agri-closedE2.htm (accessed 25 May 2005).

3 The short project overviews posted on the Internet rarely name specific breeds, though a few do mention the use of foreign breeds. See www.ifad.org/lrkm/range/projects.htm (accessed 14 August 2004).

4 De Haan 2003.

5 GTZ 1976.

6 FAO 2001, Geerlings et al. 2002.

7 Chantalakhana and Skunmun 2002.

8 See www.ssu.missouri.edu/ssu/srcrsp/srcrspal.htm (accessed 12 August 2004) and www.gm-unccd.org/FIELD/Bilaterals/USA/FR_GL.htm (accessed 12 August 2004).

9 See www.ssu.missouri.edu/faculty/CValdivia/publications/SocietyRM98/genderone.htm (accessed 25 May 2005).

10 See www.baif.com/livestock_dvlpt_gainful.htm (accessed 30 May 2005).

Herd Movements

services that will serve dairy producers.”⁵ WorldWide Sires regards itself as “the world’s leading cattle genetics marketing organization” and represents the majority of US artificial insemination cooperatives.⁶

Another example is the collaboration of the International Finance Corporation (the private sector development arm of the World Bank Group) with PIC International to support the establishment of pig breeding farms in China.⁷

Development paradigms in livestock breeding

Approaches used in development cooperation have changed along a continuum from top-down to bottom-up – although the latter is rarely truly achieved in reality. In the early phases of development work, technologies developed in the North were transferred without much adaptation to the South. Many of these attempts failed, and the emphasis switched to the promotion of “appropriate technologies”. However, many of these projects also did not live up to expectations because they continued to view people as “targets” rather than partners, and they neglected the social dimension of development. Participatory and institution-building approaches then emerged, involving local people – first as informants (e.g., rapid rural appraisal) and later as partners (participatory appraisals). Finally, some development professionals started “handing over the stick”, i.e., taking on a supportive rather than a leading role.⁸ At the same time, recognition grew that local people’s own knowledge and inventions might be useful, rather than merely out-of-date and superstitious.

Livestock development has followed a similar path, moving from the transfer of unadapted high technologies, to the promotion of more adapted technologies, and finally to the recognition of the value of locally available resources. The overarching goal was to help smallholder livestock keepers in rural areas.

Breed substitution

At first, “exotic” pure breeds from the North were introduced to the South. In the 1970s and early 1980s, “massive exports of lots of 500–1000 head of mostly female stock, especially Holstein Friesian from US and Europe” went to large parastatals and private producers in East Africa and Latin America.⁹ The animals were not adapted to hot and humid climates, and required high-quality fodder not available on small farms. They failed to produce in their new environment, and many succumbed to local diseases.

5 Nooter 2004.

6 www.wwsires.com/Flash/HomePage.html (accessed 14 August 2004).

7 See www.worldbank.org.cn/English/ifc/jilin-adc.htm (accessed 23 August 2004).

8 Chambers 1997.

9 De Haan 2003.

Crossbreeding – a shortcut to higher yields

Crossbreeding local with high-yielding breeds became the new paradigm. It was viewed as a cheap method to raise yields quickly, especially when semen rather than live animals was used.¹⁰ One author even speaks of an “arbitrary crossbreeding euphoria” in developing countries.¹¹ When tested on-station, crossbreds commonly produced better than their local parent, and coped better with climate and diseases than their exotic parent. However, in low-input traditional systems, the crossbreds reached their potential only if the conditions were favourable and their keepers could supply the necessary inputs, such as improved fodder. But smallholder livestock keepers, especially, could not maintain the animals in the long run, and many development projects failed to achieve sustainable improvements.¹²

Recognizing the value of local breeds

Finally, attention moved to the local breeds that the communities in the South themselves have developed over many centuries. These breeds had long been regarded as low-producing and inferior. Studies on their performance commonly concentrated on productive and reproductive aspects, rarely considering inputs, an animal’s multiple functions and other factors – though quite a few sources also noted that improved management was likely to raise the performance of the traditional system.¹³ Furthermore, official statistics rarely fully reflect the production of pastoralists and smallholder farmers, many of whom continue to rely on local breeds.

The value of local breeds became widely recognized only when studies began to measure performance comprehensively and when other ways were found to compare the output between local and improved breeds. Examples are using the unit of body weight or a herd’s economic output per area as the basis of comparison, instead of weighing the performance of individual animals against each other.¹⁴ Furthermore, local breeds have many traits of potential value to livestock industries elsewhere.¹⁵ Nowadays a number of projects focus on the conservation of selected local breeds, and help their keepers to improve their breeds and explore market niches for their products.¹⁶

Government regulations and incentives

In the 1960s, many governments in the South started drafting and implementing livestock breeding policies, favouring the introduction of pure breeds and widespread crossbreeding.¹⁷ This opened the door to the introduction of high-yielding animals and semen from other countries.

10 Pirchner 1982.

11 Horst 1985:59.

12 Sölkner et al. 1998, FAO 2001, Kosgey 2004.

13 Examples can be found in the issues of the *Tropical Animal Health and Production* published in the 1970s and 1980s.

14 For examples, see Fletcher et al. 1985 and FAO 2001; Bayer et al. (2003); and several articles in *Ecological Economics* 45(3), 2004.

15 Gibson 2002.

16 Geerlings et al. 2002, Kosgey 2004.

17 For example, see the country reports on India, Pakistan, the Philippines and Sri Lanka in MLD&RI and GTZ 1997.

Herd Movements

For example, by importing breeding stock, raw material for feed and farm equipment, Malaysia became more than 100% self-sufficient in poultry meat, eggs and pork in less than 20 years.¹⁸

However, government-run programmes often lacked clear and long-term breeding goals. In many countries, animal dispersal programmes seemed to have followed the principle of trial-and-error – basically experimenting with livestock keepers' animals, without systematic selection and performance testing. National breeding programmes were halted and switched their breeds and strategies before the first offspring generation was ready for evaluation.¹⁹ Despite the strong government support and substantial amounts of money invested in such breeding programmes their overall coverage remained low in many countries.²⁰

In some countries politics promoted the breed-improvement programmes so strongly that information on their drawbacks was suppressed. In Indonesia, for example, university researchers found that Australian Brahms imported through a development project failed to get pregnant – but they were not allowed to voice this in public.²¹

The introduction of exotic pure breeds and crossbreeding between local and high performance breeds have often been facilitated through incentives. These have included:

- Credit schemes, as in the introduction of European cattle breeds to Turkey.²²
- The distribution of free livestock, semen and other inputs.
- The provision of free extension and animal health services.

If animals are given on credit, some projects have requested recipients to pay back cash. However, farmers may sell their animal(s) if they cannot repay the money. Another common way of repayment has been to ask farmers to return one or more offspring to the project for further dispersal. HPI has practised such a keep-one, share-one approach in numerous countries for the past five or six decades, combined with the provision of information and training.²³

Commercialization in the South

In many countries in the South, a large proportion of livestock keepers continue to raise their animals as they have learned from their parents. They may have adopted modern veterinary drugs, and perhaps they raise crossbred animals rather than traditional breeds. But the paraphernalia of modern production – high-tech housing, feeding and watering systems, artificial insemination, transport, and formal slaughter and marketing systems – are often confined to only the largest farms and enterprises.

However, the situation is rapidly changing. During the past few decades, industrial pig and poultry units started expanding into the South. Driven by commercial interests of northern firms and the rising interest in modern breeds and technologies of developing countries, modern production systems have been transferred more or less wholesale to the developing world. In the dairy sector, too, large-scale production units have started to expand (see also pages 27 and 48). As a result, a two-level structure to the industry is emerging: modern and traditional.

18 Salim 1984, p.2.

19 See, for example, Apelo 1997:140, 149-150.

20 Gall 1997:211.

21 Author's personal experience in Indonesia in 1981.

22 Barwinek and Gürer 1997.

23 See www.heifer.org (accessed 21 April 2005).

These trends will be enhanced, as demand for meat and milk in developing countries is rising rapidly. It is expected to double in the next two decades, triggering a “Livestock Revolution”.²⁴ Introduced pig and poultry breeds (often hybrids) still make up a small proportion of the overall numbers of these species in the South. More than 80% of the developing world’s poultry are kept in traditional family-based production systems²⁵ – a large portion of which rely mainly on local breeds. But in the long run, the rapid expansion of industrial production may put these local populations increasingly under pressure.

24 Delgado et al. 1999.

25 Guèye 2005.

6 Impact of global gene flows in the South

MASSIVE IMPORTS of breeding animals and materials – but the frequent failure of high-performance animals and crossbreds, and the low calving rates from artificial insemination (Box 3): These trends seem to counterbalance each other. So what impact have gene flows from the North actually had on the South?

Breed numbers

According to data collected by the FAO, during the 20th century 740 breeds have been recorded extinct globally. Only about 18% of these were located in the South (Table 6).¹ The data probably underestimate the losses in the South. Systematic data collection in the South started later and is more difficult than in the North, so breeds might have been overlooked or died out before the onset of recording. Besides, the listing includes suspiciously few southern countries and the extinction of poultry breeds is mentioned only for China. Furthermore, while the 3rd edition of the World Watch List of Domestic Animals reports only one pig breed extinct for Brazil,² more recent counts put the number up to 20.³ All these observations point to higher losses in the South than have been published so far. Nevertheless the data indicate that most breed losses in the 20th century occurred in the North – a conclusion supported also by other sources.⁴

The situation is different when it comes to the numbers of breeds at risk, rather than extinct. Of 6,379 recognized livestock and poultry breeds, 1,694 are listed as critical or endangered,⁵ and 60% of these are in the South.⁶ A preliminary assessment of information in more than 80 country reports compiled as the basis of the forthcoming State of the World's Report indicates that the number of threatened breeds is further increasing.⁷

The Domestic Animal Genetic Resources Information System (DAGRIS) of the International Livestock Research Centre (ILRI) documents the status of cattle, sheep and goat breeds in Africa. Of the 152 cattle breeds listed, 47 are shown as at risk in at least one country (the risk status of a further 42 breeds is unknown).⁸

The situation for other species is also disturbing. In goats, DAGRIS classifies nearly three-quarters (45 of 62) of the documented breeds in Africa as “critical” or “endangered”. For pigs, the 12 still existing native pig breeds in Brazil are all at risk.⁹

These figures are alarming. They indicate that the South could become the hotspot of 21st century's breed loss. However, the literature offers little information on specific cases. Recent

1 Scherf 2000.

2 Scherf 2000.

3 Northoff 2004.

4 Hall and Ruane 1993 and IDL Group 2002.

5 Scherf 2000.

6 FAO undated: 1.

7 Northoff 2004.

8 For cattle, DAGRIS lists the risk status of 115 breeds (<http://dagris.ilri.cgiar.org>, accessed 1 Sept 2005). However, if a breed occurs in several countries, DAGRIS lists it separately for each one. The figures from DAGRIS for cattle and goats in this chapter eliminate such double-counting.

9 Northoff 2004.

Table 6 Number of breeds of domestic livestock (mammals and poultry) recorded as extinct in the South

	Breeds
Africa	39
Asia & Pacific (except Australia & New Zealand)	38
Latin America & Caribbean	27
Near East	27
Total South	131
World	740

Source: Scherf 2000.

case studies in Ghana, Kenya and Thailand did not reveal any indications that breed losses had occurred.¹⁰ Other sources mention cases where cattle and sheep have been threatened through animals and genes coming in from outside (Box 7).

Risk factors

The DAGRIS database mentions risk factors for 47 cattle breeds categorized as threatened (“critical”, “endangered”, “vulnerable” or “rare”). Nearly 30% are threatened by crossbreeding with exotics. “Crossbreeding”, “neglect” or “replacement” together threaten about 60% of these breeds. Other important causes are uncontrolled interbreeding with other local breeds, and conflict (Table 7).

These data suggest that crossbreeding with exotic breeds and disregard for the local breeds are major threats to some indigenous livestock breeds in the South. In this context the term “crossbreeding” probably stands for breed improvement programmes in general: crossbreeding has a long history in livestock development both in modern and traditional breeding practice¹¹ and the technology *per se* will not automatically lead to breed extinction. However, if used indiscriminately in breeding programmes, crossbreeding can become a threat. The example of some pig breeds in China shows that breed loss can be avoided if adequate conservation measures are implemented, or if the population size of the local breed is large.¹²

DAGRIS does not mention other risk factors such as “change of husbandry system”, “expansion of large-scale intensive livestock production” or “people giving up herding or farming” – perhaps because such issues are hard to trace and statistics difficult to find.¹³ Other sources, however, see them as key threats to breed diversity.¹⁴

Such changes are very complex and it is not always clear what is the cause and what the outcome. Politics has been a key modulator, through setting the stage for development and by laws affecting breeds and breeding. The Nguni cattle population in South Africa, for example, was decimated due to an Act in 1934 that designated local cattle as “scrub” and empowered livestock inspectors to castrate bulls in the communities.¹⁵

10 IDL Group 2002.

11 See Wu 1998 for traditional (cross)breeding in yaks.

12 Horst 1989, Mason and Crawford 1993:153.

13 Delgado et al. 2003, section 9.2.1.

14 Hall and Ruane 1993, Köhler-Rollefson 2005, Hoffmann 2005.

15 Bester et al. 2003:46.

Box 7 Examples of livestock breeds endangered through crossbreeding

- The Namaqua Afrikaner sheep in South Africa and Namibia has nearly become extinct through crossbreeding for a more market-acceptable carcass.¹
- In Kenya, purebred Red Maasai sheep are hard to find because of widespread crossbreeding with Dorper and other breeds.²
- A crossbreeding programme in Kerala, India, converted about two-thirds of the state's cattle population to crossbreds, nearly driving the Vechur cattle to extinction.³
- In Thailand the number of purebred Kao (white) Lumpoon cattle has drastically declined over the past few decades due to the introduction of a crossbreeding programme with Brahman cattle.⁴

1 Ramsay et al. undated:36.

2 John Gibson personal communication 2004, Baker and Gray (2003) cited in Kosgey 2004:219.

3 FAO 2001.

4 Director General of the Department of Livestock Development in Thailand cited in Anonymous 1995:118.

Table 7 Main causes of threat to African cattle breeds

Cause ^a	Number of breeds	Percentage of total
Crossbreeding or upgrading with exotics	13	28%
Neglect	13	28%
Replacement	6	13%
Subtotal (crossbreeding, neglect or replacement)	27	57%
Interbreeding	19	40%
Conflict	11	23%
Other reasons (lack of programmes, disease, etc.)	3	6%
Not specified	12	26%
Total number of breeds^b	47	

^a The database does not include sources for specific information nor gives it explanations and definitions of the different causes.

^b Includes "critical", "endangered", "vulnerable" and "rare" categories. A breed may be subject to more than one type of threat, so items in the column do not sum to the total.

Source: summarized from DAGRIS, <http://dagris.ilri.cgiar.org> (accessed on 1 Sept 2005).

