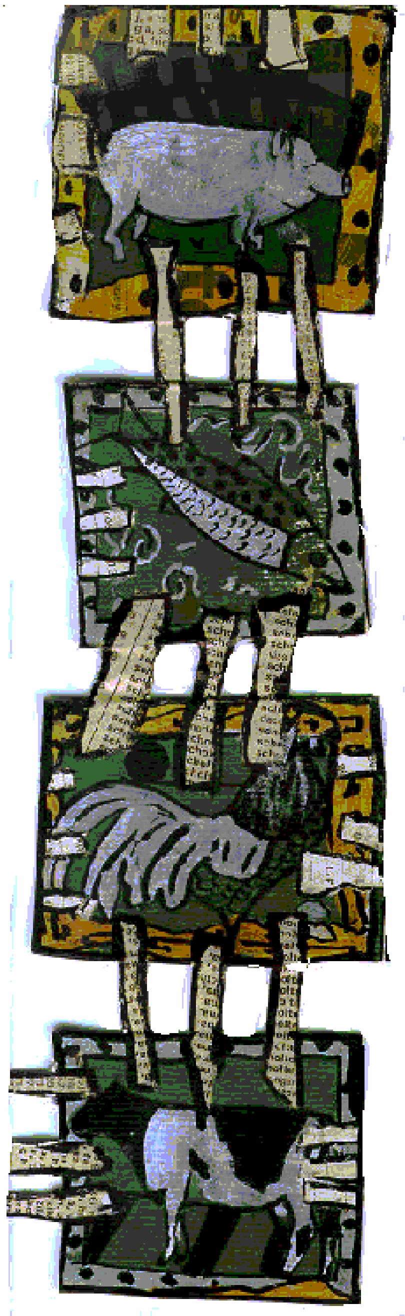
# Farm Animal Industrial Platform *(FAIP)*



# The future developments in farm animal breeding and reproduction and their ethical, legal and consumer implications

# REPORT

**Ed. A.M. Neeteson-van Nieuwenhoven**

**EC-ELSA project**

**4th Framework Programme for RTD**

**November 1999**

# EC - ELSA Project

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## Farm Animal Breeding and Society

## *Report*

***Ed. A.M. Neeteson-van Nieuwenhoven***

***September 1998 – December 1999***

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**Project Farm Animal Breeding and Society, Utrecht, The Netherlands**
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**Report**

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# Preface

The European farm animal reproduction and selection industry is on the threshold of a new era: evolving biotechnologies and the challenge of finding an European answer to breeding. New reproduction and selection technologies like cloning and transgenesis, in combination with existing breeding goals will raise questions that involve society. Although application in farm animal reproduction and selection of cloning and transgenesis for food production may not be likely to take place in Europe in the near future, there is a growing scientific and societal interest in these technologies due to the recent imports of GM crops and the development of transgenic and / or cloned animals for medical purposes. Therefore, an explanation of what breeding is and what are the possibilities to face the future is on its place. Furthermore, what are the ethical, legal and consumer implications of new developments in breeding and biotechnology?

This report is the final report of the project 'the future developments in farm animal breeding and reproduction and its ethical, legal and consumer implications'. The project was financed by the EU Fourth Framework Programme for RTD, and aims at making farm animal breeding and reproduction developments more transparent for both industry and society.

Farm animal breeding industry and specialists in bio-ethics, legal affairs and consumer affairs have given an overview of the breeding developments and their ethical, legal and consumer implications before the technologies are developed or applied. Consequently, the project is a survey based on expert opinions, formed by literature studies, and dialogues among experts and informed key persons.

The results of the project have been presented and discussed at a workshop in Utrecht, the Netherlands. It was a learning experience for the breeding industry and scientists to look at and discuss their breeding goals from other viewpoints than technological and economical merits. Society was confronted with the questions, practical dilemmas and challenges faced by the farm animal breeding and reproduction industry. A scientist: “Being educated as a scientist I am used to work towards a conclusion. But the quality and the content of the discussion can also be a goal.“

We hope the contacts that have been initiated will improve the mutual understanding between the breeding industry on the one side of the food chain and the consumers on the other side.

While the project was running developments in science and society went fast. Further contacts will be important in order to ensure that also in the future consumers and producers are aware of each others questions and points of view in order to finetune the demand in society and the possibilities in reproduction and selection.

Jan Merks, Chairman FAIP

Beuningen, 20 July 1999

# Contents

# Summary

The issues surrounding developments in farm animal breeding (cattle, sheep, pigs, poultry and fish) are ones in which the public has a real stake: new reproduction and selection technologies like transgenesis and cloning, but also undesirable side effects of high production in farm animals. Furthermore, food production has moved from being supply side driven to consumer driven. Farm animal reproduction and selection, on the outermost beginning of the food production chain, has to deal with this new situation in which awareness about the demand of the consumer, and the license to produce of society play a considerable role, at least in Europe. There is a growing need for rational debate among producers, consumers and policy makers and for decision-making based on technological, economical and societal information. The project "the future developments in farm animal reproduction and selection and its ethical, legal and consumer implications", financed by the EU 4th Framework Programme for RTD, has worked out a picture of challenges and future scenarios in farm animal breeding and the possible societal merits and constraints.

**Breeding and reproduction**

The first step in the breeding of farm animals involves the definition of a breeding goal: what kind of cattle, pigs, poultry or fish is desired? The following steps in the process are the selection of those animals that describe best this goal as future parents and the reproduction of the animals. Breeding companies and co-operations do this work for the farmers. Further globalisation of breeding, increase of the size of farms, improved computing facilities, (bio)technological developments, sustainable production and biodiversity will influence the structure and content of breeding. Three future scenarios – conventional, alternative and low cost – are represented. Each with consequences for production costs, uniformity of breeding goals and balanced breeding, and with possibilities for or likeliness that certain (bio)technologies will be applied. For example, heat induction may be an ideal instument to guide reproduction in low input areas, but does it reflect the ideas of the customers of organic agriculture products?

**Ethics**

Society – both consumers and producers – has an ethical responsibility towards breeding and reproduction. What is it that people are concerned about? On the one hand there are concerns towards animals, humans, the environment or biotechnology itself: unintended negative side effects of breeding and (bio)technologies can be in conflict with animal welfare and animal integrity. Humans are concerned about the possible effects of new developments on their own health and welfare, on genetic diversity and the environment. Furthermore, they question biotechnology itself. On the other hand the positive applications represent an obligation not to dismiss these options. Methods to weigh the concerns and the possibilities are outlined to help working towards acceptable solutions.

**Law**

Developments in farm animal breeding and biotechnology have legal consequences. The impact of the new patent law on production methods, marker assisted selection, the patentability of animals and of

animal genes has been analysed. The potential problems associated with patents are outlined: the risk of competition between patent holder and breeder, the research exemption, effects of broad claims or patents on biotechnological processes, the impact of the farmer's privilege and the traceability of genetically modified animals. Furthermore, animal welfare legislations will influence breeding (developments) more and more. Case-by-case assessment seems to be a workable option.

**Consumer**

Breeding farm animals seems far away from the consumer. However, consumers have clear opinions about the genetic modification (GM) of animals. Animal welfare is a concern, but so is the price and quality of the product. Benefits should be evident to consumers before novelties get accepted. GM of animals, at least for food production, is expected to raise a lot of opposition. However, even if animal breeders will not GM or clone their animals, they may expect to meet negative publicity of GM/cloned animals for medical purposes: the general public will not make the distinction. Awareness about consumers is important, even if their behaviour is not very predictable at large. Contacts with animal welfare organisations are important. The concerns of society deserve serious consideration.

**Workshop**

The framework of possibilities and concerns was represented and discussed before an audience of industry, scientists and representatives from society at 3 June 1999 in Utrecht, The Netherlands. The workshop was opened by Sally Keeble UK MP, who put the role of farm animals in society in perspective. The vice-chairman of the Farm Animal Welfare Council added economical considerations on welfare to the picture. A lively discussion on all these presentations and project results took place. The scene has been set. Breeding industry learns about the concerns and wishes in society, and brings its questions and possibilities to the public. Developments continue. The dialogue, necessary to build understanding and to finetune the activities of both consumers and breeders, should continue. More detailed information about the exact wishes of society, the cultural differences within society and between North/South Europe, the possibilities of breeding industry and research to address society demand, the legal, economical and global framework and the involvement of animal welfare representatives will help the realisation of a further, informed dialogue.

**Conclusions**

Clearly, the project is finished but not the discussion that was raised in this project. This discussion on societal aspects of farm animal breeding and reproduction must be continued. Not only because it is not yet finished, but especially because the opinion in society and the (potential) possibilities in farm animal breeding and reproduction are changing continuously. The animal breeding and reproduction industry in Europe, as represented in the Farm Animal Industrial Platform, is aware of that need and is active in promoting discussion and debate with society on the different aspects goals and techniques involved in animal breeding.

The results of this project are a perfect start for a further dialogue. All relevant information is gathered for both students, scientists and industrial managers as well as for politicians and societal groups like consumer, animal welfare and farmers organisations, to make farm animal breeding and reproduction transparent.

Part of the project “the reproduction and selection of farm animals and its ethical, legal and consumer implications” has been a workshop, to discuss the results with an audience of science, industry and society, at Thursday 3 June 1999 at the Veterinary Faculty of Utrecht University in the Netherlands.

## Programme

*Chairman Jan Merks*

9.00 Registration, coffee/tea

9.30 Welcome

9.45 **S. Keeble,** Member Parliament UK: **Farm Animals - their Role in Society**

10.05 **J. Merks**, Chairman FAIP: **Farm Animal Breeding and Society**

10.15 Coffee/tea

10.50 **A. Bagnato**, Università degli Studi di Milano / **A. Neeteson**, FAIP:
**The Reproduction and Selection of Farm Animals**

11.10 Questions and discussion

11.25 **P. Sandøe**, Royal Veterinary and Agricultural University Frederiksberg:
**Ethical Perspectives on Breeding and Biotechnology**

11.45 Questions and discussion

12.00 LUNCH

13.20 **J. McInerney**, vice chairman Farm Animal Welfare Council: **Economic Pressures, Livestock Productivity and Animal Welfare – Seeking the Balance**

13.40 **A. van Genderen**, Consumer & Biotechnology Foundation:
**Farm Animal Breeding and the Consumer**

14.00 Questions and discussion

14.15 **C. Noiville/ C.Labrusse**, Faculty of Law Paris University I:
**Farm Animal Breeding and the Law**

14.35 Questions and discussion

14.50 Coffee/tea

15.20 **Discussion panel**

16.20 Conclusions

16.30 END

# Farm animals – their role in society

*Sally Keeble MP*[1]

I am grateful to be invited to speak to this conference on an important and complex subject. I will address the animal welfare implications of breeding regimes, and more especially of the impact of genetic modification in animal breeding. Furthermore, I will set out some of the particular challenges that are posed to these new developments by the consumer concern for animal welfare.

Your industry has to deal with some of the most difficult issues of our times – the role of science, the environment, international trade and development, ethical investment, and animal welfare. In the past two years stories about food and farming have never been far from the headlines in the UK. Recent newspaper reports of the Prince of Wales' views about GM food show that the combination of royalty and genetically modified (GM) food puts it right at the top of the news agenda.

Even without the royal interest, the issues surrounding developments in animal breeding are ones in which the public have a real stake. There is a pressing need for rational debate and good decision-making. Developments in your industry have the potential for real benefits to society, but with potential costs that some people find unacceptable. People need to think these through and take the decisions that will in some senses literally shape the future.

If the public were to accept some modern farming techniques and if subsidy systems were changed, we could have smaller areas of the countryside devoted to commercial agriculture, and more of it devoted to environmental and recreational purposes. But then people would have to accept more intensive farming techniques. People could have much cheaper food – but the price would probably have to be a decline in animal welfare standards, more imports from developing countries, possibly a reduction in food standards, and almost certainly a profound change in agriculture and by extension the rural landscapes we all enjoy – certainly in the UK.

**Behind the public anxiety**

Many of these issues are already upon us in the current debate about GM crops. The debate about GM animals has, in comparison, barely begun. Yet the science has been around a long time. The Polkinghorne committee, set up by the UK government in July 1989, was charged with looking into the implications of the emerging science. It concluded in one of its reports that "ethical concerns over genetic modification and animal welfare are not different in nature from those raised by modern breeding and farming methods generally".

This statement is an inaccurate assessment of the public's perception. It might be correct from the scientific point of view, in that most of the things that can be done with modern techniques of genetic modification could be done, albeit on a more protracted basis, by traditional selective breeding. Indeed,

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some of the most profound animal welfare issues are raised by methods of animal rearing rather than breeding. However, the furore that exists around GM crops illustrates the danger of misjudging, or under-valuing, public anxiety over the development of biotechnology and its application to food production.

What is behind this public anxiety? It may sometimes be dismissed as prejudice, or social values, and judged irrational. But both farmers and politicians ignore these factors at their peril.
Firstly there is the high concern about animal welfare in UK, which has already been responsible for the unilateral introduction of animal welfare standards.
The second major pre-occupation is food safety, especially heightened by the BSE disaster. I suspect that the UK have a higher level of concern than many other nations, and certainly than the US. On a select committee visit to Washington we were all shocked to hear about the animal welfare implications of the use of hormones in beef production - as well as the food safety implications. We also saw some standards of food production that would not be tolerated in a major factory in Britain.
The third major concern shaping public policy in this area is the demand for cheap food. People in Europe have become used to supplies of high quality exotic food year round at prices that are often *unsustainable*.

**Citizen's concern and consumer purchases**

The source of the real problem for farmers lies in the contradiction between citizen's concern and consumer behaviour. Because there is not the evidence that consumers are prepared to pay for the higher welfare standards, nor necessarily for the safer food, that we say we want. Among the papers being delivered at this conference is one that has information about public attitudes towards free range eggs and other produce, showing that people do not understand the labelling and demonstrating some contradictory attitudes towards their decision-making when they buy food (Arie van Genderen and Huib de Vriend). There is real conflict between the different strands in public opinion, and the views of different sections of the community.
However, this does not deny the need to deal with the views of those in the animal welfare or food safety lobby. The former in particular are extremely adept shapers of public opinion, in many ways acting as gatekeepers to public approval. If the industry is to ensure that it retains the public's confidence over the longer term, it is essential that it is seen to deal in a substantial way with the animal welfare and food safety lobbies and not to be in conflict with them. In the UK, the Government's decision to set up the new Food Standards Agency and two new commissions to look at the human and agricultural and environmental aspects of the GM will provide a public arena in which these issues can be properly discussed, and also where "best science" can be established. This is particularly important for the farm animal breeding organisations, given the public antipathy that has been evident thus far towards 'big farmers' and biotechnology.

**Welfare and ethical concerns**

Much of the public is remarkably ill-informed about the implications even of existing "traditional" farming methods. I certainly was before spending time in the past two years visiting farms. We do not know that some cattle have been bred for meat production to an extent that they often require ceasarians in order to give birth; that even with the new regulations in place for pig farming, sows give birth conditions that some of us did not know existed; and that chickens have been bred so that they reach their optimum weight in a matter of weeks. If the public saw some of these, and other practices, they would demand higher, not lower, animal welfare standards.

However, these animal welfare concerns associated with "traditional" farming methods are likely to be overshadowed by the debate about the welfare implications of genetic modification of farm animals. The concern about "unnaturalness" raised in connection with GM crops can only increase in relation to animals. Mucking about with plants is one thing – mucking about with animals is going to be much less acceptable. This was recognised in the Polkinghorne report as being a concern that must be addressed. It referred to "a degree of unease about the unnaturalness of the process", a "moral taint" related to the nature of the technology. The report did not conclude that this was enough to ban genetic modification of animals for food production. This idea of unnaturalness can also be seen as springing largely from a mistrust of science. Although not a scientist; I do not share the mistrust, and find it quite difficult to appreciate. For example, as is shown in a paper to this conference, people are prepared to accept GM of animals for production of medicine but not food, which is really quite illogical. There is also a degree of hostility to animal husbandry techniques which are applied with relatively little controversy to reproductive medicine for human beings.

A further consideration in this issue of "unnaturalness" is the transfer of genes between species. These are in part animal welfare concerns, in part more general ethical issues that the farming industry will need to address. What does it do to the intrinsic nature of an animal if it includes genes from other species, and especially if it includes human genes? One of my colleagues who was a research scientist before entering parliament will explain at great length that transferring a gene is only copying a formula. However, this explanation may not be readily acceptable to the public. Arguments over transgenic animals may make the present row about "Frankenstein" vegetables pale into insignificance. One of the original drivers behind the decision to look at regulation of GM animals was the production in the late 1980s of a sheep modified to carry a human protein involved in blood clotting. I sometimes wonder whether the public is aware that this is even possible.

Another welfare concern about genetic modification of farm animals is likely to be the concern about the impact of rapid accentuation of specific traits. This is already a major source of objection by the animal welfare lobby to selective breeding techniques currently used in farming. In parliamentary debates about welfare of laying hens, broiler chickens and pigs, the concerns focus on intensive rearing methods. But much of it is also concerned with the selective breeding of animals for traits which make for cheap efficient food production, but which run counter to the welfare of the animals concerned.

There are also ethical and animal welfare concerns about the particular traits that are selected. For example, there is discussion in the literature of the production of cows milk that is like human milk. This will no doubt have excellent medical applications. What the implications are for the cow when feeding its own calves, assuming that was to be permitted in any event, is another matter. Equally, how human mothers will respond to one of their functions being usurped in quite such dramatic fashion is also likely to be problematic.

Equally there is discussion about the development of poultry which are non-aggressive, to avoid beak trimming. Whilst this might be a perfectly valid way to breed poultry and might also be seen as a solution to the animal welfare lobby's objection to beak clipping, the more obvious solution might be to have different management systems.

Finally all these developments can only be made on the basis of experimentation, and therefore also with some failed experimentation. There are animal welfare issues in whether it is justifiable to carry out these experiments if they cause unnecessary hardship to the animals for no benefit, certainly to the animals, and possibly not to human beings either.

