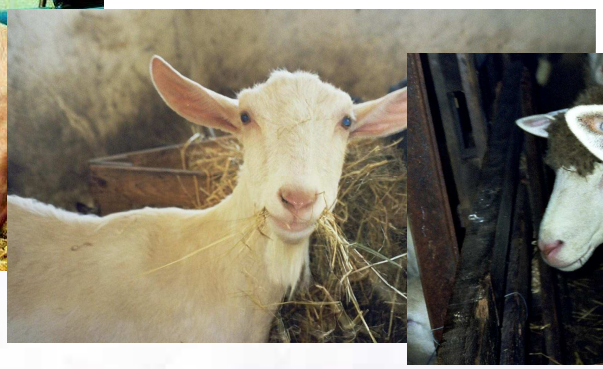
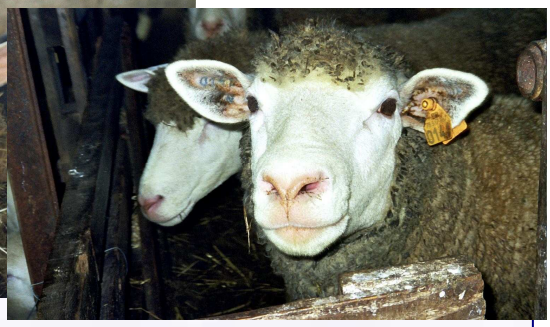
Sustainable Farm Animal Breeding & Reproduction Technology Platform





Strategic Research Agenda

2008

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FABRE Technology Platform

Sustainable Farm Animal Breeding and Reproduction Technology Platform

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Web site: www.fabretp.org

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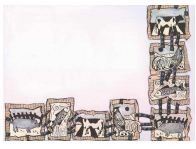


Added Value Animal Breeding in the EU/Europe

Economic *gain* (cumulative, permanent)	€1,89 billion/y
of which	
Dairy cattle	€ 430 Million/y
Beef cattle	€ 70 Million/y
Pigs (Europe)	€ 520 Million/y
Sheep/goats (Europe)	€ 156 million/y
Broilers (Europe)	€ 610 Million/y
Layers (Europe)	€ 125 Million/y
Salmon/rainbow trout/seabass/seabream/turbot	€ 80 Million/y

Animal Production in the EU

Value (EU25, 2003)	€132 Billion/y
Of total agricultural production	40 %

AgriFood in the EU

Number of farms (EU 25)	17 million
Number of jobs	15 million fte
Annual turnover AgriFood industry	€600 billion
Number of jobs	2,6 million fte

Demand Driven Livestock Revolution

Increase animal consumption coming 15-20 years	7 %/year

In all species aspects of **environmental footprint** (e.g. efficient use of inputs, reduction of waste) and consideration of **animal welfare and health** are critical features of the breeding process.

- Farm animal breeding takes place where **the high level research** takes place.
- Major breeding organisations with **business globally** are based in Europe or European owned (see page 8)
- Next to this, many farm animal breeding and reproduction organisations all over Europe play an important role in the **diversity and distinctiveness** of European animal production and the **European landscape and culture**.
- A sustainable, strong, broad and competitive breeding sector in Europe includes both the large and the small breeding structures.
- The application of expensive breeding and reproduction technologies is likely to continue to be applied first by larger companies.
- Once ideas and techniques are developed they will be available for use by smaller breeding companies working with species or breeds of lesser economic importance, and for further development for diversity, distinctiveness and developing countries.

[1] Sources: Economic gain = number of animals * % genetic progress per year * added value of 1 unit genetic progress

Summary

Animal agriculture plays an important role in European society. Optimised animal production systems can contribute to a safe, healthy and diverse diet, can help maintain sustainable human communities in more marginal regions of Europe and can facilitate reductions in our environmental footprint on the planet. A vibrant and effective animal breeding and reproduction industry is essential if Europe is to meet the future challenges of animal agriculture in a rapidly changing ecological, economic and social environment. Farm animal breeding and reproduction are a globally highly competitive, knowledge intensive sector. Currently, Europe has a major influence on the genetic make up of future animals and hence on the whole of animal production. European breeding organisations are major players in the global market and hence have a world wide impact.

FABRE TP, the **Sustainable Farm Animal Breeding and Reproduction Technology Platform (SSPE-CT-2006-004428)** has been set up to maintain and develop this technology sector for the benefit of Europe's future. In its first year of EU funding, FABRE TP has been developing a Strategic Research Agenda (SRA). In this period, the commitment for FABRE TP has been growing from 63 to 102 organisations. The SRA is based upon the Vision Paper "Sustainable Farm Animal Breeding and Reproduction – A Vision for 2025". Three types of effort have been undertaken to accomplish the SRA: expert group discussions, horizontal efforts, and country discussions. The results of the various discussions are available as separate Annex documents to this SRA.
The expert consultancy encompassed seven expert groups on farm animal species where there is a professional interest in breeding (cattle, sheep and goats, horses, pigs, poultry and aquaculture as well as dogs, honeybee, fur animals and rabbits) . Furthermore, three expert groups on themes (safe and healthy food; robust, adapted, healthy animals; diversity and distinctiveness) and three expert groups on technologies (genomics, genetics, reproduction) have been set up. The expert groups have produced reports identifying opportunities, knowledge gaps, and strategic and basic research needs for the next 15-25 years. Each group was presided over by a high level group of two industrial and two scientific experts. In total over 1000 specialists all over Europe have been involved in the exercise. An overall expert group discussion at 6 June 2007 in Utrecht completed this exercise. The results have been incorporated into the SRA – the full reports can be found in Annex I.

The horizontal work has been taking place throughout the project. Society representatives are being consulted at various stages, and invited to the steering, working and expert groups. A technology transfer and education group have identified the need for international technology transfer and lifelong learning. A society meeting with NGOs and breeders has dealt with environment, ethics, consumer issues, third countries, social responsibility (Spring 2008). The sustainable breeding scenarios developed during the last seven years with the input of various groups of researchers, industry representatives and society specialists and representatives are being linked to the food area forward outlook efforts that are currently being developed. (Annex II).

FABRE TP has undertaken 34 country discussions. Representatives from the European Forum of Farm Animal Breeders, European Association for Animal Production, Genesis Faraday and Roslin have visited all EU countries, plus Iceland, Israel, Norway, Russia, Switzerland, Turkey and Urkain, for a FABRE TP meeting to which the local organisers invited all interested stakeholders. These meetings have given voice to the numerous governmental, funding body, research and industry voices in Europe. Between 10 (Malta) to over 100 (Bulgaria) people have contributed to the SRA, relating the SRA to their national situation, and considering the initiation of a National Platform. The reports are available in Annex III.

FABRE TP has developed a specific easy reading SRA for policy makers, available in 28 languages.
In the spring of 2008 FABRE TP will present its Implementation Action Plan.
All expert group reports, country reports, various SRA versions, as well as a leaflet and poster are available from the web site: www.fabretp.org.

Introduction

The Sustainable Farm Animal Breeding and Reproduction Technology Platform (FABRE TP) presented its Vision Paper (Sustainable Farm Animal Breeding and Reproduction – A Vision for 2025), in March 2006 at the official launch of the FABRE TP at the Salon de l'Agriculture in Paris. This Vision is now being converted into an agenda for research. This Strategic Research Agenda will focus on the opportunities and challenges identified in the Vision relating to the breeding and reproduction of farmed animal and aquaculture species.

The Strategic Research Agenda is developing in various phases, from an initial draft (Draft 0), and a draft including the results of 13 expert groups (Draft 1), a draft including technology transfer and lifelong learning and other horizontal results, and the first country discussions (Draft 2), and this final SRA.
The SRA is the base for the development of the Implementation Action Plan.

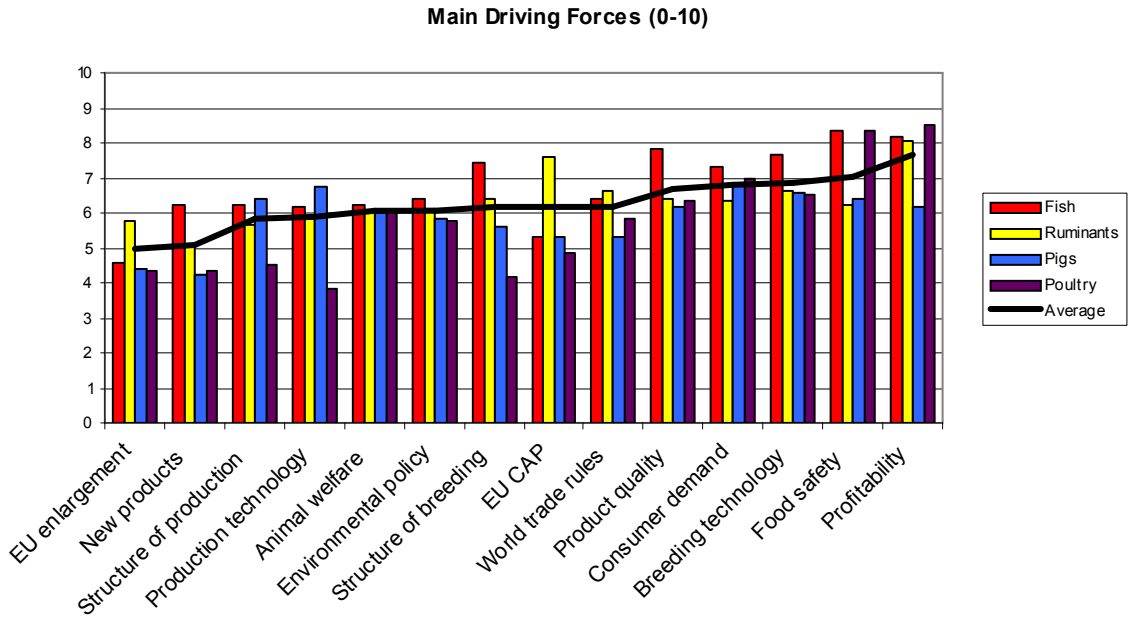
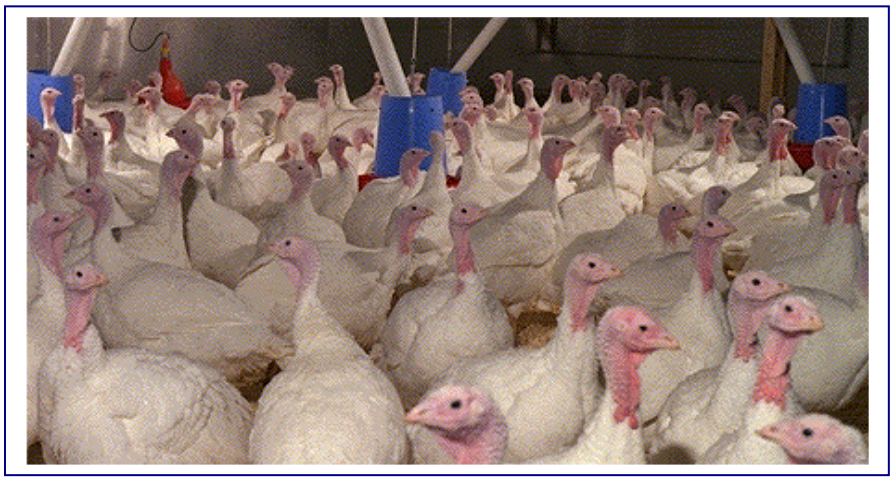


Figure 1. The main driving forces of change toward 2020 *(McInerney & Bennett, 2003 in: SEFABAR, 2003)*

In SEFABAR (Sustainable European Farm Animal Breeding and Reproduction; QLG7-2000-01368, www.sefabar.org) McInerney and Bennett have defined the major driving forces of change in farm animal breeding toward 2020. In broad outline, they are in line with the forces identified by the expert groups, horizontal groups and country discussions.