Camels in Rajasthan, in semi-arid western India, offer another example of the importance of politics. In parts of the state, the camel population fell by nearly half between 1995 and 2004 as the area's grazing resources shrank drastically through a combination of government-encouraged expansion of irrigated cropping and the closure of national parks to grazing.¹⁶ But as irrigation depletes the groundwater, it is unlikely to be sustainable in the long run, so livestock keeping is likely to regain importance. Will livestock keepers be interested in reviving their camel herds? This depends in large part on whether government regulations support their struggle to make a living.

Market competition as a threat to local breeds

The situation is somewhat different in pigs and poultry. Here market competition has clearly posed a bigger threat to local breeds than efforts to upgrade poultry stock and crossbreeding programmes.¹⁷ The latter have rarely been successful because the introduced animals and their crossbred offspring did not perform and often died under the disease-prone conditions in developing countries. A telling example is Nigeria's Operation Coq, which in the 1970s endeavoured to replace all local cocks in cooperating villages within one or two years. The scheme ended in failure – but not without absorbing almost all of the nation's poultry research and veterinary resources.¹⁸

Because of the worldwide trends towards livestock industrialization, market competition will increasingly affect also the production of cattle and perhaps other species both in the South and North. Given the speed of globalization and rural change, industrialization and market competition are likely to affect local producers and breeds on a much larger scale and much more quickly than crossbreeding and other gene-flow-related factors have done in the past. The pressure of market competition on local breeds rises if governments facilitate the establishment of livestock industries through laws and incentives that disadvantage smallholders. Such incentives include access to credits, pricing politics, and offering services geared towards large producers.¹⁹

Genetic diversity

Breed diversity is just one indicator of livestock diversity. Another indicator is genetic diversity within the breed.

Tracing impacts of gene flows at the genetic level is more complicated than assessing breed numbers. The loss of a breed does not necessarily mean the loss of its genes. It may have interbred or been crossbred with other strains. Its genes may still be present (though diluted) in the crossbred animals, even when no more purebred stock can be found.²⁰ A recent study on poverty and breed diversity could find little evidence for losses of genetic variability from livestock populations of poor livestock keepers in the South, especially in regions where transhumance results in the occurrence of similar genes in different populations.²¹ Furthermore, the introduction of exotic genes has likely added to genetic diversity. However, further studies in this field are needed.

16 LPPS 2004.

17 See Hoffmann et al. 2004 for a discussion on this in poultry.

18 Ibrahim and Abdu 1996.

19 For examples, see the different case studies in Delgado et al. 2003.

20 Horst 1985.

21 IDL Group 2002.

National livestock populations

The foregoing sections have shown that the flows of livestock and their genes into the South have been posing some threat to local breeds, though their impact on breed numbers and genetic diversity has so far been limited. What has been their influence on national livestock populations?

The proportion of crossbreds in the national herds greatly varies from country to country. In Africa, exotic dairy cattle are found especially in Kenya where they make up 23% of the herd, which in turn represents more than 75% of all specialized dairy cattle in eastern and southern Africa. The high percentage of crossbreds in Kenya and the high adoption of dairying by the country's smallholders partly have historical reasons due the longstanding presence of an original settler dairy cattle population. In Tanzania, Uganda, Ethiopia, Malawi, Zambia and Zimbabwe the share of exotic dairy cattle is much lower, lying at 3% and less.²²

In Asia the percentage of crossbred cattle tends to be the higher the richer a country is and the better its infrastructure is developed. While the percentages of crossbreds in Laos and Bangladesh are very low, rapidly developing Thailand has a much higher proportion of crossbreds (Table 8). In Taiwan, a newly industrialized country, where the conditions favour intensification, breed replacement seems to have advanced even further, as the fate of local pig breeds indicates. These have been replaced almost entirely by improved breeds from the USA and Europe.²³ Along the same lines, a study of Ghana and Thailand attributed these countries' falling proportions of local purebreds to the expansion of large-scale intensive livestock production and a shift in breed preferences among wealthier people.²⁴

The regional and in-country distribution of crossbreds and exotics also varies. In Kenya and Tanzania, the bulk of the exotic-breed-based dairy cattle cluster in the wetter highlands.²⁵ In Sri Lanka, too, crosses with breeds from the North occur mainly in favourable agro-climatic zones.²⁶

Pastoralists, on the other hand, have often kept their local (pure) breeds. They commonly live in marginal areas with extreme climates and sparse vegetation – steppes, deserts and mountains. Under such harsh conditions, crosses with exotic breeds offer few advantages.²⁷

These observations indicate that along with infrastructure, climate and environment are important determinants for the success of breeding programmes with exotics from the North. Of course, countries with difficult agroclimatic conditions often lack good infrastructure, limiting the impact of imported breeds.

In India, the pattern is different: the states with the highest crossbred populations – Punjab, Kerala, Haryana, Uttar Pradesh, Tamil Nadu, Maharashtra, and West Bengal²⁸ – are scattered across the country's climatic zones, indicating that other factors are in play (see the next section).

The data do not allow direct conclusions on how far the quantity of incoming gene flows has influenced the outcome. However, extensive imports of exotic cattle have not necessarily affected the national herd. Bangladesh, for example, has few crossbreds, despite a history of importing exotic breeds dating back to 1930.²⁹ Nearly five decades of breed improvement programmes

22 Muriuki and Thorpe 2002. The source doesn't provide data for South Africa.

23 Mason and Crawford 1993:153.

24 IDL Group 2002.

25 Muriuki and Thorpe 2002.

26 Schrage et al. 1997.

27 Köhler-Rollefson 2004b.

28 Delgado et al. 2003, Annex III.

29 Faruque and Bhuiyan in Allen and Na-Chiangmai 2001.

Table 8 Percentage of crossbreeds with indigenous cattle in Asian countries

Country	Percentage of total cattle population	Additional information	Source
Bangladesh	2–3 %	Holstein, Jersey, Sahiwal and Sindh	Faruque and Bhuiyan in Allen and Na-Chiangmai 2001
India	7%		Singh in Allen and Na-Chiangmai 2001
Laos	< 1%		Phomsouvanh in Allen and Na-Chiangmai 2001
Pakistan	7.5%	Holstein Friesian, Jerseys and other dairy breeds	Khan in Allen and Na-Chiangmai 2001
Sri Lanka	29%	12% of cattle population European crossbreeds, 17% Indian crossbreeds; 2% European and 8% Indian purebreds	Sompala in Allen and Na-Chiangmai 2001
Thailand	84% of cattle held by small-scale producers ^a	Beef: Brahman x local Dairy: mostly Holstein–Friesians (HF) x local zebu; also crosses with Red Sindh and Sahiwal	Thummabood & Morathop in Murphy and Tisdell 1995; Chantalakhana & Skunmun 2002

^a Another recent report (IDL Group 2002) mentions that Thai purebreds form about 50% of the national herd, indicating a much lower percentage of crossbreeds than the 84% cited by Murphy and Tisdell 1995.

in Nepal (where crossbreeding started in 1951) have induced little change in the nation's cattle population.³⁰ Between 1985 and 1993, Nepal received about 64,000 doses of frozen cattle semen (29,150 Jersey, 19,640 Holstein Friesian, 11,786 Brown Swiss and the remainder Tarentaise and Ayrshire).³¹ But at the end of the 1990s, about 95% of the country's animals still were of local breeds, and the improved cattle occurred mostly around the cities.³²

The example of Turkey illustrates the fate that incoming gene flows can take in the destination country. In the mid 1990s, Turkey imported several hundred thousand pregnant Holstein Friesian, Brown Swiss and Simmentaler heifers, mainly from Western Europe. In 1996, a Turkish newspaper reported that of 40,000 heifers imported from Western Europe, 17% had died before giving birth, and 9% within 2 months afterwards. Some 28% of the survivors had to be slaughtered because of reproductive disorders. Only 10% of all animals survived their second pregnancy, and none produced more than 3,000 kg of milk in a lactation³³ (compared to about 7,000 kg in Germany).³⁴

30 Shrest and Sherchand 1997: 97.

31 Shrest and Sherchand et al. 1997:106.

32 Tulachan 1998, cited in Köhler-Rollefson 2005. According to Shrest and Sherchand (1997), in 1995/96 Nepal had a cattle population of about 6.8 million.

33 Barwinek and Güreer 1997.

34 See, e.g., ADR 2002.

Animal productivity and production

Over the past three decades the production of meat and milk has substantially grown in many countries in the South.³⁵ How much of the increase can be attributed to gene flows?

The following analysis concentrates on dairy development because, judged by the amount of information available, breed improvement programmes seemed to have targeted especially milk production. Meat has often been a byproduct of crossbreeding local breeds with high-yielding exotics, or of upgrading them in more elaborate breeding schemes to form dual-purpose breeds.

Dairy production

With the exception of South Africa and Zimbabwe, dairy production in Africa and many Asian countries rests mostly in the hands of smallholders.³⁶ However, there are many variations in how milk production has grown in the different countries.

In India, the large rises in milk production during the past three decades can be attributed mostly to rising buffalo numbers and structural changes in the dairy sector. The number of crossbred animals has risen too and their productivity is generally higher than that of buffaloes and indigenous cattle. But overall, their contribution to the country's milk production has remained limited because they account for a comparatively small percentage of the total national milk herd (Box 8).

In other Asian countries, dairy development needed longer start-up phases. In Thailand, for example, the onset dates back to the early 1960s. But in contrast to India, Thai people are historically not milk drinkers, and domestic milk production started to take off only in the 1980s due to the promotion of drinking milk in the mass media and the passing of facilitating legislation. In the 1990s, production grew by almost 20% a year.³⁷ Because Thailand has a large share of crossbreds (see Table 8), it is likely that a large share of the country's milk supply comes from crossbred cows. Crossbreds mostly produce between 2500–3000 kg milk in 305 days, although production can be as high as 5000 kg. The use of purebred Holstein Friesian cattle has proven economically unviable because of the high production costs per litre.³⁸

Sub-Saharan Africa has the lowest milk production per cow of all regions of the developing world. But also here cow milk production has risen. In countries in an ILRI study,³⁹ production rose by about 3,200,000 tonnes during the period 1985–1998. About 60% of the rise was attributable to increases in herd size, 14% from an increase in the number of animals within the herd that are in milk, and 18% through enhanced productivity (Table 9).

As crossbreeding has been a major means to raise productivity, the “productivity” column in Table 9 offers an indirect indication of the effects of gene flows. According to this indicator, during the past two decades gene flows have had the largest impact in Tanzania (where it accounted for 41% of the increased milk output) and Madagascar (39%), and to a lesser degree in Ethiopia and Kenya. Increasing the number of animals in milk might also be partly attributable to gene flows, since high-yielding animals have shorter calving intervals than local breeds. But management changes such as better feeding may play also a role, and perhaps a bigger one. This “milking effect” was important in Zimbabwe, Uganda, Kenya and Madagascar. In Somalia,

35 Delgado et al. 1999, Rangnekar and Thorpe 2002, Delgado et al. 2003.

36 See Rangnekar and Thorpe 2002.

37 Chantalakhana and Skunmun 2002.

38 Chantalakhana and Skunmun 2002.

39 Muriuki and Thorpe 2002.

Box 8 The “White Revolution” in India

In India “Operation Flood” – a cooperative movement – and other dairy development programmes raised milk production about 4.5% per year between the early 1970s and late 1990s.¹ During this period, buffalo numbers rose from 58 million to 84 million. At the same time, structural changes occurred in the dairy sector: a shift to milk production and away from keeping bovines for work, and an increasing proportion of crossbred cattle in the total cattle population. In 1998–99, India produced about 75 million tonnes of milk, 54% of which came from buffaloes, 42% from cattle and 4% from goats.

Crossbreeding of nondescript Indian cattle on field scale started in 1964, and became official government policy by 1969.² In 1992, crossbred cattle constituted about 7.5% of the total cattle population and about 10% of all adult female cattle in India.³ Their daily milk yield varies between the different states. In 1996–97, it ranged from 3.2 to 8.4 kg/day, with an average of 6.2 kg/day, or 1860 kg in 300 days. This is far below the yield of milk cattle in the North. But it is higher than that of indigenous cattle, which averaged 1.8 kg/day over a 150–200 day lactation) and buffaloes (3.9 kg/day for 200–250 days).⁴

In 1998, the Department of Animal Health estimated that in 2001 crossbred cows would make up 15% of the total adult female cattle population, producing nearly 10 million tons or 33% of the cow milk⁵ – or 14% if expressed as a percentage of the total milk produced in India.

1 Delgado et al. 2003, Annex III.

2 Kurup 2002.

3 Numbers calculated from data given in Table 4 in Kurup 2002.

4 Delgado et al. 2003, Annex III; Kurup 2002.

5 Kurup 2002.

Table 9 Sources of change in cows’ milk production in sub-Saharan Africa, 1985–98

Country	Total change (1000 litres)	Sources of change (% of total)			
		Herd size	Animals in milk	Produc- tivity	Inter- action
Ethiopia	258	62	7	24	8
Kenya	793	10	61	18	10
Madagascar	62	6	52	39	3
Somalia	93	112	0	–10	–2
Sudan	1235	84	10	0	6
Tanzania	188	28	19	41	11
Uganda	121	22	73	0	5
Zimbabwe	60	–24	136	–8	–5
Total sub-Saharan Africa	3214	60	14	18	9

Source: adapted from Tambi et al. 2001, quoted in Muriuki and Thorpe 2002. The source does not specify which additional countries are included in the total for sub-Saharan Africa.

Herd Movements

Sudan and Ethiopia, increasing the herd size was the main factor enhancing milk output, and probably has little relationship to gene flows. The fact that the productivity effect was so small in Kenya despite its relatively large crossbred population might be due to the country's long history of dairy development, suggesting that the gene flows into the country probably peaked prior to 1985.

Socio-economic benefits

Data on the socio-economic impacts of gene flows are scarce.

A study from Kenya⁴⁰ concluded that crossbreeding had positive impacts on the country's economy and society's welfare through raising the availability of milk, lowering milk prices and reducing milk imports. This is likely also the case in other countries where crossbreeding raised dairy productivity and milk production. However, the balance might be less favourable if calculations of welfare benefits were to include the costs of crossbreeding programmes. For example, because of their low resistance and tolerance to diseases, crossbreds require enhanced veterinary services.

In contrast to the positive findings at the national level, indications from the farm level are mixed. The Kenya study showed that replacing indigenous zebu cattle with exotic breeds improved farm performance little, especially for livestock keepers who were unable to buy the inputs needed to realize the crossbreds' potential. Under such conditions, improving local zebu breeds might prove advantageous.⁴¹ But few breed improvement programmes have pursued this possibility.