**Discussion**

What does all of this mean for your industry? And not just your industry. The debate around these issues will involve Government in almost as much controversy as it will involve you. Firstly it requires transparency in what is happening. It is astonishing to see, how far the science had advanced in 1989, when the Polkinghorne report was written, and how little has been done, since then, to inform the public about the scientific processes, and the potential which it holds. It is a tragedy that the debate about GM crops has been media rather than science driven. On the more sensitive issue of genetic modification of animals, we will need a much more informed public debate. Much of the debate about genetic modification of animals has focussed on cloning and on Dolly. The somewhat comical treatment of her ageing problem – mutton dressed up as lamb etc – has not ensured that the public are properly informed about the really complex scientific and welfare issues involved.

Secondly we will need an early and careful labelling system. One of the particularly damaging aspects of the GM crop argument is that the four GM foods were on the market before there was a labelling system in place to ensure that consumers could exercise choice. This seriously undermined efforts to win public acceptability for these foodstuffs. It has been argued that GM meat will only need to be labelled where it contains transgenic material, especially from human beings. However, I suspect public opinion will demand something more exhaustive than this. The industry is best placed to produce a labelling that is the GM equivalent of Freedom Food. And there needs to be agreement on what is a non-modified animal, the issue of segregation that has so bedevilled the debate about GM crops. The public may expect non GM to mean zero. Possibly some of the groundwork for this has been done through the traceability systems put in place for cattle in the wake of BSE. One of the issues the Polkinghorne committee raised was the need for traceability from animal breeders right through the industry to the final consumer.

Most of all, though, it means the farming industry ensuring that its practises are acceptable to the wider public opinion on animal welfare, recognising the increasing role that animal welfare is likely to have in public policy decisions.

Government acts as a point of reference in society. Regulator of industry, supporter of industry, protector of public health, upholder of values of society, regulator of internal trade, and increasingly, of

European and world trade. But Government cannot make people eat certain foodstuffs or force them to accept particular farming practices and in this sense Government can not solve the farming industry's problems. To achieve that will involve the active engagement of the scientific community, the farming community, and the general public. Winning over public confidence is a project for which the farming industry is in some ways well placed. Over the past two years one of the more interesting mobilisers of public opinion in the UK has been the Keep Britain Farming campaign run by the National Farmers Union. It is perhaps easy to overlook that one. The Farmers Union held rallies and lobbies in my constituency and took farm animals into the town's shopping centre. All the evidence I had from people in my wholly urban constituency was that they were profoundly concerned about rural landscape issues, foreign competition issues and food production and safety. It demonstrated to me that there is no reason to have dislocation between food producers and food consumers. Overcoming that divide will best serve the interests of both consumers and your industry.

# Farm animal breeding and society

*Jan Merks*[1]

Since mankind started the domestication of farm animals, we have tried to get progeny from the animals that seemed best fit for the purpose we had in mind. Since the beginning of this century, initiated by governmental organisations by the set up of herdbooks, the farm animal reproduction and selection organisations are doing this important job. They provide the farmers with genetically high value animals to produce milk, meat, eggs or wool. All towards enough food at low cost.

Nowadays, not the opinion of the farmers about the quality of their product or production system is important for animal breeders, but the opinion of society and the 'licence to produce' determines the goal of farm animal selection and reproduction. The awareness of the European public concerning diseases in farm animals and new technologies in use for transgenic crops, animals for xenotransplantation and cloning has been the challenge for the European reproduction and selection industry to start a dialogue with society about the future of farm animal breeding. Especially new technologies may raise questions that involve consumers, the moral values of society and the legal rights of animal breeders and farmers. In order to enable that dialogue the project "The future developments in farm animal breeding and reproduction and their ethical, legal and consumer implications" has been initiated, of which we will discuss the results today. The project is a research project, funded in the Fourth EC Framework Programme for Research and Technological Development. It started at 1 September 1998 and it is expected to be finished by September this year.
The goal of project farm animal breeding and society is making farm animal breeding and reproduction developments more transparent for society, and to look at these developments from an ethical, legal and consumer viewpoint.

Before we start with the presentation and discussion of the project results, the partners in the project are:

1) Farm Animal Industrial Platform *(FAIP)* and Institute for Pig Genetics (IPG). Their task was to make an inventory of the present and future aspects of breeding and reproduction, together with the
2) Zootechnical Institute of the University of Milan;
3) Veterinary and Agricultural University, Frederiksberg Copenhagen. Their task involved the ethical aspects of farm animal breeding and reproduction;
4) Centre de Droit des Obligations, Faculty of Law Paris University I investigated the legal aspects, and
5) Consumer and Biotechnology Foundation from the Netherlands is responsible for the viewpoint of consumer organisations.

Each of the partners has executed part of the project. During the project, numerous contacts by e-mail and telephone, and a few fruitful personal meetings with a lot of discussion enabled a consistent project with all necessary interaction.
The breeding part is developed together with working groups from the breeding industry, all FAIP members. Furthermore, three future scenarios: a conventional path, a modified path and a low cost path

have been worked out. These scenarios give an overview of what is possible, and how breeding, technologies, production systems, consumer quality and cost price can be linked. Above all, they are meant to be a basis for discussion on the future of farm animal breeding and production.

Looking at reproduction and selection of farm animals from an ethical viewpoint, Peter Sandøe and Stine Christiansen will review those aspects of the breeding and reproduction of today and tomorrow with respect to the ethical values of society.

Research and development, costing a lot of money, need to get a return from the products and processes that result from it. Christine Noiville very clearly will address the impact of the legal protection of biotechnological inventions by patents for farm animal reproduction and selection. Furthermore, she has made an overview of the role that animal welfare legislations could play on the future breeding work.

Last but not least, the role of the consumer – who is THE consumer – is the subject of the study and the survey that Arie van Genderen has made. How does THE consumer react to new technologies? How important is consumer choice? What can we expect?

The aim of today is to open a dialogue between social parties that did not meet before to discuss common interests in farm animal breeding and reproduction.

Today, the results of the first part of that dialogue will be presented to you, for further discussion. In this way, the farm animal industry wants to start a dialogue between producers and consumers – together with the providers of legal and political conditions – to achieve a better finetuning of possibilities, wishes and expectations. This will help breeding industry, consumers and politicians in making well informed decisions.

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# The Reproduction and Selection of Farm Animals

*Anne-Marie Neeteson[1], Alessandro Bagnato[2], Jan Merks[1], Raffaella Finocchiaro[2], Egbert Knol[1], Cliff Nixey[3], Pierrick Haffray[4], Duncan Pullar[5]*

Farm animal industry is on the threshold of the application of new biotechnologies in farm animal reproduction and selection. The developments in breeding and livestock production have resulted in the farm animals of today producing high quality products at relatively low cost. Both the new technologies and the traditional breeding of farm animals may raise questions that involve society. Milk, meat, fish and eggs are an important part of our daily food consumption. Before a consumer buys a product, it has made its way through the food production chain, making the origin of the product and the way it is produced very distant. However, consumers influence livestock production directly with their purchases. Farmers produce the food that will be bought by consumers. Breeders breed the animals that will be used by the farmers. The aim of this article is to make farm animal breeding and its role in animal food production more transparent. To achieve this, the European reproduction and selection industries of cattle and other ruminants, pigs, poultry and farmed fish, represented in the Farm Animal Industrial Platform *(FAIP)*, have jointly made an overview of the history and state of the art in breeding (Farm Animal Industrial Platform, 1999) and of the factors that will affect the development of farm animal breeding. Furthermore, possible future models of farm animal reproduction and selection have been worked out. These models are meant to be the subjects for discussion on the possible and desired developments in farm animal breeding.

**The contribution of farm breeding to food production.**

The breeding of farm animals takes place at the beginning of the food chain. From consumer purchases it is a long road from the retailer to the processor, to the farmer and finally to the animal breeder. Animal production takes place on farms where farmers fit both the market's and the consumer needs by choosing with great care replacement animals for their own production. In this way farmers gradually bring the population characteristics in the direction of the consumer needs. This is called *genetic improvement*. The role of animal breeders and breeding companies is to produce and disseminate improved animals to the farmers.

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Breeding farm animals takes place in three steps. A breeding goal is determined. The animals that answer best to the breeding goal are identified and selected. Then, they are reproduced and disseminated to the farmer.

**Definition of the characteristics to improve (breeding goal).** In general, farm animal populations do not have all the desired characteristics. The first step in a selection programme is the definition of a breeding goal. This is a description of the qualities an animal should ideally have in certain circumstances or, in other terms, the definition of the characteristics to improve. Different markets and different farming systems may need different animals and consequently different traits need to be improved to achieve the breeding objective. Most of the time the breeding objective involves more than one trait, for example laying hens should produce more eggs with better shell quality, lay longer and have stronger legs. When more than one trait is included in the selection programme it must be decided for each trait how important it is compared to the others. One should also bear in mind that improvement for a trait may influence positively or negatively other traits.

Moreover a breeding goal must be determined a long time in advance. Depending on the species, (i.e. the biology of the animal and the characteristics of the population), on the tools available to realise the desired improvement, and on the number and the characteristics of traits one wants to bring nearer to the goal, it takes three, five, ten years or more to achieve appreciable results. The definition of a breeding goal is then a long term prediction of the consumer and of the market needs. Besides that the breeding goal may change in time, one should be aware that the decided breeding goal will influence the management of animals, and consumer appreciation for a relatively long period.

**Identification and selection of superior animals.** To achieve improvement for the characteristics in the breeding goal, animals must be identified, and a value (selection index) given to each animal indicating their ability to improve the desired characteristics. Those animals fitting the breeding goal best are preferred when producing the next generation. This is called “selection”. The performance of an animal (phenotype) is a mixture of its genetic make up (genotype) and of the environment. Animals are selected according to their phenotype (mass selection), estimated genotype (index selection) or measured genotype (Marker Assisted Selection). Only heritable traits can be selected for.

An animal does not necessarily have to express the trait one wants to select for. This is the case for sex limited traits like milk production. Males can carry excellent genes for milk production and one can measure the genetic value through the daughters or directly in the genes of the animal itself.

Furthermore in poultry and pigs, dam and sire lines are selected separately for reproduction traits and for production traits. These lines are then crossed to achieve the benefits of both, and to benefit from heterosis in the form of vitality and production. Heterosis is the improved performance of offspring gained by crossing unrelated populations.

**Reproduction.** Reproduction is simply the ability of an animal to produce offspring. This is not always an easy process, e.g. zoos sometimes have to try hard to get some of the animals reproduce. Farmers and breeding organisations are involved in various phases of the reproductive process such as identification of optimum time of insemination, health status of the reproductive organs, semen production and conservation, embryo transfer and ovum pick up.
Control of reproduction enables a more optimal distribution of breeding stock to distant farmers. It also is an important tool in disease prevention. A certified artificial insemination station does not spread disease as easily as a natural mating male going from farm to farm. Furthermore, semen and embryo conservation can be important tools in the conservation of biodiversity.

The size of the farm animal reproduction and selection sector is small. Despite this, its impact on livestock production is high because genetic improvement is permanent (improvements are genetically determined), cumulative (every effort is built upon the improvement reached in the previous generation), and disseminated widely through the production chain. For that reason a discussion about farm animal breeding and breeding developments is a discussion about the kind of animals that are or will be used in livestock production.

**History and state of the art in farm animal breeding**

Today's farm animal breeds originate from a few wild species. The domestication of most of the farm animals took place millennia ago (Zeuner, 1963). At first, only animals which were easy to handle, easy to reproduce and which survived the winter period were actually used for breeding, thus domesticating the animal. It took until the 19th century before the first official herd books and breed societies appeared in cattle, sheep and pigs. They registered family records and/or production information. Early selection procedures were based on individual performance only. Later, selection was carried out by using family information to determine differences between non-heritable management and heritable animal effects on the performance of an individual animal (Van Vleck, 1993). Own performance and family information were combined in indexes enabling the selection of top animals, best fitted for the breeding goal. Improved availability of computers and improved statistical methods allow much more accuracy and allow more traits to be included in the selection index.
In poultry, extensive family records are kept of the low heritable reproductive traits such as egg numbers, egg size and hatchability. For growth and conformation characteristics, which are more highly heritable, the techniques in poultry breeding are based on mass selection on phenotypic characteristics. Poultry and pig breeding programmes work with several unrelated lines to select for a number of traits, in the end crossing these (two or three) breeds for the extra vitality and performance of the heterosis effect.
Although fish farming has been practised for more than 4000 years, fish breeding programmes are still at the initial phase, and in some breeds no selection takes place. Most of the genetic improvement in fish is based on mass selection without pedigree information. In several countries selection programmes incorporating genetic information are in place, enabling selection for several traits or traits that need to

be collected from families (quality traits, disease resistance). Fish hybridise naturally in the wild (carps, salmonids, sturgeons). Hybrid fish can be created by farmers, e.g. fish resistant to certain diseases. Oysters and molluscs are mainly coming from wild spats collected form natural spawns. Hatcheries use wild breeders without a breeding programme.

Recently, the first DNA tests in farm animals to detect genetic defects have been developed (Lenstra, 1999). The best known single gene is the one for stress susceptibility in pigs, causing sudden death if the animal is stressed (Ollivier *et al.*, 1975). A DNA test is available to detect this defective allele and to avoid the use of animals carrying it as reproducers.

The breeding goal of farm animals has changed over the years. Many cattle breeds were originally dual purpose, used for milk and meat production and occasionally draught purposes. Even now a lot of breeds are dual purpose breeds, combining relatively high milk production with good meat production thus providing significant extra revenue for the farmers. Beef recording and specialisation into beef breeds has mainly developed in the last 40 years – starting in the 1960s with weight recording on farm, later followed by performance testing in test stations allowing direct comparison of animals. Breeding goals in pigs in the early 1900s was also dual purpose (litter size and growth) and based on phenotype. Pig breeding was almost entirely pure breeding until 1960. In the late 1980s, improved computing technologies and statistical methods allowed to select for traits with a low heritability, followed by further specialisation into sire and dam lines. Before the 2nd World War all poultry breeds were dual purpose as well. The females would be used for table egg production and the males were grown for meat consumption. Other species of poultry such as turkeys and ducks had no organised breeding programme. After 1945, in the USA, breeding programmes were developed, with specialised lines and breeds for table egg chicken (layers) and meat chicken (broilers) instead of dual purpose chicken. At a later date, also breeding programmes for turkeys and ducks emerged.

Furthermore, the possibility of incorporating more traits into selection programmes did change the breeding goal from purely aiming at production towards the incorporation of health, reproduction and behavioural characteristics. There are differences in Europe between the breeding goals of companies and between regions. For instance Scandinavian countries have routinely recorded health and functional traits like mastitis and fertility in their system. Some poultry firms, starting from having only production characteristics like carcass quality in the breeding goal, have moved towards incorporating taste and health, and later also welfare in the breeding goals as well.

In cattle, artificial insemination is used in most of the cases. Non-surgical embryo transplantation is possible, but is mainly used for highly valuable animals because it is a relatively costly procedure. In goats and sheep artificial insemination is not common practice, because semen cannot be frozen easily and fertility, after thawing and insemination, is still not acceptable (Barillet, 1997). The reproduction period of sheep and goats is usually seasonal. Oestrus synchronisation is practised occasionally. The exchange of genetic material in pigs is mainly by fresh semen, since frozen semen technology in pigs is still underdeveloped (Meredith, 1995). Non surgical embryo transfer might be available for commercial use in one or two years. In poultry breeding, mainly artificial insemination is used nowadays (Surai & Wishart, 1996). Eggs can be transported world wide, thus enabling the use of breeding eggs from the

USA or Europe in e.g. the Far East. In most fish, the season of spawning can be managed with control of e.g. light or thermo-period. Most fish species ovulate or give semen by gently stripping of the flanks. In marine species hormonal synchronisation is the only possibility to get ova and semen. Freezing semen is possible, but mainly practised for conservation purposes. Embryonic eggs can be transported, and disinfected to prevent disease risks.
A more detailed description of breeding technologies and developments in research is provided in Appendix 1.

**Factors influencing the future of farm animal breeding**

An exercise is made to determine which factors most probably will influence and determine the farm animal breeding of tomorrow in Europe. The implication of consumers, legal climate and bio ethics on breeding will be worked out by the other partners. The main scientific, technological, and economical factors are described below.

**Sustainability.** Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). Sustainable agriculture aims at production systems that can provide man with food in a balanced way. European animal production is characterised by no use of additional hormones nor growth promoters. Many by-products from human food industry (e.g. soybean and citrus extractions) find their way in animal feed. A lot of farms are family farms, and they play an active part in the maintenance of their local rural environment. Compared with other continents, in Europe there is more concern about animal welfare and sustainable production. Breeding can be directed towards animals having the ability to digest by-products in a better way, to use feed more efficiently, or to produce in extensive environments. The art will be to find the right balance between animal production, animal welfare, environment, product quality and consumer price.

**Structure of farms.** The size of farms is expected to grow continuously. In the first place the profit per animal decreases year after year. Consumer prices tend to get lower. Production costs increase. The result will be increased production per hectare, per litter, per animal. Also automation, hygiene regulations and a controlled food chain may force small farmers to give up business, because the investments needed are too high. On the other hand, high quota prices (Europe, Canada) keep farm sizes from expanding. European (cattle) farmers, but also Canadian poultry and dairy farmers currently protected by import barriers and subsidies, will have to adapt to world market prices. Farms where the farmer lives near the farm will disappear more and more. In the USA farms with one million pigs or a hundred thousand beef cows already exist.

Exceptions will occur for farmers producing for niche markets or in a special production system (e.g. organic) who will be able to get a higher return per animal. However, with the increase of organic production prices tend to go down because of the power of the intermediates that buy and sell the products. More and more primary producers will have less control on the marketing of their products.

**Global markets/international developments.** A great deal of breeding knowledge and a number of international breeding companies are situated in Northern Europe and North America. Farm animal breeding will globalise more in the future, especially in cattle and pigs, while poultry breeding is already organised globally. The push for borderless organisation will not come from the scientific communities, but from breeding companies that need to stimulate the development of international genetic programmes in order to finance the necessary investments in software development (Lohuis, 1999) and DNA technology.