Overview of the Opportunities of FABRE TP

The opportunities

FABRE Technology Platform have identified the following opportunities to contribute to a sustainable competitive Europe:

Opportunities and Implementation

Global Responsibility and Competitiveness (1)

- Food Security and Sustainability
- Environment
- Consumer demand
- Competitiveness
- Ownership

Social Responsibility (2)

- Food Safety
- Product Quality
- Welfare and Health
- Transparency
- Regulatory Framework
- Dialogue
- Information for Society

A Diverse and Distinctive Europe (3)

- Farm Animal Genetic Resources
- Cultural Values
- Regional Values
- Access to Knowledge
- Data Collection and Selection Programmes

Implementation

- Reproductive technologies
- Phenomics
- Genetics
- Genomics
- Technology transfer
- Education (post-doc and lifelong)
- Socio-economics

Opportunities from investments in research

- Competitiveness against lower cost **imported food**
- Respond rapidly to a **changing environment**
- Rebalance breeding goals as effectively as desired for the benefit of **animal welfare**
- Management **biodiversity and optimisation land use**
- Contribution to significant reduction in **environmental footprint** of animal agriculture
- Improvement of **human health** by breeding animals resistant to zoonotic diseases
- Development of new **affordable, high quality and distinctive food products**
- **New scientific knowledge in biology** generally for the benefit of agriculture, the environment and society
- **Understanding the benefits and risks** of new technologies
- Gain from **coordination, synergy and critical mass already present in Europe**

Global Market Shares Animal Breeding

Pigs and Pig Breeding in the World.

According to the FAO report "Livestocks' long shadow" (Steinfeld *et al.* 2007), there are worldwide almost 920 million pigs of which 285 million in developed and 632 million in developing countries (see page 365 of FAO report). The resource population of these pigs are about 75 million sows of which almost 60% in developing countries (East and South East Asia), and mainly in back yard farming systems.

EU based org	% dev countr	% worldw
PIC (= Genus)	18	10
TOPIGS NL	8	5
Danbred DK	6	3
Hypor-Genex NL*	6	3
JSR UK	3	1
Seghers Rattlerow B-UK (incl. NewshamUS)	3	1
Herdbooks/Nucleus F	3	1
ACMC UK	2	1
Herdbook Poland	2	1
Herdbooks It	2	0,5
Herdbooks D	2	0,5
BHZP D	1,5	0,5
France Hybrides FR ****	1,5	0,5
Herdbooks East EU	2	0,5
Total EU based	60 %	28,5 %

Non-EU based org	% dev countr	% worldw
Monsanto USA**	5	2
Smithfield Genetics USA	3	1
Geneticporc (C)	3	1
National Swine Registry US	5	2
Canadian National Breeders	5	2
Total non-EU based	21%	8 %

To estimate the worldwide influence of pig breeding organisations, the replacement of sows is the best reference. Based on 75 million sows and 35-40% replacement of sows/year, there is annually a need of 28 million young sows per year. In developed countries, there is a need of 11,5 million replacement sows per year.
Version 2 April 2007.
**Hendrix Genetics have acquired the pig breeding part of Nutreco (Euribrid: Hypor –Genex) June 2007*
***Newsham (US) have acquired the breeding part of Monsanto September 2007*

Other species
There are around 1.3 billion cattle in the world, of which 327 million in developed and 983 million in developing countries. A more extensive table, including cattle market shares will come available from the EFFAB website www.effab.info (members / market shares). AquaGenome will provide aquaculture market shares in 2009.

Poultry and Poultry Breeding in the World

There are worldwide over 15 000 000 000 poultryof which over 4,5 billion in developing countries and over 10.5 billion in developing countries. In poultry breeding, with relatively a lot of offspring per animal and a short generation interval, the situation has developed into a few organizations owning and executing poultry breeding globally. All large players except Cobb-Vantress (30 % of global broiler breeding) are European owned.

Poultry – Broilers	% worldw
Aviagen (Wesjohann GE Europe)	50 %
Cobb Vantress (Tyson Food USA)***	30 %
Hubbard (Grimaud Fr Europe) *****	15 %
Hybro (Hendrix Genetics NL Europe)	7 %
Poultry - Layers	
Lohmann (Wesjohann GE Europe)	45 %
Hendrix (e.g. ISA, Euribrid, HPB NL Europe)	50 %
Ducks	
Cherry Valley (UK, Europe)	50 %
Grimaud (Grimaud Fr Europe) ****	40 %
There is around 40% of global duck production in unorganised breeding, mainly in China	
Turkeys	
BUT, Nicholas (Wesjohann GE Europe)	65 %
Hybrid (Hendrix Genetics NL Europe)	35 %

****Cobb Vantress and Hendrix-Genetics have agreed a Memorandum of Understanding (Spring 2008)*
*****France Hybrides will be acquired by Hendrix Genetics (Summer 2008) @ Wesjohann Group have acquired AquaGen (January 2008)*
******Grimaud take an interest in Newsham (US) (Summer 2008)*

Opportunity 1: Global Responsibility and Competitiveness

Scope: Farm animal breeding and reproduction are market leaders in a competitive global environment. Opportunities stem from the global need for a sustainable increase of food in a transparent way with respect for the environment in a favourable competitive business and regulatory climate.

a. Goal: To assure security and Sustainability of food production

Given the expected global population growth of 1.5 % per year and even without any change in per capita consumption, demand for foods of animal origin will grow enormously. However per capita consumption is expected to increase and in the next 15 years, urban populations are expected to grow at an average of 2.9% per year in all developing countries (Delgado *et al*., 1999).
Per capita income will also grow and provided the less wealthy benefit from these trends, they will also significantly contribute to the increasing demand for animal food products. Other factors may further boost demand. Increased trade and better communications, for example, will expose people even in remote areas to other cultures and foods.
An increasing need for security of supply in an uncertain world could increase food costs, especially the less privileged would suffer from this.
European animal breeding and reproduction will contribute to European and global food safety and affordability by increased efficiency, transfer of knowledge, organisation, technologies, and data collection across and outside of Europe.

Major opportunities:

- Research into more **efficient production systems**
- Development of efficient **animal breeding and reproduction technologies**
- Increase **knowledge and technology transfer** (better exchange of knowledge, technologies and skills)
- Research into (improved) **data collection systems** across and outside of Europe
- Research to improve the **quality and consistence** of products of animal origin, besides selecting for food safety and efficient production
- Research to maintain **food safety** in a high production environment.

Key Message: The future will bring increased global demand for safe and sustainable food - this can be achieved through new technological developments, efficient production systems and transfer of knowledge.

b. Goal: To lessen environmental impact

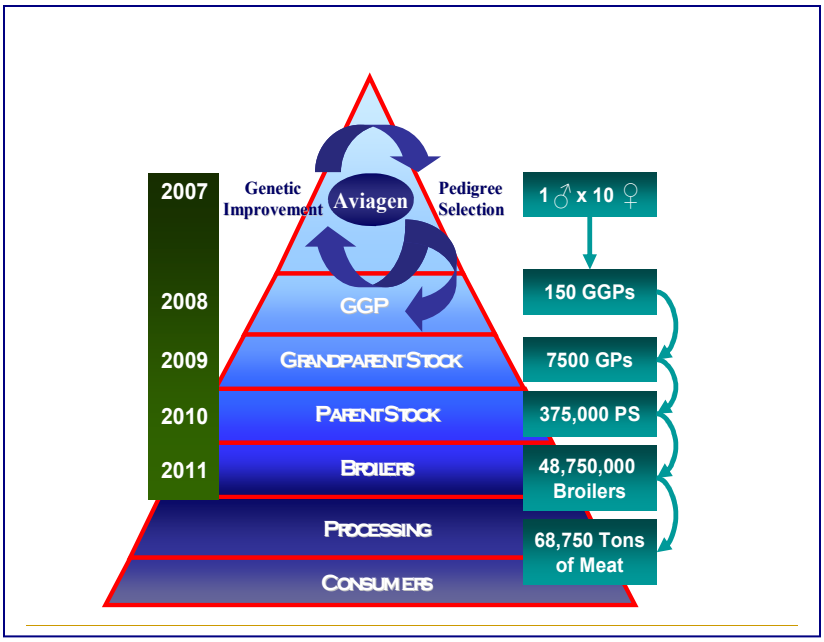
Increased emphasis on the environment will have a significant impact on the viability of livestock production and production level in the EU. Improved biological efficiency and more specifically reduced production of waste per unit output will be important future breeding goals. The challenge is to reduce labour requirements, whilst maintaining or improving animal health and welfare, and product quality. Selection for improved Food Conversion Ratio (FCR) is likely to have an important effect and there is potential for this to be done in more species. It is likely that there is genetic variation in other important traits that have not yet been measured. In more robust (e.g., fertile) animals such as high producing dairy and beef cattle, interaction between reproduction and environment are often unknown.

Global ecological and geo-political factors will have an impact, particularly in the longer term. The rising costs of energy and transport could stimulate production close to the point of consumption. Competition for land use between subsidised energy production (e.g. bio ethanol) and feed will inevitably increase feed prices.
Better consideration for reductions in greenhouse gas production and more efficient use of resources will be required. Global warming will have an ever-increasing impact, resulting in the need to reduce emissions of greenhouse gases, modify systems of animal husbandry, develop crops that can be grown as animal feed as well as increasing the likelihood of new disease and parasite challenges. The production of green house gases (GHG) has had the greatest effect. There are now strong social and political pressures on all (European) industries to reduce their emissions. The livestock sector (globally) is currently responsible for 18% of total human-related GHG production (CO2 equivalent). This is likely to increase as demand and thus the level of livestock production increases.

Major opportunities:

- Research into **environmental production efficiency** (e.g., less pollution per kg meat)
- Research on the **environmental impact** of animal production, emission of biogases
- Develop a **data collection modelling** system, to calculate efficiency and environmental waste (e.g., waste, diet, daily gain).

Key Message: Farm animal breeding can contribute to the decrease of environmental output, e.g. by increasing environmental production efficiency, and decreasing outputs like green house gas emissions. This could be mitigated through better research on environmental production efficiency and impact, improved data recording and the use of modelling systems.