The Kenya study suggests that the benefits of breed improvement programmes bypassed poor farmers because they cannot afford the necessary investments. In other countries too, exotic-based crossbreds are more likely to be kept by wealthier livestock keepers.⁴²

The situation appears to be different in India. Here a survey by the National Sample Survey Organisation found that three-quarters of the crossbred dairy cattle are kept by marginal and smallholder farmers, and about 3.4% by landless farmers (Table 10). However, there are differences between states. In Gujarat, 90% of the milk animals kept by small and medium farmers were buffaloes, and crossbred cattle were mainly found in the herds of large and commercial farmers.⁴³ Furthermore, the available data do not allow conclusions on whether crossbreds kept by the poor produce as well as those kept by wealthier livestock keepers, or whether under such suboptimal condition buffaloes may prove superior.

Furthermore, economic studies commonly focus on costs and benefits. But there is little information on whether farmers might have been better off without the breed improvement programmes. Farmers sometimes had to make substantial investments when introducing crossbred animals into their herd. For example, the pregnant heifers imported from Western Europe to Turkey were heavily subsidized by the Turkish government through credits to farmers. The money had to be repaid over a 5-year period. Furthermore, after they received the animals, the farmers had to insure the animals at a cost of about 5% of the animal's value per year, which was a substantial cost to them.⁴⁴

40 Karugia et al. 2001.

41 Karugia et al. 2001.

42 E.g., Chantalakhana and Skunmun 2002, IDL Group 2002.

43 Delgado et al. 2003, Annex III.

44 Barwinek and Gürer 1997.

Table 10 Distribution of milking animals^a in rural households by land holding category, India, 1992

Land holding type	Households (1000)	Milking animals per 100 households	Crossbred milking animals per 100 households	All milking animals (% of total)	Crossbred milking animals (% of total)
Landless ^b	25,425	11	1	3.2	3.6
Marginal	56,178	68	8	43.4	57.1
Small	16,549	114	8	21.5	17.3
Semi-medium	11,291	136	9	17.5	13.3
Medium	5,737	168	10	11.0	7.5
Large	1,238	239	7	3.4	1.1

^a Milking animals comprise dry, in-milk and others (livestock census classification: adult breedable females), including crossbreds.

^b Landless category includes households with < 0.002 ha of land, as well as those without any land.

Source: NSSO 1992, quoted from Kurup 2002.

Gender

The introduction of exotic animals or crossbreds can mean additional income to women and better nutrition to the whole family, especially to the children. On the other hand, crossbreds require higher inputs of feed and labour. Introducing them can change the amount of work that men, women and children have to do. Sometimes it will mean a bigger workload for women. If a sheep has more than two lambs, the additional one needs to be bottle-fed because ewes have only two teats. Bottle-feeding is commonly women's work.

In other cases, introducing crossbreeds deprives women of their income. This is because replacing local breeds with high-performing crossbred animals is often combined with reorienting a farm towards commercialization – which commonly gives more prominent roles for men.

Children may also be affected. They may lose out if they are given the additional task of cutting and carrying extra fodder. But they can also benefit: more milk means better nutrition, and children who used to herd animals may be able to go to school instead if their parents commercialize their farming activities.

Factors influencing the outcome of gene flows and breed improvement programmes

The foregoing sections indicate that gene flows from the North have had some impacts on production in the South, especially in the past two decades. These impacts have varied from place to place, and overall, they appear small considering the large amounts of genetic materials that have been channelled into the South since the early 1960s. Other factors – increasing animal

Herd Movements

numbers, improved management and enhanced market competition through globalization – appear more important sources of change than the gene flows into the South. Furthermore, the benefits of crossbreeding and breed replacement have mostly bypassed poor livestock keepers. Why have breed improvement efforts had relatively low efficacy? Under which conditions have they worked?

External conditions and the fit of the breed

A breed needs to fit the external conditions of the place of its destination. High-yielding animals from the North can produce and reproduce only if climate and environment are suitable, and if the necessary inputs such as fodder and veterinary care are available. For these reasons, improvement programmes for cattle, goats and sheep have had impacts mostly in favourable agroclimatic zones with reasonable infrastructure. Crossbreds have been more successful than purebreds because the former can better cope under the local production conditions than the latter.

High-performance pigs and poultry have special management requirements. These animals are relatively small and the required environment can be created artificially much easier than is possible for cattle. They can be isolated from their environments – and especially from diseases – through housing, cooling systems, and intensive feed and watering systems much more easily than ruminants.

Towards the end of the 20th century, movements of pigs and poultry into the South were increasingly combined with the transfer of inputs and the necessary knowhow. In other words, the production conditions were adapted to the introduced breeds and not vice-versa. This is perhaps one of the reasons that large-scale production units for pigs and poultry have been successfully established in the South. Questions arise about long-term sustainability, as such enterprises require huge amounts of energy and water that are scarce resources in many developing countries.

Programme design and implementation

Especially during the early years of development assistance, programmes in the South commonly focused on raising production quickly, exploiting the high yields occurring in the first crossbred generation (the “heterosis effect”). Long-term strategies were lacking, and conserving sufficient numbers of the local parent breed was rarely a consideration.

However, to secure breeding progress in the long run, breed improvement programmes need to go beyond the first generation. Systematic breed development requires certain levels of organization and inputs, and can be very costly. For example, crossbreeding with European breeds entails the maintenance of exotic purebred herds – the costs of which can rarely be borne by smallholders⁴⁵ and may also exceed what governments can afford. Few countries in the South have the means and facilities for the systematic performance testing conducted in the North, and poor infrastructure has hampered the use of artificial insemination and the extension of veterinary and other services, especially in remote and marginal areas. All of these factors have negatively impacted on the success and sustainability of breed improvement programmes and explain their relatively low contribution to productivity increase.

45 Kahi 2000 cited in Hoffmann 2000.

Box 9 Goat upgrading programme in East Java, Indonesia¹

In the 1980s the Indonesian government started animal distribution schemes to raise livestock numbers and improve the genetic quality of the existing stock. Under this programme, farmers in East Java received Etawah-grade goats to reintroduce the milking of goats. Etawah-grades are crosses between the Indonesian Kacang breed and Jamnapari goats, introduced from India early 20th century and called Etawah in Indonesia.

About 2–3 years after the first goats were distributed, a review found it had been planned without evaluating local breeds and conditions, or checking the farmers' preferences. The production difference between the two breeds proved too small to make a difference. The local breed was as prolific as the Etawah-grades, but was smaller: an advantage from the farmers' point of view since it required less feed. The farmers kept goats mainly as a living savings account, and were not interested in milking. But because of the upgrading programme, the local type of goat was rapidly disappearing.

1 Djohariani and Udo 1986.

On the other hand, northern-type performance testing may not be feasible for smallholders' conditions, as these may not be able to reach and sustain optimum production levels anyway. In the 1980s foreign experts tried to introduce German-type breeding and progeny testing for dairy cattle in Kenya. But data collection remained too irregular for the results to become useful. In hindsight, the programme appeared to have hindered rather than furthered the improvement of small producers' livelihoods.⁴⁶

Livestock keepers' needs and participation

A breed's fit to the local environment and climate is not enough to guarantee that livestock keepers will accept the animals after the project ends. Despite the advantages of transferring animals between areas with similar climates, South–South exchanges have not always been successful. An attempt in Indonesia failed to improve Kacang goats with animals containing Jamnapari blood (Box 9). And a German project's work to introduce Boer goats to Sri Lanka in the mid-1990s for crossbreeding did not bring the expected long-term results: the farmers did not maintain the crossbreeds after the project ended.⁴⁷

Focusing on yields, projects often overlook that in many areas, production may not be a primary goal. Rather, livestock fulfil multiple roles. Farmers may keep a cow mostly for field work, or a goat as a "bank on hooves" that can be sold in emergencies. Production traits may be improved at the expense of such other traits. For example, Thai farmers complained that crossbreeds between swamp and dairy buffaloes did not work well in the fields.⁴⁸ Besides, if production is not the main breeding goal, minimizing inputs and avoiding risks might be more important than maximizing outputs.⁴⁹

Especially in the early decades of breed improvement, livestock keepers were seldom involved in selecting breeding stock. As a result, the crossbreeds did not match the farmers' breeding and management objectives.⁵⁰ In some instances, livestock keepers did not even see the need to

46 Baptist 1994.

47 D.V.S.de S.Gamage personal communication March 2004.

48 Murphy and Tisdell 1995.

49 Sölkner et al. 1998.

50 Horst 1985; Sölkner et al. 1998, FAO 2001; Kosgey 2004.

Herd Movements

introduce the foreign genes that scientists and governments still view as the key for improving smallholder dairy performance.⁵¹ For example, some smallholder dairy farmers in India regarded better feed and fodder availability and improved management as more crucial than breed improvement.⁵²

In short, to increase the chance of a breeding programme being successful, it is necessary to closely involve the livestock keepers in breed selection. It is equally important to seek their participation in other stages of projects. A beef project in Vanuatu illustrates this: from its very beginning, the project initiated an intensive dialogue between livestock services and farmer groups. This helped develop appropriate strategies considering local priorities, constraints and opportunities. Smallholders benefited from the introduction of exotic breeds, and these farmers' contribution to commercial beef production increased by 60% over a four-year period.⁵³

Having said this, livestock keepers' involvement in breeding decisions and breed selection is not always a guarantee for success. Farmers may opt for a Holstein Friesian cow rather than a more appropriate breed because it has high status. Some breeders may be more interested in external criteria rather than functional qualities. For example, some groups may put more weight on desirable horn shapes or skin colours than on hardiness or milk yield. In the extreme, such preferences can enrich detrimental genes, especially if the animals are not used for production. An example is the ear tufts in poultry popular among hobby breeders in the North. The tufts are associated with a lethal recessive gene. Such extremes are less likely to occur if animals are kept for a living rather than as a hobby.

Institutional support, policies and other factors

Examples from both North and South have shown that institutional support and policies are crucial determinants in the use of introduced genetic resources and the conservation of local resources. The Australian Awassi sheep venture (Box 5) would not have been possible without the government's involvement in the initial stages. Malaysia would not have become so quickly self-sufficient in pork and poultry without the government's support.¹⁸⁸

On the other hand, Malaysia's efforts in the 1960s to initiate the industrialization of beef production failed because marketing strategies were inadequate, and cheap imports from India reduced the demand for locally produced beef.⁵⁴ A further reason for the differing outcomes might have been capital: while the pig and poultry sectors in Malaysia have traditionally been in the hands of richer livestock keepers (in the case of pigs often Christians of Chinese origin), cattle have been mostly in the domain of smallholders.

However, there is increasing evidence that smallholder production can compete with large-scale producers if policies and institutional backup set a level playing field.⁵⁵ Factors that can make a difference include access to credit, transport and information; access to natural and commercial feed resources (through prices and pricing policies); access to appropriate services; regulations on hygiene and (zoonotic) disease control; and the supply and pricing of inputs such as electricity.⁵⁶

51 See, for example, Singh and Pundir 2002.

52 Delgado et al. 2003, Appendix III.

53 Bazeley 1992.

54 Jalaludin and Halim 1998.

55 LID 1999, Delgado et al. 2003, Leonard 2004.

56 See the different case studies in Delgado et al. 2003.

However, there is disagreement on how such institutional support can best be brought about. Some development professionals see vertical integration and contract farming as solutions.⁵⁷ But these strategies combine high labour productivity with low employment⁵⁸ and so appear inappropriate instruments for pro-poor development. Besides, examples from other countries indicate that contractual agreements can force farmers into a debt spiral. Experiences from the Indian dairy sector highlight that cooperatives can be useful support institutions.⁵⁹

A study by FAO's Pro-Poor Livestock Policy Initiative of suggests that the best way to support poor livestock keepers is by helping them build strong associations and empower them to argue for their rights.⁶⁰

Furthermore, informal markets appear to play an important role for smallholders and offer them a chance to get some income from livestock production. In Brazil, for example, the intensification of dairy production induced by market competition and government incentives for industrial producers forced many small producers out of the official market.⁶¹ However, while turnover on the formal market stagnated between 1990 and 2000, turnover on the informal market doubled:⁶² many of the small producers may have started selling their milk informally. Legalizing and optimizing such markets may help smallholder producers continue livestock keeping and contribute to their food security.⁶³ Because informal markets are the domain of smallholders who rely on local breeds more than intensive units, strengthening such markets may provide opportunities for breed conservation.

57 For example Delgado et al. 2003.

58 Sere and Steinfeld cited in Köhler-Rollefson forthcoming.

59 See Delgado et al. 2003, Annex III; Kurup 2002.

60 Leonard 2004.

61 Delgado et al. 2003, Annex V; Kerkow 2005.

62 Kerkow 2005:20.

63 Steve Staal of ILRI cited in Kerkow 2005:17.

7 Factors shaping the future

DURING THE past few decades, the field of biotechnology has advanced rapidly, and various international agreements have been reached that directly or indirectly influence the extent and quality of gene flows.

Advances in biotechnology and genetics

Biotechnology is “any technique that uses a living organism or substances from those organisms to make or modify a product, improve plants or animals or develop micro-organisms for specific uses”.¹ Under this broad definition, the biotechnology with the most widespread impact on animal breeding has been artificial insemination (see page 6). Newer technologies include cloning, genomics and genetic engineering, which allow individual animals to be copied or genetic traits to be manipulated directly, instead of relying on the rather random process of sexual reproduction.

Cloning

Cloning means producing multiple copies from an individual. Several techniques exist to create clones.²

Cloning has the potential to enhance gene flows because it can multiply especially valuable breeding and transgenic animals. Some firms envision the sale of clone families as an alternative to artificial insemination.³ The number of cloned animals worldwide is on the rise, and in the USA some cloned elite cows have sold for over US 40,000. “Starbuck”, the top-performing Holstein bull (page 7), already has a clone.⁴

Still, it remains to be seen whether the clones reach the same performance as their parents. Until now the success rate or cloning efficiency (the number of live offspring obtained from 100 nuclear transfer embryos) is very low. For example, 87 cloned embryos had to be implanted into eight foster mothers to produce “Copycat”, the first cloned kitten.⁵ To obtain the first cloned mule, 305 embryos were needed.⁶ The overall efficiency is 0–3%.⁷

Contrary to the common notion, cloned animals may not be identical with the animal from which they stem.⁸ Besides, the high prices obtained for some clones may reflect their novelty rather than their true economic worth, and the high costs of cloning might justify its application only in cattle and pigs.⁹

Another controversial issue is the question of animal welfare. While Infigen, one of the major cloning companies in the USA, claims that its clones are as healthy and normal as other ani-

1 Persley and Doyle 1999 cited in Persley 2000:5.

2 For details, see www.roslin.ac.uk/public/cloning.html (accessed 25 May 2005) and Kräußlich 1994.

3 Turner 2002.

4 See www.ciaq.com/Starbuckridesagain.html (accessed 25 May 2005).

5 Shin et al. 2002.

6 Woods et al. 2003.

7 Paterson 2002.

8 See www.vets-at-work.com/news_article.jsp?news_storyID=300 (accessed 25 May 2005).

9 See www.roslin.ac.uk/public/cloning.html (accessed 25 May 2005).

mals,¹⁰ other sources report differently. According to the Roslin Institute, cloned offspring of cattle and sheep are often much larger than normal animals, and many die shortly before or after birth, often due to lung and heart problems. Besides, seemingly healthy animals may have hidden abnormalities.¹¹

Genomics

It is possible to determine whether two individual animals are related by comparing their gene sequences. Using the same technique helps scientists to discover how different animal breeds or species are related, measure how distinct they are, and trace their origins.¹²

Genomics – the mapping and sequencing of genes – also makes it possible to associate certain characteristics with specific genes. If a trait is determined by only one gene, animals that carry this gene can be selected and reproduced by conventional breeding methods or using cloning. In the USA, the firm GenMark offers genetic tests for a variety of problems: resistance to scrapie (a brain disease in sheep), spider lamb syndrome (a disease that causes limb deformities), porcine stress syndrome in pigs, and coat colour, freemartinism (a cause of infertility in females) and a number of other factors in cattle. The tests require blood samples and cost US\$ 35–70 per animal.¹³ Germany now routinely conducts random tests in slaughtered sheep for scrapie, and has started a scrapie resistance breeding programme based on identifying animals carrying the relevant trait.¹⁴ The programme has been controversial as the exclusion from breeding of animals not carrying the gene may negatively impact on production.