**Structure of animal breeding.** The structure of breeding companies differs between species, mainly due to the biology of the species. In ruminants there is mainly an open structure, in which a proportion of the day to day producing female animals can become future breeding animals. Dairy bulls are even compared world-wide by the International Bull Evaluation Board (INTERBULL) and frozen bull semen is traded globally. In poultry all the breeding work can be done in house and a few companies can and do provide the world with breeding stock. Pig breeding is in an intermediate situation. In aquaculture breeding is at the very start of developments, but in a few decennia a few breeding companies may provide the world with breeding fish. In the future cattle breeding companies may merge to form fewer world-wide operating companies, providing farmers with semen and embryos. Furthermore, in cattle breeding nucleus herds, and maybe hybrid lines, will become part of the picture. The number of pig and poultry breeding companies may reduce further and their size increase. Alongside that there may be smaller companies serving niche markets in cattle, pig, poultry and aquaculture breeding.

**Computing and handling data.** Handling information is very important in animal breeding. More sophisticated hardware and software will improve these possibilities. 'On farm data' can be sent electronically to any estimation company . The improved computing capacity makes it possible to analyse all these data together. For example pig breeding companies will increase involvement of the farmers by using on-farm data for the genetic evaluation and reproductive management of breeding animals. Specially designed or adapted breeding programmes can prevent small breeds from having too much inbreeding and at the same time the maximum genetic improvement (Gandini & Oldenbroek, 1999; Meuwissen, 1999).

**Biotechnologies.** New technologies are DNA technologies from Marker Assisted Selection to transgenesis, and reproduction technologies like gamete sexing, embryotechnologies or cloning. Some DNA tests or embryotechnology in cattle are already applied. Others are under research and could be used in the near or more distant future. Marker Assisted Selection could be used to detect genes for genetic disorders (Hoeschele & Meinert, 1990; Georges *et al.*, 1993), disease resistance, product quality (Andersson *et al.*, 1994; Georges *et al.*, 1995; Ashwell *et al.*, 1997) or other traits of interest. Transgenic animals would have a special feature, e.g. in New Zealand there are plans to set up a flock of genetically alternative cows producing milk that is similar to human breast milk. Cloned animals could be used to determine the genetic component of important traits, or to disseminate valuable production animals from top breeding population to production populations more quickly. Technologies can only be applied if their use is economically viable. Furthermore, the question is whether public opinion and consumer purchases would favour the application of new technologies.

The development of new technologies and the high cost involved in research, may force the market players legally to protect their research efforts by means of patents or to use trademarks in order to get a return for the research efforts. The possibility of their legal protection may introduce exclusive rights for certain applications and thus influence the structure of breeding and the technologies applied by the several market players. Furthermore, the need to fund research that is too expensive for one market player may stimulate companies to become partners in research or to amalgate their companies.

**Biodiversity.** Breeding companies rely, for their selection possibilities, on the genetic diversity that is available in the species/the populations they work with. It is only possible to select for a certain trait, if the animals you select from show variation for this trait. Breeding companies carefully take care of the variation within their breeding stock. It is part of their breeding policy to maintain the available genetic variation, to maintain a 'zoo of special animals or species' and to keep an eye on the extremes of the genetic horizon. However, the genetic make-up of the breeding animals is not known, only estimated by means of performance measurements of the animals and their relatives. In general, information is available about traits that are taken into consideration. Although more traits are incorporated in the breeding goal than a few decennia ago, there can be genes or gene combinations for traits that are presently unimportant or that we are not aware of yet. Loss of genetic material can take place invisibly, as the role and exchange of genetic material between populations, selection and crossing take place gradually. For instance, it is not known what exactly is the definition of European lines and breeds, e.g. German and Dutch Landrace. Knowledge about their real genetic distance (Nei, 1987; Eding & Laval, 1999) and relationships is insufficient. Research on the consequences of 'invisible loss' through genetic drift, selection or crossing could give a better picture of this.

Breeding often concentrates on a few breeds per species. Also, 'popular' breeds like the Holstein Friesian cattle get mixed with local breeds world wide. The consequences for biodiversity of farm animals need further consideration (Farm Animal Industrial Platform, 1998).

Animal genetic improvement and conservation of genetic diversity need and use the same tools and technologies (data analysis, reproductive technologies). Co-ordination at the European level of efforts undertaken in different countries is necessary.

**Future models of farm animal production systems**

Global market, technological, biotechnological, animal welfare, management, political, economical, legal and societal developments may force animal production systems to change. In order to be able to consider new evolutions with care, and to have future pathways for discussion, three models are worked out in this section.

Partly they represent an extrapolation of today’s reality into the future as, currently, diversification of breeding is already part of the reality in Europe. Different organisations, different countries or different farming systems work with their own breeding goals. Several models can be applied in one country or within one organisation, each serving part of the market. The drive behind the differentiation is historically determined, following market demands and/or motivation comes from pressure for animal welfare and other societal demands.

In the first model (*conventional path*) farm animal breeding and production develop further towards a system similar to the current one. There is no need to change the actual animal production system,

mainly taking place at family farms.
In the second model (*alternative path*) the emphasis is on welfare, disease resistance, environment (pollution), niche markets, organic products, regional and special products. Consumers with differentiated demands for food and societal needs are the main drive behind this scenario.
The drive behind the third model (*low cost path*) is the demand of consumers for cheap and safe products in a global competitive market.
In all models the quality of products must be good. The first and third models are targeted on economic characteristics taking into account certain thresholds for e.g. mortality, welfare etc.
In general a breeding goal is determined by economic motives of farmers, mainly based on market and economy. Next to this, political or societal conditions may determine the breeding goal.
Animal breeding is associated with reproductive technologies, like Artificial Insemination (AI) and Embryo Technology (ET) and with DNA technologies, like Marker Assisted Selection (MAS). Although in principle newly developed techniques (Ovum Pick Up, cloning, transgenesis) could be used to achieve the different goals described in all models, their application may be less likely or would have to be adapted, in order to meet public demand or to reach the breeding goal faster in a specific model. Table 1 and Table 2 represent today's perception that traditional aspects and technologies will be used in the several models.

**Table 1. Today's perception that traditional aspects may be used in the conventional, alternative or low cost path**

| **Traditional aspects** | **Conventional path** | **Alternative path** | **Low cost path** |
|---|---|---|---|
| Decrease production costs | ++ | +/- | ++++ |
| Increase uniformity in breeds/goals | + | --- | ++++ |
| Balanced breeding | ++ | ++++ | + |

++++ used routinely, +++ likely to be applied, ++ will probably be applied, + may be applied, +/- may (not) be applied, - not likely to be applied, -- very unlikely to be applied

**Table 2. Today's perception whether technologies may be used in the conventional, alternative or low cost path**

| Technologies | Conventional path | Alternative path | Low cost path |
|---|---|---|---|
| Marker Assisted Selection | +++ | +++ | ++++ |
| Artificial Insemination and Embryo Technologies | +++ | ++ | ++++ |
| Transgenesis | - | -- | ++ |
| Monosexing (fish) | ++ | - | +++ |
| Triploïdy (fish) | + | +++ | ++ |
| Cloning | +/- | -- | +++ |

++++ used routinely, +++ likely to be applied, ++ will probably be applied, + may be applied, +/- may (not) be applied, - not likely to be applied, -- very unlikely to be applied

**1. Conventional path**

In the actual production system, mainly taking place at family farms, the breeding goal aims at improved efficiency of animal production in order to provide consumers with high quality animal products (milk, eggs, meat) at a reasonable cost price. In the conventional path, more genetic information on functional traits would be considered in the breeding goal because of factors limiting increase of production, e.g. milk quotas, and the awareness that genetic improvement for high production efficiency may produce undesirable side effects (Rauw *et al.,* 1998). There would be more emphasis on quality traits and disease resistance, to increase food quality and food safety. International competition would be likely to favour those companies that provide breeding stock that will improve general animal efficiency and/or deliver improved products.

Technologies available today like Artificial Insemination, and Embryo Technologies would also be used in the management of populations in the conventional path. Developments in research would enable the use of Artificial Insemination routinely in all species and Embryo Technologies in all farmed mammals. The development and use of new biotechnologies would not be seen as a primary need to achieve more quickly breeding goals.

**Description of conventional path in cattle, sheep, goats, pigs, poultry and aquaculture.** As high producing cows may exhibit lower fertility, some metabolic disorders, and some health problems, the breeding goals in milk cattle would incorporate, next to milk production and body structure, issues related to health, metabolism, non productive traits, and longevity (Groen *et al.*, 1997). The quota system that does not allow farmers to increase their production, and thus stimulate more efficient and profitable production, would favour selection for traits other than production in order to decrease the costs of production and increase the farmers' income although production will remain the main selection criterium. DNA tests would be available to detect animals carrying genetically transmittable diseases or genes improving better milk quality, e.g. k-casein (Lenstra, 1999). The aim in beef cattle and meat sheep would be to produce more meat in less time, with the minimum amount of feed, and with the best possible reproductive rate. Characteristics considered in the breeding objective would be mainly growth, carcass, and reproductive traits. Traits like meat quality that are now only measurable on slaughtered animals would be measured on live animals due to improved technologies. The double muscle would be present in some beef breeds, although double muscle causes mainly caesarians in e.g. the Belgian Blue. (Hanset, 1996). DNA tests on the myostatine gene (beef) (Ott, 1990; Grobet *et al.,* 1997; Masabanda *et al.*, 1998) or the Callipyge gene (less fat and more muscles in meat sheep) (Cocket *et al.*, 1993) would assist further selection. Milk composition and milkability, udder traits, and prolificity could be included in the breeding goal of milk sheep and goats next to milk production traits.

In pigs, selection would be aimed at strong, efficient, and high producing animals. To achieve this, selection criteria would be further differentiated between males and females lines, to take advantage of extra productivity and vitality due to the heterosis effect. Special crosses would be developed for specific housing systems. Information of the individual farms would be used to decide which families within the population contain valuable genetic characteristics and which do not. DNA tests would be available to detect deviant alleles.

The selection of poultry for table eggs (layers) would mainly aim at larger numbers of eggs per hen housed, optimum egg weight, efficient feed conversion, and improved egg quality. Demand for eggs from non cage-systems would change the layers farming system, especially in Northern Europe.

In broilers, turkeys and ducks (poultry meat production) there would be continued selection for growth rate, feed conversion, eviscerated yield and breastmeat yield. The improvements in growth and yield characteristics would be achieved with increasing emphasis on quality and fitness traits through improved population structure, statistical methods and selection technologies. Examples of improved selection technologies include real-time X-ray technology to improve assessment of skeletal quality. Also other than production traits, e.g. skeletal quality, heart and lung function, disease resistance and other traits related to fitness or welfare would be incorporated in the breeding goal. Broiler breeding has used marker-assisted selection for many years in the form of serological determinants of resistance to Mareks Disease virus. Other markers could be used to improve disease resistance.

Currently selection in aquaculture has taken place for less than six generations in salmonids and two generations in marine species. No selection of breeders is recorded in molluscs. Breeding programmes would initiate selection for quality traits to decrease fat content in the muscle, improve yields at harvesting, and decrease the variation of the repartition of the lipids in the filet that causes variation of smoking success and the taste of smoke and salt. Furthermore, the development of lean strains could improve feed efficiency and decrease waste. This improvement could be extended to new lines and other species.

**2. Alternative path**

The production system, and consequently the breeding goal, would aim at moderate production levels, specific products (niche markets, organic products, regional products), health and welfare of the animals, environment and improved feed efficiency. The breeding goal would be towards balanced breeding, avoiding possible negative effects of breeding for production on other biological traits, e.g. mobility, reproduction, disease resistance. Not all technologies available today would be used to allow a product to be advertised and marketed with certain characteristics, e.g. organic products. Specific technologies or recently developed biotechnologies would be an exception. They could be used when there would be a strong need to reach a specific breeding objective. Examples could be the use of Embryo Transplantation and Embryo Sexing to ensure the survival and development of small and endangered breeds, the use of Artificial Insemination and Embryo Transfer, allowing the dissemination of genetic material free of diseases, or the use of Marker Assisted Selection to improve longevity, feather pecking, stress resistance, or a desired animal behaviour characteristic.

Three possible production systems are described:

a) **Animal Welfare** Non productive traits that can improve animal welfare would be emphasized in the breeding objective. Selection for increased production has also increased the danger that the homeostatic balance of animals gets affected. In a literature study Rauw *et al.* (1998) have presented over a 100 references of undesirable side effects of selection for high production efficiency for broilers, pigs and dairy cattle. High productive animals seem to be more at risk for behavioural, physiological and immunological problems. When selection and farming is aimed at higher production, the individual resources would be used mostly for production, and less for other demands, and the buffer capacity of the animals could be affected (Resource Allocation Theory, Beilharz *et al.*, 1993). Reducing emphasis on production would accelerate genetic improvement for non-productive functional traits. If the economic benefit of “welfare traits” does not overcome the decreased revenue due to limited improvement in production, consumers may be ready to pay for the animal welfare through the higher prices of products.

b) **Link region-breed-product / niche markets** Products of high quality and limited in quantity represent the typical production in different geographical areas. Usually these products are part of the local culture. Breeding objectives should be addressed to maintain breeds and production systems that guarantee the variety of local food (Gandini & Giacomelli, 1997). Associations between region of production and breed or particular product (cheese, meat) could increase the value of the production, especially in areas where intensive farming cannot take place. The farming system could be addressed to maintain a balance between production and environment, by subscribing a maximum amount of animals of a breed on a specific extension in order to produce a limited amount of product, guaranteeing a good price to the farmers. Moreover, the presence of farmers is important for land conservation in areas otherwise destined to be abandoned.

c) **Organic products** The demand for organic products is rising. The definition of organic products could lead to the application of particular breeding objectives. It will depend on the final EC regulation on organic production concerning what will be allowed or forbidden, and which technologies can be applied.

**Description of alternative path in cattle, sheep, goats, pigs, poultry and aquaculture**. Next to the selection criteria mentioned in the conventional path, other reasons would be brought forward to change breeding goals and to consider alternative traits on top of the production criterion. Traits, like longevity, calving ease, udder health, somatic cell counts, control of mastitis, fertility, would be weighted heavier in the breeding goals in dairy cattle than would be the case in conventional breeding. For example, instead of obtaining a genetic improvement of 100 kg a year for milk production with no benefit for other characteristics, one could decide to improve milk production only 50 kg and reduce in the meantime health problems and metabolic disorders. Another example comes from beef cattle. Here the selection criterion could be to avoid the use of animals carrying the double muscle characteristic as reproducers to increase calving ease. Furthermore, selection could be aimed at animals able to adapt to difficult environments and able to produce a live healthy new-born calf each year. Some examples of regional products, produced by local breeds are the Fontina from the Aosta Red Pie and the Reblochon cheese from the Abbondance breeds. Niche markets could request particular products, as is the case for the "Parmigiano Reggiano delle Vacche Rosse" made from the milk of the Reggiana cattle breed, today counting only 1000 head (51,000 in 1955). Multiple Ovulation and Embryo Transfer (MOET) could improve selection schemes in breeds limited in size but with an economic importance (niche markets) and help their maintenance and their survival.

In the alternative model for pigs wishes from society would be integrated in a rural production system with medium sized isolated family farms, evenly spread over the country, with high healthy animals. The breeding goal would aim at animal friendly production, possibility for display of natural behaviour, and residue free pork, incorporating traits like litter size, piglet survival, mothering abilities, ease of growing and lack of fat accretion. Farmers could combine these estimates in a personal index. In this way uniformity within a farm could increase, while at the same moment genetic variation between farms could be maintained. Import of new genetic material would be by means of semen or embryos because of the limitation of disease risk. There would be niche markets with local breeds or regional products (e.g. Iberian ham). Single gene technology could help to assess the presence of deleterious alleles, responsible for among others congenital disorders like atresia ani and tremor piglets.

Poultry breeders for table egg chicken (layers) would respond to customer preferences for eggs from non-cage systems in having a slower genetic progress for conventional traits and extra emphasis on behaviour traits and liveability in order to decrease the tendency towards feather pecking and/or cannibalism, and to minimise the incidence of floor eggs i.e. eggs not laid in a nest. There is some evidence that selection against undesirable behaviour could be effective. Breeding programmes could be developed for certain niche markets. The further development of the egg products market may require selection for the egg components.

Poultry meat breeding programmes (broilers, turkeys, ducks) would emphasise the quality and welfare of individual birds, skeletal quality, and improved heart and lung function, next to continued selection on meat production and feed efficiency. Although some progress has been made in improving disease

resistance, new technologies could accelerate this and make further improvements to bird welfare. Breeding programmes could be developed for certain niche markets, e.g. a particular type of broiler based on specific requirements such as colour, regional breed, organic production system etc. There is a growing niche market for Bronze and Black feathered turkeys. Slow growing turkey breeds with an increased subcutaneous fat content over the breast represent a market for traditional farmed Christmas turkeys.
In fishes and molluscs, the development of resistant strains could be one of the solutions to avoid diseases in open farming conditions, limiting the use of drugs and increasing product safety. Furthermore, specialised breeding lines would be developed for fish species not yet farmed (halibut, char, cod, sole, sparides,  perch, catfish), in order to provide consumers with a high diversity of products. Some have potentially very high growth rates (thunnus, seriola). Others originate from other geographic areas in Japan, Chile, South America, Asia or Australia.

**3. Low cost path**

In the low cost path the goal would be to provide safe food at the lowest production costs. New methodologies to reach the objective of improved production efficiency would be explored and expensive research funded. Economic interest would be the pushing drive to use the most effective technologies available. Biotechnologies like cloning or transgenesis would most likely find their way here. Their application would mainly be related to ensure higher production at lower cost. This path is expected to be followed by producers at the global market: USA, South East Asia, South America, Canada, and maybe Europe. It can affect a large part of the food supply and may be of great interest to public opinion.