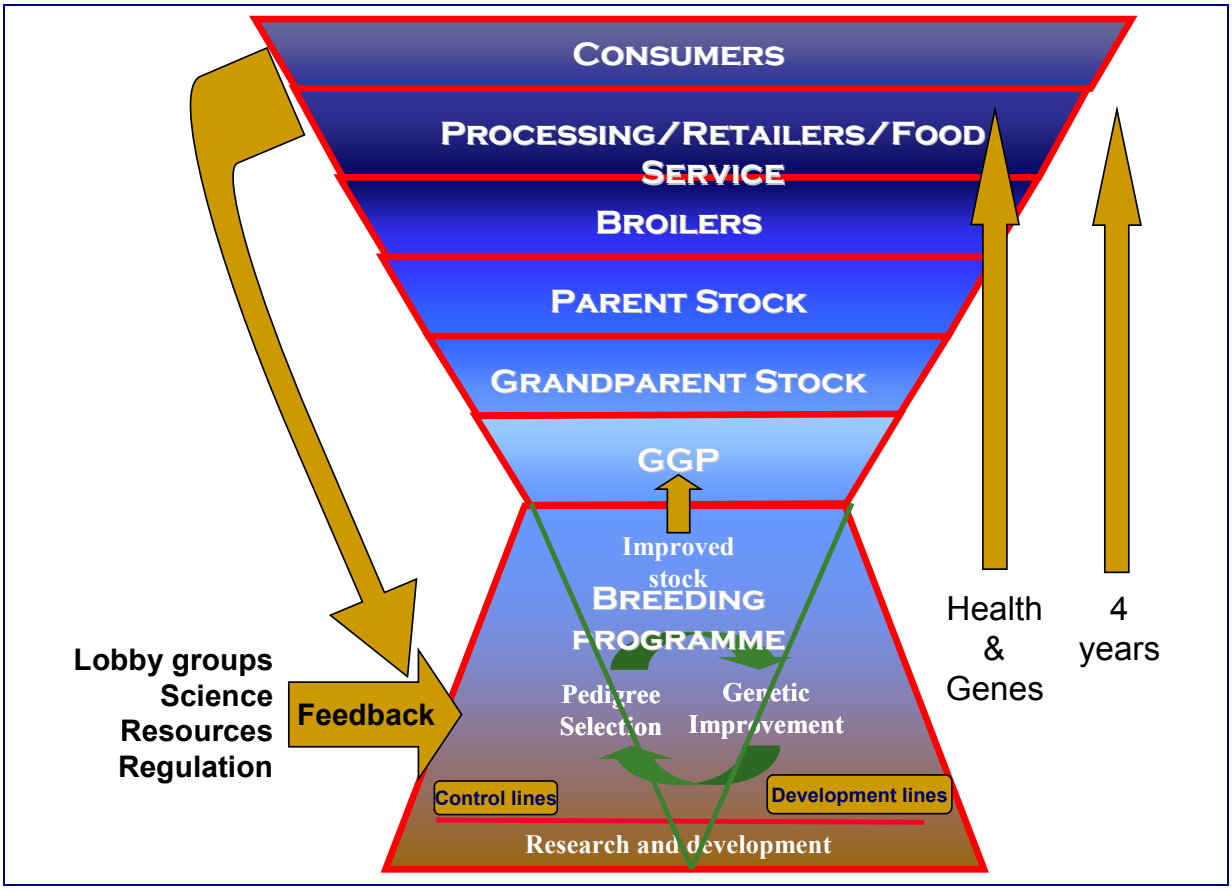


Figure 2. Traditional and new breeding pyramid (poultry). Aviagen, 2007.

The traditional way of describing a breeding system has been to use a pyramid. (top figure). Identifying the pedigree programme as the apex and expanding the levels as they pass through great grandparents (GGP), grandparents (GP), parents (PS) and commercial (broiler) production. The scale and timescale of the operation can be added to this to give an indication of the importance of both. The top figure understates the current importance of the modern programmes. This would be better described by two pyramids – one smaller which supports the larger (inverted) one. The latter contains all the elements necessary for an agricultural production system and the former all the requirements to develop and maintain a breeding programme – experimental lines, test lines, pure lines, and the not inconsiderable support systems of modern genetics (bottom figure) (Laughlin, 2007).

c. Goal: To address consumer demand

Consumers enter the debate on animal breeding in two ways – personally and through consumer organisations. People often express opinions they later abandon in the supermarket, so consumer opinion (citizens) and consumer behaviour (buyers) must be separated. Regarding food, consumer preferences reflect health-value, convenience, variety, price, animal welfare and environment. Food safety has been a serious concern for the past decade.

According to Ouédraogo (in: SEFABAR, 2003), consumers identify breeding and reproduction as indicators of other more important issues related to food like food safety, quality and health, associating high technology with food risks and uncertainty, whereas 'traditional breeding and reproduction' are seen as natural ànd related to safe, healthy, quality food. High income groups want to pay more for food produced to higher standards, others will not.

Consumers claim to be uninformed about animal breeding practices and would trust breeders to provide more reliable information, Farm animal breeding organisations need to include consumer wishes and demands into the definition of their breeding goal – it is part of their breeding strategy (see example of breeding scheme table on left page). As breeding decisions taken now will have their effect in 5-15 years time, the outlook on the long term is a constant challenge for animal breeding organisations.

Consumers do not trust the government or food industry as sources of information. Consumer opinion tends, unsurprisingly, to be more positive where medical products of biotechnology are at stake. A human health benefit can push worries about price and animal welfare down the priority list.

Consumers are aware of the risks entailed with free markets, especially with products circulating freely among countries with different legislative standards. They would agree to protect European breeders through imposing EU standards and labels to all imports.

Major opportunities:

- Improved translation of consumer wishes, consumer demand in breeding programme development.
- Improved outlook methods to include consumer and society feedback in breeding programme development

Key Message: Farm animal breeding organisations should strive to continuously improve the inclusion of consumer and society feedback in breeding.

d. Goal: Strengthen European competitiveness

Europe has always played an important role in improving the world's major livestock and aquaculture species. European breeds are used across the world, and European farmers and breeding organisations are major players on the global market. The European farm animal breeding sector will thus have a great influence on, and therefore responsibility for, the future genetic makeup and characteristics of farm animal populations worldwide.

The future success of European farm animal breeding and reproduction will be dependant on its ability to remain competitive and accepted by society. Farm-animal breeding and reproduction are knowledge intensive. This means not only that it exploits knowledge to provide the world with breeding stock, but also that the knowledge developed is or can be used to meet local, niche, or cultural demands inside or outside Europe. The past success of European breeding owes much to its longstanding close ties with universities and research institutes, fostering the dissemination of knowledge to the farm and individual breeder level.

'Because the operating environment almost inevitably changes over time, a sustainable process is a dynamic one that adapts to exogenous influences and evolves over time. Animal breeding and reproduction has to respond to new demands and adopt new techniques in response to social, economic or competitive pressures. Equally it will be important to exploit new opportunities that offer greater productivity and reject/eliminate procedures which are unacceptable, carry risks or where the costs outweigh the short term benefits.' (McInerney and Bennett, in SEFABAR, 2003).

Breeding farm animals performing optimally in economic and production environments is a key challenge. This will require a vibrant basic research and education base, linked with effective, industrially and governmentally supported applied research and technology transfer. It is vital to enable Europe to have a real choice regarding new technologies and a solid basis for discussion of their possibilities, desirability and uncertainties.

Major Opportunities:

- **Development of improved (breeding) technologies and programmes** in response to social, economic or competitive pressures (e.g., efficient overall indexes integrating molecular and phenotypic data)
- For governments to invest in **new technologies in a transparent way**, and in dialogue with all stakeholders, from farming to consumers.

Key Message: For European farm animal breeding and reproduction to remain competitive and sustainable it must adapt to changing social, economic and competitive pressures. This will require a strong basic research base together with strategic research and technology transfer.

Farm Animal Breeding Organisation Structures

Until the 1950s, most breeds of ***ruminants*** — i.e. most cattle, sheep and goats — were multi-purpose. A single breed of cattle, for example, would be kept for both beef and milk. That same breed might even be kept for draught purposes, as well. Over the last fifty years, specialisation has taken place. In general, cattle are now bred either for meat or to produce milk, and sheep bred for their milk are generally distinct from those bred for their meat (wool is mainly a co-product in Europe).

In **cattle** a small number of major breeds are used extensively around the world. Globally there are many breeds, some of which are at risk or endangered. Many of these are geographically specialised and therefore also at risk from disease outbreaks. Most European beef cattle breeders are individual farmers who are members of farmer's cooperatives or breed societies. Dairy farmer cooperatives often provide their members with semen of several breeds of bulls. Both breed societies and cooperatives may support research on AI and ET, and undertake data registration for their members. AI is widely used in dairy breeds. For beef breeds, natural mating still is important. In dairy cattle breeding, next to production functional traits, such as disease resistance, fertility, calving ease and longevity, are taken into. For example, cows bred to be less susceptible to mastitis may have lower milk yields, but reduced veterinary costs can favour these cattle. New developments of incorporating genetic marker information will assist progress further, especially for traits which are not directly measured or which have low heritability.

The organisation of **sheep** and **goat** farmers in regional and national farmer's cooperatives or societies is often similar to that in cattle but with a higher number of breeders with few animals and a reduced frequency of data recording and performance testing. This is in part a result of lower margins from their sales of milk, meat and especially for wool. Natural mating with rams is the widely used practice for reproduction. Next to production and reproduction traits, sheep and goat breeding programmes start including improvement of resistance to diseases/ endoparasites. Selection on scrapie genotype is common.

H**orses** are primarily bred for sport and leisure purposes. Breeding for meat is taking place in a few member states and horse milk has become more popular in Europe with some consumers. Breeding for working is of minor importance. There are many small and private breeding units (farms and hobby breeders), organised in regional or national studbook organisations especially in sport horses. Breeding of horses is characterised for many breeds by a constant process of introduction of genes from thoroughbred breeds to improve regional breeds. Breeding goals focus on e.g. performance, functional traits such as fertility, behaviour, conformation and animal health and handling. Performance testing schemes need to overcome problems related to subjective and difficult to measure traits, small groups for data analysis (e.g. race on a track). In sport horses Europe has a global leading position.

European **pig** breeding organisations are half organised in cooperatives and half privately owned companies. They have been and still are world leaders in their sector (see Table 1). A trend towards concentration is visible. Purebred animals of several specialised sire and dam lines in nucleus herds form the top of breeding, are providing the animals used for crossbreeding for the production level. The breeding goals have evolved from highly heritable traits such as growth, feed efficiency and carcass composition to sustainability related traits such as litter size, piglet vitality, sow longevity and meat quality.

In **poultry**, a few large-scale but still relatively small (max € 500-700 mln annual turnover) private companies supply breeding stocks. Most eggs today come from specialist crossbred laying hens. Broilers are also crossbred for their meat. The main selection criteria in poultry breeding are productivity, product quality, increase of health (e.g. robustness) and welfare (resistance to metabolic and skeletal diseases in broilers) and traits enhancing the processing and marketability, such as breast meat yield and uniformity of products. Crossbreeding farm animals brings natural benefits. For example, production birds bred for meat (broiler chickens, turkeys and ducks) combine male and female lines selected to ensure a balance between growth, uniformity and reproductive performance. In the cross, hybrid vigour is also secured, and so the offspring have added vitality and productivity.