Genomics will affect gene flows indirectly because it makes it possible to change the genetic composition of animal populations. The identification of animals with wanted and unwanted traits allows the exclusion of the latter from breeding, while animals with wanted traits can be multiplied through conventional breeding techniques.¹⁵ The information provided through genomics may also influence breeding policies and decisions on which breeds to conserve.

Genetic engineering

Genetic engineering involves altering the genetic code, leading to genetically modified organisms and transgenic animals. Unlike conventional breeding, it can bring together genes from species that would not be able to breed together naturally.

Under certain conditions, it is possible to transfer the gene associated with a specific trait into other breeds, and even into another species. The resulting transgenic animals have foreign DNA incorporated into their genome. The main applications so far have been in medical research, where transgenic animals are used as disease models, to produce therapeutic proteins (“gene pharming”), and to develop methods for producing organs for transplantation (“xenotransplantation”).¹⁶

10 Steinerman 2001.

11 See www.roslin.ac.uk/public/cloning.html (accessed 25 May 2005). The famous sheep Dolly developed arthritis at the age of 5 years and needed to be put down a year later because of a progressive lung disease (see Turner 2002 and <http://news.bbc.co.uk/2/hi/science/nature/2764039.stm>, accessed 25 May 2005).

12 See for example, Mafeni et al. 1997, Hanotte et al. 2000 and BMVEL 2002.

13 See www.genmarkag.com/faqs.php (accessed 25 May 2005).

14 Haumann 2002.

15 Kaden et al. 1998, FAO 2003.

16 See for example www.infigen.com/sci_tech_prot.html (accessed 25 May 2005).

Herd Movements

Genetic engineering could also be used in farm animals – to increase their productivity, make them more disease-resistant, or to improve various other traits. But these efforts are still far behind developments in the medical sector. As with cloning, the success rate of producing a transgenic animal is very low, and the animals born may have a shorter lifespan, have malformed organs, and may not transfer the new genes to their offspring. Besides, the process is time-consuming and very expensive, making it uneconomic for routine livestock production.¹⁷ Another hurdle to the introduction of genetically engineered livestock may be consumer acceptance of the animals and their products, especially in Europe. Furthermore, the fact that some forms of genetic engineering overcome species barriers can pose risks the extent and consequences of which are not yet fully understood.

In the view of these problems it remains to be seen whether genetic engineering will become an important mode of transferring farm animal genes internationally. However, genetic engineering is likely to play a role for vaccine production and disease diagnosis.¹⁸

International agreements affecting gene livestock production

Since the middle of the 20th century a growing number of international agreements and regulations have guided trade relations. This section lists the most important agreements and summarizes their impacts on livestock production in the South. The implications for gene flows of these and other future-shaping factors will be discussed in the subsequent section.

World Trade Organization

The General Agreement on Tariffs and Trade (GATT), established in 1946 to reduce barriers to trade, was succeeded in 1995 by the World Trade Organization (WTO). Among its goals are fair and free international trade, free market access of all member states to all markets, fair competition, and the promotion of economic reforms, sustainable development and environmental protection. WTO regulations are legally binding to its 148 member states.¹⁹

Progress towards these goals has been slow as it has had to consider other pre-existing structures (e.g. the EU) and bilateral and multilateral agreements. These allow the USA, Europe and other countries in the North to continue – albeit at a reduced level – subsidizing the production of many agricultural products, imposing unfair competition on countries that cannot afford to support their farmers and livestock keepers.

The furthering of trade under WTO regulations has facilitated the global expansion of large firms and multinational corporations. Northern countries may support transfers of their firms to other countries through tax breaks, as for example Germany does for enterprises wanting to expand to countries in Eastern Europe. Southern countries, on the other hand, may attract investment by multinational corporations by offering subsidized credits.²⁰

17 Christ and Schürkens 2003. According to Leeb 2003, it costs €50,000 to produce a transgenic sheep and €450,000 a transgenic cow (estimate probably valid for the early 2000s).

18 Kaden et al. 1998, FAO 2003.

19 See www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm (accessed 26 April 2005).

20 Kerkow 2005.

Trade Related Aspects of Intellectual Property Rights

The international agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) came into force in 1995 to protect the intellectual property rights of inventors. Among other things, TRIPS regulates the use of trademarks²¹ and the protection of inventions through patents that grant inventors exclusive user rights to their inventions for 20 years. TRIPS requires all member states to establish national laws to guarantee minimum standards for the protection of intellectual property.

With regard to livestock production in general and livestock keepers in the South, two issues need to be mentioned: patents on livestock varieties, and patents on indigenous knowledge.

Patents on livestock varieties TRIPS provides an option to exclude plants and animals, as well as essential biological processes, from patenting. But WTO member states have to protect plant varieties either by patents or *sui generis* systems – systems of rights unique for a specific item or technology. For animals, such specifications are lacking.²² Consequently, the handling of patent issues varies between countries and regions,²³ although breeds created through natural mating do not seem to have been patented yet.

On the other hand “genes and markers for genetic improvement, statistical methods for genetic improvement, transgenic and cloned animals, methods to measure traits..., electronic methods to identify animals, computer software and other written materials” constitutes intellectual property that can be protected. As a consequence, a growing number of patents related to genes are being issued (see also Box 4).

Patenting of indigenous knowledge This is the knowledge developed by communities rather than through modern science and technology. With globalization, the hunt for potentially useful indigenous knowledge (including information on animal breeding and locally developed animal breeds) has been speeding up. It should not be possible for outsiders to patent indigenous knowledge because it is neither new nor an invention. But in practice it is very difficult to prove a practice has been in longstanding use – partly because indigenous knowledge is commonly transferred by word of mouth and rarely written down. As a result, several such patents have been issued in the plant sector. China, for example, has issued a rather dubious patent for a breeding strategy on improving cattle that infringes on indigenous knowledge (Box 10).

Opinions differ how to protect indigenous knowledge from abuse, and how to ensure that local people benefit from its wider use. The measures so far have been insufficient. Members of indigenous peoples’ organizations are concerned that the World Intellectual Property Organization (WIPO) set up to tackle such issues and work out global standards for patent laws²⁴ is not adequately representing their interests.²⁵ Challenging patents is expensive and requires legal skills and insider knowledge that communities don’t have.

Issuing patents on livestock breeds, genes and breeding practices is questionable on several grounds:

- **Ethics of patents on life** Naturally occurring genes and breeds are not inventions, so should not be patentable. Patents on life forms have also been questioned on moral and ethical grounds.

21 For example, the breed name Senepol was trademarked in 1954 (see “Senepol” in OSU breed database www.ansi.okstate.edu/breeds/cattle/, accessed 30 April 2005).

22 The Crucial II Group 2000:89.

23 For discussions on intellectual property rights and patents for plant and animal genetic resources, see Rothschild et al. 2004 and Wolff 2004.

24 See www.wipo.int (accessed 2 May 2005).

25 Joji Carino personal communication 7 July 2003.

Box 10 Chinese patent on “Method of improving cattle”

In 1999, according to the database of the European Patent Office, Espacenet, China issued a patent as follows:

“A method for improving the ox breed includes natural mating between breeding stocks and artificial insemination, and features that the sperm of wild yak or the sperm in the blood line of wild yak is used for insemination to the breeding cow except yak. The obtained hybridized ox (such as native cattle) features high resistance to cold and disease, rough raising, quick growth, and high output of beef and milk.”¹

The novelty of such a patent is questionable because pastoralists in Tibet who depend on yaks for their living reportedly have long experimented with different ways to crossbreed cattle and yaks² – albeit not using artificial insemination. Nor is artificial insemination a new technique.

1 Patent No. CN1229629 issued 1999-09-29 (see <http://v3.espacenet.com/textdoc?DB=EPODOC&IDX=CN1229629&F=0> accessed 28 April 2005).

2 Wu 1998; interestingly, Wu notes that the herders regard the offspring of cows crossed with yak bulls as less suitable for their harsh conditions than offspring stemming from cattle bulls mated to yak cows.

- **Restrictions on breeding and research** Patents are intended to encourage investment in research and the development of new products. But they are proving an increasing obstacle to exploratory trials and to the free exchange of information and genetic materials – which are common among researchers and breeders. Researchers now have to consider a rapidly growing number of patents. There is a risk of research and breeding efforts becoming concentrated in the hands of a few firms with access to resources and information. These hardly represent the interests of pastoralists, small-scale livestock keepers, or other “non-industrialized” livestock producers such as organic farmers.
- **Leakage of genetic material** The patenting of plants has restricted the freedom of farmers to grow crops and use seed. Patented animal genes will almost inevitably leak into the broader population, as has occurred with plants. This could happen in many ways: the animals may be sold to livestock keepers who are not aware of the patenting restrictions; the animals may breed with other stock; they may escape through damaged fencing; and so on. Farmers have been sued for growing patented maize – even though they may have done so inadvertently and unwittingly: their neighbour’s genetically modified maize had pollinated their fields. The same may happen with animals.
- **Restrictions on farmers’ choices** Livestock keepers may be prohibited from breeding or selling the offspring of animals that carry patent-protected genes. That affects the keepers’ livelihoods, as well as breed development and maintenance at the community level. If the patented animals are successful, they may come to dominate in the same way as Holstein Friesians have the dairy cattle industry in the North. Small-scale farmers may find it difficult to find any other source of breeding stock. They may have no choice but to accept the patented animals – and to pay for something they previously had been able to get for free.

Future interest in patents of livestock and their genes will depend on how profitable such patents prove. In theory, a gene conferring disease resistance could help livestock raisers save millions of euros, so patenting this gene promises high profits. But some economists doubt whether patents on genetically engineered animal breeds would be profitable, as the enforcement costs

and royalty collection would present a great challenge – especially for cattle because of the dispersed structure of the cattle industry.²⁶

It is difficult to predict the future value of such patents, and patenting in the livestock sector is progressing in a legal maze: patents are subject to a raft of overlapping and contradictory national and international laws. One country may not recognize a patent issued elsewhere. This makes it urgent to tackle issues of ownership, access, livestock keepers' rights, user rights and benefit-sharing.

Codex Alimentarius Commission

The Codex Alimentarius Commission (CAC) was created in 1963 by FAO and the World Health Organization. Its central responsibilities are protecting the health of consumers, ensuring fair practices in the food trade, and promoting coordination of food standards work.²⁷ However, consumer organizations have been concerned that the Codex so far appears to interpret “ensuring fair practices in trade” as “facilitating trade exchanges and international trade” – rather than ensuring equitable fair practices for all countries and parties involved (in particular the smaller ones).²⁸

The Codex standards are not legally binding, but serve as a basis for standard setting under the SPS agreement (see below). Livestock trade and production are affected by food standards, limits for pesticide residues and evaluations of additives and veterinary drugs. Codex standards have been criticized for discriminating against the South because they do not adequately consider the different conditions there.

SPS Agreement

In 1995, the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) came into force. This legally binding agreement develops international standards, guidelines and recommendations focusing on animal health and zoonoses to minimize “the negative effects of unjustified health barriers on international trade”. The agreement requires its members to establish national animal health measures in concordance with the standards developed by the World Organization for Animal Health (OIE).²⁹ Developing countries have repeatedly expressed concerns that they had little involvement in the developing of international standards. “As a consequence of the inadequacy of the process, international standards are often inappropriate for use as a basis for domestic regulations in developing countries and these countries face problems when they have to meet regulations in the importing markets developed on the basis of international standards.”³⁰

26 Rothschild et al. 2004.

27 See www.codexalimentarius.net/web/index_en.jsp (accessed 7 August 2004).

28 www.foodaware.org.uk/food/15_02.htm (accessed 7 August 2004).

29 See www.oie.int/eng/normes/en_norm.htm (accessed 7 August 2004).

30 Zarrilli 1999.

Convention on Biological Diversity

To protect the globe's biodiversity and ensure national sovereignty over biodiversity, in 1992 the United Nations Conference on Environment and Development negotiated the Convention on Biological Diversity (CBD), an intergovernmental convention. It came into force in 1993 and 188 countries (with the notable exception of the USA) are party to it.³¹ The convention governs:

- the conservation of biological biodiversity (including agricultural plants and livestock),
- the sustainable use of its components, and
- the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.³²

The convention is legally binding. However, the phrasing leaves room for interpretation and implementation. Since 2004 the use of plant genetic resources for food and agriculture is regulated by the Treaty on Plant Genetic Resources for Food and Agriculture. The treaty includes a section on farmers' rights, guaranteeing farmers the rights to save and sell seeds.³³

A comparable agreement regulating the use of livestock and poultry resources is still missing. However, FAO has initiated the development of a global strategy to document and conserve local breeds.³⁴ An agreement that recognizes the contribution of pastoralists and smallholder producers to the creation and maintenance of their breeds and warrants them certain rights such as secure access to grazing lands, water and other key resources would enable these keepers to continue their livestock keeping and facilitate breed conservation in communities.³⁵

Biosafety protocol to the CBD

The Cartagena Protocol on Biosafety to the CBD that came into force in 2003 addresses the use of genetically modified organisms. It "seeks to protect biological diversity from potential risks posed by living organisms resulting from biotechnology. On the livestock sector these include genetically modified animals, modified rumen microflora and vaccines and growth promoters developed from recombinant DNA technology."³⁶ However, in many countries its realization is only at its beginning.

Implications for gene flows

The development of technologies, trade, and intellectual property rights can affect gene flows both directly and indirectly.

The liberalization of trade with livestock products has an indirect influence because of its impacts on a country's livestock production and breed spectrum. Cheap imported products compete with local products, and may drive local producers out of business, speeding up the ongoing intensification and consolidation of the livestock sector. The examples of Europe and elsewhere show that structural changes induced by the intensified agriculture tend to go hand-

31 See www.biodiv.org/world/parties.asp (accessed 28 April 2005).

32 See www.biodiv.org/welcome.aspx (accessed 28 April 2005).

33 Köhler-Rollefson 2004b.

34 For information see section "State of the World" at <http://dad.fao.org/> (accessed 16 August 2005).

35 Köhler-Rollefson and Wanyama 2003.

36 Köhler-Rollefson 2004a:35.

in-hand with a switch to high-yielding breeds and a reduction of the breed diversity, unless appropriate conservation measures are taken.