**Description of low cost path in cattle, sheep, goats, pigs, poultry and aquaculture.** In cattle, sheep and goats all breeding objectives would be aimed at reducing the cost of production. The cost/benefit ratio would determine which technologies and production systems could be used. Intensive farming would be the main instrument of production. In beef cattle there would be selection for double muscle. In sheep the Boorola gene to produce more offspring per delivery would be used.
In pig farming, family farms would gradually or rapidly be replaced by industrial farms, large well organised farms with very low labour input per animal. The selection for this environment would be on strong animals with a very good and adaptive digestive tract able to grow and farrow with little human intervention. Pig families with easy farrowing and good interaction between sow and piglets would be best adapted to this environment, even if litter size would be a little lower than usual in the conventional path. Uniformity in start of oestrus, in size of animals, in birth weight and quality of piglets etc. would be very important. A reduction in on farm variation would inevitably mean a reduction in genetic variation. Large farms grow large numbers of animals close together, causing increased disease risks. In large populations it is easier for pathogens to survive, making subdivisions within farms necessary or selection for animals with higher resistance.
The breeding goal for poultry table egg production (layers) would be for low cost safe production

systems, although the rates of progress for egg mass and feed conversion are expected to be lower in poultry, due to approaching biological limitations. Genes or genetic markers for desirable behavioural or disease resistance may be found and applied. When more cost-effective screening methods could be found, transgenic animals would also contribute to the genetic progress.

Genetic progress in poultry for meat production would be mainly aimed at growth rate, feed conversion, eviscerated yield and breastmeat yield in a cost-effective production system. Progress would be accelerated if marker genes or the trait genes themselves are identified. A better knowledge of Quantitative Trait Loci (QTL) affecting disease resistance would allow more accurate estimation of breeding values for such traits. Since pathogens evolve faster than the domesticated populations, it is vital that the new technologies do not narrow the genetic resource.

The genetic variability of all the traits in fish is 2 to 3 times higher than in the livestock species as fish species are still wild species. This means that an important potential of genetic progress exists. The benefit of the increase of the return rate of investment per kilogram produced and the decrease of the cost of raising would rapidly decrease the cost of the products. For example, Atlantic salmon cost have decreased from 12 US $ per kilo in the 1980s to 3 to 4 US $ per kilo in 1998. The part due to the genetic progress is still difficult to estimate as very few estimations have been published, but it could be expected that this cost would continue to decrease in the next decades. Furthermore, monosexing or triploïdy could be induced by external factors, e.g. temperature. Monosexing fish would allow fish of commercial size without hormonal treatment. Triploïdy, already present in the wild and giving sterile animals, would prevent selected fish from reproducing in the wild.

**Discussion**

This article has given an insight into the mechanisms and structure of breeding, in order to enable society to understand and direct livestock breeding and production. It has outlined which technological, economical and global factors will most probably influence the future of breeding and the animals used in livestock production. The future developments in production systems would differ according to species mainly because of biological differences. Nevertheless, many examples carried out previously for a particular case could be extended to different species or productions. For example feed conversion efficiency in all the species and production systems reduces the necessary amount of arable land.

The scenarios mentioned are model scenarios, meant to facilitate a discussion on the future of breeding. Differences between countries, farmers and breeding companies have resulted in a variety of breeding goals and practices. The conventional, alternative and low cost model can therefore also be seen as an extrapolation of today's reality into the future. The overall picture of future possibilities - moderate, alternative or just convenient for the consumer - gives an idea of the choices that can be made (Figure 1).

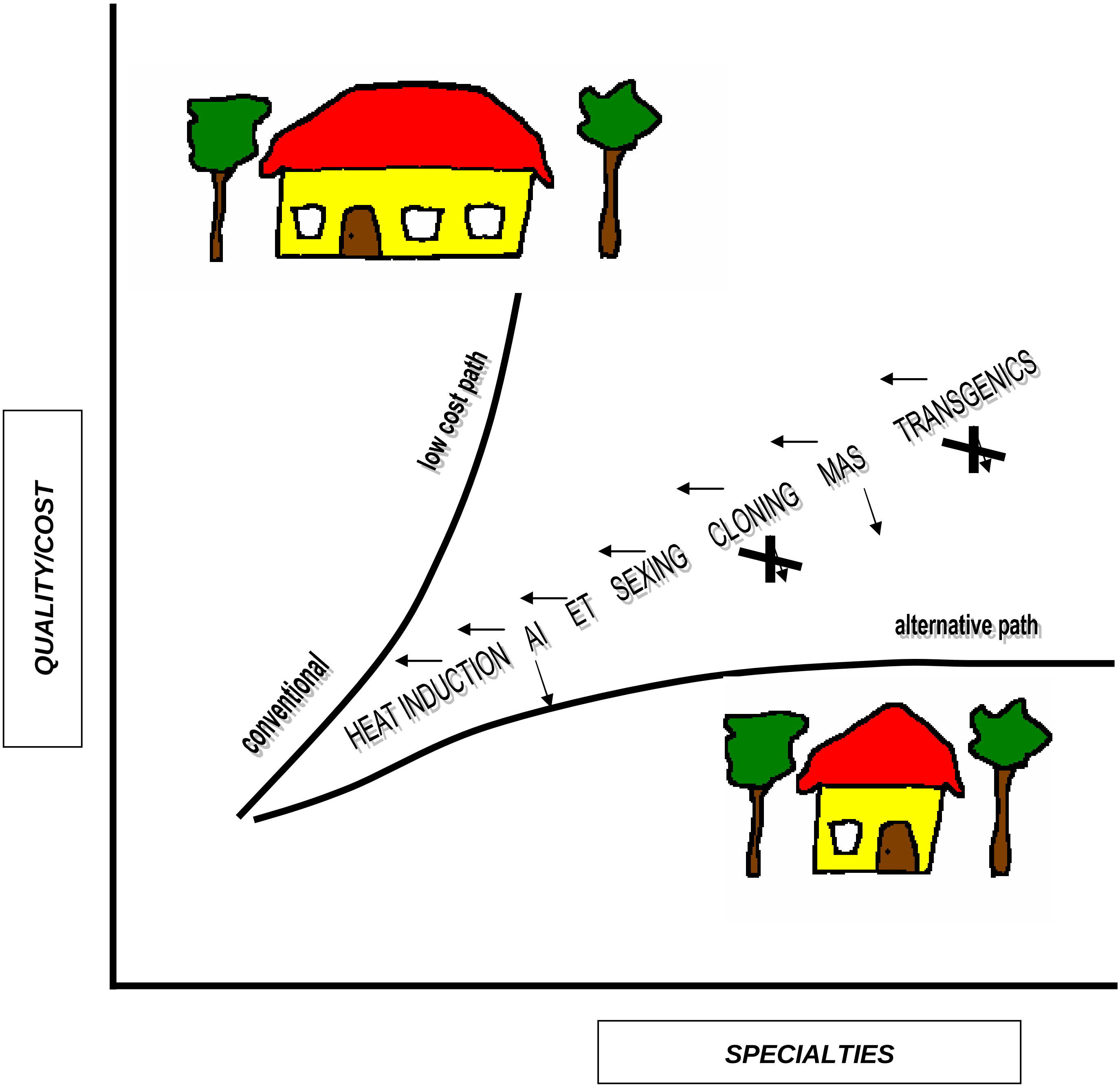


**Figure 1. The overall picture of possibilities – moderate, alternative or just convenient for the consumer – gives an idea of the choices that can be made**

Directly livestock production and thus animal breeding are influenced by the consumer purchases. This is the most powerful way of influencing the way food is produced. Any discussion to influence decisions in selection programmes and farming systems should address the consumer needs and the public desire, bearing in mind that

a) changes in breeding goals will not give results now but in five or ten years or more from now. In setting breeding goals, the consumer and societal wishes of a future that lays a decade or more ahead need to be predicted,

b) the actual economical system is moving towards market globalisation, and

c) not everything can be reached by breeding. Breeding is a tool that can be used alongside other management tools. Genetic improvement is a part of the production chain, dealing with the choice of the parents of the next generation, and with the production of this generation. The farming system and the technologies involved (the environment) play the other large role in animal production. Even for characters with a very high heritability of 40 %, 60 % of the eventual expression for this character would still be determined by factors in the environment.

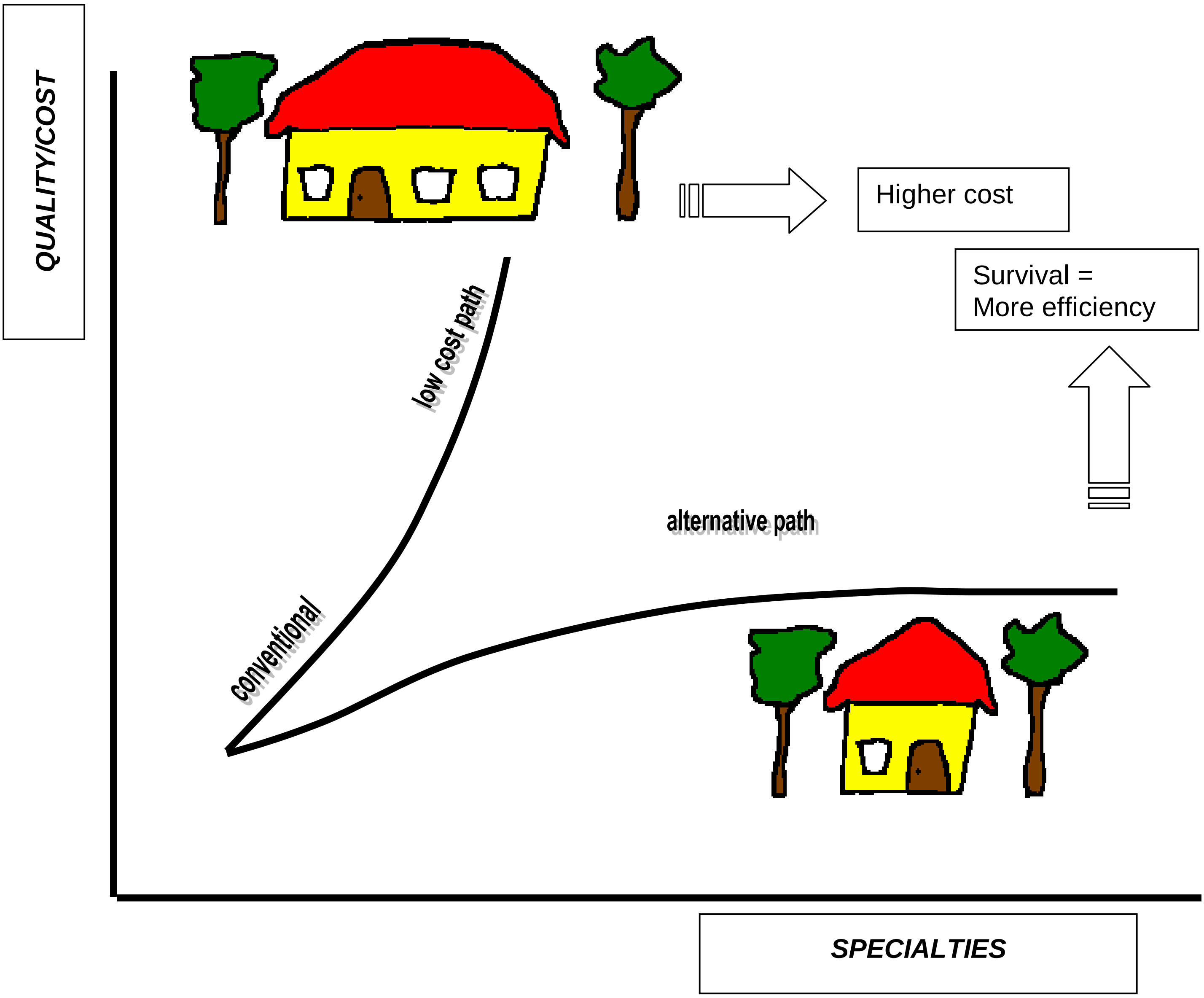


**Figure 2. The ideas and experience in the alternative path can be used by the farmers in the low cost path and vice versa**

The future reality could fit into the pre-described conventional, alternative or low-cost path, but it could also present a variety of the different production systems. There is no clear answer to what should be the future scenario. They could co-exist and the one could benefit from the other. The ideas and experience in the alternative path could be used by the farmers in the low cost path and vice versa (Figure 2). Also in the future, the wish to express cultural differences in Europe could lead to different farming systems. Part of the differences might be due to different levels of acceptance of technologies involved in the production system or different perceptions of quality and price. Furthermore, consumers may want to have a freedom of choice in their purchases.

In order to be able to adapt to the wishes of society, it will be important to know what society really wants. How much would one be willing to pay in terms of money, sustainability, or land that could not be used for leasure, nature or tourism if it should be used for more extensive production? What could be the value of food labelling and trademarks for production systems? How important is the right to have local and cultural differences in Europe? What would Europe be willing to pay in WHO negotiations in terms of trade barriers? Hopefully the scenarios can initiate a fruitful discussion on the future of farm animal breeding in which users and producers weigh the possibilities and price of the different breeding goals, using all or part of the available technologies, and representing different production systems.

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# Discussion

*regarding presentation by Alessandro Bagnato and Anne-Marie Neeteson*

***J.P.M Schenkelaars – The Netherlands***

I am wondering whether the low cost path can be sustainable too.

***Anne-Marie Neeteson:***

We have tried to be provocative in distinguishing several paths for the future, mainly based on the breeding goal. There are overlaps between paths and in principle agriculture can be sustainable in all paths.

***Alessio Valentini - Italy***

I was thinking about the possibility of sustainable systems to produce the same amount of products as non sustainable systems. Think about Holland for instance: if you would hold the pigs with arable land for feed production, I think the countryside would be used for mainly pig production. It would be expected to reduce the number of animals in order to have less mineral output, which is the current policy in the Netherlands. Politics with regard to animal production will have to be restructured. The future will be more products with variable economy***.***

***Alessandro Bagnato***

Where to hold the animals is a point. Furthermore, in terms of sustainability it is important what is the efficiency of production. Animals forced to produce more may have a lower economic productive efficiency because of health problems or undesirable secondary effects. In other terms: in terms of economical costs and benefit, is it worth to increase production to higher and higher levels or, at a certain point, is it better to have a moderate production and better health?

***Paolo Ajmone Marsan – Italy***

I wonder if there may be an additional, fourth scenario, which includes both the low cost path, very intensive breeding, and the less intensive path aimed to biodiversity conservation. They can co-exist, the last functioning as a reservoir of genes, through both normal breeding and biotechnology.

***Anne-Marie Neeteson***

That is one of the questions to society. Can these paths co-exist? Maybe people want to have a choice about the products they want to have. Sally Keeble mentioned it too: maybe people want to be able to buy these products, and maybe they want to have a lot of nature at the same time. In that case you have to put the animals together and have intensive farming in one area and in another area there can be woods where people can have leasure. One can not have it all: extensive agriculture and nature in dense areas. This aspect has to be part of the discussion.

***Alessandro Bagnato***

Certainly there can be a fourth scenario. The scenarios presented are not the only possible ones. A fourth scenario in which we have a sort of a source of genes that we can transfer when we need them in the low cost path is possible. Is this what you mean (to Paolo Aimone)?

***Paolo Ajmone – Italy***

Yes, like having more biodiversity in marginal areas and agriculture integrated into the environment: low input breeding, low input agriculture. Then to have high intensive agriculture in other areas where you can have probably more low cost and more effective products.

***H. Lommers – The Netherlands***

What do you think about another fourth path, a so called high tech path. A path where one breeds farm animals for pharmaceutical goals. The welfare of these animals may be high, but in many respects the goal differs so much from animals on farms for food purposes that people might get frightened. The point is: are farm animals going to be used for other goals than food production in the future or in the near future, in the so called high tech path? What is your opinion about that?

***Alessandro Bagnato***

While we were writing the paper we discussed this topic a lot. One of the things we decided is not to relate technology directly to a path. Technologies can in principle be used across all paths and scenarios that we can think of. And the second point, whether breeders today are prepared or interested in raising animals for pharmaceutical purposes. Is this already an activity of breeding industry or not? Will it be in the future of animal breeding industry? Are these kind of animals only in of the interest of pharmaceuticals? And what is the final destination of the meat of these animals? We like to have feedback from you about this question.

***Anne-Marie Neeteson***

In the first instance we had included this fourth scenario in the paper. In order to make a clear distinction between breeding for food and other goals, and to target the discussion to agriculture. I would like to stress that the meat of these animals, whether bred by farmers or not, should never go to the slaughterhouse: it has to be destroyed. Not because it would be bad meat. But for clarity to the consumer that they can be sure about what they eat and have a real choice and not be obliged to eat meat from animals that are used for medicine production. If you have a headache you can take an aspirin. You could also if you would not have a headache. But why should you?

***Jan Merks***

Is there somebody of the breeding organisations who wants to respond? The perspectives in this direction?

***Nanke den Daas – The Netherlands***

I see more responsibility of the breeding organisations. We do see a response from the life sciences industry. There is an ongoing urge for production of non food animals. This is probably not coming now or in the next five years. But maybe in ten it will. I do not know whether this is going to influence our industry or that it is going to be a technique alongside our industry.

***Jan Merks***

That is a clear question. This is also a part of the discussion. At present most breeding organisations have not yet decided whether they want to be involved. They are capable to get involved. But do they want to? Do they like to be associated with activities, like in the Netherlands bull Herman who would be used for other than farming purposes? I think that at this moment breeding organisations are hesitating.
More and more pharmaceutical companies come to breeding companies with the question: "Do you want to co-operate, e.g. in xenotransplantation, producing transgenic animals?". The question probably is: are we willing to do that? Do we see a future in that? Or do we just see a threat in that path? Really, as one can say, it may influence the activities or at least the main activities of a breeding organisation. Breeding organisations get these requests all the time. Are we willing to decide about this at this moment?

***Jean-Louis Donal – France***

Coming back to the scenarios presented, I would say that at least for some production it is not a *future* scenario. It is already what farmers are doing now. Now 30-40% of the chicken consumed in France is of this welfare path and 60% comes from a low cost path, without introducing biotech investment in *either* of the paths. We have the feeling this is going to be the case in a lot of different countries. However, the alternative path will not be the same in the UK and in France and in other countries. There are different opinions, different objectives. We feel it already as an organisation on the market. The scenarios are already a reality in part of the market.

***Jan Merks***

Two final remarks to summarise the discussion.