The 'oldest' breeding programmes in **aquaculture** breeding have rarely been running for more than seven or eight generations. To date it has targeted a limited number of species of freshwater fish (trout, carp and salmon) and marine species (bass, bream, cod and halibut) and none in molluscs. Genetic improvement is based on the development of large selective breeding programmes using genealogic performances (mostly by multinationals or very big companies) and on the development of smaller scale selective breeding programmes, more adapted to Small and Medium Enterprises, using individual selection and in some cases fingerprinting to allow genealogical reproduction. However pedigree data are increasingly available. The traits currently of interest relate to growth and processing yields including fat content, disease resistance, spawning season, age at maturation and body shape. Aquaculture genetic improvement is also performed using sterile triploids as in oyster and sterile triploids monosex female in salmonids to avoid loss of flesh quality that occurs with sexual maturation of diploids.

Europe is internationally leading within fur animal, honeybee, and rabbit research, breeding and production, and plays globally an important role in breeding of dogs for police/army/customs.

In **rabbit** crossbreeding is the common breeding programme with specialised dam and sire lines similar to pigs. Selection traits are litter size and milk production in dam lines and meat % for sire lines. Farmed rabbits are genetically not far removed from rabbits in the wild - their needs, the causes of poor welfare, and their susceptibility to disease are very similar.

In **honeybees** there is, next to the production of honey, benefit from the pollination of plants. The 25 geographical honeybee races arose from natural selection. Natural honeybee populations are strongly affected by the transport of non-native races. Breeding honeybees for resistance to parasites is becoming more and more important.

Dogs are used as companion animals, and as working dogs. Companion animal breeding is in the hands of private people and is largely non-commercial. Working dogs (e.g. herding and guarding, guiding, dogs for police, customs, and army, assistance dogs) are mainly a relatively new field of work.

Fur animal breeding focuses on mink and foxes, concentrating to Northern Europe (high quality fur) in nationally organized schemes and in non-European countries (e.g. China) with much lower production costs.

e. Goal: Develop responsible ownership systems

As the opportunities created from biotechnological developments increase and larger investments in research are made, the interest in and worries about patents grow. In animal breeding, there are no 'animal breeder's rights equivalent to Plant Breeder's Rights. Most arrangements for the transfer of ownership of genetic improvement is governed by contractual arrangements. Breeding animals are expensive – you pay for the animal and for the right to use it for breeding.

In order to encourage investment in R&D, breeders are keen that the regulatory framework should provide a period of protection for those that invest in new technologies. At the same time, it is important that the owners of potentially valuable biodiversity should be rewarded for the value of their animals should their genes be commercially exploited in the future. In general breeders are supportive of the current regulatory framework, but it is important to periodically identify ways in which it could be improved.

A large number of new processes that are being presently developed are theoretically patentable. This is the case for methods to produce transgenic animals, cloning techniques, methods to increase fertility of farm animals, or multi-step processes like the method of inducing polyploidy in oysters, which are to be seen "technical" even if they involve a purely biological stage at one point or another (Noiville, 1999).

Patents are frequently written with a number of claims, which may cover genes or gene sequences. Such products are patentable, even if their structure is identical to that of natural elements present in the animal body. As long as the gene has been isolated from the animal body and the inventor has disclosed its concrete use, it is no longer considered as a discovery but as an invention. In such cases as developing a selection test based on the sequence information, utilising the gene to produce a transgenic animal or as a marker gene etc., the gene itself may be patentable. Such patents have no effect on traditional breeders: patent holders are not able to claim rights on farm animals naturally carrying this gene; they may only claim rights on the use they proposed of this gene (Noiville, in Farm Animal Breeding and Society, 1999).

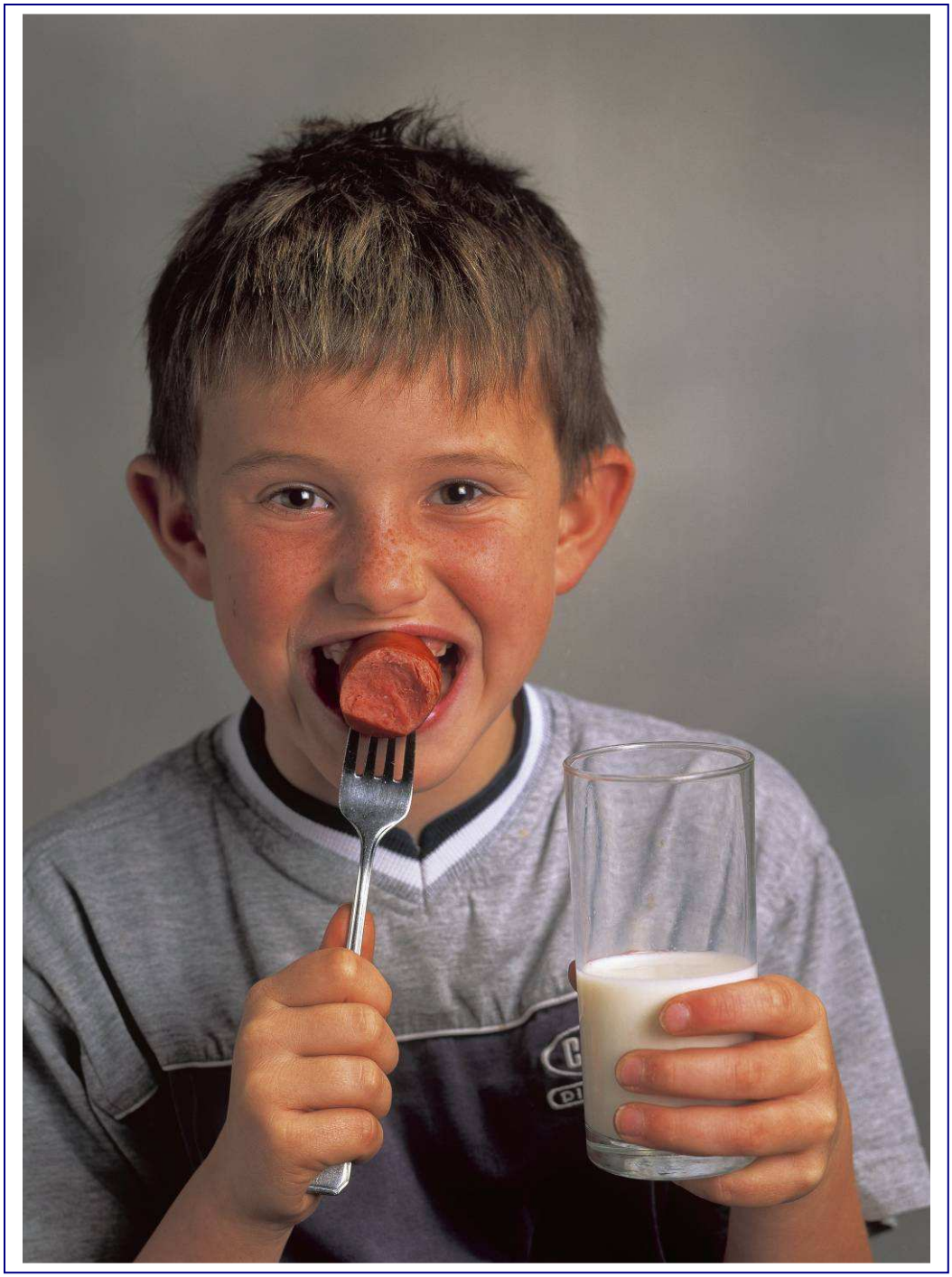
Where excessively broad patent claims are being made, or patents applied covering already running businesses, companies can ask for re-examination with the respective patent offices. In the practice, breeders exercise patent watches jointly, so as to assure that patents are granted on 'new inventions covering reasonable breadths of application'.

'The need for market driven incentives as part of the process for using and developing traditional breeds at local, national and international levels where this might be possible is recognised (FAO Interlaken, 2007), e.g. having public policies that support the conservation of traditional breeds. It may also be valuable to have discussion on the perceived positive and negative opportunities of some system of "animal breeder's rights" in this regard' (Laughlin at FAO Interlaken (Scientific Forum), 2007).

Major opportunities:

- Suitable framework for the protection and exploitation of **intellectual property** that encourages investment by industry in R&D
- Investigation on the opportunities **intellectual property systems** for animal breeding.

Key Message: Intellectual property is an issue that needs balanced consideration. In Europe, it is not possible to patent an animal, but methods can be patented. The regulatory framework should provide a period of protection for those that invest in new technologies. Animal breeders' rights can provide incentives for pure breeds as a basis for cross breeding. The development of suitable regulatory frameworks needs careful investigations and close involvement of animal breeders.



Opportunity 2: Social Responsibility

Scope: Animal breeding and reproduction have an enormous potential to improve our lifestyles and prosperity. Opportunities stem from the possibilities to improve animal welfare, health and product quality ensuring safe animal products. To achieve a balanced regulatory framework, full transparency, constructive dialogue and accessible information.

a. Goal: Produce safe animal products

Food-borne infection is a significant cause of human ill health and foods from farmed species are significant cause of such infections. For some of the responsible zoonotic organisms, such as Salmonella and Campylobacter, there is genetic variation in the susceptibility of farmed species to carrying or shedding these organisms. New zoonotic infections will emerge and the importance of as yet poorly characterised zoonoses will become apparent.
At a wider level, farmed poultry and pigs play a role in the evolution of pathogenesis of human infections, most notably influenza. It may be that there are opportunities through genetics/genomics research to reduce the risk of the evolution of increased pathogenesis of human influenza, via recombination with non-human influenza viruses. Such opportunities might include genetically modified (GM) chickens resistant to avian influenza.

Major opportunities:

- Research to understand better the cause of the genetic variation in the **susceptibility of farm animal species** to zoonotic diseases
- Research into the possibilities and development of sustainable breeding **strategies** to exploit such variation
- **(Basic) (GM) research** into zoonoses and farm animals
- Development of **dialogue and transparency strategies** to involve society in the weighing of opportunities and concerns.
- Research into automatic on-farm performance recording (e.g., milk ingredients and hygienic status), interaction between recording protocols and modelling of genetic and non-genetic goals

Key Message: Zoonotic organisms carried in farmed animals are a major cause of food borne infection in humans. Further research is needed to understand and exploit the genetic variation underlying animal's susceptibility as carriers.

b. Goal: Enhance product quality

The approach towards quality and identification of livestock products will change: today product quality (including processing), animal and territory are only linked in a few food chain systems, such as well identified local products. Other products go to the processing industry where quality standards are based on safety and basic characteristics. A more sophisticated approach to product quality from the industry is expected.
Much of the potential for human wellbeing to be enhanced through better human nutrition will be achieved by consumption of more appropriate diets (mix and level of different foods).
The taste of foods is an important factor in various European countries, especially in Southern Europe. Some important sensory quality attributes in animal foods (e.g. tenderness, colour and texture of meat or albumen quality of eggs) are heritable.
There is potential for foods of animal origin to be identified as sources of valuable bioactive compounds. Such evidence may increase our understanding of the nutritional value of such foods and in addition to this these compounds may be extracted to form 'nutraceutical' dietary supplements for at-risk individuals.
The opposite situation is that we may identify anti-nutritive or harmful components in foods of animal origin

Major opportunities:

- Research to improve the **quality and consistence** of products of animal origin, besides selecting for food safety, quality and environmental production efficiency.
- Research into improvement through breeding of milk **components**, meat characteristics such as fatty-acid profile of the product, taste etc.
- Research to improve the **quality and consistency** of animal products, development of better tools to measure/predict phenotypes and b) genomics research to develop molecular genetic selection tools.)
- Research to improve the **sensory quality** of animal food through breeding both in general and related to specific regions/markets.
- Research into breeding to improve **bioactive compounds** in animal food
- Research into breeding to decrease the concentration of **anti-nutritive components** in animal foods.