Furthermore, the opening of markets facilitates the global expansion of (multinational) firms and corporations. This directly furthers livestock gene flows because such transfers are often combined with the introduction of exotic genetic materials.

Although the globalization of livestock trade affects livestock keepers all over the globe, its effects will be especially marked in poor developing countries. It is likely to increase the flow of live animals, sperm, eggs and embryos to the South, for the following reasons:

- Little of the livestock production in these countries is industrialized. Large numbers of people still depend on agriculture and local breeds for their living. Demand for livestock products is rising. So there is high potential for change.
- National policies commonly favour livestock industrialization and intensive production at the expense of smallholder producers.³⁷
- The present international regulations of agricultural trade advantage Europe, the USA and other large producers who can comply with the stringent hygienic standards under the SPS agreement (page 57). In contrast, it is much more difficult for developing countries to meet these criteria.

On the other hand, new technical options opened by advances in biotechnology, together with incentives through the intellectual property regimes prescribed by TRIPS, will increase interest in potentially useful livestock genes from other regions. Southern breeds have an especially large potential in this respect (see page 19). Transfers of single genes and other genetic materials from the South to countries with highly developed livestock industries and research facilities are likely to grow. The extent of these transfers will depend on:

- Whether cloning, genetic engineering and other new technologies will bring reliable results and become so cheap that it is feasible to use them on a large scale.
- Whether consumers will accept genetically modified products.
- Whether patents on genetically engineered animal breeds would be profitable.

The ability to patent animal breeds or their genetic material could have various effects. It might increase the amount of private (rather than public) research on hitherto neglected breeds and the development of new strains. But it would hinder the unrestricted exchange of materials that has so far been the mainstay of breed development (see also pages 55–56).

Biopiracy, patents and benefits

Biopiracy has been defined as the unauthorized use of genetic resources and indigenous knowledge of communities through outsiders.³⁸ Although it is often depicted as a North–South issue, it is rather a problem of the unequal distribution of power and access to resources.

In contrast to plants, few cases in animals have been described so far.

37 See, for example, the discussion of the “Vision 2020 Livestock Development Policy” of Andhra Pradesh, India by Ramdas and Ghotge 2001.

38 Sahai 2005.

Box 11 Tuli cattle from Zimbabwe

“The Tuli is a pure African Sanga breed. The Sanga breeds were taken by the Bantu tribesmen on their southern migration, and eventually occupied most of Eastern and Southern Africa. In 1945 the Tuli breeding station was established in Zimbabwe to enhance the productivity of local herds being recognized for their increased beef production...

The Tuli was introduced to Australia in 1990 by CSIRO [the Commonwealth Scientific and Industrial Research Organization] and the Boran and Tuli Consortium [an Australian producer consortium] through the use of embryo transfer. Embryos were collected from purebred registered Tuli donors in Zimbabwe and were implanted into Australian-bred recipients in the Cocos Islands. This embryo transfer program began in August 1988 and continued for 5 months: 74 calves resulted from the project and were cleared for transportation to Australia on 2 March 1990.”¹

In 1994, Tuli embryos set a new world record price at an embryo sale in Australia, while 2–3 year old Tuli bulls also experienced heavy demand from America. A trial of several breeds at Clay Centre in Nebraska, USA, showed that Tuli had the juiciest meat and was second to the Angus for marbling.²

1 New South Wales Department of Primary Industries 2001.

2 Köhler-Rollefson 2004a.

One example is the Tuli cattle, imported to Australia from southern Africa (Box 11). According to a Canada-based non-government organization, the animals were taken “quietly” to Cocos Island, i.e., without official permission.³⁹

Imports of African fat-tail sheep breeds into Australia have also been marked by some as biopiracy. Others argue that breeding with southern breeds by outsiders is justified as long as these animals are used with the permission of their owners or have been rightfully purchased; after all, southern breeders have the same right to use and improve the breeds they have received or imported from the North. However, on the pig and poultry sector these rights are increasingly restricted by contractual agreements between firms and producers.

Biopiracy or not, it is a fact that the original breeders in the South have generally not been able to capitalize on the international success of their breeds. Instead, these breeds have been further developed by outsiders, who then successfully marketed them to third parties. Often the southern breed has reached a destination over several steps:

- Pakistani Sahiwal cattle came to Australia first, and from there to the USA.⁴⁰
- Awassi sheep, originally from Iraq, were bred and improved in Israel and then Cyprus before being brought to Australia.
- Dorper sheep were developed by crossing Blackheaded Persian ewes (from Somalia) with English Dorset Horn rams in South Africa. From there, the breed has spread to many other countries.⁴¹

Even if the subsequent breeding work was done in a breed’s native country, the community that originally developed it did not necessarily benefit. For example, Borana cattle, bred by pasto-

39 ETC Group 2000.

40 CAST 1984:25.

41 OSU breed database www.ansi.okstate.edu/breeds/sheep/dorper/ (accessed 22 October 2004).

ralists in Ethiopia and northern Kenya, have been improved by Kenyan ranchers before being exported to Australia.⁴²

Controversy over biopiracy is likely to be fuelled further if livestock genes are patented whose origin can be traced to a specific pastoralist or farmer group more clearly than is the case with the Booroola gene (Box 4). One candidate is the gene (or genes) of the Red Maasai sheep that confer resistance to intestinal worms. The Red Maasai is a hardy hair-type sheep breed developed by pastoralists in East Africa. These animals are resistant to internal worms. If it is possible to identify the relevant gene(s) and incorporate them into other breeds, these genes could be very valuable for sheep raisers worldwide – in the North as well as the South.⁴³

Still, it is doubtful whether pastoralists would benefit. For one, it is difficult to attribute the development of this breed to a specific pastoralist society. Second, there are no satisfactory models for sharing benefits among the various parties involved – an argument voiced especially by opponents of an international agreement regulating access and benefit-sharing for animal genetic resources.

It is morally and ethically imperative to find just solutions that recognize the contributions of livestock keepers to breed development, and that enable them to continue their role in breed development and conservation.

42 OSU breed database www.ansi.okstate.edu/breeds/cattle/boran/ (accessed 10 June 2004).

43 ILRI undated.

8 Comparing Northbound and Southbound gene flows

DURING THE 20th century, the number of breeds and genetic materials shipped around the globe has increased dramatically. The movement of animals, semen, embryos and eggs from South to North has been smaller than shipments in the opposite direction.¹

The North has often subsidized its live animal exports, while its imports have mostly followed free market criteria. A deviation from this pattern has been the Australian government's backing for efforts to expand its beef and mutton industries by importing embryos and building up initial herds of animals.

In the South, the pattern seems to have been the other way round: exports to other regions have been arranged without subsidies, while imports have often been connected with incentives of some type (e.g., credit, supply of cheap feed, veterinary drugs, and services).

The intensification of livestock production and various other factors have reduced the breed spectrum in the North, and have narrowed the genetic variation within selected breeds.

In the North – though less so in Germany – and some of the newly industrializing countries, breeds and genes from the South have enriched livestock biodiversity – especially in beef cattle, sheep and goats.

In some instances the economic contribution of southern breeds in the North and other selected regions has been substantial. The story of the Awassi fat-tail sheep (Box 5) and other breeds recently introduced to Australia illustrates that it does not need large quantities of animals, semen or embryos for a breed to become economically important. Ingredients for a successful transfer operation include a functioning infrastructure, a systematic multiplication scheme, securing finances for the operation, and contacts that open marketing channels.

In the South, comparatively few breeds have so far been lost. But more and more breeds are at risk. Crossbreeding has been one factor, because of the unsystematic way that breed improvement programmes have been designed and implemented, rather than because of crossbreeding itself.

Other factors, including unfavourable policies, have negatively impacted on local breeds. Market competition, enhanced by globalization, will pose a major threat to local breeds because it will further structural changes in livestock production and increase inflows of high-yielding breeds in the South. Countries with intensive livestock production are likely to become more interested in the genes of promising Southern breeds.

The effects of gene flows on national herds in the South vary greatly, and appear to increase as development progresses. Within countries, exotic (cross)breeds cluster especially around cities and in high-potential areas. Pastoralists' herds in harsh environments appear to have changed less than the herds kept by small-scale keepers in more favourable areas.

The introduction of exotic genetic materials and crossbreeding have contributed to increased animal productivity and have raised production in the South. But despite the large amounts of animals, semen and embryos imported during the latter half of the 20th century, the contribution of foreign materials has remained limited. This holds especially for cattle, sheep and goats.

¹ While the results of this study confirm this mostly for mammals, Hoffmann et al. 2004 confirm this flow pattern for poultry.

Crossbreeding can have some impact on a country's welfare, but does not necessarily improve farm performance much. Its benefits appear to have mostly bypassed pastoralists and resource-poor smallholder keepers. Factors influencing the outcome of breeding programmes in the South include the fit of a breed to the local environment, infrastructure and culture, the quality and planning of the breeding strategy, producer participation, and the institutional and legal support available to producers.

The situation in pigs and poultry is slightly different. As with ruminants, crossbreeding programmes in these species have often failed. But the recent expansion of industrial pork and poultry production in the South is leading to the successful establishment of exotic genetic materials. How far these introductions will eventually replace local breeds and small-scale livestock keeping will depend on many factors – including the institutional and policy support that pastoralists and small-scale keepers receive from their governments.

9 Conclusions and recommendations

Gene flows need to remain unrestricted

FROM THE beginning of livestock history, the exchange of genetic resources has laid the foundation for breed formation. Without them, the development of modern animal breeding and production would not have been possible. Without gene flows, the familiar black-and-white Holstein Friesian cow would not exist.

Intellectual property rights regimes have made it possible to patent animals, genes and other genetic materials and breeding methods. But such patents risk negatively affecting gene flows and research, and with it, breed development. National and international legislation needs to ensure that the exchange of and access to genetic resources remain unrestricted.

Livestock keepers need to stay involved in breeding decisions

Herders' and farmers' close involvement has been another essential factor in breed development. With progressing intensification and industrialization of livestock production, breeding decisions are increasingly taken out of their hands in both the North and the South. As the breeding goals of industrial producers do not necessarily reflect those of pastoralists, smallholder farmers and poor livestock keepers, the animals bred for intensive production are mostly unsuited for the conditions under which these clienteles have to manage their animals. Furthermore, the intensive selection for production has reduced the numbers of breeds and within-breed genetic diversity in the North.

The increasing exclusion of the field-level keepers from breeding decisions is especially marked in the pig and poultry sectors. But also in the cattle sector, farmer organizations tend to be dominated by large, resource-rich farmers who do not necessarily represent their resource-poor peers. In the South, governments and development projects tend to decide on the breeds to be promoted among small producers. They have only recently started to involve herders and farmers in the decision process.

To guarantee that future breed development represents more than the goals pursued by industrial breeders and organizations of large-scale farmers, it is important that field-level livestock keepers and users of livestock and poultry breeds stay involved in breeding decisions.

The South needs to find its own path to breed development and conservation

Breed improvement programmes in the South have been dominated by an attempt to transfer, without any adaptation, breeds and livestock production models developed for the North to the South. Many of these attempts failed due to environmental, social and cultural differences. Also present day's wholesome transfers of industrial production systems follow the same scheme, overlooking that such systems are highly input-dependent and may be unsustainable especially in marginal areas. Until now breed loss has been limited. But many breeds are at risk, and current breathtaking structural changes in the national livestock sectors and the drive for globalization could quickly push many breeds to extinction.

Countries in the South differ greatly from the North in their environment, infrastructure, capital and culture. They need to develop their own livestock production strategies and make full use of all resources they have available. In their efforts to promote industrial livestock production, governments commonly disregard the important functions that pastoralists, smallholder farmers and poor livestock keepers play in breed development, conservation and the sustainable use of marginal areas. Moreover, national politics and legislation often discriminate against these livestock keepers, and statistics rarely reflect their contribution to the country's livestock production.

Governments would be well advised to strengthen these livestock keepers by

- Recognizing their contribution to breed development and conservation and livestock production.
- Securing their access to grazing lands, water, and other key resources such as services and education.
- Developing breeding schemes adapted to local conditions, considering the improvement of local breeds through selective breeding as a viable option.
- Ensuring that legislation does not favour industrial production at the expense of millions of small producers.

Breed improvement programmes for pastoralists, small farmers and landless livestock keepers should enable these livestock keepers to make their own breeding decisions. Access to information, credit, transport and markets are key issues to be addressed. Programmes also need to safeguard sufficient stock of the local breed – optimally by enabling livestock keepers to continue keeping animals in their natural environment – as it is only there that the breeds can further develop. It is also important that keepers can continue producing and exchanging or selling animals for breeding.

International institutions and agreements should support these efforts by providing a level playing-field to developing countries in the South, and by ensuring that the rights of pastoralists, smallholder farmers and poor livestock keepers are recognized and are adequately addressed.

Appendix

Records of trade in breeding stock and semen in Germany

THE DATA sources do not make it easy to extract detailed information on imports and exports of breeding animals and semen in Germany. Some of the data are in a form that makes it very time-consuming to extract the relevant information (e.g., Federal Statistics Office). Or they do not include the necessary key features: for example, the data published by the Arbeitsgemeinschaft deutscher Tierzüchter (ADT)¹ lack country information, and the HI-Tier (see below) data fail to list the purpose of the animals. The following sections provide some details.

Breed societies

As with respect to the export of breeding stock, cattle appear to play a far greater role than other species. Therefore this section focuses on cattle.

German breeding cattle are mostly sold off-farm or through auctions. Exports are carried out via the breed societies on the basis of voluntary self-control. For more than two decades they were assisted by the *Deutsche Zucht und Nutzvieh Im- und Export GmbH* or “IMEX”, a special export office of ADT founded in the 1950s.² After 1980, the percentage of exports implemented through IMEX fell, until the export office ceased operations.³ The exports are nowadays implemented by private firms.

The annual reports of the Arbeitsgemeinschaft Deutscher Rinderzüchter (ADR)⁴ contain export data for German breeding cattle 1958–2001. For the period 1971–1990, the data are differentiated by their destination into EU and non-EU countries. As of 1991, total export numbers per breed are presented. Both options allow neither the tracking of exports to the South as a whole (because non-EU countries include Eastern Europe and of the former Soviet Union), nor the identification of exports to specific countries.

Information on imports of live animals is scarce.

The export of German cattle semen dates back to 1954, when a special working group was founded on this subject in response to requests for semen from abroad. In 1958, a regulation for the export of bull sperm was passed. All requests for bull semen and exports originally had to be channelled through IMEX.⁵ Up to 1987 the annual reports of ADR contain sporadic information on semen exports. As of 1987, they present summaries of export and import data by both region and breed. Again, specific countries are not listed. With regard to semen imports from southern countries, the ADR reports specify only 116 portions from Latin America in 1997. However, it could be some further imports from the South are hidden in the category “others”, which includes all imports of unknown origin.