1. Does the breeding industry want to be involved in the fourth path: the path producing for human health? It is important for our industry to decide, to give a clear view to society, whether we will be part of it or not?
2. We should address more clearly whether the alternative path and high tech aspects of technology may be combined or not. It is important to have a clear view on that in the future.

# Ethical Perspectives on Breeding and Biotechnology

*Stine B. Christiansen[1] & Peter Sandøe[1]*

## Introduction

Modern genetics has had an incalculable impact on domestic animal breeding. We now possess powerful tools with which we can change animals and make farm animal production more efficient. However, some of the genetic alterations made in pursuit of breeding goals have had unintended negative side-effects on animal welfare and integrity. The fact that we are now aware of some of the potentially harmful consequences of genetic manipulation, and the fact that we are able to control these, places an ethical responsibility on us.

Despite their growing awareness of this responsibility, people today take quite different views about what is acceptable in farm animal breeding. The use of biotechnology within farm animal breeding and reproduction, e.g., gives rise to a range of ethical concerns and worries in many quarters (Rutgers *et al.*, 1996; Sandøe *et al.*, 1999). Others point to positive applications and an obligation not to dismiss these options (Thompson, 1993; Smidt, 1994; Seidel, 1998). It is therefore important to discuss what breeding goals and reproductive tools are acceptable. A good starting point for an ethical discussion regarding breeding and the use of biotechnology, then, would be an attempt to set out and understand what it is that people are concerned about. There are a number of different, complementary, ways of gaining such an understanding. One way, which is pursued in another part of the present project, is by means of surveys or interviews. In this paper the task is approached using a different method: we try to assess specialist opinion by reviewing recent papers and reports within agricultural bioethics.

The review is based on an automated literature search, covering material published since 1992, and in it the focus is on understanding rather than criticism. We think it is important, before engaging in a more critical form of discussion, to try to present the various viewpoints in a clear, unbiased manner, which allows one to see how the views contrast with each other. We begin by explaining briefly what we understand by the term "biotechnology" in relation to breeding. Then we present the various concerns, including some animal welfare problems which have been mentioned in the reviewed literature, consider cultural differences, and describe different ways of weighing the concerns against each other. Finally we discuss different ways of handling the concerns in practice.

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**Breeding and biotechnology**

'Biotechnologies' can be defined as technologies intended to change the biological functioning of animals, plants or micro-organisms. Within animal production the aim may be to change: 1. What the animals take in - by giving them genetically modified feed and feed additives. 2. Existing animals - by giving them hormones and similar substances promoting growth, feed conversion, milk production and the like. 3. Future animals - using reproductive technologies and genetic modifications. The latter may not only improve the efficiency of selective breeding, it may also present options that would otherwise not be possible. In the following, the focus is on the use of reproductive technologies and genetic modification to change future animals.

The oldest and least technical method of producing desirable characteristics in future generations of animals is *selective breeding.* This has developed rapidly during this century by means of modern genetics. Equally, some biotechnologies can be seen as means of making selective breeding more efficient. Thus, freezing of semen, artificial insemination (AI), embryo transfer, cloning of embryos, trans-vaginal oocyte recovery followed by in vitro embryo production, and other *reproductive technologies* can be used to ensure, that animals with good genetic potential produces more offspring than they would otherwise have had and furthermore, with a reduced generation interval. In this way the process of selective breeding is accelerated. Sex selection is another biotechnology, which could prove useful in improving breeding efficiency. A new and more radical biotechnology introduces into the fertilised egg, or the early embryo of a host, genes from the same or another species and thus creates so-called *transgenic animals.* So far no transgenic animals have been put into use in ordinary farm animal production, but gene technology is interesting in ways other than as a means of creating transgenic animals and may become an effective and commonly used tool in animal breeding. (This will be just one possible outcome of current efforts to map the genome of the most important species used in animal production.)

The increase in power, and the potential increase of speed and efficiency that modern breeding and biotechnology presents, force us both to recognise our moral responsibility and to discuss the limits of acceptability (Schroten, 1992; Habgood, 1993). In such discussion ethics provides a way of ensuring systematic and rational reflection on the moral issues involved within a framework of values and principles guiding behaviour (Schroten, 1992; Brom & Schroten, 1993). Our efforts to breed for higher production efficiency and our use of biotechnology raise concerns regarding both animal welfare and animal integrity. These concerns can usefully be explored further: the ethical significance of breeding goals and biotechnologies can thus be evaluated according to their potential to damage animal welfare and violate animal integrity (Mepham, 1993*b*; Mepham, 1995). In addition to the concerns regarding animals, concerns relating to humans or biological and environmental issues may be considered.

**Ethical concerns relating to animals**

Ethical concerns associated with the animals themselves can, then, be divided into two categories – these relating to animal health and welfare on the one hand, and the integrity of the animal on the other. It should be borne in mind that these categories interrelate (Vorstenbosch, 1993).

**Animal welfare**

Although it is presently a focus of scientific research, the concept of animal welfare is hard to define, especially when one wants to extend it beyond just animal health. What is meant by welfare and how is it to be measured? Usually animal welfare is taken to include both physical health and behaviour and is evaluated with regard both to the animal itself and how it copes with its environment (Sandøe *et al.*, 1996). Potentially, several types of animal welfare problems associated with breeding for high production efficiency and the use of biotechnology can arise. These problems can be related to a variety of factors, such as the genetic expression (e.g. rapid growth or high milk production), the breeding technique itself (e.g. a certain form of biotechnology), or mutations in transgenic animals.

Ethical concerns relating to animal health are often linked to a subsequent reduction in animal welfare. E.g., increased milk production is likely to cause a higher incidence of mastitis in cows (Boer *et al.*, 1995), which will in turn cause a reduction in animal welfare. Several authors think that the use of biotechnology is likely to cause animal suffering (Rollin, 1994; Boer *et al.*, 1995; Hahn, 1996; King, 1996; Rollin, 1997; Schroten, 1997). One reason for this is the potential of the technologies to make farm animal production even more efficient, and thus put higher pressure on the animals than is seen today, worsening conditions already considered unacceptable. To date, if pain, suffering or disease has not interfered with production efficiency, the condition has often been ignored, as happens with production-related diseases (Rollin, 1996). This priority of productivity over animal welfare is an ethical problem in farm animal production as such, and is not specific to the use of biotechnologies (Irrgang, 1992; Roenningen, 1995; Idel, 1998). Thus, discussion of the use of biotechnologies becomes part of a wider discussion concerning the ethics of farm animal breeding. However, the use of biotechnology towards the same goals of high efficiency as are set in conventional breeding is considered by some much more powerful and dangerous as biotechnology will increase the speed and efficiency of selection (King, 1996; Rauw *et al.*, 1998). Furthermore, selection and genetic manipulation is likely to affect more than one trait (Rauw *et al.*, 1998), and thus, additional animal welfare problems may arise as an indirect consequence. However, biotechnology may also be used to redress welfare problems created through selective breeding (Irrgang, 1992).

One of the first cases exposing welfare problems associated with the use of biotechnology is the case of the "Beltsville pigs". The "Beltsville pigs" contained human growth hormone genes to accelerate growth, but suffered from health problems such as lameness, ulcers, cardiac diseases and reproductive problems (King, 1996; Rollin, 1997). However, animal welfare has been impaired by conventional selective breeding as well. There are several reports of animal welfare problems relating to breeding for high production efficiency and the use of biotechnological breeding techniques. It is reasonable to assume that ongoing selection for high production efficiency is likely to cause ever more welfare problems, regardless of the reproduction method used. In the following two sub-sections we give some examples of these welfare problems. Some are connected with breeding goals, some with the techniques involved in the reproduction.

**Animal welfare problems related to breeding goals**

Today the broiler chicken grows to a weight of approx. 2 kg in around 40 days. This is half the time it took 30 years ago and the age of a broiler chicken at slaughter weight is still reduced by one day per year. The muscles and gut grow fast but the skeleton and cardiovascular system do not follow, resulting in leg problems and heart failure (Broom, 1998; D'Silva, 1998; Rauw *et al.*, 1998). Turkeys have been bred for large muscular development and male turkeys are now too heavy to mount the females, so they need artificial insemination to reproduce. The turkeys suffer from severe leg problems, as their bone structure cannot support the heavy weight (D'Silva, 1998; Rauw *et al.*, 1998). Both broilers and turkeys have been found to have a reduced immune response, making them more susceptible to disease (Rauw *et al.*, 1998). Pigs, having been selected for high growth rate and lean tissue have leg problems (D'Silva, 1998; Rauw *et al.*, 1998). They are also more likely to become stressed or die during activity than their ancestors due to a different muscle composition and size of heart (Broom, 1998). The dairy cow now produces 10 times as much milk as her calf would suckle from her - if it were allowed (D'Silva, 1998). Breeding for this level of milk production increases the risk of mastitis. Furthermore this breeding goal results in digestive disorders, foot rot, skin and skeletal disorders, udder edema and teat injuries (D'Silva, 1998; Rauw *et al.*, 1998). In beef cattle, the breeding of double-muscled cattle is leading to birth difficulties (Broom, 1998).

**Animal welfare problems related to biotechnology**

The very carrying out of some reproductive techniques, such as superovulation, insemination and embryo transfer, can cause stress and pose a risk to animal welfare. E.g. in smaller animals, such as sheep and pigs, embryo transfer requires surgery (Seamark, 1993; Broom, 1998; D'Silva, 1998). Furthermore, techniques where the embryo is manipulated *in vitro* may create offspring that are too large for normal birth. Thus, research exists showing that the offspring of sheep and cattle developing from *in vitro* produced embryos cause longer gestation, display increased birth weight, a higher incidence of birth difficulties (and therefore Caesarean sections), and increased frequency of genetic anomalies (Mepham, 1994; van Reenen & Blokhuis, 1997; Broom, 1998). This diminishes the welfare of both the mother and her young. In contrast with this it should be noted that positive effects on animal welfare can result from biotechnology. The use, e.g., of artificial insemination and embryo transfer, means that breeding animals need to be transported less often.

In addition to the problems of oversized offspring, which are found in relation to the *in vitro* manipulation of the embryo, cloning and transgenesis may cause harm to the animals. Many cloned calves have difficulties surviving. They are behaviourally retarded and may also have joint problems (Mepham, 1995; Rollin, 1997; D'Silva, 1998). Transgenic calves have also been found to be behaviourally retarded (Mepham, 1995; Rollin, 1997). Attempts to create transgenic sheep with increased growth have resulted in unhealthy animals (Rollin, 1996); and equally, an attempt to produce transgenic cattle with double-muscling resulted in a calf, which within one month was unable to stand up on its own (Rollin, 1996).

The conduct of research on transgenesis is itself beset with welfare problems. E.g., current techniques used to produce transgenic animals are very inefficient. Less than 1% of the embryos result in live transgenic animals and several of these animals will develop serious abnormalities and thus must be expected to suffer before being killed (Mepham, 1995; King, 1996). However, as these techniques improve, the production of transgenic animals may become more efficient. Finally, there is a risk of unrelated, harmful mutations. When creating transgenic animals foreign DNA is inserted into the host's DNA. The foreign DNA may, however, be integrated in the genome in a way, which causes mutations. Such unpredictable responses from totally unrelated genes have been reported in mice showing lethal or deforming mutations (Mepham, 1994; King, 1996; Rollin, 1996; van Reenen & Blokhuis, 1997).

A possible application of biotechnology is the introduction of genes that code for disease resistance. This may reduce suffering and improve animal health and welfare (Mepham, 1995). However, the targets of research on disease resistance are often production-related diseases like mastitis (King, 1996; Idel, 1998), which might encourage higher production and thereby recreate the same problems just at a higher production level. One concern is that genes associated with resistance to disease may have unforeseen consequences which override the expected improvement (Mepham, 1994). Some additional concerns are a potential reduction in the susceptibility to metabolic or environmental stress (in which case an even higher metabolic pressure may be put on the animals) (Mepham, 1995), or the creation of new, questionable production practices (Thompson, 1997). Furthermore, our current understanding of physiology is inadequate – e.g. the relation between growth hormone genes and diabetes, kidney diseases and bone malformations is unclear (Mepham, 1994) – and this makes it hard to foresee what the consequences for animal welfare would be of the selected traits. Some ask us to consider whether animals are not already at their biological limit before we proceed with transgenesis for increased production (Broom, 1998). Finally, there is a fear that genetic engineering poses a risk to welfare by introducing changes in phenotype or animal experience which make it harder to detect welfare problems. Standard methods for the evaluation of welfare continue to be applied, but these may well be ineffective if transgenic animals have altered sensory or physiological responses (Mepham, 1995; Thompson, 1997; Broom, 1998).

**Animal integrity**

Animal integrity is as hard to define as the concept of animal welfare. Some describe integrity as a naturally evolved, unharmed wholeness of either an individual, a species or an ecosystem. In respect of this integrity, or the intrinsic value of animals, they therefore conclude that human beings should leave animal genomes intact (Vorstenbosch, 1993; Thompson, 1997). Others argue that respecting an animal's integrity does not necessarily mean that it is wrong to use animals as such, but it does imply that they may not be reduced to mere instruments for human interests (Brom & Schroten, 1993). Thus, some people feel that the integrity of the animals is not respected when biotechnology is applied (Brom & Schroten, 1993; Sandøe & Holtug, 1993; Schroten, 1997). According to some integrity is specifically violated by using invasive procedures to increase reproduction – e.g., through embryo transfer in sheep and goats, and transvaginal oocyte puncture in cows. Besides posing a risk to animal welfare, several authors find that this use of non-therapeutic surgery also requires a special ethical justification (Seamark, 1993; Boer *et al.*, 1995; MAFF, 1995; The Veterinary Record, 1995; Rutgers *et al.*, 1996). The integrity can be considered violated even by non-invasive biotechnologies – e.g. a change in the composition of the milk in a transgenic cow – although this technique will not necessarily pose any risk to the welfare of the animal (Seamark, 1993). Finally, the potential to change the animals so that they are better suited for intensive farming instead of solving the problems with e.g. housing conditions, and the fact that some animals can no longer reproduce unassisted may be considered violations of animal integrity.

The perception of animals as things, or instruments for human interests, is according to some reflected in the option of patenting (Schroten, 1997; Habgood, 1993). However, the treatment of animals as things already takes place in intensive farming and is therefore not particularly associated with biotechnology, although the use of biotechnology may be seen as another step in the process (Sandøe & Holtug, 1993; Schroten, 1997). Also, the externalisation of the whole reproduction process as such may be seen as an interference with animal integrity (Boer *et al.*, 1995).

**Other ethical concerns**

Besides the concerns regarding animals, biotechnology raises additional ethical concerns relating to humans and to biological and environmental issues; and some people are concerned with the use of biotechnology itself.

**Concerns relating to humans**

One of the major concerns relating to humans is the "slippery slope" argument, i.e. the fear that what can be done with animals will also be done with humans (Schroten, 1997). Thus, the "slippery slope" argument is concerned not only with a potential technological development, but also a potential change in attitudes regarding what is considered acceptable. In fact, many of the techniques were developed for, and used on, humans first before being applied in farm animal breeding. A technique like cloning from somatic cells, which is developed for use in animals, is not at present generally considered morally acceptable for use on human beings (Boer *et al.*, 1995), nor is it yet technically possible. And as some argue, if at some stage it does become possible to clone humans, it still does not follow that we have to do so (Sandøe & Holtug, 1993).

Another concern is that of human health and welfare. An example would be the potential risk to human beings when eating meat from genetically engineered animals (Brom & Schroten, 1993; Alestroem, 1995; Rollin, 1996). Others argue that biotechnology may bring better or healthier food, e.g. meat with less fat or more easily digested milk. Finally, some argue that there may be a potential risk for humans, either directly through the intake of antibiotic residues in e.g. the meat, or through development of antibiotic resistant pathogens due to medication used to mask animal welfare problems (Mepham, 1994).

The ability to produce better, cheaper food more efficiently is often mentioned as an argument in favour of modern breeding and its reliance on biotechnology. Here lies a potential for lower food prices and increased food production in developing countries. Means to achieve this are, however, already available, and it is questioned whether the use of biotechnology would make any moral difference (Thompson, 1997). It is obvious that developing countries could benefit greatly from the use of some biotechnologies, and therefore it is argued that these countries could more easily justify using the techniques than the developed countries, which already have a surplus food production (Sahai, 1997). But this presupposes that the technologies become available for these countries' own food production. Increased production in the developed countries is considered unlikely to benefit developing countries (Hahn, 1996). Finally, one last concern stated is a potential military application, e.g. using animals to carry human pathogens (Rollin, 1996).

**Concerns relating to biological and environmental issues**

Several authors express serious concern about the risk of loosing genetic diversity through biotechnology (Brom & Schroten, 1993; Sandøe & Holtug, 1993; Mepham, 1994; Boer *et al.*, 1995; Rollin, 1996; Rollin, 1997; Idel, 1998). Although this would allow a standardisation of e.g. dairy products (Boer *et al.*, 1995), the loss of genetic diversity makes the animals more vulnerable to diseases and other challenges (Mepham, 1994; Boer *et al.*, 1995; Rollin, 1996; Rollin, 1997). In a group-housing situation it may also be more difficult for the animals to form groups if the variation between individuals is too small (Boer *et al.*, 1995). The loss of individuality may be a concern in itself (Boer *et al.*, 1995), but as is seen in identical twins, the repetition of a genotype still allows individuals to develop as a consequence of environmental influences (Milani-Comparetti, 1997). However, some see a potential increase in genetic diversity, as genes are more often added to a species than removed. This gives rise to another concern, however, since distinctions between species may become less distinct, or blurred (Sandøe & Holtug, 1993). The loss of genetic diversity may be considered irreversible (Boer *et al.*, 1995), although the potential exists to preserve genetic material (Sandøe & Holtug, 1993; Mepham, 1994; MAFF, 1995), which could prove useful in the preservation of endangered species. Some also argue that an extensive gene pool may still be available from hobby breeders (Rollin, 1997).