Key Message: In the future the approach to classifying product quality will expand beyond that of the basic characteristics used today. Further research could enable the exploitation of valuable bioactive compounds and a general improvement in terms of product quality and consistency.

In the context of this document the welfare of animals should always address first **the actual welfare of animals** rather than a perceived human oriented good feeling type of animal welfare.

Animal production is undergoing a great transformation, both in terms of market and of products. As the world's population grows, so will its demands for food. Global milk and meat consumption is expanding, meaning a need for more feed production. Farm prices for milk, beef, pork and poultry after years of regression are now increasing. At the same time prices for corn, wheat and oilseeds are raising. Production costs are expected to climb for dairy and beef, probably even more for pork and poultry. While consumers might not notice farm prices, they will notice when this trend will affect the retail prices.

The major reasons behind the overall growth of animal production prices and market perturbation are:

- Increased oil price, leading to a faster transition towards renewable energy like bio-fuel on the one hand and increased purchasing power of several countries becoming significant importers on the other hand.
- Global climatic phenomena (drought, rainstorms) modifying global cereal production and inflating milk (product) prices.
- Consequently break of symmetry between demand and supply: to strong ones first, then to weak ones due to limited worlds stock.

According to animal welfare organisations, the general acceptance of farm animal breeding depends on the circumstances (Denmark, Germany, The Netherlands, UK), in particular the effect on health and welfare. Welfare organisations (e.g. Germany, The Netherlands, UK) regard traditional breeding acceptable if it does not cause welfare problems, i.e. not results in physical damage, pain or distress. Breeding goals are accepted if not used to mask poor management systems or at the risk of adverse effects on other welfare aspects, e.g. because of increased inbreeding. (Farm Animal Breeding and Society, 1999; SEFABAR, 2003).

c. Goal: Promote animal welfare and health

Being able to identify welfare through use of objective criteria is important. Preferably the criteria should be those which can be easily and routinely measured. Measurable indicators include good animal health, and robust animals that can adapt to a reasonable production environment. These include:

- robustness in terms of fitness,
- health in terms of infectious, metabolic and inherited disease and,
- robustness in terms of adaptability to a wide range of production environments, including low (labour) input systems and climate change.

The shift to selection for improved product quality and health is considered a major challenge in all species from poultry to buffalos. Resistance to disease is currently a hot topic in genetics research on farmed animals - variation in resistance exists to a very wide variety of diseases and it is possible to select for enhanced resistance to a range of diseases. The relationships between hosts and their many pathogens are complex - disease resistance of the host is likely to be only one component of effective health control strategies. There may be circumstances where improved resistance to one disease can have unwanted effects on other diseases.

There is considerable scientific opportunity to develop better understanding of the molecular genetics of host/pathogen interactions, but there is much we need to know before this opportunity is converted into real impacts on animal health. The impact of improved health across populations is not known (herd immunity).

Commercial producers, especially of extensively farmed species, want breeding stock that continues to breed and produce food profitably in a range of different environments. If, for example, supply of animal feed is limited, the more robust animal diverts resources to maintaining fitness at the expense of productivity, but remains productive at a lower level.

Major opportunities:

- Research into genetic variation underlying welfare traits
- Research into the genetic components and implementation into breeding of
  - relative **fitness**,
  - **health** in terms of infectious, metabolic and inherited disease and,
  - **robustness** in the sense of adaptability to a wide range of production environments, including low (labour) input systems and climate change
- Development of an indicator trait for general disease resistance and of new and better disease resistance traits (e. g., immunocompetence, resistance or tolerance)
- Assessment of the impact of selection for disease resistance vs. disease tolerance.

Key Message: The genetic variation underlying health and welfare traits is complex and poorly understood. This creates significant opportunity to better define and research desirable traits and implement strategies that exploit the underlying variation.

d. Goal: Attain full transparency

Transparency in farm animal breeding is an important tool to encourage an active dialogue with society. It is important that industry has its own structures to ensure it is effective in working together on pre-competitive and joint/collective issues.

Major opportunities:

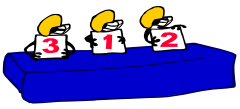
- **Sectoral representation** so that industrial needs and challenges are properly **captured and communicated** to policy makers and legislators
- Processes for agreeing and further developing industrially driven research policy such as this **Strategic Research Agenda or Technology Roadmaps**
- Mechanisms that share risks and costs of pre-competitive research through **industrial research-funding consortia**
- **Structures for developing**, agreeing and sharing **best practice** including industry standards and codes of practice
- **Structures for watching** over industry standards (e.g. broad claims, patenting already running business) and codes of practice
- Implementation of Code of Good Practice for Farm Animal Breeding and Reproduction **Code-EFABAR**
- **Forecasting of and dealing with** breeding business related to pre-competitive and animal health/society/ethical/transparency issues
- In this respect **socio-economic research policy and outlook projects** are very important. They need to include **various stakeholders/social partners**. The safe environment of an EU project will enable various different partners to communicate and develop **practical tools or outlooks** while maintaining their own **professional independence and integrity**. It is of key importance that such projects should include the **'subject of study'** (in this case the breeding industry) **as an active and responsible partner**. Situations in which specialists start studying, debating and sidewise involving the 'subject of study' should be avoided as much as possible.

Key Message: To encourage transparency and effective dialogue with society it is important that industry develops the strategies and structures which will enable effective collaboration on shared issues.

Perception Gap

Welfare organisations:
individuals

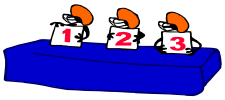
- Intrinsic Value
- Sentient Beings



Desirability:
« Ideal outcome
Drivers:
EU welfare legislation

Breeders:
populations

- Traits:
  - Mean, variance
  - Adjustable by breeding



Feasibility:
How to put into practice
Drivers:
Competitiveness, economic and social viability

There exists a Gap in Perception on what is and should be animal breeding, between Society and Specialists
In dialogue with society one should be aware of the gaps in perception between the various parties
(SEFABAR, A.-E. Liinamo, 2003)

The representatives of breeding ("industry") and animal welfare ("society") not only look at the same problems from different angles, but also have "language problems" in the sense that the same technical terms may have different meanings to different people. These communication problems can best be overcome if we accept that the animal welfare organisation and other parts of the society are guided by what seems *"desirable"* from an ethical point of view, while breeders as representatives of the food industry are rather guided by what seems *"feasible"* on the basis of genetic parameters of existing populations and what they expect to be saleable to their customers.

A basic difference between animal breeding and animal welfare is that the former thinks in terms of co-adaptation of *animal populations* and the environment in which animals are kept for food production, whereas the latter thinks in terms of species-specific needs which have to be respected for *each individual animal*. For animal welfare, the aim is to maximise the welfare of each individual animal; for breeders the aim is to combine demands of animal welfare with traditional production traits in selection indexes which will lead to progress in all important traits, even if they may be negatively correlated.

However, people who only focus on one side of the issue, i.e. what seems desirable from an ethical viewpoint *or* what seems feasible from an industry viewpoint, may overlook important facts of the other side. It would therefore be helpful if existing data recording schemes for all species of farm animals could be further developed to yield reliable estimates of time trends in all major traits, which are considered important under animal welfare or other considerations of sustainability in the broad sense (Liinamo *et al*., 2005).

*Christiansen & Sandøe (2000) divided ethical considerations relating to animals into **animal health and welfare**, and animal integrity. Animal integrity, or **intrinsic value**, is naturally evolved, unharmed wholeness of an individual, species or ecosystem. According to some, the use of non-therapeutic surgery and invasive procedures to increase reproduction is violating the animal's integrity (Seamark, 1993, MAFF, 1995, Rutgers et al., 1996). Other ethical considerations relate to humans, biological and environmental issues or biotechnology. Regarding humans, the **'slippery slope' argument** is the major one: the fear that what can be done with animals will also be done with humans (Schroten, 1997). Human health is another "hot" topic: e.g. does eating meat from genetically modified animals pose extra risks? Regarding biology and the environment the fear for the loss of diversity prevails. The opportunities of reproductive technologies for preserving biodiversity (cryoconservation semen, eggs, embryos) are the other side of the picture. Considerations regarding biotechnology itself may be due to 'fear of the unknown', misunderstandings, or because techniques are considered 'unnatural'.*

f. Goal: Achieve a balanced, transparent regulatory framework

'Two possible policy scenarios for sustainable livestock breeding and reproduction within the EU are (i) A reformed Common Agricultural Policy and Common Fisheries Policy (CAP, CFP) with decoupled support, land-based environmental payments, interim direct income payments to farmers currently receiving support, lower level of trade tariff barriers. (ii) A return to protectionism within the EU, with regional trade agreements and high tariff barriers to trade. Under both scenarios, the enlarged EU will produce largely for its own internal market (McInerney and Bennett, in SEFABAR, 2003). These scenarios are expected to take place simultaneously. CAP will probably favour agricultural production only in the most economically efficient zones. Then marginal areas would become abandoned and environmentally at risk (fires, floods, etc.).
A policy environment that enables business and innovation, i.e. a workable, practical regulatory environment and world trade rules are important for the development of farm animal breeding and reproduction, operating in a global environment, whilst welfare and animal health are major issues and the lack of an equivalence of "plant breeders rights" affects the business models used to capture value from breeding.

Major opportunities:

- Improve **dialogue and transparency** with agricultural policy
- Legislation fine tuned with global developments enabling businesses to operate globally while based in Europe
- Appropriate legislation to protect **consumers** from unsafe foods
- Appropriate legislation to enable the improvement and protection of the **actual welfare of farmed animals**
- Legislation and policy measures to promote **best environmental practice** in the production of foods from animals
- An **open and transparent dialogue** with citizens on the benefits and risks of **new technologies** (including the risks of not adopting new technologies or the risks of existing technologies being withdrawn or discouraged) such that regulatory processes recognise the plurality of consumer opinion and foster informed consumer choice
- Adoption of **socially responsible trade policy and regulation that is fair and transparen**t; ensuring equitable access to the benefits arising from animal breeding and reproduction R&D for all farmers and citizens, wherever in the world they live.

Key Message: Future policy decisions and regulatory frameworks will have a strong influence on the development of sustainable livestock breeding and reproduction within Europe. It is essential that these decisions are as inclusive and transparent as possible. Given the global environment that animal breeding and production organisations operate in it is essential that there is effective regulatory framework which encourages business and innovation as well as protecting and informing the consumer.

g. Goal: Achieve constructive dialogue among stakeholders

Trust building and openness are important, as well as learning how to develop a dialogue by scientists, industry and other stakeholders.
The next step will involve going from the internal effort to external. This is needed to bring breeding to the society agenda. As such, society/citizen is not interested in a research agenda. An implementation action plan, with its goals and deadlines, is per definition a one way communication. A two- way communication, with a helicopter view from outside, involves like:

- What is relevant for people outside the breeding sector?
- What is relevant for policy makers, society groups, the public at large?
- How can this be built into opportunities for the agricultural policy?