1 ADT = Umbrella Association of German Livestock Breeders' Associations.

2 ADR 1959a and ADT 1961.

3 Based on figures in annual reports of ADR.

4 ADR = Umbrella Association of German Cattle Breeders' Association, a subgroup of ADT.

5 ADR 1959b.

Customs Office in Hamburg

In order to get export subsidies, all exports of breeding cattle to non-EU countries have to go through the customs office in Hamburg-Jonas. It is not clear in which form the data there are stored, as attempts to get information from there were unsuccessful.

European Association for Animal Production

The EAAP data bank monitors information on breeds and country populations of buffalo, cattle, goat, sheep, horse, ass, pig, rabbits in 46 member countries and other European countries.⁶

Eurostat

Eurostat reportedly has data for the export of breeding stock for the past 15 years differentiated by male and female. For pigs, only purebreds are included.⁷ The data are available on per country base, but they were too expensive for this study.

Federal Statistical Office

The data of the Federal Statistical Office (*Statistisches Bundesamt*) of Germany go back to the 1950s and possibly earlier. The data are stored by year and country. The animals are classified according to the coding system of the *Warenverzeichnis für die Außenhandelsstatistik*, which is a list of goods for the foreign trade statistics. For example, for horse, cattle and pig, the statistics differentiate between “purebreds” and “others”, and each category is further differentiated. Purebred cattle split into heifers, female cattle and other cattle. “Other cattle” consists of 12 subcategories, distinguished by sex, weight, age group (heifer versus cows), and purpose (“for slaughter” and “others”). To compile an overview of exports and imports for the past decades, it would be necessary to look up all countries of interest for each year and find out how many animals of which species and category had been exported and imported.

HI-Tier database

According to EU regulations, since 1999 all EU countries have to establish electronic databanks that allow the identification and tracing of their cattle and pigs. In Germany, the *Herkunftssicherungs- und Informationssystem für Tiere* (HI-Tier) database is managed on behalf of all federal states by the Bavarian Ministry of Agriculture and Forestry.⁸ This database keeps track on the origin and movement of cattle and pigs in Germany. Although the databank documents animal imports and exports, it does not include the purpose of the animals and therefore does not allow to distinguish between breeding animals and animals for slaughter.⁹ Germany does not seem to be the sole country with not recording the purposes. For example, a report

6 EAAP database www.tiho-hannover.de/einricht/zucht/eaap/ (accessed 1 August 2004).

7 Ferdinand Schmitt personal communication 2004.

8 www.hi-tier.de (accessed 28 August 2005).

9 Andrea Wienecke personal communication 12 Jan 2004.

Herd Movements

from Australia complains that “no organization maintains records of importation that distinguish beef from dairy”.¹⁰

¹⁰ Griffith et al. 2003.

Glossary

Agrobiodiversity The spectrum of all plant and animal breeds and species used in agriculture.

Animal genetic resources Collective name for the whole spectrum of animal species and breeds and their genetic information. Commonly used to refer to domesticated animals only.

Breed In the North, this is understood as, “a group of animals with definable and identifiable external characteristics that distinguish it from other groups within the same species”. In the South, it refers to a group of animals belonging to the same species that is kept by a particular community in a specific environment and subjected to the same utilization pattern.

Domestic animal diversity Collective name for the whole spectrum of domesticated animal species and breeds and the genetic information they contain.

In situ conservation Conservation within the native habitat or an environment similar to this.

Ex situ conservation Conservation approaches outside of the breed’s natural habitat – for example, in zoos and in gene banks.

Gene A special substance in the body’s cells (building blocks) determining how an animal looks and develops. An animal’s genes are a combination of the genes from both parents.

Heterosis effect This effect is responsible in large part for high yields and robustness observed in first cross-breed generations compared to the average performance of their parents. Heterosis is triggered when mating partners are not related (cross-breeding), because then the genes paired together differ from each other (heterozygosity). If cross-bred animals are used for breeding, the effects of heterosis are lost together with heterozygosity.

Local breed A breed that is adapted to a specific habitat and has been shaped, often over centuries, by the cultural preferences of a particular community or ethnic group – in contrast to an “international” high-performing breed produced through very intensive selection for very specific traits, often with the use of biotechnologies.

Ruminants Cattle, sheep, goats, camels and other cud-chewing species.

Species A group of animals that freely breeds with each other and produces fertile offspring. Example: Donkey and horse are different species. Although they may be able to interbreed, their offspring (mules) are not fertile.

References

- ADR.** 1955. *Stand der Rinderbesamung im Bundesgebiet am 1. 1. 1955*. Verlag M. u. H. Schaper, Hannover.
- ADR.** 1959–2002. *Annual reports for the years 1959–2002*. Arbeitsgemeinschaft Deutscher Rinderzüchter, Bonn.
- ADR.** 1959a. *Die Rinderzucht in der BRD. Jahresbericht für 1958*. Arbeitsgemeinschaft Deutscher Rinderzüchter, Bonn.
- ADR.** 1959b. *Die Rinderbesamung in der BRD, Stand 1.1.1959*. M. und H. Schaper, Hannover.
- ADR.** undated, 1960? *Die Rinderzucht in der BRD. Jahresbericht für 1959*. ADR, Bonn.
- ADR.** 1974. *Rinderproduktion 1973: Zucht, Leistungsprüfung, Besamung in der BRD*. Land- und Hauswirtschaftlicher Auswertungs- und Informationsdienst (AID), Bonn.
- ADR.** 1983. *Rinderproduktion in der Bundesrepublik Deutschland*. Arbeitsgemeinschaft Deutscher Rinderzüchter, Bonn.
- ADR.** 1985. *Rinderproduktion in der Bundesrepublik Deutschland*. Arbeitsgemeinschaft Deutscher Rinderzüchter, Bonn.
- ADR.** 2002. *Rinderproduktion in der Bundesrepublik Deutschland 2001*. Arbeitsgemeinschaft Deutscher Rinderzüchter, Bonn.
- ADT.** 1961. *Livestock breeding in the Federal Republic of Germany*. Land- und hauswirtschaftlicher Auswertungs- und Informationsdienst, Bonn.
- Allen, Jack and Ancharlie Na-Chiangmai.** 2001. *Development strategies for genetic evaluation for beef production in developing countries*. Proceedings of an international workshop held in Khon Kaen Province, Thailand, July 23–28, 2001. [www.aciar.gov.au/web.nsf/doc/JFRN-5J473J/\\$file/PR108.pdf](http://www.aciar.gov.au/web.nsf/doc/JFRN-5J473J/$file/PR108.pdf) (accessed 17 January 2005).
- Anonymous** (based on Tweesackdi Sesaweech). 1995. His Majesty's contribution to livestock development in Thailand. *Asian Livestock* 20(10):110–118.
- Apelo, Carmen.** 1997. Genetic improvement of cattle, buffalo and small ruminants in the Philippines: Requirement and past experience. *MLD&RI and GTZ 1997*, pp. 135–172.
- Arik, M. Z. Zöð, N. Akkoca and N. M. Taylor.** 1996. A micro-economic survey of mixed livestock and crop farms in Ankara Province of Central Anatolia, Turkey. *Vieh & Fisch*. Fachliche Beiträge über Viehwirtschaft, Veterinärwesen und Fischerei aus Projekten und der Zentrale. GTZ, Eschborn, Germany. Pp. 83–89.
- ARS.** 2003. Annual report, beef cattle research. Project: Evaluation of beef cattle germplasm for the Subtropics of the United States. Agricultural Research Service, US Department of Agriculture. www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=405830&showpars=true&fy=2003 (accessed 2 August 2004).
- Augsten, Frank.** 2001. Rinderzucht – Quo vadis? In: *Landwirtschaft 2002: Der kritische Agrarbericht*. Agrarbündnis e.V., Rheda-Wiedenbrück, Germany. Pp. 134–138.
- Baldia, Maximilian O.** 2000 (updated on 27 October 2003). The origins of agriculture. *The Comparative Archaeology Web*, www.comp-archaeology.org/AgricultureOrigins.htm (accessed 25 May 2005).
- Baptist, R.** 1994. Nationaler Reinzuchtplan für Milchvieh am Beispiel Kenias: Nachhaltig wirkungslos. In: *Vieh & Fisch*. Fachliche Beiträge über Viehwirtschaft, Veterinärwesen und Fischerei aus Projekten und der Zentrale. GTZ, Eschborn, Germany. Pp. 147–162.
- Barwinek, F. and C. Gürer.** 1997. Assessment of financial losses incurred after import of pregnant heifers from Europe to Turkey. In: *Vieh & Fisch*. Fachliche Beiträge über Viehwirtschaft, Veterinärwesen und Fischerei aus Projekten und der Zentrale. GTZ, Eschborn, Germany. Pp. 273–303.
- Bayer, Wolfgang, Annette von Lossau and Antje Feldmann.** 2003. Smallholders and community-based management of farm animal genetic resources. In: SADC, UNDP, GTZ, CTA and FAO. *Community-based*

- management of animal genetic resources*. Proceedings of a workshop held in Mbabane, Swaziland, 7–11 May 2001. Food and Agriculture Organization of the United Nations, Rome. Pp. 1–12.
- Bazeley, Peter B.S.** 1992. Making it happen: The professional challenge. In P.W. Daniels et al. (eds). *Livestock services for smallholders*. Proceedings of a seminar, Yogyakarta, Indonesia. Indonesia International Animal Science Research and Development Foundation, Bogor, Indonesia. Pp. 333–338.
- Beck, E.** 1983. Wirtschaftliche Bedeutung der wichtigsten Rinder- und Wasserbüffelrassen Indiens. *Tierärztliche Umschau* 38(9):602–612.
- Berge, S.** 1959. Historische Übersicht über Zuchttheorien und Zuchtmethoden bis zur Jahrhundertwende. In: John Hammond, Ivar Johannson and Fritz Haring (eds). *Handbuch der Tierzucht*, Bd. 2: Haustiergenetik. Paul Parey, Hamburg. Pp. 1–23.
- Bester, Jenny, L.E. Matjuda, J.M. Rust and H.J. Fourie.** 2003. The Nguni: A case study. In: *Community-based management of animal genetic resources*. Proceedings of the workshop held in Mbabane, Swaziland, 7–11 May 2001. Food and Agriculture Organization of the United Nations, Rome. Pp. 45–69.
- Blackburn, H.D.** 2002. Management of US genetic resources. In: *Proceedings of the 7th World Congress on Genetics Applied to Livestock Production*, August 19–23, 2002, Montpellier, France.
- BMVEL.** 2001. *Agrarbericht der Bundesregierung 2001*. Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft, Bonn.
- BMVEL.** 2002. *Molekulargenetische Differenzierung verschiedener Rotviehpopulationen*. Landwirtschaftsverlag, Münster.
- Boehncke, Engelhard and Christian Krutzinna.** 2001. Agrarwende – aus der Sicht der Milchkühe. In: *Landwirtschaft 2002: Der kritische Agrarbericht*. Agrarbündnis e.V., Rheda-Wiedenbrück, Germany. Pp. 129–133.
- Bradley, D.J.** 2003. Genetic hoofprints. *Natural History Magazine* www.naturalhistorymag.com/0203/0203_feature.html (accessed 15 January 05).
- Bühler, Rudolf.** 1998. Das Schwäbisch-Hällische Landschwein – die älteste und traditionsreichste Schweinerrasse Deutschlands. 4-page leaflet, reprinted from *Der goldene Pflug* 9, University of Hohenheim, Stuttgart.
- Bundesregierung.** 2003. Tierschutzbericht 2003: Bericht über den Stand der Entwicklung des Tierschutzes. Deutscher Bundestag Drucksache 15/723 dated 26. 3. 2003. <http://dip.bundestag.de/btd/15/007/1500723.pdf>
- Campbell, John R. and John F. Lasley.** 1985. *The science of animals that serve humanity*. McGraw-Hill, New York.
- CAST.** 1984. *Animal germplasm preservation and utilization in agriculture*. Report No. 101. Council for Agricultural Science and Technology, Ames, Iowa.
- CEI.** 2000. Bovine spongiform encephalopathy, Germany. Impact Worksheet, December 2000. Center for Emerging Issues, USDA at www.aphis.usda.gov/vs/ceah/cei/IW_2000_files/bse_germany1200e.htm (accessed 23 August 2003).
- Chambers, Robert.** 1997. *Whose reality counts? Putting the first last*. Intermediate Technology Publications, London.
- Chantalakhana, C. and P. Skunmun.** 2002. Dairy development in Thailand and a case study on environmental impacts of peri-urban dairy colonies. Part I. Smallholder dairy development. In: Rangnekar and Thorpe 2002.
- Chark, Yap Boon.** 1998. Development of pig farming areas and pig waste management – the Singapore experience. In: Y.W. Ho and Y.K. Chan (eds). *Proceedings of the regional workshop on area-wide integration of crop-livestock activities*, held 18–20 June, 1998, FAO Regional Office, Bangkok Thailand. www.fao.org/WAIRDOCS/LEAD/X6105E/x6105e10.htm (accessed 27 May 2005).
- Christ, Holger and Steffen Schürkens.** 2003. Transgenic livestock. *Genetic Engineering Newsletter Special Issue* 13.