If transgenic animals should escape or be released in the wild the consequences are unknown, and there is a concern that such a change would upset the ecological balance (Kohler *et al.*, 1992; Brom & Schroten, 1993; Sandøe & Holtug, 1993; Hahn, 1996; Rollin, 1996; Rollin, 1997). There is a potential for these animals to replace existing animals in nature, e.g. if they manage better in that habitat or pass on infections to other species. Such infections may develop due to an introduced disease resistance or unpredictable pathogens (Sandøe & Holtug, 1993; Rollin, 1996; Rollin, 1997). Precautions against escape and genetic disadvantages of the transgenic animals are considered to make this scenario unlikely (Sandøe & Holtug, 1993; Alestroem, 1995), although aquaculture animals, e.g., have been known to escape into natural aquatic ecosystems (Kohler *et al.*, 1992).

One advantage of using biotechnology and thus making farm animal production more efficient is the potential to produce the same amount of food using fewer animals. This could reduce problems of pollution. If it did it would be of great benefit to the environment (Mepham, 1994).

**Concerns with biotechnology in itself**

The use of biotechnology may in itself cause concern. This may be due to "fear of the unknown", ignorance or misunderstandings (Hahn, 1996). It may also be because the techniques are considered "unnatural" (Brom & Schroten, 1993; Schroten, 1997), or inherently wrong (Rollin, 1994; Rollin, 1997), or a violation of the animals' integrity (Mepham, 1994; Boer *et al.*, 1995; Rollin, 1996). These concerns, however, are not restricted to biotechnologies. They must be viewed in the context of our ways of handling animals and nature in general. Thus, some find it hard to see why biotechnology is dismissed on the basis that it is unnatural if it is acceptable to e.g. dam rivers and build cities (Rollin, 1996). Furthermore, some point out that all conventional breeding can be dismissed as a violation of species integrity (Sandøe & Holtug, 1993; Rollin, 1996). Although the effect on the animals' integrity may thus be considered an "either-or"–issue, and something which may therefore be used against selective breeding as such, it can also be questioned whether one can draw a non-arbitrary line. One suggestion is to draw the line at the technical changing of the DNA, as happens in the creation of transgenic animals, as some consider the transfer of genes between species to be ethically relevant (Boer *et al.*, 1995; Idel, 1998).

To sum up, there seem to be two central issues regarding animals in ethical discussions concerning breeding and the use of biotechnology. These are animal welfare and animal integrity. Although animal welfare research may give some insight into how animals are affected by our treatment, such studies will provide primarily indirect answers, which do not in any simple way tell how badly animals are affected. The concern for an animal's integrity goes beyond that of concern for health and welfare (Rutgers *et al.*, 1996). One of the observed differences between welfare and integrity is that welfare can be affected by natural circumstances. In contrast, human action is required to affect integrity, and thus integrity demands human respect. Another difference is that the consequences of affecting an animal's welfare can be dealt with in empirical terms, whereas the question of integrity is more of a philosophical issue.

**Cultural differences**

The findings of this literature review were expected to reveal some information on cultural differences across Europe over what ethical aspects of breeding and biotechnology are being raised and handled in different countries. However, the majority of the literature was from Northern Europe and the United States, and virtually no references from Southern Europe were found. Our search profile was pretty general and is unlikely to have caused this difference. However, papers of Southern European authors which have been published only in national journals in the original language may not have been covered by the data bases. A recently held conference on agricultural ethics attracted participants from those same countries as the literature was representing, although it was advertised in Southern European countries as well. We have been informed that in Southern Europe the focus of bioethics is primarily on issues concerning humans, e.g. biomedical ethics. It is not clear which social, cultural and religious factors may explain these differences (Zechendorf, 1998).

**Weighing concerns against each other**

As a starting point for a dialogue about the acceptability of a particular breeding goal or biotechnology one may consider the implications for all the parties involved – i.e. for the animals, the humans and the environment. Next, those implications – potential risks and benefits – must be weighed against each other. In moral decision making one seeks a balance between intuitions, principles and relevant facts, notwithstanding the fact that our intuitions may change with new information (Boer *et al.*, 1995). To enable the detection and identification of the issues, and the weighing of the concerns, different models have been developed.

The general view in our society is that it is acceptable to use animals in e.g. farming and research if this is done humanely. This view is reflected in principles of humane use of animals, such as animal protection laws, which state e.g. that no harm must be done unless necessary, that the harm must be outweighed by benefits, and that some types of harm should be prohibited (MAFF, 1995). This attitude towards the use of animals is based on two of the most important groups of ethical theories, utilitarianism and deontology (Mepham, 1993*a*; Boer *et al.*, 1995; Fisher, 1997).

**Utilitarianism**

In utilitarianism an action is judged to be right or wrong according to its consequences. The consequences are estimated in a cost-benefit analysis, and what is right depends on what among the available lines of action will produce the greatest net benefit (Mepham, 1993*b*; Boer *et al.*, 1995; Fisher, 1997; Thompson, 1997). Thus, one will always seek to maximise the benefit for all parties involved. In practice this usually means an evaluation of the implications for humans and animals. This way of arguing may easily justify using biotechnology in biomedical research, where the potential risks for animal welfare will be outweighed by the benefits of, e.g., life-saving treatments for human beings. In contrast, farm animal production for better and cheaper food is unlikely to improve human welfare to the same extent, and so on utilitarian grounds any technology that increases the risk of animal suffering will be unacceptable (Irrgang, 1992; Thompson, 1997). However a problem with this ethical theory arises when we seek to define what is considered beneficial and harmful, and to qualify, quantify and balance the good and bad against each other.

**Deontology**

A group of views object to the utilitarian claim that a decision of what is morally right or wrong should be made solely in terms of the consequences (Mepham, 1993*b*; Boer *et al.*, 1995; Fisher, 1997). Thus some will claim that we in our moral decisions rather should focus on what we *do* to the animals than on what happen as *a consequence* of what we do. E.g., in the case of biotechnology used to make breeding more efficient, utilitarians may accept the use of the technology, including negative side-effects on animal welfare, if the overall consequences of the breeding programme are better than the alternatives, and if the use of biotechnology is necessary to make the programme competitive. Deontologists will on the other hand say that we cannot justify the use of the technology if it is bad to the animals – i.e. the end cannot justify the means. Another related consideration is that the use of evil means to a good goal may have an adverse effect on the character of the person who uses these means (Thompson, 1997).

A specific version of the deontological views is the so-called animal rights view according to which each animal should be protected against being used as a means to promote the general good – comparable to how individual persons in our culture are protected. For example, we do not accept that people are used in biomedical research against their will, even when the research may have very beneficial consequences. Radical versions of the animal rights view will ban all use of animals for food production. But there may also be more moderate versions of the view which claim that there are certain minimum requirements for the care and protection of the individual animal which should always be complied with.

Both ethical theories can reasonably be regarded as inadequate to deal with issues like specific breeding goals and biotechnology. Other ethical theoretical frameworks have been suggested – e.g. the "ethics of intervention", which recognises the fact that simply by pursuing our own existence, humankind must intervene in nature, including in animal lives, but insists that we must still regard ourselves as part of nature (Donnelley, 1993).

Some have argued that there is a need for a decision model that recognises several ethical principles. One such "pluralist" model, which was originally developed in medical ethics, has been modified and applied to animal ethics issues such as those arising in connection with the use of biotechnology. The model is based on four principles (Mepham, 1993*a*; Mepham, 1993*b*; Boer *et al.*, 1995; Mepham, 1995; Rutgers *et al.*, 1996; Fisher, 1997):

"Beneficence": one should care for and promote animal health and welfare, and beneficial outcomes like pharmaceuticals and disease resistance.

"Non-maleficence": one should refrain from doing harm to animals, humans and the environment, e.g. not jeopardise animal welfare.

"Autonomy": one should ensure that freedom is not diminished, e.g. freedom of behavioural expression.

"Justice": one should treat animals of comparable species equally and ensure a fair distribution of good and evil between humans and animals. The animals' integrity should be respected. Real benefit should be achieved.

Other principles may be added (Brom & Schroten, 1993; Boer *et al.*, 1995):

"The principle of irreversibility": always act in such a way that the consequences of your actions may be redressed.

"The controllability principle": the far-reaching consequences of biotechnology require the availability of public debate and effective democratic control.

Besides animals, these principles must be applied to the different interest groups, e.g. producers, consumers and society (Mepham, 1995). Not all of these principles are necessarily given any weight in the final decision, but considering them may be part of the evaluation process. The application of these principles in a given case is a three-step process, which involves (Brom & Schroten, 1993):

1: Collecting any facts which are morally relevant to the project.
2: Assessing the consequences of the project to each of the involved groups.
3: Weighing the harms and the advantages of the project, using the information that becomes available in step 1 and 2.

If it is possible, the risks involved must be assessed before attempting to make any changes to the animals. However, the overall interpretation and the priority we attach to implications will still be determined by our own ethical view – e.g., what we understand as the meaning of integrity and animal welfare, what we consider good reasons, and how we weigh the interests of the animals against those of human beings and the environment (Schroten, 1992; Boer *et al.*, 1995; Fisher, 1997; Sandøe & Holtug, 1998).

**Handling ethical concerns in practice**

In recent years public awareness of the moral status of animals has increased. This is reflected in e.g. legislation relating to the protection of animals. In Holland legislation has developed in three phases, each recognising a new dimension of moral status in animals. First an anti-cruelty law was introduced (recognising that cruelty to animals is morally wrong); next an animal-protection law (recognising that animal experiments have to be justified); and then a law ensuring that conflicting interests are weighed (recognising that animals have intrinsic value and are not purely instrumental to man) (Brom & Schroten, 1993). On a European level animals kept for farming purposes are e.g. protected against natural or artificial breeding which is likely to cause suffering. Furthermore, they may not be kept for farming purposes, if they can not be kept without detrimental effect on health and welfare (Council Directive 98/58/EC, 1998).

The concept of "no, unless"-policies has been suggested as a way of expressing whether or not e.g. a particular biotechnology is acceptable for a certain purpose. The idea of the "no, unless"-policy is, that the biotechnological activity is to be prohibited unless the relevant values are not violated or the aim is so important that a violation of these values is overruled. The "no, unless"-policy thus balances good against bad, while still taking into account the principles of doing good and avoiding harm. Furthermore, the burden of proof is on the side of the person who wants to engage in biotechnological activities, and thus forces the scientists and policy-makers to back their moral judgements with an argued case. Alternatively one can adopt a "yes, but"-policy, taking into account the fact that this shifts the burden of proof to those who wish to limit the use of biotechnology.

On either approach, a final decision could be taken by an assessment committee of experts (Brom & Schroten, 1993; MAFF, 1993; Boer *et al.*, 1995; MAFF, 1995). Such expert committees might have an advisory and/or licensing function. Their tasks might be to look at the benefits – e.g. progress in breeding, health, performance and food quality – and to consider the ethical concerns and consequences on such factors as animal welfare, the economy, and the environment. Also, the objectives and proportionality of the means and ends could be examined, as well as the possibility of alternatives (Hahn, 1996; Schroten, 1997; van Vugt & Nap, 1997). It is unclear whether such a committee would be better placed on a national or international level. In a European survey one third of those questioned believed that international organisations, such as the United Nations, are best placed to regulate biotechnology (Eurobarometer, 1997), even though the working procedures of such organisations are often too slow to keep up with the new technical developments.

Some authors have claimed that, in order to comply with some of the concerns associated with biotechnology, it is important to ensure that research is performed in accordance with animal welfare legislation and subject to the same control as other animal experimentation (Donnelley, 1993; Smidt, 1994; MAFF, 1995; Hahn, 1996; Seidel, 1998). In addition, some encourage assessment of the breeding goals rather than the methods by which these goals are obtained (Irrgang, 1992). Policy makers are expected to have a range of strategies available to control the use of biotechnology (Mepham, 1995). Certain applications are felt by some to be best prohibited – e.g. use on humans or as biological weapons (Hahn, 1996). Extensive application of some of the technologies is considered inadvisable at present due to lack of safety, and part of the funds therefore could be used to estimate potential adverse effects (Hahn, 1996). Ethical assessment is by some considered necessary on a case by case basis, both in the research phase and when it comes to general application (Irrgang, 1992; Schroten, 1992; Smidt, 1994; MAFF, 1995). In such an assessment attention is drawn to the importance of considering not only the ethical acceptability of future applications but also the likelihood that good or bad effects will happen (Sandøe, 1997). Furthermore, it has been suggested that forums, or platforms, should be created to stimulate the dialogue between science, industry and the public (Schroten, 1997). Several point to a strong and obvious need for open ethical evaluation if these technologies are to be accepted by the public (Mepham, 1993*a*; Alestroem, 1995; MAFF, 1995; Rollin, 1997; van Vugt & Nap, 1997; Seidel, 1998). Finally, some recommend that food products from genetically modified animals should be labelled to allow consumers to make an informed choice (MAFF, 1993).

**Conclusions**

In discussions of breeding goals and biotechnology, one of the primary concerns is that of animal welfare. However, many of the problems arising in relation to animal welfare arise also with conventional selective breeding. Regardless of the method of breeding, questions arise about whether the purpose of the breeding goal is necessary, and whether that goal can justify certain risks (e.g. of reduced animal welfare). For medical research, such risks are more easily accepted, since here the expected benefit may be vital to humans. However, in farm animal production - especially in our part of the world - it may be more difficult to accept risks if those risks are being taken in order to produce cheaper food.

There seems to be general agreement that the use of biotechnology should be controlled, although it is unclear what type of organisation, and at what level, is best suited to carry out such a control. It is, however, important to realise that current legislation already offers some protection of animal welfare, regardless of the method of breeding. Alternatively, efforts could be made to improve, enforce and control the existing legislation to protect animals from potential threats to their welfare. However, even if the risks of reduced animal welfare were eliminated, other concerns and risks would still be present and call for open public evaluation.

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# Discussion

*regarding presentation by Peter Sandøe*

***Gerard Albers – The Netherlands***

This is not a question but a remark that every breeder has in discussions about the breeding goals. You can have a good discussion within the company about breeding goals and you could even decide that probably it would be better to be a little bit more emphasising on welfare aspects but acting like that might push yourself out of the today business. That is reality. Breeders' choice and real life show that.

***Peter Sandøe***

I have been told by Ross breeders that if you can't do what you say, you also go out of business. Ross breeders told me that they think they have to protect animal welfare. Otherwise they will go out of business in 10 years time.

**Gerard Albers – *The Netherlands***

It is a matter of emphasis. Because that is also true. That is an easy answer. Reality is not so easy.

***Peter Sandøe***

I know that. But I think the answer is to be more honest with the public. I mean, you should go to the public and at least convince them that you have done something to deal with this, explain carefully how you would like to go further, and what is standing in your way. And be honest. In my experience the Danish animal industry does well in this respect. Ten years ago the pig industry just denied that there was any problem. They became extremely unpopular as a result. Now, the strategy for a number of years has been to accept that there are problems, and explain why they cannot be solved right away. If you do this, you will become involved in a dialogue, and then you can move towards the public and suggest that you have a role to play too. You can say " Come and help us, because there are things we cannot do, in this very competitive market, on our own."

Of course, the danger is that the public will think that you can do it and force you to do things that will take you out of business. But the chances are that they will see that point. Come and show us that you have made modest and sensible progress. We will support you and will find other ways to help. To my mind, that is the only feasible strategy.

***John McInerney - UK***

In your paper you implied that the way forward is in our hands, a selective group of decision makers, of managers. However, the man in the street does not care about ethical interest or the concerns that you have emphasised. Who is to decide about the way forward? Just putting in terms of human ethics: I could equally talk about equity, attitudes towards welfare. It is quite clear most people are not that much interested in poverty, or in other people. There is not a way forward other than a slow way forward. There is a danger in making this discussion more amongst US, by the standards *we* think. *"This is how we should go forward."* I wonder how society wants to go forward.

***Peter Sandøe***

The point of this is not the general way forward for society. I thought today I was going to address mainly animal breeders. And I thought: they will expect from me some advice on what should they do. So in my mind that is the way forward for animal breeders. I think that if you are a breeding organisation planning to remain in business fifty, or hundred years from now, you should consider these things. Because I think (though I may be wrong) that there will be more and more discussion of this kind. Take the discussion about housing systems: first industries are denying any problem, and they get a very bad press and a lot of problems. Suddenly they start admitting their problems and get into a more constructive dialogue. They could have avoided the original problems with a more corrective and open-minded policy. What I am suggesting to you is that you should this kind of policy - not wait until things go badly and only then make adjustments. Failing this, you will become cynical react only when are forced to.

***Luca Buttazzoni – Italy***

A general remark. We spend most of our professional lifes dealing with two groups of animals, what we would call an equlibrate selection. Some animals are selected for specialities, like “Prosciutto di Parma”. But even then, our selected animals tend to be most sensible. They are crosses. I do not think this is a niche with future. If we talk about welfare issues we talk about equilibrated breeding goals. This is why my attitude now for equlibrate breeding is quite strong. Sustainable agriculture is understandable when we talk about e.g. the environmental impact. We have to be very clear about the words we use and what we mean with them. Otherwise, we will not be understood at all and finish in not having different paths, nor a low cost path and an alternative path. Just laws saying you can not have stables for this, cages for sows or so. Or, just an example, that we should forbid farrowing cages. We do not know how to do without them. But already there is a proposal to ban them.

***Peter Sandøe***

Well, I think this is very interesting. And the disagreement between us is mainly empirical actually. Because there are two hypotheses one can have. I think your hypothesis is this: If you go into all this ethics talk, at some point you will be trapped, and forced to do things that will take you out of business. Do I understand you correctly? My hypothesis opposes yours. If you do not go into the ethical issues you will be trapped by people who regulate you without talking to you.

This has happened with housing systems. In Denmark the pig industry has just negotiated sensible regulation for housing systems. Of course it has a costs on them, but these would probably have been imposed anyway, without any discussion of what really matters. Fundamentally this is an empirical question about political power, and your influence and the influence of the rest of society. But I do not want to say you are wrong. I think it is an open question about perhaps neither of us is wholly right. But I think we should agree that these are two empirical possibilities, and that it is at least possible that if you go into dialogue you will encourage and receive more goodwill and have more chance to effect what is vital to you.

***H. Lommers - The Netherlands***

Coming back to the concerns you have expressed. We talk about animal integrity and then go on to another area of human concerns. Animal integrity and animal disease resistance which is a fundamental sort of welfare. The conflict is 1) human wants animals to be treated against diseases from a viewpoint of animal welfare and 2) he is concerned from a food safety point of view, a self concern.