Furthermore, a good starting point would be to understand and outline what people are concerned about. Breeders having a notion of what worries people, and the people's notion that breeders do listen to them, take their concerns seriously, and explain to them how they weigh their decisions, may be a good modus in a dialogue with 'society'. Farm animals are domesticated and recognisably distinct from their wild relatives and ancestors. The key ethical question is not whether we should abandon animal breeding, but how we should breed (Gamborg & Sandøe, 2003). The general view in society (Christiansen & Sandøe, 2000) is that it is acceptable to use animals if it is done 'humanely'. This attitude is based on the ethical theories of utilitarianism (e.g. what decision gives greatest benefit?) and deontology (e.g. what do we do to an animal?).

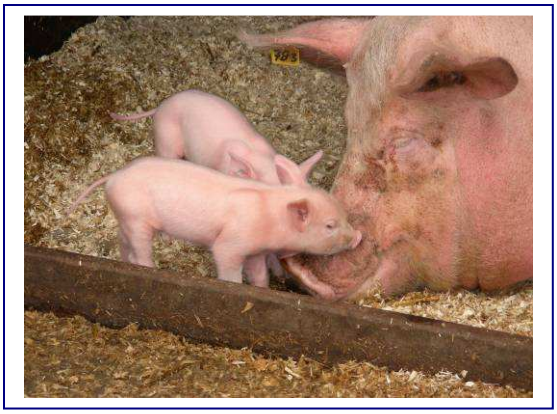
Major opportunities:

- Specific knowledge needs to be built involving political, society, communication knowledge, to be able to make the **one way into a two way communication**, and to make the society agenda into an agenda in which society has a real stake
- **Building ethical awareness** can be a useful tool in education systems in farm animal breeding
- **Internal ethical guidelines** already in place in various breeding organisations can be used as an example for other organisations
- Consideration of regulation in this area should consider the **full implications of any approval or restriction** of a technology, i.e. both opportunities and concerns. For instance, AI has been demonstrated as helpful in biosecurity and the control or eradication of infectious diseases
- **Ethical deliberation models** can be used to guide the process of weighing opportunities and concerns.

Key message: A constructive dialogue with stakeholders needs a helicopter view. Skills need to be developed among breeders and scientists to enter the dialogue. Next to available ethical tools, new communication models need to be developed to assist two way communication.

h. Goal: Improve the availability of information for Society

Society may wish to know more about farm animal production, the way animals are treated, herds managed and selection oriented. *Consumer attitudes to modern breeding goals and biotechnologies are continually developing: scientists, governments and industry have a real opportunity to respond to public opinion.*
It may be interesting to know how animal (breed)s can keep the landscape open (e.g. Scandinavia), how they relate to their culture or cultures in the countries they visit on holidays. They may wish to see openness about the way breeding balances goals and what the global influence of breeding has on animal food production, availability, welfare or environmental output.



Major opportunity:

- Improve easily accessible information flow via web sites and easily accessible information of representative organisations.

Key Message: There is real opportunity to develop easily accessible information for the public which could help develop trust and aid understanding of the wider implications of modern breeding goals and technologies.

Diversity of farm animal species in the EU is important for

- *Viability and diversity of the European landscape*
- *Providing a reservoir of variation that may become useful as circumstances change*
- *Use of less favoured regions*
- *Attractiveness of regions for e.g. tourism*
- *Recognition and exploitation of cultural values*

This can be achieved by

- *Maintaining a large variety of breeds economically competitive by*
  - *increasing the efficiency of breeding for less intensive or small-scale animal farming,*
  - *developing mechanisms to have markets taking into account the non-market services of farming, including the environmental and cultural roles; and*
- *Developing models/strategies for the management of genetic diversity when breeding in a centralised way to avoid the risk that a too narrow genetic basis will be used - enhanced reproduction, molecular genetic and statistic tools for preserving genetic diversity are key technologies to achieve this*
- *Involving a wider participation of stakeholders in animal genetic resources sustainable use and conservation, incl. industry*
- *Developing low cost strategies for animal genetic resources inventories, conservation and development.*

For aquaculture species, the diversity of wild stocks must also be taken care of by reducing the number of escapees and/or develop e.g. sterile fish where possible. Wild fish can also be used as a reservoir of genes for introduction into the farmed population using introgression schemes.

Opportunity 3: A Diverse and Distinctive Europe

Scope: In Europe and worldwide, farm animal breeding and reproduction can help maintain and further develop sustainable agriculture, a liveable and pleasant countryside, and consumer choice.

a. Goal: Achieve sustainable management of farm animal genetic resources

Recent years have seen significant consolidation of the breeding sector and this will likely continue. Cooperative and national breeding programmes will likely be most resistant to this trend, but even in these cases we should expect to see greater internationalisation.
The current level of biodiversity in EU animal populations has costs and benefits. There are sustainability costs to retaining inappropriate diversity and sub-optimal alleles in a given environment. On the other hand, it is important to maintain diversity within EU farm animal species:

- to meet a variety of market, societal and environmental needs
- to exploit variation e.g. through cross-breeding programmes
- to provide a reservoir of variation that may become useful as circumstances change
- to reduce the risks of catastrophic disease outbreaks where a pathogen evolves to challenge the viability of a particular genotype
- to develop economically efficient animal breeding for marginal areas where the only viable options are distinctive breeds with high fitness in these environments.

Major Opportunities

- Research into **optimal breeding programmes** with greater focus on (correlation of) biodiversity, fitness in environment and resistance.
- Develop responsible **ownership systems** (see 1e)
- **Knowledge and Technology Transfer** – transfer of national / niche market knowledge and specific technologies.
- An **open and transparent dialogue** with citizens on the benefits and risks of current breeding programmes.

Key Message: The trend towards greater internationalisation of the breeding sector will make it essential that further research is carried out to identify optimal breeding programmes whilst maintaining potentially valuable biodiversity.

b. Goal: Respect and develop cultural values

There are considerable national and regional differences in breeding practices and in public attitudes. Each country tries to identify an equilibrium between local needs and global uniformity demands. In Norway, collectivity and a positive climate towards agriculture, led to a fair distribution of profits and work for farmers and breeders. In Italy it is not the farmer but the end product which is the focus of agriculture and breeding programmes: gastronomic quality, cultural suitability and product diversity are important. In France where the end product also prevails, breeding is best understood through the rules/organisations which together form a national breeding culture. Dutch breeders are world players seeking to develop breeds suiting a wide variety of conditions. In Thailand, a newly 'agro-industrialised' country, which produces four times as much food as needed, a balance must be found between short term gain, environmental damage and rural poverty. The USA food market is largely undifferentiated and contrary to Europe there is limited societal resistance to technologies such as genetic modification (Schakel & Van Broekhuizen, in SEFABAR, 2003).

Major Opportunities

- Implement reliable data collection in all countries.
- Adapt selective breeding programmes to specific regionally / cultural breeding goals.
- Develop **quality schemes**, e.g., Label, Appellation d'Origine Contrôlée.
- Develop umbrella covering quality schemes.
- Development of **dialogue and transparency** in terms of a strategy which involves **society** in the weighing up of opportunities and concerns.
- Development of quality assurance systems.

Key Message: Globally there are considerable differences in terms of the approach to breeding practices. The involvement of society in the development of new strategies is essential in order to balance local needs with demand for global uniformity.

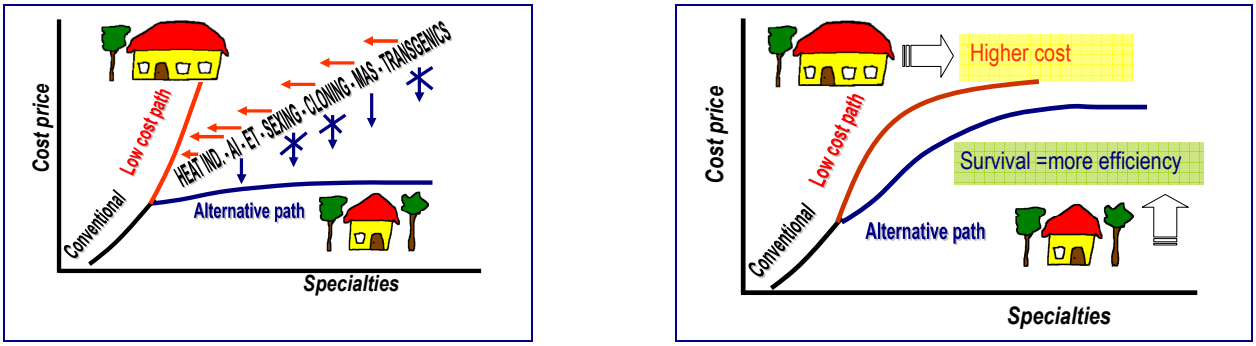


Figure 3. Breeding Scenarios *(Farm Animal Breeding and Society, 1999)*

Species	"Global"	"Local"	"Global"	"Local"
Dairy cattle	High output farming	Niche markets	Productive cattle	Easy to manage
Beef cattle	Low price	High (beef) quality	Labour extensive	Good quality beef
Dairy sheep	Safe food/ok prize	Organic	Productive ewes	Adapted, long living ewes
Meat sheep	Market based	Subsidised	Efficient lambs	Easy care breeds
Pigs	International	Combined local/int.	Efficient pigs	Well adapted pigs
Layers	High technology	High value	Efficient hens	Quality producers
Meat poultry	Supply world market	Niche markets	Incr. efficiency	Better quality
Salmon	High output	Extra value	Production traits	Non-production traits

Table 1 Future Breeding Scenarios and Major Breeding Goals as defined in SEFABAR *(Liinamo et al, 2005)*

Future Breeding Scenarios have been developed in European projects involving animal breeders and scientists, and society specialists (e.g. Farm Animal Breeding and Society, Sustainable Farm Animal Breeding and Reproduction SEFABAR). They facilitate awareness building and discussion about possible futures in breeding and their consequences, desirability, impact etc.

c. Goal: Build on regional values

Breeding of animals well fitted for marginal areas or extensive production systems will be of help to the environmental maintenance of such areas and for increasing the economic efficiency of agriculture farming in less favourable areas. European marginal areas are increasing in size.
Given the current evolution of European agriculture and the demand for environmental friendly production systems; adapted breeding for low input and industrial production systems will be needed, breeding should be considered from a management perspective. Breeding objectives would need to focus on obtaining animals well fitted to harsh environments or feed of marginal nutritious value and at the same time animals able to produce safe, healthy and also typical food. Often the higher market price of recognised typical local food is the only reason that production is some environments can be economically sustainable. Accounting for environmental impact (e.g., waste, diet) when calculating efficiency and preservation of genetic resources, particularly in local breeds has yet to be done.