Herd Movements

- Chupin, D. and H. Schuh.** 1992. Survey of present status of the use of artificial insemination in developing countries. www.fao.org/ag/aga/agap/war/warall/u9550b/u9550b0d.htm (accessed 25 May 2005; online version is a condensed version of paper in *Elevage et Insémination* 256:1–26).
- Crucial II Group, The.** 2000. *Seeding solutions. Vol. 1: Policy options for genetic resources: Peoples, plants and patents revisited.* International Development Research Centre, International Plant Genetic Resources Institute and Dag Hammarskjöld Foundation, Rome, Italy.
- DAD-IS.** 2004. *State of the world's animal genetic resources: Germany.* Domestic Animal Diversity Information System (DAD-IS), Food and Agriculture Organization of the United Nations (FAO). <http://dad.fao.org/en/refer/library/sow/407.pdf> (accessed 25 May 2005).
- De Haan, Cees.** 2003. Livestock breeding technologies and rural development: Development experiences. Unpublished paper, World Bank Group. [http://lnweb18.worldbank.org/ESSD/ardext.nsf/26ByDocName/LivestockBreedingTechnologiesandRuralDevelopment/\\$FILE/LivestockBreedingTechnologies.pdf](http://lnweb18.worldbank.org/ESSD/ardext.nsf/26ByDocName/LivestockBreedingTechnologiesandRuralDevelopment/$FILE/LivestockBreedingTechnologies.pdf) (accessed 12 August 2004).
- De Haan, Cees, Henning Steinfeld and Harvey Blackburn.** Undated (1999?). *Livestock & environment: Finding a balance.* Commission of the European Communities. www.fao.org/documents/show_cdr.asp?url_file=/docrep/x5303e/x5303e00.htm (accessed 25 May 2005).
- Djimde, Mamadou and Joachim Hans Weniger.** 1986. Semen quality in relation to genotype and season in the tropics of Bangladesh. *Animal Research and Development* 23:116–127.
- Djoharjani T. and H.M.J. Udo.** 1986. Goat production performances in an upland area of East Java, *Tropical Animal Health and Production* 18:76–80.
- Delgado, C., M. Rosegrant, H. Steinfeld, S. Ehui, and C. Corbois.** 1999. Livestock to 2020: The next food revolution. *Food, Agriculture, and the Environment Discussion Paper* 28. International Food Policy Research Institute (IFPRI), Washington, DC, Food and Agriculture Organization of the United Nations (FAO), Rome, and International Livestock Research Institute (ILRI), Nairobi.
- Delgado, Christopher, Clar A. Narrod and Marites M. Tiongco.** 2003. *Policy, technical and environmental determinants and implications of the scaling-up of livestock production in four fast-growing developing countries: A synthesis.* Project on livestock industrialization, trade and social-health-environment impacts in developing countries. Final research report of Phase II, submitted by IFPRI to FAO, Rome. www.fao.org/WAIRDOCS/LEAD/X6170E/X6170E00.HTM (accessed 25 May 2005).
- Economist, The.** 30 Oct 1997. *Workers of the world.* www.economist.com/displaystory.cfm?story_id=104823 (accessed 25 May 2005).
- ETC Group.** 2000. *Biopiracy – RAFI's Sixth Annual Update: Captain Hook, the cattle rustlers, and the plant privateers: Biopiracy of marine, plant, and livestock continues.* www.etcgroup.org/article.asp?newsid=174 (accessed 10 June 2004).
- European Commission.** 2002. *The welfare of animals during transport (details for horses, pigs, sheep and cattle).* Report of the Scientific Committee on Animal Health and Animal Welfare, Health & Consumer Protection Directorate-General. March 2002. www.europa.eu.int/comm/food/fs/sc/scah/out71_en.pdf (accessed 25 May 2005).
- FAO.** 1993/4. Fact sheet: Agrobiodiversity: the case for conserving domestic and related animals. *World Animal Review* 77, www.fao.org/docrep/v1650t/v1650t0y.htm (accessed 10 June 2004).
- FAO.** 2001. *Lessons learnt from case studies on animal genetic resources.* Document No. UNEP/CBD/SBSTTA/7/INF/12. Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), Secretariat of the Convention on Biological Diversity, Quebec, Canada.
- FAO.** 2003. *Animals: Unexpected products?* FAO Newsroom, www.fao.org/english/newsroom/focus/2003/gmo4.htm (accessed 25 May 2005).
- FAO.** undated. *Conserving and developing farm animal diversity.* FAO, Rome, Italy. 3 pp.
- FAOSTAT.** 2004. *Trade in live animals.* <http://faostat.fao.org> (accessed 17 October 2004).
- Fletcher, C., B. Gunawan, D.J.S. Hetzel, B. Bakrie, N.G. Yates and T.D. Chaniago.** 1985. Comparison of lamb production from indigenous and exotic x indigenous ewes in Indonesia. *Tropical Animal Health and Production* 17:127–134.

- Flock, D.K. and R. Preisinger.** 2002. Breeding plans for poultry with emphasis on sustainability. In: *Proceedings of the 7th World Congress on Genetics Applied to Livestock Production*, August 19–23, 2002, Montpellier, France.
- Foote, R.H.** 2002. The history of artificial insemination: Selected notes and notables. *Journal of Animal Science* 80, Electronic Supplement 2. www.asas.org/symposia/esupp2/Footehist.pdf (accessed 26 May 2005).
- Freeden, Uta von and Siegmar von Schnurbein** (eds). 2002. *Spuren der Jahrtausende. Archäologie und Geschichte in Deutschland*. Konrad Theiss Verlag, Stuttgart, Germany.
- Gall, C.F.** 1997. Discussions and recommendations of the workshop. In: MLD&RI and GTZ 1997, pp. 205–215.
- Geerlings, E.** 2001. *Sheep husbandry and ethnoveterinary knowledge of Raika sheep pastoralists in Rajasthan, India*. MSc thesis. Environmental Sciences, Wageningen University, Wageningen, The Netherlands. www.pastoralpeoples.org/geerlings.htm
- Geerlings, Ellen, Evelyn Mathias and Ilse Köhler-Rollefson.** 2002. *Securing tomorrow's food: Promoting the sustainable use of farm animal genetic resources. Information for action*. League for Pastoral Peoples, Ober-Ramstadt, Germany. www.pastoralpeoples.org/securing.htm
- GEH.** Undated. *Schwerpunkt Schafe und Ziegen*. Gesellschaft zur Erhaltung alter und gefährdeter Haustierrassen e.V., Witzenhausen, Germany.
- Gibson, J.P.** 2002. Role of genetically determined resistance of livestock to disease in the developing world: Potential impact and researchable issues. In: B.D. Perry, T.F. Randolph, J.J. McDermott, K.R. Sones and P.K. Thornton. *Investing in animal health research to alleviate poverty*. ILRI, Nairobi Kenya. Appendix 13 (on CD-ROM attached to book, or www.ilri.cgiar.org/InfoServ/Webpub/Fulldocs/InvestAnim/Book1/media/Appendex/13/append.htm (accessed 25 May 2005).
- Greising, Thomas.** 1998. In-vitro-Erzeugung von Rinderembryonen: Ultraschallgeleitete Entnahme von Eizellen beschleunigt den Zuchterfolg. *ForschungsReport* (Zeitschrift des Senats der Bundesforschungsanstalten) 2:14–17.
- Greenhill, Romilly and Patrick Watt.** 2005. *Real aid: An agenda for making aid work*. Action Aid, Johannesburg, South Africa. www.actionaid.org.uk/wps/content/documents/real_aid.pdf (accessed 30 May 2005).
- Grell, H.** 1973. Produktionssysteme in der Schafhaltung an subtropischen und Tropischen Standorten. In: Horst and Grell 1973, pp. 30–98.
- Griffith, G.R., R.J. Farquharson, S.A. Barwick, R.G. Banks and W.E. Holmes.** 2003. Estimating returns from past investments into beef cattle genetics RD&E in Australia. *Proceedings of the 25th International Conference of Agricultural Economics*, 16–22 August 2003. ISBN 0-958-46098-1.
- GTZ.** 1976. *International cooperation in the agricultural sector: Veterinary projects*. German Agency for Technical Cooperation, Eschborn.
- Guèye, E.F.** 2005. Editorial: Family poultry must no longer be a 'hidden harvest'. *INFPD Newsletter* 15(1):1.
- Hall, S., and J. Ruane.** 1993. Livestock breeds and their conservation: A global overview. *Conservation Biology* 7(4):815–25.
- Hanotte, O., C. L.Tawah, D.G. Bradley, M. Okomo, Y. Verjee, J. Ochieng and J.E.O. Rege.** 2000. Geographic distribution and frequency of taurine *Bos taurus* and indicine *Bos indicus* Y species allele amongst sub-Saharan African cattle breeds. *Molecular Ecology* 9:387–396.
- Hanotte, O., D.G. Bradley, J.W. Ochieng, Y. Verjee, E.W. Hill, and J.E.O. Rege.** 2002. African Pastoralism: Genetic Imprints of Origins and Migrations. *Science* 296:336–339.
- Haumann, Petra.** 2002. Zur Entwicklung in der Scrapie-Resistenzucht. *Arche Nova* 4–5.
- Höfer, Fritz, Kurt Bauer, Albert Görlach, Rudolf Hahn and Hans-Friedrich Zoder.** 1982. Hygiene-Fahrplan des Besamungsvereins Neustadt a. d. Aisch (BVN). *Tierärztliche Umschau*, special edition combining articles from volume 36(6–12) 1981 and 37(1) 1982.
- Hills, Rachel and Matthew Young.** 1999. *Damara sheep in Western Australia*. Market Intelligence Project, AGWEST Trade and Development, Perth, Australia.

Herd Movements

- Hirooka, H., T.K. Mukherjee, J.M. Panandam and P. Horst.** 1997. Genetic parameters for growth performance of the Malaysian local goats and their crossbreds with German (improved) Fawn goats. *Journal of Animal Breeding and Genetics* 114:191–199.
- Hoffmann, Irene.** 2000. Milchproduktion in Afrika. In: *Milch*. BUKO Agrar Dossier 23. Schmetterling Verlag, Stuttgart. Pp. 52–58.
- Hoffmann, I.** 2005 (in press). Management of livestock genetic resources: Change and interaction. In: Jarvis, D., C. Padoch and D. Cooper (eds): *Managing biodiversity in agroecosystems*. Columbia University Press.
- Hoffmann, I., F. Siewerdt, and D. Manzella.** 2004. *Research and investment: Challenges and options for sustainable use of poultry genetic resources*. Paper presented at the XXII World's Poultry Congress, Istanbul, 8–13 August 2004.
- Horst, Peter.** 1985. Preservation of genetic resources in tropical and subtropical animal production. *Animal Research and Development* 22:59–69.
- Horst, Peter.** 1989. Local breeds of swine as gene reserves for future breeding. *Animal Research and Development* 29:102–110.
- Horst, P. and H. Grell.** 1973. Studien zur Schaf- und Ziegenhaltung in den Tropen und Subtropen. *IFO Forschungsberichte der Afrika-Studienstelle* No. 46. IFO-Institut für Wirtschaftsforschung, Weltforum Verlag, no place of publication given.
- Ibrahim, Mamman Aminu and Paul Ayuba Abdu.** 1996. Ethno-agroveterinary perspectives on poultry production in rural Nigeria. In: Constance M. McCorkle, Evelyn Mathias and Tjaart W. Schillhorn van Venn (eds). *Ethnoveterinary research & development*. Intermediate Technology Publications, London. Pp. 104–115.
- IDL Group.** 2002. *Poverty and livestock breed diversity – The way forward for DfID*. Draft consultation document. IDL Group, Crewkerne, UK. www.theidlgroup.com/downloads/bioreportpart1.pdf (accessed 25 May 2005).
- ILRI.** 1995. *Livestock policy analysis*. ILRI Training Manual 2. International Livestock Research Institute, Nairobi. ISBN 92-9146-003-6.
- ILRI.** undated. African genetic treasures key to reducing disease and poverty – briefing. International Livestock Research Institute, Nairobi. www.ilri.cgiar.org/ilripublication/index_list.asp?Topic=Disease&Section=Hot+topics (accessed 25 May 2005).
- Jalaludin, S. and R.A. Halim.** 1998. Development of the livestock industry in Malaysia. In: Y.W. Ho and Y.K. Chan (eds). *Proceedings of the Regional Workshop on Area-Wide Integration of Crop-Livestock Activities*, held 18-20 June, 1998, FAO Regional Office, Bangkok Thailand. www.fao.org/WAIRDOCS/LEAD/X6105E/x6105e08.htm (accessed 12 August 2004).
- Jilg, Thomas.** 2003. *Zucht von Schafen ohne Wolle*. Internationale Fachtagung für Schafhaltung, Innsbruck. www.gumpenstein.at/publikationen/fachtagungschaf/jilg.pdf (accessed 25 May 2005).
- Kaal-Lansbergen, Lucia and Sipke Joost Hiemstra.** 2003. Relevance of access and benefit sharing for farm animal genetic resources. *North-South Policy Brief 2003–5*. Programme International Cooperation, Wageningen University and Research Centre, Wageningen, Netherlands.
- Kaden, V., G.M. Keil, N. Osterrieder, H. Schirrmeier and T.C. Mettenleiter.** 1998. Neue Impfstoffe gegen Viruskrankheiten bei Tieren. Entwicklungssprung durch die Gentechnologie. *ForschungsReport* (Zeitschrift des Senats der Bundesforschungsanstalten) 2:4–8.
- Kalm, Ernst.** 2000. *Potential of biotechnologies to enhance animal production*. Paper presented at the Global Dialogue EXPO 2000 Forum, Hanover, 15 August 2000. Zentrum für Entwicklungsforschung/Centre for Development Research, University of Bonn. www.zef.de/gdialogue/Program/Papers_Day_1/sid-biotechnology-kalm.pdf (accessed 20 October 2004).
- Karugia, Josef T., Okeyo A. Mwai, Robert Kaitho, Adam Drucker, Clemens B.A. Wollny and J.E.O. Rege.** 2001. Economic analysis of crossbreeding programmes in Sub-Saharan Africa: A conceptual framework and Kenyan case study. *FEEM Working Paper* No. 106.2001 http://papers.ssrn.com/sol3/papers.cfm?abstract_id=297058 (accessed 25 May 2005).