***Peter Sandøe***

I agree totally. My aim was not to defend (for example) animal integrity. In my own professional work I spend most of my time, and a lot of energy, fighting with the Dutch and defending animal welfare *against* integrity. My point was only that you should be aware of concerns about integrity and avoid being seen as arrogant. You should explain, if you go for the welfare-line, why you do so: you must make it clear that you still recognise that other people have other views but explain why you think welfare is more important. Then you will be taken seriously.

Let me say what I think about organic farming. Organic farming is popular in some countries as a result of a combination of concern for environment and welfare and concern for this naturalness and integrity thing. And you are quite right: these are coming into conflict. Yes, organic farming systems have high mortality rates and characteristic welfare problems. We should be discussing these problems. But it is very important, right at the start, that you should understand and respect other people's views. Then you will be trusted when you say: "Well, we have a different strategy. We go for welfare." When you explain your views, you will be respected by the integrity people, because they will be able to see that you are taking an ethical stand, not just being arrogant.

***H. Lommers – The Netherlands***

Cloning may be a certain way of breeding farm animals which is going to cost highly. Not where cloning is used, but only the mere fact that people hear that you are using cloning.

***Peter Sandøe***

Well, if you use cloning on black and white HF cattle, they won't be even alike, so people will not find out! Sorry. [This was a joke]

I think you can give a sensible explanation why you would use cloning. I spent a lot of time philosophing about the difference between Tracy and Dolly. You know, Tracy was a sheep from the same place (the Roslin Institute and PPL pharmaceutics) who was genetically modified to produce medicine in her milk. Dolly is simply a genetic copy of another sheep. I think one reason why people got so upset about Dolly is that they did not understand why. So you should tell people that you would be using clonig for a specific purpose, that it would not mean that there will be identical animals out in the field, and there still will be variation. People will then be much more willing to accept it. An answer to the question "Why?" was missing where Dolly was concerned. The media noise stopped it getting through.

***Jan Merks***

I like to add to the last discussion that just adding cloning, or just using cloning tomorrow in farm animal breeding and reproduction is almost of *no use*. In breeding cloning is adding only very little. Due to the present cost it is even more expensive than not using it. You are right: just adding something is not the way where we are going for. It is a combination on the long term that may be of interest. That was shown in the first presentation. We have to find out which combination is of interest in the long term. From that point of view we look at different stages of the process, and then try to see how animal integrity etcetera are involved or not. Adding something may change that view completely. Cloning would mean just adding a small part that is even economically of little interest.
One of the purposes of today is to make clear to each other that we need to have these kind of discussions. And that we know and realise in our thinking about technologies that not only the technology itself is important.

***Maurizio Gallo – Italy***

The main force behind the ethical issues is the interest of mankind. Most of us can understand that. Society is concerned about cloning. Most people do not like to read about cloned animals. There is something unusual about that. They look at the scientists not in a not very positive way. This is because for a long time scientists have been hired by industrial companies in order to increase profits. This resulted in mistrust by the public opinion about scientists. They do not feel scientists as being fair ones. Public opinion believe they are just payed by large companies. The current system does not favour ethical behaviour, because we work on an economic basis. For very long time people only worked on important species. We are also providing education, only regarding productivity issues. In fact very few lectures are given to students on ethical and societal issues. I think public opinion is right. There are several examples of lacunes/mistakes.

***Peter Sandøe***

Well, I certainly agree. I just want to add another observation. There is also a clash of views between the general public and science. Roughly speaking, the general public still take the view of the old testament. For them animal nature should be stable, or unchanging, and when they hear about the scientists changing the gene of an animal, they say: “What a terrible thing! Can’t you let the animals just as they are?” But for scientists the genome is changing all the time, so hearing about a scientist changing a genome is no big news. I think that is part of what you are saying. Getting modern biology, and modern genetics into the mind of the people is a big task. Since the greater part of the population lives, as it were, in the world of the old testament, where animals are created, we need to take on board that agenda too. Otherwise we will not enter into a good dialogue. So it is very important that energy is invested in *better biology teaching* at schools. In most of Europe biology teaching is terrible.

***Jan Merks:***

It is important that animal breeders think about animal integrity and see how they can include that in their breeding goal.

# Economic Pressures, Livestock Productivity and Animal Welfare – Seeking the Balance

*John McInerney*[1]

This paper will give another focus on animal welfare – not because it is the most important aspect of farm animal breeding and reproduction, but simply because it is increasingly recognised as an area that all participants in the livestock production industries must give more attention to.

I have been invited to this workshop as the vice-chairman of the UK Farm Animal Welfare Council (FAWC). The FAWC is a body of approximately 25 independent individuals, drawn from a wide range of interests, whose role is to advise the UK Minister of Agriculture on appropriate standards regarding the keeping of farm livestock. In addition, however, I am also a professor of agricultural economics at the University of Exeter and so spend much of my time, on FAWC and elsewhere, emphasising that animal welfare is an *economic* issue. As well as all the ethical and other considerations, animal welfare is an aspect of the value that people feel they gain from consuming livestock products, and as a result it has major implications for consumer satisfaction and for the commercial operations of agricultural and food producers.

**From supply side concerns to consumer concerns**

There is an entirely logical and understandable economic explanation for the current pressures on agriculture, and for the raised consumer interest in what farmers are doing and how they conduct their business. But this is something that people in the agricultural industries have been slow to appreciate. Even though farming has always been about supplying the food system, the food consumer has not actually been a major focus for interest, and unlike in most industries consumer demand has not exercised much direct influence. For the past 50 years or more agricultural production has, in fact, been dominated almost totally by an emphasis on supply side concerns. There has been a continual pressure from new technology, and encouragement by agricultural policy, that have led agriculture to concentrate on expanding production and supplying more output. The focus has been on increasing intensity, efficiency gains, investment, R&D, more and cheaper products, and this has pushed agricultural productivity onwards and upwards. Now, however, throughout Europe the stage of food sufficiency and food security has been reached. (In the Third World the situation is different, but these are not the markets that European farmers have to deal with.)

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Now, however, there are two major changes that have emerged in the food systems of western countries:

**1.** The supply side pressures are being moderated and are no longer the dominant force. The expansionary stimulus from operational policy is being rapidly reduced and the push of new technology is no longer allowed free rein, with society increasingly suspicious of new developments. In the past, new technologies have been taken for granted because "increase in efficiency" was automatically presumed a good thing. It is not like that any more, at least in Europe, and many are voicing direct opposition to aspects of modern technologies – GMSs, new agro-chemicals, modern drug use, new livestock production possibilities.

**2.** Consumers largely take for granted the availability of food. Virtually anything they want – certainly anything they need – is readily available in the stores, and there is almost no experience or expectation of food scarcity. With food supplies sufficient and apparently secure, there is no obvious basis for the traditional concerns over food supply – and there is no longer a need for further agricultural expansion.

The result of these developments is that today agriculture is dominated almost totally by demand side pressures. This is a new phenomenon, which has emerged only since food supplies became secure in the last few years, but is not yet widely accepted or recognised enough. Food has become a typical consumer good, with consumers more concerned about the quality and nature of what they eat than with its price or the quantity of it available. The economic pressures operating on agriculture therefore now increasingly come back down from the demand end of the food chain. (It should be noted – because there is still resistance to this change – that this consumer influence is not simply a tiresome problem the industry has to face; in principle producers and food suppliers, like every business, have an obligation to be responsive to the demand side, and to the preferences expressed by consumers.)

**Quality aspects and animal welfare**

The concerns of well-fed and affluent consumers are now increasingly dominated by the *qualitative* aspects of the food they eat – safety, variety, nutritional value, taste, the additives it contains, its 'wholesomeness' and origin – all play a far more important role than in the past. In this context the welfare conditions under which the farm animal was kept are seen and reacted to as a quality characteristic of a livestock product. People increasingly begin to feel uncomfortable about what happened to the animal that provided their food, in the same way they feel a concern to ensure the timber for their garden seat came from a sustainable forest, their clothes were not made by exploiting cheap labour or their consumption is not responsible for environmental damage. These are common aspects of preferences in a consumer society and become a major influence on the way markets develop.

**Balance between human and animal interest**

However, the problem is that animals are resources in the food production system, and their primary value comes from their productivity for this purpose. In economic terms, animals are like any other (land, labour, capital) resources; their purpose is to add a value, and the more output they provide, and the cheaper that output, the better. Nevertheless, as with other resources, this exploitation of 'use value' is moderated by other considerations, so that improved productivity is not desired regardless of everything else. In the case of the labour resource, for example, the more productive labour is the better but it does not mean to say that society totally wants to exploit its workforce. Similarly, environmental concerns arise in rich societies because although people want productive land, they also want pleasant countryside, wildlife, sustainability, biodiversity, local products, etc. In relation to animal welfare society faces a clear dilemma. It is interested in the animal as a resource and the economic value it can provide, but this may conflict with an ethical concern over its welfare. Hence, as in all resource use there is a question of balance, of a trade-off between conflicting interests and values.

**Concepts of animal welfare**

In analysing this conflict it is helpful to be clear what people mean when they talk about animal welfare. Two different approaches are identifiable.

**1.** ***Scientific view (exclusive)***. Animal scientists have a specific definition of welfare (the common one is that given by Professor Don Broom of Cambridge University: "the animal's state as regards its ability to cope with its environment") – but, like many definitions, they often only have meaning if you know what it is to begin with! This 'scientific' approach presumes that the characteristics of animal welfare can be identified and measured in terms of homeostasis, corticosteroid levels, measures of stress, health, behavioural aspects, welfare indices. This implies that welfare is an empirical concept, and can be used to make comparisons and judgements about 'better' or 'worse'. However, scientists are only one group in society who are interested in welfare issues and other viewpoints are influential.

**2.** ***Popular view (common)***. A wider group of people with welfare concerns are the members of the general public, both as consumers and as members of society, and other (non-science) professionals in the food system. Here the images of animal welfare are much more qualitative and descriptive. The FAWC talks in terms of "The Five Freedoms" – freedom from hunger and thirst; from discomfort; from pain, injury or disease; from fear and distress; and freedom to express normal behaviour. These are treated as qualitative conditions for good welfare, but not absolutes. It is evident that people have a variety of images – all largely anthropomorphic and based on the view that "we humans know what is good for animals in mind" in the broad discussions on animal welfare issues – and this conditions the concerns that are expressed over animal welfare. The following popular concepts of animal welfare seem to be discernible:

*A.* *'Natural' welfare*. This reflects the welfare state that the animal would experience, and is presumed to be best suited to by virtue of its genetic make-up, rather than the artificial environment of domestication.

*B.* *'Maximal' welfare*. This implies looking after animals in the best way one can think of – in effect treating animals in the way people treat children.

*C.* *'Minimal' welfare*. This represents the lowest standard of welfare tolerated or accepted in society, often embodied in the framework of regulations and legislation below which treatment would be regarded as 'cruel'.

*D.* *'Desired/appropriate' welfare*. Somewhere between maximal and minimal welfare there is what a society would see as the desirable or appropriate standard for its farm animals. Where this point actually lies is determined by the culture, income and other characteristics of a society, and changes over time. Most of the discussion and controversy about animal welfare relates to the definition of desired or appropriate welfare standards.

What these concepts of animal welfare have in common is that they are all *human* perceptions of the animal's welfare. Our discussion should always therefore refer specifically to 'perceived welfare', rather than actual welfare, because we can never actually know what the animal feels about it all, and it is on the basis of their perceptions that humans decide what is good and bad for the animals anyway.

**The trade-off between human and animal interest**

All economic and social choices involve trade-offs and there is an unavoidable trade-off between the human (economic) interest and the animal (welfare) interest, as represented in Figure 1. The diagram shows that if nothing were done to animals in pursuit of their productivity their (perceived) welfare would be at the position equivalent to point A – approximating the concept of 'natural' welfare. As we domesticate animals and provide them with food, shelter, treat them against diseases, and protect them from predators, both their productivity and their welfare increases to point B, where perceived welfare is at a maximum. However, economic pressures inevitably force livestock production to progress beyond this point in pursuit of the animal's potential economic productivity, and in the process it imposes a progressive cost in terms of its perceived welfare. However, this is not a cost to the producer in a financial sense and so, despite the increasing conflict between the animal's welfare and its productivity, commercial considerations create pressures to drive animal production practices towards point C, the threshold of 'minimal' welfare. Somewhere between producing at point B (which is not economically rational) and point C (which is socially unacceptable) is the particular point (D) of 'appropriate' or 'desirable' animal welfare standards that are consistent with the broad preferences of society.

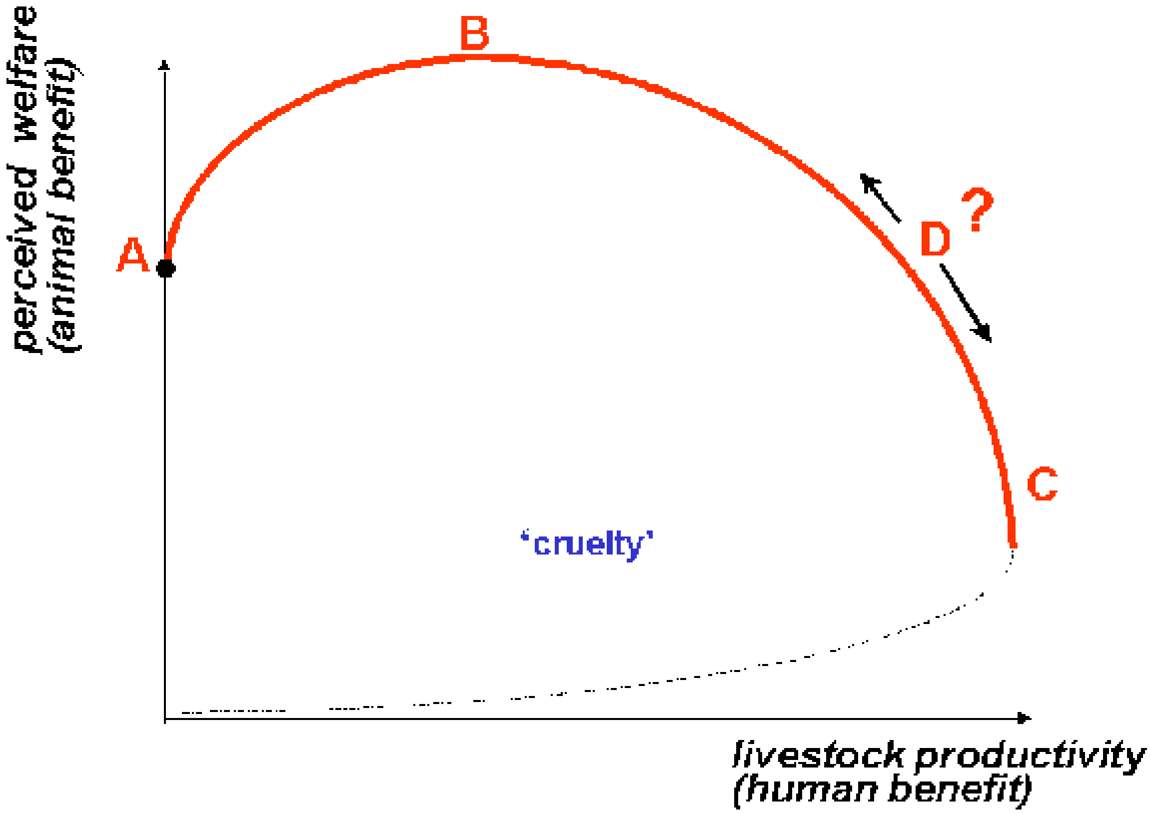


**Figure 1. Trade-off between the human (economic) interest and the animal (welfare) interest**
**A = 'Natural' welfare, B = 'Maximal' welfare, C = 'Minimal' welfare,**
**D = 'Desired/appropriate' welfare**

This is not obviously a unique point, however, and different groups in society have different views about where it lies. At one extreme are people who are affluent, well-fed, compassionate, environmentally aware, able and inclined to emphasise a concern for the animal (indicated in Figure 2 as representing the 'liberal view') who seek high welfare standards. At the other extreme are individuals on low income whose major concern is to have the lowest possible food prices, and those who are unaware, complacent or totally indifferent to animal welfare issues; this group will emphasise more the value of the animal's productivity and thereby accept lower levels of animal welfare. There is a presumption that farmers and others in the livestock industry are dominantly concerned with the economic benefits, rather than the welfare costs, of livestock production – and their past record in many areas of modern intensive farming supports this view – implying they favour the position labelled in Figure 2 as indicating a 'producer view'.