Major opportunities

- Research on ***and implementation*** of (improved) **data collection / recording systems** across and outside of Europe.
- Develop quality schemes, e.g., Label, Appellation d'Origine Controlée.
- Develop umbrella covering quality schemes.
- A sustainable framework for the protection and exploitation of **intellectual property** that encourages investment by industry in R&D.
- Wider, better aligned and refined **breeding systems**.
- Possibility to better utilise the available **gene pool and biodiversity.**

Key Message – The enlargement of the EU will open up new possibilities in terms of data collection and recording systems. This information could be used to develop more effective breeding systems which best utilise the available gene pool and biodiversity.

d. Goal: Ensure access to relevant knowledge

Animal breeding organisations need research for developing new methods, that make breeding broader, more balanced, more sustainable, as the areas to be studied and implemented are complex and diverse: biosystems, genetics, genomics, development and refinement of reproduction technologies in various animal species, domestication of fish species, high tech computing, extensive data gathering, complicated data processing, physiology, animal health, environmental output. Both, high level results in each area, ànd combining these areas are important. They are 'fed' by inventions in the human biology and medical area. The forefront developments take place at larger research and breeding organisations, and in the wealthier EU countries. This adds to the competitiveness of breeding in Europe, the affordability of animal food, the broadening of breeding goals, balanced breeding, environmentally friendly breeding, sustainable breeding.
Breeding is also balancing, cooperating, ànd it is much related to the populations, typicalities, landscapes, cultures in the EU member states. Luckily a lot of that is still available in Europe and needs input from research and implementation to be able to sustain in the future. A) Small populations easily suffer from narrow breeding goals, inbreeding (i.e. very limited diversity), increased health risks). Extensive breeding and small populations 'need' reproduction technologies and adapted refined breeding programmes to sustain both economically, socially and from a viewpoint of diversity. 'Smaller scale species' need to get input from the larger ones (e.g., the poultry genome knowledge can and is to be extended to easily serve turkey, duck, ostrich). The knowledge and implementation examples mentioned previously thus are and should being further refined and finetuned towards specific applications throughout Europe.

Responsibility. Furthermore, the developed knowledge can be used to increase the competitiveness and efficiency of breeds and populations outside Europe in less favoured countries – this represents European responsibilities.

Major Opportunities

- Knowledge and Technology Transfer of larger organisations to smaller organisations, of broad markets to niche markets.
- Increase collaborations between research and industry, large and small industries, broad and niche markets.
- Exploiting already existing knowledge and technologies.

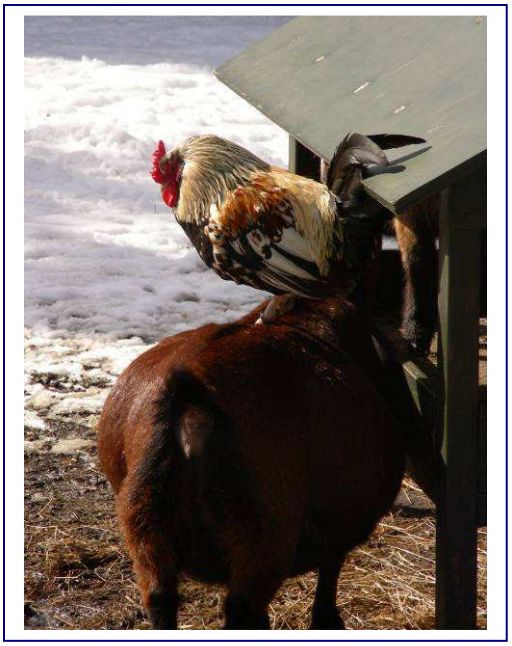
Key Message: Better coordination and knowledge transfer is needed between research organisations and the animal breeding industry, and across and outside Europe, to create balanced, broad and sustainable breeding programmes.

World market
= “Global”

Focus on low cost and high productivity/efficiency

Regional/
special markets
= “Local”

Require/facilitate other traits and methods



g. Goal: Enhance data collection and selection programmes

Management systems will change, and identification and quality systems will become commonplace. Among them automatic identification and recording systems will be used more systematically to trace products along the whole production chain. This will provide new opportunities to record performance data in open selection programmes or record entirely new traits related to health and welfare. These systems will also enable the results of animal breeding to be tested (e.g. have we really achieved improved bone quality?), allow comparability of data over countries and between species and the use of large data sets for research. International efforts will be necessary to achieve comparable data gathering, arrange IP issues and enhance availability of the data.

These increased technological and scientific possibilities will lead to

- Wider, more aligned and refined breeding systems
- The possibility to better utilise the available gene pool and diversity.

In most species there is a close link with national breeds, and for many breeds, breeding is organised nationally. In addition to production traits, biodiversity, food security and diversity of products, rural landscape management and cultural values are also at stake. In addition to the larger global players there are for ruminants and pigs smaller cooperative structures, often regionally organised, with representative organisations at the national level. Further development of breeding structures and programmes is needed in East European countries to allow local and regional breeds and research and breeding organisations enough time to adapt to the rapidly changing organisational and economic environment.

Major opportunities

- Establishment of structures for watching over **local, cultural standards**
- Developing **sustainable local breeding structures** which maintain local breeds and niche markets organisation and environment ensuring their competitiveness in broader, global markets.

Key Message: It is important to implement effective structures that help maintain competitive and effective local breeding programmes and standards. This will ensure they are able to adapt to the changing global environment.

Current Status of Breeding Industries

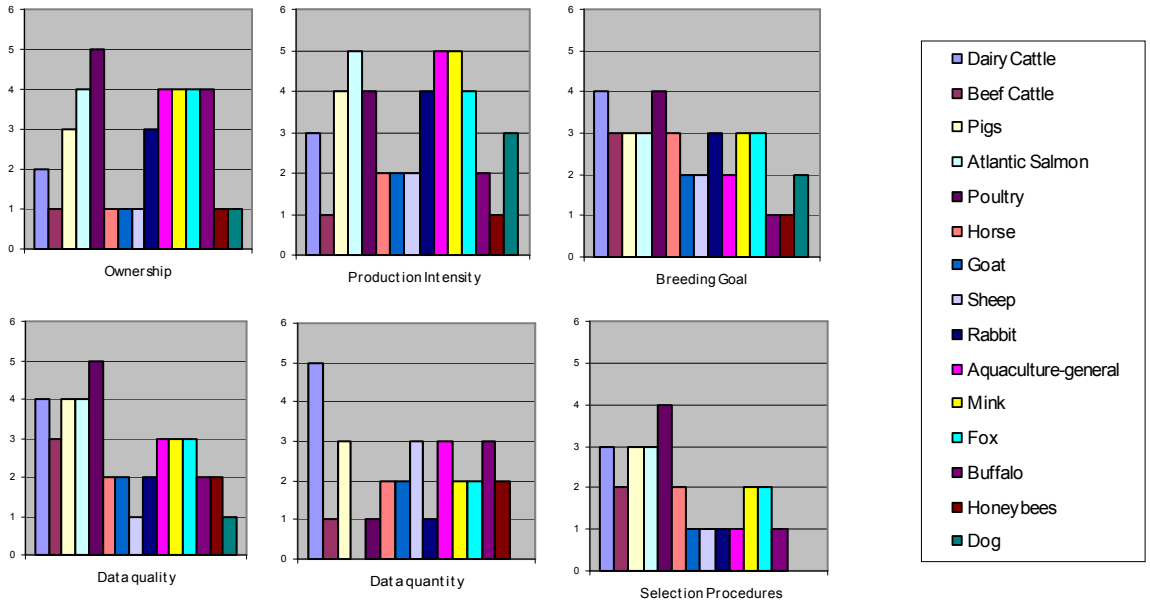
The current status of the breeding industries is being presented per species. For each species each status has been evaluated and graded (0-5) by experts. Around each point considerable variation is possible.

A. Set up of breeding programme:
Ownership: Many breeders/producers ⇔Specialised or individual breeder(s).
Production Intensity: Extensive (low input) ⇔ Intensive (high input) production systems.
Breeding goal: Few traits (narrow) ⇔ many traits (balanced breeding goal).
Data quality: simple/crude traits & data ⇔ sophisticated phenotypic measurements
Data quantity: Elite/pureline data ⇔through value chain-data/results.
Selection procedures: Mass selection- truncation selection ⇔ **c**omplex–multi-trait and – environment selection including controlling inbreeding

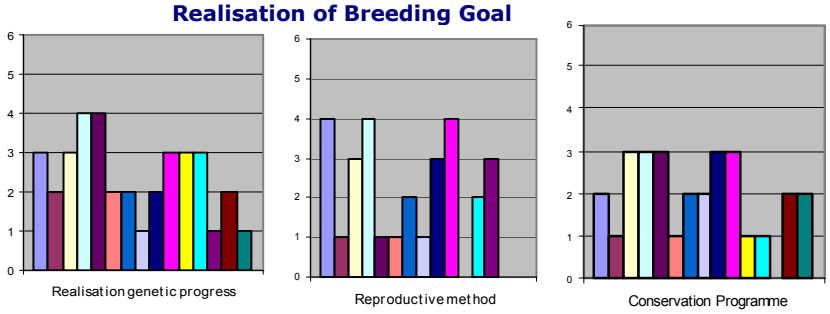
B. Realisation of breeding goal:
Realisation genetic progress: Weak ⇔Strong- realised & targeted genetic gains.
Reproduction method: Natural mating ⇔ Artificial reproduction.
Conservation programme: None ⇔ advanced
Advanced-active procedures for conservation.

C. Genomics use:
Genomic use: None ⇔Full-
State of genome: Black box- unknown ⇔fully annotated-genome with catalogues of DNA markers.
Genomic tools: None ⇔sophisticated- high density SNP panels, gene expression profiles etc.

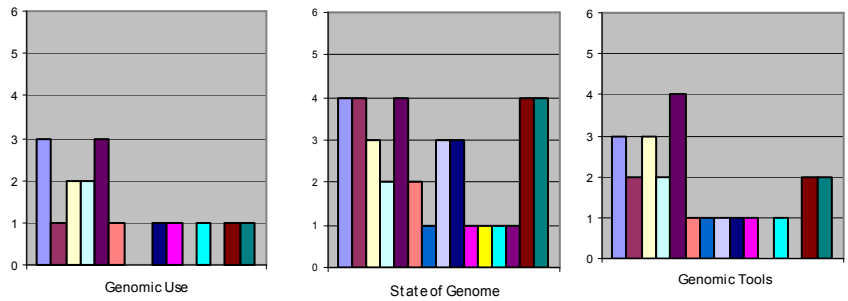
Set Up of Breeding Programme



Realisation of Breeding Goal



Use of Genomics



Implementation Plan

For a more detailed description see: Implementation Plan

The development of new tools and understanding in biology and genetics provides the means to adapt to the changes, opening major opportunities for effective animal breeding. These opportunities can only be realised if tools, resources and understanding that are currently missing are developed and are disseminated and employed at the appropriate level within farm animal breeding pyramids.

The missing components that will allow us to bridge the gap between potential and realisation of course vary between different livestock species. We will not attempt here to elaborate the current status and the missing components in detail for each species (see Annex I (2 page expert group reports)), but rather will provide an overview. In general realising the potential of breeding will require technical developments in broad areas:

- Tools and resources for genetics, genomics and reproduction
- Understanding of biology of individual traits and of livestock species and the systems in which they operate
- Improved identification and traceability
- Definition of traits and cheap collection of more precise, comparable and appropriate data and information that allows genetic change to be implemented
- Integration of molecular genetic technologies into breeding programmes, especially for low heritability traits and traits associated with health, animal physiology and product quality
- Dissemination of this knowledge and the removal of bottlenecks to its implementation at the appropriate level in a breeding programme.

The ability to fully exploit these developments will need an appropriate framework of enabling factors (such as education and training, together with appropriate regulatory structures that have societal support – see later chapters on these factors).