- Kaziboni, S., N.T. Kusina, S. Sibanda, S. Makuza, O. Nyoni and E. Bhebhe.** 2004. Performance of artificial insemination in smallholder dairies of Nharira-Lancashire in Zimbabwe. *Livestock Research for Rural Development*. Vol. 16, Art. #25. www.cipav.org.co/Irrd/Irrd16/4/kazi16025.htm (accessed 20 October 2004).
- Kerkow, Uwe.** 2005. *Die überschätzte Gefahr. Subventionierte Milch(pulver)exporte: Probleme von Milcherzeugern und –konsumenten in Entwicklungsländern*. German Agro Action, Bonn. www.welthungerhilfe.de/WHHDE/download/themen/milch_entwicklungslaender.pdf (accessed 25 May 2005).
- Khurana, Indira.** 1997. Vanishing breeds. *Down to Earth* 6(8):27–37.
- Köhler-Rollefson, I.** 2000. *Management of animal genetic diversity at the community level*. German Agency for Technical Cooperation (GTZ), Eschborn, Germany.
- Köhler-Rollefson, I.** 2003. Community-based management of animal genetic resources – with special reference to pastoralists. In: *Community-based management of animal genetic resources*. Proceedings of the workshop held in Mbabane, Swaziland, 7–11 May 2001. Food and Agriculture Organization of the United Nations, Rome. Pp. 13–26.
- Köhler-Rollefson, I.** 2004a. *Farm animal genetic resources: Safeguarding national assets for food security and trade*. A summary of workshops on farm animal genetic resources held in the Southern Africa Development Community (SADC). GTZ, FAO and CTA, Eschborn, Germany.
- Köhler-Rollefson, I.** 2004b. *Livestock keepers' rights: Conserving breeds, supporting livelihoods*. League for Pastoral Peoples and Endogenous Livestock Development, Ober-Ramstadt.
- Köhler-Rollefson, Ilse.** 2005. *Building an international legal framework on animal genetic resources: Can it help the drylands and food-insecure countries?* German NGO Forum on Environment & Development, Bonn, Germany. www.pastoralpeoples.org/docs/int_legal_framework_an_gen_res.pdf (accessed 8 June 2005).
- Köhler-Rollefson, Ilse.** Forthcoming. *An alternative vision of livestock development for the poor*. League for Pastoral Peoples, Ober-Ramstadt.
- Köhler-Rollefson, I. and J. Wanyama** (eds). 2003. *The Karen Commitment: Proceedings of a conference of indigenous livestock breeding communities on animal genetic resources*. German NGO Forum on Environment and Development, Bonn. www.pastoralpeoples.org/karen.htm (accessed 25 May 2005).
- Kosgey, Isaac Sanga.** 2004. *Breeding objectives and breeding strategies for small ruminants in the tropics*. PhD thesis, Animal Breeding and Genetics Group, Wageningen University, Wageningen, Netherlands.
- Kräußlich, Horst.** 1994. *Tierzüchtungslehre* (4th ed). Eugen Ulmer, Stuttgart.
- Kurup, M.P.G.** 2002. Smallholder dairy production and marketing in India: Constraints and opportunities. In: Rangnekar and Thorpe 2002.
- Leeb, Tosso.** 2003. Vorlesungsfolien “Tierzucht und Genetik I”. www.tiho-hannover.de/einricht/zucht/t_leeb.htm (accessed 2 May 2003).
- Leonard, D.K.** 2004. The political economy of international development and pro-poor livestock policies: A comparative assessment. *PPLPI Working Paper* No. 12, FAO, Rome.
- LID.** 1999. *Livestock in poverty focused development*. Livestock in Development, Crewkerne, UK.
- Lohmann Tierzucht.** 1999. Lohmann SLS: Marktführer in Saudi Arabien. *Lohmann Poultry News* 4 (November 1999):6.
- Lohmann Tierzucht.** 2002. Breeding for success – Malaysia: Huat Lai Resources Berhad. *Lohmann Poultry News* 7(July 2002):3.
- LPPS.** 2004. *The camel in Rajasthan. Agricultural biodiversity under threat*. Background information for the international conference “Saving the camel and peoples’ livelihoods: Building a multi-stakeholder platform for the conservation of the camel in Rajasthan”. Lokhit Pashu-Palak Sansthan, Sadri, Rajasthan, India. www.pastoralpeoples.org/docs/camel_conf_proc.pdf
- LPPS and Ilse Köhler-Rollefson.** 2005. *Indigenous breeds, local communities. Documenting animal breeds and breeding from a community perspective*. Lokhit Pashu-Palak Sansthan, Sadri, India. www.pastoralpeoples.org (accessed 8 June 2005).

Herd Movements

- Mafeni, Mase J., Klaus Wimmers and Peter Horst.** 1997. Genetic diversity in indigenous Cameroon and German Dahlem Red fowl populations estimated from DNA fingerprints. *Archiv für Tierzucht* (Forschungsinstitut für Biologie landwirtschaftlicher Nutztiere Dummerdorf) 40(6):581–589.
- Mason, I.L and R.D. Crawford.** 1993. Global status of livestock and poultry species. In: National Research Council. *Managing global genetic resources*. National Academy Press, Washington, DC. Pp. 141–169.
- MLD&RI and GTZ.** 1997. *Breeding programmes for ruminants in Asia: Concepts, facts, recommendations*. Ministry of Livestock Development and Rural Industries, Sri Lanka, and GTZ, Eschborn, Germany.
- Menghin, Wilfried and Dieter Planck** (eds). 2002. *Menschen, Zeiten, Räume – Archäologie in Deutschland*. Staatliche Museen zu Berlin and Konrad Theiss Verlag, Stuttgart.
- Meredith, Michael.** 2002. *Swine breeds and biodiversity*. www.aasv.org/news/story.php?id=376 (accessed 20 April 2005).
- Meyer, Brian.** 1997. Egyptian chicken plan hatches... 50 years later. *Iowa Stater* May 1997, www.iastate.edu/IaStater/1997/may/chicken.html (accessed 11 June 2004).
- Muriuki, H. G. and W. Thorpe.** 2002. Smallholder dairy production and marketing in eastern and southern Africa: Regional synthesis. In: Rangnekar and Thorpe 2002.
- Murphy, Thomas and Clem Tisdell.** 1995. Specific livestock industries, livestock diseases and policies in Thailand: An overview of bovines (buffalo/cattle). *Research and Reports in Animal Health Economics* No. 9. Department of Economics, University of Queensland, Brisbane. www.geosp.uq.edu.au/Projects/aciar/papers/n9.pdf (accessed 21 January 2005).
- Musavaya, K. and A. Valle Zárate.** forthcoming. *Gene flow in animal genetic resources – A study on status, impacts, trends from exchange of breeding animals*. Institute of Animal Production in the Tropics and Subtropics, University of Hohenheim, Stuttgart.
- Nath, M. Narendra.** 1993. The Ongole cattle: A versatile resource for the Tropics. *World Animal Review* 76(3). www.fao.org/ag/AGa/AGAP/FRG/FEEDback/War/v0600b/v0600b04.htm (accessed 25 May 2005).
- New South Wales Department of Primary Industries.** 2001. *Agfact* A2.3.39. Fact sheet, first edition March 2001, www.agric.nsw.gov.au/reader/beef-breeds/a2339.htm (accessed 10 June 2004).
- Nimbkar, Chanda.** 2002. Gains from Garole – the “wonder” sheep of West Bengal. *Partners in Research for Development* 15:31–36. [www.aciar.gov.au/web.nsf/att/ACIA-5LE8CS/\\$file/Partners%2015.pdf](http://www.aciar.gov.au/web.nsf/att/ACIA-5LE8CS/$file/Partners%2015.pdf) (accessed 25 May 2005).
- Nischwitz, Guido, Alexander Bartelt, Markus Kaczmarek and Sibyl Steuer.** undated. *Lobbyverflechtungen in der deutschen Landwirtschaft. Beratungswesen, Kammern, Agrobusiness*. Report. Naturschutzbund Deutschland, Bonn und Institut für ökologische Wirtschaftsforschung, Wuppertal, www.nabu.de/downloads/landwirtschaft/lobby-studie.pdf (accessed 25 May 2005).
- Nooter, Robert.** 2004. Tanzania’s dairy enterprise. *International Outlook* 12(1):6. www.idd.landolakes.com/newsletter.asp (accessed 14 August 2004).
- Northoff, Erwin.** 2004. Domestic breeds in decline. *African Farming* May/June:10.
- Paterson, Lesley.** July 2002. *Somatic cell nuclear transfer (cloning) efficiency. Gene expression and development*. Roslin Institute, Edinburgh, www.roslin.ac.uk/public/webtablesGR.pdf (accessed 25 May 2005).
- Persley, G. J.** 2000. Agricultural biotechnology and the poor: Promethean science. In: G.J. Persley and M. M. Lantin (eds). *Agricultural biotechnology and the poor*. Consultative Group on International Agricultural Research, Washington DC, USA. Pp. 3–21.
- Pirchner, Franz.** 1982. Cattle crossbreeding trials in Egypt. *Animal Research and Development* 16:45–50. Institute for Scientific Co-operation, Tübingen, Germany.
- Ramdas, Sagari R. and Nitya S. Ghotge.** 2001. Vision 2020 livestock development policy of Andhra Pradesh, India: A skewed vision of food security for Indian farmers. In: Gabriele Stoll et al. (eds.). *Drawing on farmers’ experiences in food security: Local successes and global failures*. German NGO Forum on Environment & Development, Bonn, Germany. Pp. 53–64. www.forumue.de/pdfs/fu3cbd7b13.PDF (accessed 25 May 2005).

- Ramsay, Keith, Liz Harris and Antoinette Kotzé.** Undated. *Landrace breeds: South Africa's indigenous and locally developed farm animals*. Farm Animal Conservation Trust, Pretoria, South Africa.
- Rangnekar, D. and W. Thorpe** (eds). 2002. *Smallholder dairy production and marketing – Opportunities and constraints*. Proceedings of a South–South workshop held at NDDB, Ananda, India, 13–16 March 2001. National Dairy Development Board, Anand, India and International Livestock Research Institute, Nairobi, Kenya. www.ilri.cgiar.org/InfoServ/Webpub/Fulldocs/South_South/toc.htm (accessed 25 May 2005).
- Rothschild, M.F., Graham Plastow and Scott Newman.** 2004. Patenting in animal breeding and genetics. In: A. Rosati, A. Tewolde and C. Mosconi (eds). *WAAP Book of the year 2003: A review on developments and research in livestock systems*. World Association of Animal Production, Rome. Pp. 269–278.
- RPN.** 1980. Rinderproduktion Niedersachsen GmbH Bremen-Hannover. Hannover, Germany.
- Sahai, Suman.** 2005. The battle against biopiracy. *Indigenous Knowledge Newsletter for Community Rights and Sustainable Development* 1(4). E-newsletter by Gene Campaign, New Delhi, India.
- Salim, S.J.S.** 1984. The Malaysian livestock industry – an overview. *Animal Production in Malaysia*. Faculty of Veterinary Medicine and Animal Science, Universiti Pertanian Malaysia. Pp. 1-4.
- Sambraus, Hans Hinrich.** 1999. *Gefährdete Nutztierassen. Ihre Zuchtgeschichte, Nutzung und Bewahrung*. Ulmer, Stuttgart, Germany.
- Sambraus, Hans Hinrich.** 2001. *Farbatlas der Nutztierassen*. Eugen Ulmer, Stuttgart, Germany.
- Spharim, I. and E. Gootwine.** Undated. *Economic evaluation of breeding for higher prolificacy in awassi flocks*. Abstract at www.agri.gov.il/AnimalScience/Reproduction/Rep-Spharim.html (accessed 18 June 2004).
- Scherf, B.** 2000. *World watch list for domestic animal diversity*. Food and Agriculture Organization, Rome, Italy.
- Schrage, Reinhard, Oswin Perera and Martin Baumann.** 1997. Genetic improvement of cattle, buffalo and small ruminants in Sri Lanka, Requirements and past experience. In: MLD&RI and GTZ 1997, pp. 173–192.
- Shin, Taeyoung, Duane Kraemer, Jane Pryor, Ling Liu, James Rugila, Lisa Howe, Sandra Buck, Keith Murphy, Leslie Lyons, Mark Westhusin.** 2002. A cat cloned by nuclear transplantation. *Nature*, advanced online publication, www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v415/n6874/full/nature723_fs.html (accessed 25 May 2005).
- Shrest, Subran Lal and Laxman Sherchand.** 1997. Genetic improvement of cattle, buffalo and small ruminants in Nepal. Requirements and past experience. In: MLD&RI and GTZ 1997, pp. 93–108.
- Singh, K. and R.S. Pundir.** 2002. Problems and prospects of smallholder dairy production and marketing in South Asia: An overview. In: Rangnekar and W. Thorpe 2002.
- Sölkner, J., H. Nakimbugwe, and A. Valle Zárate.** 1998. *Analysis of determinants for success and failure of village breeding programmes*. Invited paper presented at the 6th World Congress on Genetics Applied to Livestock Production, 12–16 January 1998, Armidale, NSW, Australia, in Session 13 “Breeding in Developing Countries/Village Breeding Programmes”. (Proceedings Vol. 25, 273–280).
- Statistisches Bundesamt.** 2004a. Weitere Konzentration in der deutschen Landwirtschaft. Pressemitteilung vom 21. Januar 2004. www.destatis.de/presse/deutsch/pm2004/p0340141.htm (accessed 25 May 2005).
- Statistisches Bundesamt.** 2004b. *Landwirtschaft in Zahlen 2003*. www.destatis.de/download/d/veroe/faltblatt/landw2003.pdf (accessed 25 May 2005).
- Steinerman, Peter.** 2001. Long-term Infigen study of cloned cattle and pigs finds that they are normal and healthy. *Infigen News* www.infigen.com/news/news_20011127.html (accessed 25 May 2005).
- Sunderman, Fiona and Michael Jones.** 1994. Awassi fat tails – A chance for premium exports. *Journal of Agriculture, Western Australia* 35(3): 99–105. <http://agspsrv34.agric.wa.gov.au/agency/pubns/journalof-ag/v35/awassiFatTails.htm> (accessed 25 May 2005).

Herd Movements

- Turner, Jacky.** 2002. *The gene and the stable door: Biotechnology and farm animals*. A report for Compassion in World Farming Trust, summary and recommendations. Compassion in World Farming Trust, Petersfield, UK.
- Verband Deutscher Schwarzbuntzüchter.** undated (probably around 1969). *Die Deutsche Schwarzbuntzucht*. Information brochure for foreign breeders. IMEX, Bonn, 32 pp.
- Weigend, Steffen.** 2000. Rassenvielfalt und Erhaltung der genetischen Variabilität beim Hausgeflügel. In: Feldmann, Antje und Juliane Kirna. *Gefährdete Geflügelrassen und alternative Geflügelzüchtung*. Gesellschaft zur Erhaltung alter und gefährdeter Rassen (GEH), Witzenhausen, Germany. Pp. 5–10.
- Weigend, Steffen.** 2002. Molekulare Marker zur Bewertung genetischer Vielfalt bei Geflügel. *ForschungsReport* (Zeitschrift des Senats der Bundesforschungsanstalten) 2:34–37.
- Weigend, Steffen and Jörg Bremond.** 2004. Erhaltung und Nutzungspotenzial tiergenetischer Ressourcen unter besonderer Berücksichtigung des Haushuhns – ein Überblick [Conservation and utilization of animal genetic resources with emphasis on chicken – an overview]. In: Begemann, F. and S. Schröder (eds). *Produktvielfalt durch Ressourcenvielfalt – Potenziale genetischer Ressourcen*. Tagungsband eines Symposiums vom 24.–25. September 2003 im Gustav-Stresemann-Institut in Bonn. ZADI, Bonn. ISSN 0948-8332. Pp. 76–82.
- Williamson, G. and W. J. A. Payne.** 1978. *An introduction to animal husbandry in the Tropics*. English Language Book Society and Longman, London.
- Wolff, Franziska.** 2004. Legal factors driving agrobiodiversity loss. *ELNI Review* 1. Environmental Law Network International www.agrobiodiversitaet.net/site/page/downloads/dateien/ABD.ElNi.pdf (accessed 25 May 2005).
- Woods, G.L. et al.** 2003. A mule cloned from fetal cells by nuclear transfer. *Scienceexpress*, www.sciencemag.org/cgi/doi/10.1126/science.1086743 (accessed 25 May 2005).
- Wu, Ning.** 1998. Indigenous knowledge of yak breeding and cross-breeding among nomads in western Sichuan, China. *Indigenous Knowledge and Development Monitor* 6(1):7–9.
- Zarrilli, Simonetta.** 1999. *WTO Agreement on Sanitary and Phytosanitary Measures: Issues for developing countries*. Division on International Trade in Goods and Services, and Commodities, UNCTAD Secretariat, www.southcentre.org/publications/snp/toc.htm (accessed 7 August 2004).
- ZDS.** 2002. *Schweinproduktion 2001 in Deutschland*. Zentralverband der Deutschen Schweineproduktion, Bonn.