From the thirteen expert group reports and the thirty four country discussions the following Technical Research Priorities, Technology Transfer, Educational and Socio-Economic Issues have been deduced:

Reproductive Technologies

1. Improving the efficiency of basic reproductive technologies for implementation or dissemination of genetic improvements.

    - Improving AI and IVF capabilities and efficiency in a range of species
    - Improving current semen sexing technologies
    - Closed breeding cycles for species undergoing domestication
    - Improving cryopreservation of gametes, embryos and somatic cells
    - Improving biosecurity

2. Development of advanced reproductive technologies.

    - Derivation, maintenance and control of differentiation of livestock stem cells
    - Improved capability for use of GM technologies to generate new traits and new combinations of traits
    - Improved capability for nuclear transfer
    - Novel technologies for control of epigenetic factors

15-25 years

- In vitro gametogenesis and selection.

Phenomics

1. Development of improved tools and capability to measure and record traits.

    - Improved cost-effectiveness of existing measurement tools
    - Development of novel (to animal agriculture) measurement technologies
    - Agreed trait ontologies

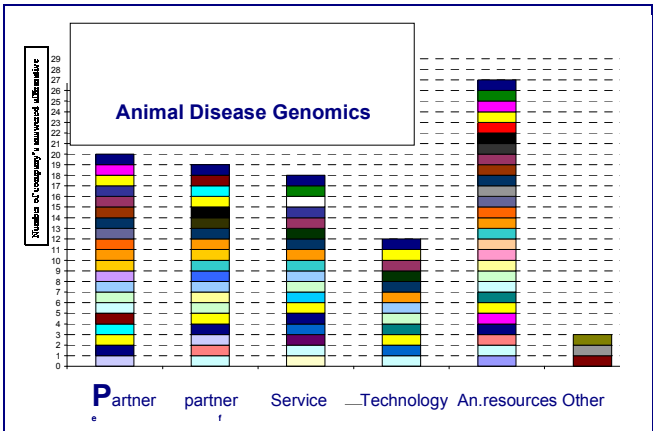
2. Systems to capture and utilise relevant information throughout the production and supply chain.

    - Electronic Identification technologies
    - Genomic relatedness and traceability technologies
    - Electronic data capture, storage and retrieval systems
    - Data interchange and access protocols.

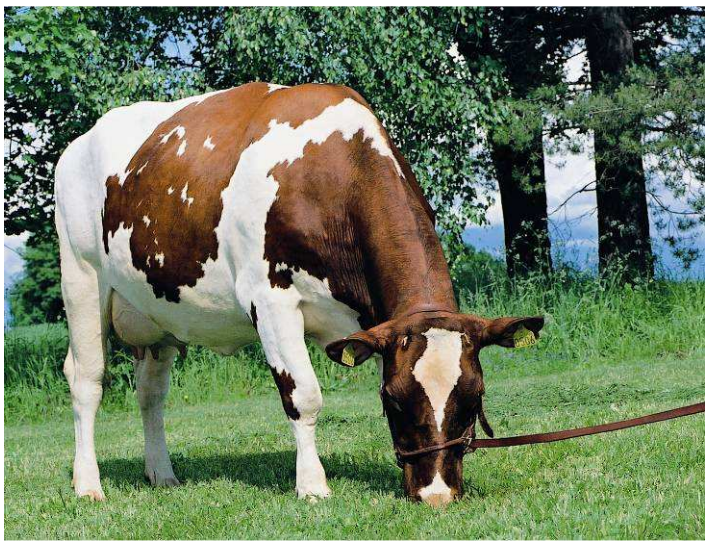
Academia-Industry Cooperation

Use strong points of each

- ✓ **Academia:**
  - Funding
  - Link to other fields (human/medical research)
  - No need for immediate application
- ✓ **Industry:**
  - Knowledge of and cheap access to genetic resources
  - Understanding of animals
  - Knowledge of market requirements



Left: Sustainable academia-industry cooperation is for the benefit of both parties. This mindset is the start of many successful applications from research in industry. An overview of the strong points of both parties in animal breeding is given by Gerard Albers, Hendrix-Genetics, at the EADGENE Industry Days (2005, Hinxton UK)
Right: Example of the interest of industry in research into animal health genomics (as Large or Small partner, Service Provider, Technology Provider, Animal Resources Provider) as gathered in EADGENE Technology Transfer amongst animal health and breeding industries in Europe. Each colour represents one industry (EADGENE www.eadgene.org)



Genetics

1. New genetic methodologies and tools to analyse interpret and predict.

    - Performance across a range of environments
    - Heterotic interactions across a range of genetic backgrounds
    - Non-linear relationships among traits
    - Population level interactions
    - Epistatic interactions
    - Developing programmes to integrate knowledge of reproductive technologies (AI, ET, IVF, embryo and gamete preservation)
    - New methods for genetic evaluation (including genomics) to design and verify the efficiency of appropriate genetic schemes aiming to optimise multiple character selection and/or maintenance of biodiversity

2. Improved tools to utilise quantitative information and/or molecular genetics information in selection.

    - Marker Assisted and Gene Assisted Selection
    - Genome-Wide Selection
    - Optimisation of diversity and heterosis in breeding systems
    - Optimised breeding programme design.

Genomics

1. Develop the basic tools for genomic research.

    - Finished genome sequence for chicken, cattle, pig, salmon and sheep (horse)
    - Draft sequence for duck, turkey, goat, trout
    - Bioinformatic tools for open-access annotation and interrogation within and across species
    - SNP panels (validated SNP panels with 0.5 to 1M SNPs for each target species
    - Tools to analyse copy number variations (CNVs) such as BAC tiling arrays and high density SNP arrays
    - Transcriptomic tools
    - Other 'omics tools
    - Implementation of new sequencing technology for the analysis of farm animal genomes

2. Develop tools for the elucidation of complex genetic traits from genomic information.

    - Gene-gene interactions
    - Gene networks
    - Heterosis and epistasis
    - Epigenetic effects
    - Environmental interactions.

Technology Transfer

- Optimise research to applicable results by increasing exchange of knowledge and technologies.
- Increase collaborations between research and industry, decreasing the distance between new knowledge and new products.

Education

1. Life long learning
    - People Development
    - Innovative Life Long Learning Mechanisms

2. Education of young people
    - People Development
    - Research and Innovation Structures.

Socio-economic Research

- Integration of socio-economic aspects including ethics in R&D projects
- Ownership and intellectual property development
- Knowledge building to move from one to two way communication
- Broad development of quality schemes and standards.

Enabling Factors

1. Networking

2. Transparency – Communication – Dialogue

3. Regulatory Framework

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Stakeholders:

Aarhus Universitet, Agricultural Biotechnology Center, Associação de Criadores de Ovinos do Sul, Arbeitsgemeinschaft Deutscher Rinderzüchter, Associazione Italiana Allevatori, Akademia Techniczno-Rolnicza im. Jana i. Jedrzeja Sniadeckich w Bydgoszczy Wydzial Zootechniczny, Akvaforsk, Alta Genetics, Associazione Nazionale Allevatori Suini, Asociación Nacional de Criadores de Ganado Porcino Selecto, APEZ (Portuguese Association of Animal Science Engineering), Aristotle University of Thessaloniki, AquaGen, Aviagen, Biotechnology and Biological Sciences Research Council, British United Turkeys, CESTR (Czech Fleckvieh Breeders Association), CF Consulting Finanziamenti Unione Europea, Cherry Valley, Cobb Europe, CONVIS Herdbuch Service Elevage et Génétique Luxembourg, COPA-COGECA, Consiglio per la Ricerca e la Sperimentazione in Agricoltura, HG/CRV Holding, CECAV (Research Center of Animal and Veterinarian Sciences), Dansire, Danish Pig Production, Deutsche Reiterliche Vereinigung, Deutsche Gesellschaft für Züchtungskunde, European Association for Animal Production, European Aquaculture Society, European Forum of Farm Animal Breeders, Eesti Tousigade Aretushustu, Euribrid Hendrix Genetics, Europabio, FABA Breeding, Animal Production Service of Animal Production Service and Health Division of FAO, Federation of European Aquaculture Producers, Forschungsinstitut für biologischen Landbau, Forschungsinstitut für die Biologie landwirtschaftlicher Nutztiere, France Hybrides, Fugato, FUSAGx (Gembloux Agricultural University), Genesis Faraday, Gentec, Genus PIC, Hubbard Breeders, Hungarian Society of Agricultural Sciences, Institute for Animal Health, Institutul de Biologie si Nutriti Animala, International Committee for Animal Recording, Irish Cattle Breeding Federation, Instituto de Investigación y Tecnolog'ia Agraria y Agroalimentaria, Institut National de la Recherche Agronomique, Institute of Animal Science, National Centre of Agricultural Sciences, Kostinbrod, Bulgaria, Institute of Biology and Immunology of Reproduction, Bulgarian Academy of Sciences, Institute for Pig Genetics, Institut de Recerca i Tecnologia Agroalimentàries, Isituto Sperimentale Per La Zootecnia, Institut Technique du Porc, Katholiek Universiteit Leuven - Fac. Wetenschappen - Afd. Ecologie en Systematiek der Dieren - Laboratorium voor Aquatische Ecologie, Lohmann Tierzucht, Marine Harvest, Marine Institute, Foras na Mara, Merial, Meat and Livestock Commission, MTT Agrifood Research Finland, National Agricultural Research Foundation, Parco Tecnologico Padano, Norwegian School of Veterinary Science, Norsvin, Panhellenic Confederation of Unions of Agricultural Cooperatives, Pfizer Animal Health, Polish Academy of Sciences - Institute of Genetics and Animal Breeding, Scottish Agricultural C, Semenitaly, Slovak Agricultural Research Authority, Slovak Agricultural University in Nitra, Drustvo Rejcev Govedi Crnobele Pasme v Sloveniji, SperiVet, Dipartimento di Scienze Sperimental Veterinarie, Svensk Avel, SUISAG , Syndicat des Sélectionneurs Avicoles et Aquacoles Francais, Teagasc, TOPIGS, UCL Université Catholique de Louvain Faculté d'ingénerie biologique, agronomique et environmentale, ULg Université de Liége Faculté de Médecine Vétérinaire, Union Nationale des Coopératives agricoles d'Elevage et d'Insémination Animale, Universita Cattolica Piacenza, Università degli Studi di Milano Dipartimento di Scienze e Tecnologie Veterinarie per la Sicurezz Alimentare, Università degli Studie di Padova Dipartimento di Scienze Sperimentali Veterinarie, Università degli Studi di Palermo Dipartimento di Scienze Entomologiche, Fitopatologiche, Mircobiologiche Agrarie e Zootechniche, University of Bologna, University Bonn / Institute of Animal Science, University of Córdoba, University of Copenhagen, faculty of Life Sciences, University of Bedfordshire, University of Ljubljana, University of Newcastle / School of Agriculture, Food and Rural Development, University of Perugia, World Association for Animal Production, Wielkopolskie Centrum Hodowli i Rozrodu Zwierat w Poznaniu z siedziba w Tulcach, World's Poultry Science Association Federation of European Branches, Wageningen University and Research Center, Zentralverband der Deutschen Schweineproduktion

Mirror group *will become available after finalisation of the country discussions*

Observers from:

DG Sanco, European Food Safety Authority, Eurogroup for Animals, Joint Research Centre (Seville)