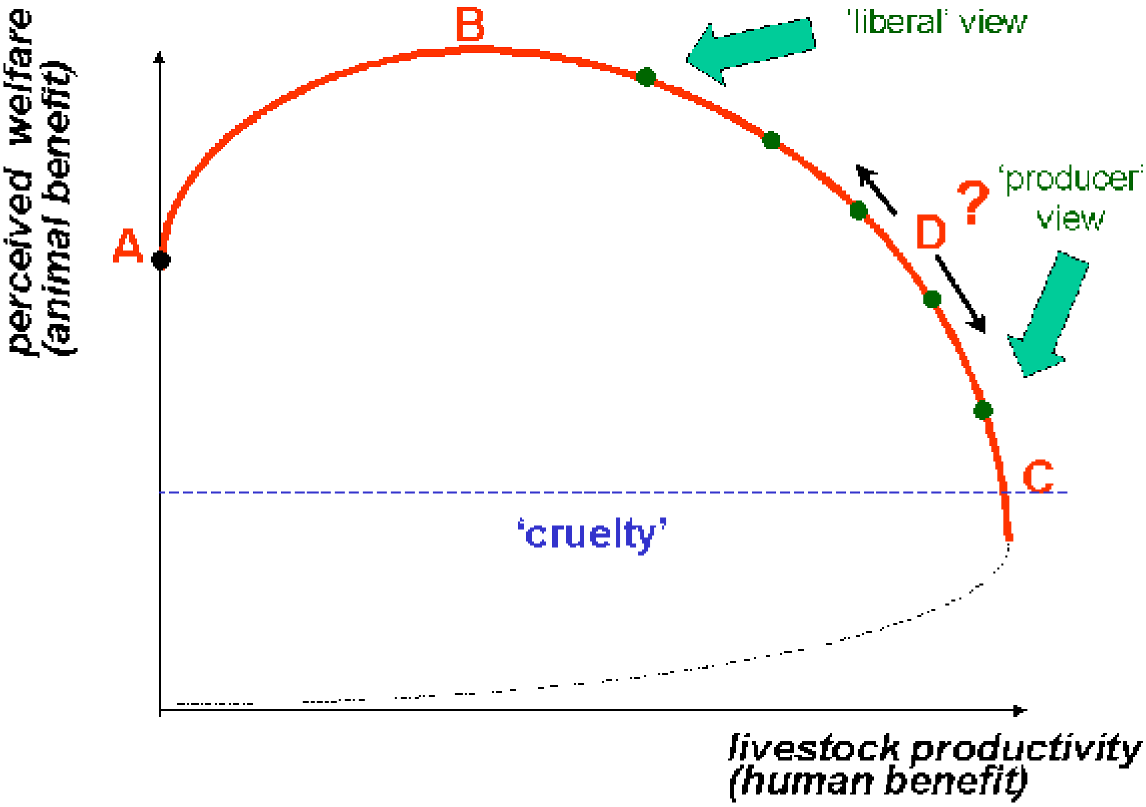


**Figure 2. Perceived welfare (human benefit) and livestock productivity (human benefit)**

**A = 'Natural' welfare, B = 'Maximal' welfare, C = 'Minimal' welfare,**

**D = 'Desired/appropriate' welfare**

Here lies the basis of the growing social and consumer concern over the new production technologies and possible development directions in livestock farming. The research and animal science emphasis on cloning, genetic modification, breeding for higher growth rates and feed conversion, selection for carcass composition, appears to be driven by the economic interest of the producer, not the consumer of livestock products, and maximum saleable product. The average member of the public does not understand the production system, and does not trust the scientists. He/she sees the current concerns over animal welfare as being a result of modern efficient production technology, and fears that the commercial interest will largely ignore the welfare aspect because it is not part of the financial cost of production. This makes animal welfare a *political* as well as an economic issue, and people are looking for governmental intervention to regulate the husbandry of our food animals.

Whatever the understanding of the *actual* welfare condition of animals in modern livestock farming, the simple images created by battery cages, sows tethered in stalls, 12,000 litre cows, veal crates, intensive veterinary regimes and slaughterhouse procedures, and the widespread use of the (almost meaningless) phrase "factory farming" adds up to a generalised pressure for standards to be 'higher' than at present.

**How do changes in animal welfare standards come about?**

Changes in animal welfare standards can occur in several ways:

*A.* *Legislation/regulation*. Codes and legal welfare requirements can be specified only as enforceable minimum standards and so define the lowest acceptable standards rather than the norms that should characterise production generally. Widespread public pressure and collective political action can result in a raising of these minimum standards (as happening in the case of the size of battery cages or maximum transport times).

*B.* *Free market processes*. The tendency is for the regulatory approach to lead to uniformity of welfare standards across the industry, but the reality (as discussed above) is that there is no single view of a uniform set of 'best' standards. The alternative would be to allow the diversity of consumer preferences to be reflected by the markets for livestock products. For example, people who feel more comfortable eating free range eggs and are prepared to pay the higher costs will buy them; those who do not value eggs produced to what are deemed to be higher welfare standards can happily buy cage eggs and as long as the minimum standards are socially acceptable everyone should be content (Though it should be noted that the market is limited in catering only for the interests of those who buy the products, and in proportion to their expenditure – so it cannot be said to appropriately capture the preferences of society more widely). What is still not clear in the debate on animal welfare is whether such a diversity of animal welfare standards as the market would produce would be acceptable for society; or whether it is presumed that there has to be a single (high) level of standards because the welfare of animals is a 'public good' and should not be subject to individual choice.

*C.* *Dominating commercial interests*. A group with strong commercial influence in the food system can impose new welfare standards and in the future this may be increasingly the case. For example, major retailers, or livestock product buyers/ suppliers, now define by their "quality assurance" criteria the conditions under which animals should be kept and then these become the parameters for both the producers and consumers. In this sense the supermarkets have now effectively become "the consumer", and exercise great influence on the definition of what are accepted as the society's appropriate welfare standards. There are some advantages in this – if only because it provides a link between consumer preference and farmer activity that is largely missing in the modern extended food chain; but insofar as supermarket buyers may be no better informed about *real* welfare criteria than are the general public, it could lead to an inappropriate bias in the development of livestock production methods.

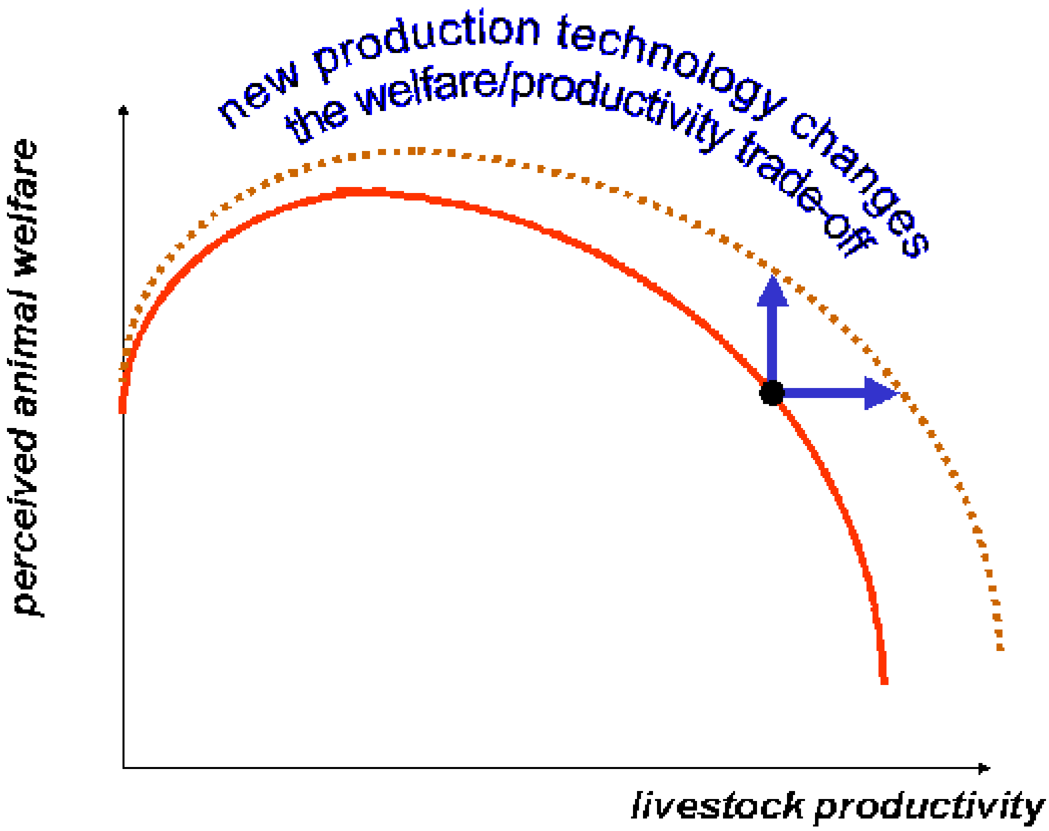


**Figure 3. Changed balance between animal welfare and livestock productivity**

*D.* *New technology*. Newly developed production systems, husbandry techniques, breeding and selection programmes which include welfare characteristics as an integral part of their evaluation parameters can also be a way in which improved animal welfare comes about. If new technology doesn't simply exploit further the animal's economic productivity, as it has in the past, but changes the whole trade-off relationship between animal welfare and livestock productivity in some way, this could become the classic win-win situation, in which everybody gains a benefit. If we can develop techniques that represent a new set of options about which economic choices will be made (see Figure 3) enhancement of animal welfare can be obtained at no cost to livestock productivity. This would satisfy the people who think the most important thing now is to have a higher level of animal welfare standards rather than food that is even cheaper. Alternatively, an increased level of productivity could be obtained – which is what the competitive commercial pressures cause the livestock industry to constantly seek – without the threat of a reduction in animal welfare. It is extremely important to recognise the influence of technology and its major significance to all the issues just discussed. The industry must be seen to take its influence and its responsibilities seriously and to be committed to welfare improvement as one of its *own* objectives, rather than doing it reluctantly due to unwelcome external pressure. Otherwise, if it is thought to be still dominantly concerned with producing 'efficient' animals rather than reasonably contented animals, it will remain locked in the old supply side economics of the past rather than the demand driven economics of the future.

**Major issues and questions**

1. **Imperfect information.** Most of us are very ill-informed as consumers. We know our own specialist areas but beyond that we are as subject to image, presumption and arbitrary preference in the things we buy as is the typical food consumer. The animal welfare debate is full of ignorance, misconceptions, ill informed presumptions and impressions, and images that owe more to Walt Disney than to knowledge and understanding. Simplistic ideas like all animals should lie in straw because it is comfortable for them, that "outdoors is good and indoors is bad", or that unwanted calves should be allowed to "have a bit of a life" before being disposed of, are all unhelpful and unnecessary perceptions in the public's attitude towards livestock production. On the other hand, there is equally a danger that a solely science-based view can over-ride real social concerns and fail to cater for the fact that action about animal welfare has ultimately to be based in what is acceptable to *people* and their perceptions, not simply what one or other exclusive interest groups thinks is right. It is instinctive in this context to remember what the great US Justice Oliver Wendall Holmes stated: "the truth is what people can't help believing is true". All human action is based on what is perceived to be the reality; whether a favoured minority know – or believe they know – the actual reality is thus irrelevant. This does not mean there is no role in educating and informing people correctly but in the end, in a decentralised market economy based on individual choice, the appropriate animal welfare standards will be those that people want.
2. **Transmission links.** If technology change and livestock production practices are to be driven by social and consumer preferences, how does the relevant information get fed back down the supply chain from food consumer to livestock farmer and animal breeder? Who specifies the message – and does it get changed by other interests as it is passed back to the farmer or his input supplier? In matters of social choice it is difficult to rely on individual decision makers to reflect this, and it is not clear that coherent information on animal welfare preferences and possibilities is adequately available to all who are concerned.
3. **Role of consumers, producers and non-consumers**. What is the relative role of consumers, producers, and non-consumers regarding animal welfare? Although consumers and livestock farmers have been considered as the main interested parties, there are numerous other groups who have an interest to pursue and maintain. For example, do those who consume few livestock products (or none at all) have as valid a voice in animal welfare issues as those who consume a large quantity? To what extent should those who are a long way from the final consumer but have a valid economic interest to protect (e.g. livestock breeding companies) be allowed to influence developments? To what extent is it a political, rather than an economic issue we are dealing with?
4. **Who decides?** Who makes the decisions about animal welfare standards anyway? Is it a decision that should be left to the market, since that is largely how our whole economy works? Or should the state act as the major stakeholder and impose a 'top-down' framework, as it does on matters of health, food safety and other aspects considered to be public goods? Whoever makes the decision or leads the debate, there is a clear and crucial role for independent bodies

like FAWC to analyse the issues from all viewpoints, encourage rational consideration, offer considered advice and provide balanced information to all interested participants.

5. **Is it a substantial economic problem?** It is inescapable that higher welfare standards will tend to raise production costs, and hence food prices, but this concern can easily be overemphasised. Because of the many value-adding processes between the raw material at farmgate and the final food commodity in the retail food store, agricultural production cost increases of 5% (due, perhaps, to a number of animal welfare changes) when factored down through the food chain may only change the price of food by about 1%. The actual impact on the consumer budget is often very little different from that of seasonal fluctuations in many commodity prices which are regarded as unremarkable. While they are of concern to agricultural producers trying to gain an income, changes in farm-level production costs are not necessarily a major issue in final food prices. And, as stated, in the modern western society the price of individual food products is not the dominant determining factor in purchasing decisions anyway.

6. **How to achieve EU-wide consensus?** There are many differences in culture, presumptions and preferences among the nation states of Europe, and reaching a common agreement on appropriate farm animal welfare standards seems a difficult task. EU enlargement will bring in new member states whose consumers and producers may both be unwilling to subscribe to animal welfare standards regarded as essential by people in UK or Germany. There may well be a North European view and a South European view which are mutually inconsistent and represent a constraint on trade within a single market. No one seems yet to have confronted the question of the different perceptions of culture, income, experience or tradition in deciding on animal welfare policy. Who will persuade the French that they should not force food down the necks of ducks and geese? Who is going to tell Jews and Muslims that they should stun animals before slaughter? Who can convince poor people that better animal welfare is more important than an improvement in their own standard of living? In many senses these may be the major challenges in welfare reform in the future.

**OUTLOOK**

There is a long way to go in the finding the balance in the current debate on animal welfare standards. A lot of questions still need to be answered, and a lot of dialogue between the parties involved has yet to commence. One of the good things of this Workshop is that there is a recognition that this dialogue between audiences has to take place. It is becoming clear that it is not primarily a concern of consumers or of welfare activists, but of all those connected with livestock production. Workshops like this, and organisations like the UK FAWC (and the intent to have similar bodies on a European-wide basis) are increasingly the way to discover and explore the issues. The dialogue between interested parties within the supplier industry, with livestock producers, with the food retail trade, with consumers and with public bodies is essential if society is to identify and move rationally towards the higher farm animal welfare standards it seems to prefer.

# Farm Animal Breeding and the Consumer

*Arie van Genderen[1] & Huib de Vriend[1]*

## 1. Introduction

In general, the breeding of farm animals is not exactly an issue that appeals to the regular consumer because it is an activity that is not clearly visible at the very beginning of a production chain. The quality of the end product, the meat, the milk or the eggs is of more importance to them than the way in which those products are produced. Discussing the future of farm animal breeding is even more out of sight. On the other hand, consumers all around the world have clear opinions about the large-scale introduction of genetic modification. Through the genetic modification of farm animals the farm animal breeders find themselves on the brink of a whole new era in their sector. It is exactly this development that could trigger a dialogue on farm animal breeding at large.

This creates an opportunity for more consumer involvement in a debate about the future developments and animal breeding techniques including genetic modification and cloning. Those subjects are the main areas of expertise of our organisation.

## 2. Hypothesis

Looking into the future is tricky business. Especially when it comes to issues about which one can only speculate. There is a lot of information available about the research that is going on in regard to farm animal breeding. Nevertheless, it is extremely difficult to predict which application will reach the point of large-scale introduction and how and when.

With the introduction of the genetically modified (gmo) soy and maize in several European countries, a debate is triggered on several aspects of farming and food security. Aspects which are not always directly related the technology of genetic modification. Questions that arise are on sustainability of modern agriculture, the role of seed companies, the use of pesticides, environmental and ecological safety, food safety and the possible allergy of gmo’s. The genetic modification as such does create some concern with consumers and is the focus of the discussion at this moment for a relatively small, but rather noisy group.

Although genetic modification of farm animals for production purposes seems far away, the modifications aimed at production of medicines and organs already started and are gaining momentum. Very recently the set up of a flock of 10.000 sheep in New Zealand, for the production of a medicine in the milk, was announced. The sheep are genetically modified and cloned. And also in New Zealand they are planning to set up a herd of cows, genetically modified to produce milk that equals human breast milk. Also recently the company Genzyme announced the cloning of goats. And last but not least the genetic modification of pigs, aimed at producing organs for xenotranspantations, is coming up strongly.

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It is not very clear whether those sheep, goats, pigs and cows are a special breed to be kept separated from the 'ordinary' animals or just plain farm animals. Further questions that will arise concern the wool, the meat and other products that can be derived from those animals. Will the animals be destroyed after lactation or when the organs are taken out? Or will the wool and meat get on the market? And if so, shall those products be labelled then? Is destruction ethically and morally acceptable to citizens and consumers, let alone animal welfare organisations? The same questions apply to all genetically modified animals to come, be it for medical, pharmaceutical or plain production purposes.

The hypothesis with regard to the future of farm animal breeding is that the genetic modification of farm animals will trigger the same type of broad discussion on animal production at large, as is the case with gmo crops. The additional ethical aspects with regard to animals will increase the complexity of the debate (see also the article of Stine Christiansen and Peter Sandøe).
This leads to the following questions:
How to define 'consumers';
is genetic modification of (farm) animals an issue that concerns consumers;
is it possible to distinguish between different purposes (plain production or medicines) of the modification;
is it possible to influence the direction farm animal breeding is taking through dialogue between the sector on the one hand and consumers on the other hand.

**3. Methods**

Assuming there may be a parallel with developments in crop production, it is interesting to take a closer look at the market introductions and the reactions these triggered.
Several years ago, Monsanto took the world by surprise with the Roundup Ready Soya Beans. All of a sudden the product was on the market, without any preliminary discussion or introduction. Moreover, it entailed a commodity product and the gmo-soy was not segregated from the non-gmo products, thus limiting consumer choice, to be used in a whole range of consumer products and without any adherent consumer benefit. At first the US government tried to block any discussion on segregation and labelling products that contained gmo-soy. A fight they lost. The perceived environmental benefit (using less herbicides) was not confirmed by an independent source. Finally, at the moment consumer and environmental organisations started to mobilise public opinion, the soy sector was very reluctant in starting a dialogue and supplying the Non Governmental Organisations (NGO's) with independent information. By the time it became clear that openness and dialogue was probably the best strategy, it was too late. The NGO's have lost all confidence in companies like Monsanto and other biotech companies. Which makes it hard to have an open, frank and reasonable dialogue on new applications and products.
On the other hand, having such a dialogue between the industry and the NGO's does not mean that all applications are to be accepted. Dialogue should be a two-sided sword and just trying to pursuade the NGO's to accept all gm-products and applications, as is the case, will not work.

The interesting point in this case is that even Greenpeace, one of the fiercest opponents of the soy, hardly ever speaks out on genetic modification of plants as such. Which does not mean that they have no eye for the inherent risks that genetic modification of plants could pose. What they do say in their campaigns is that the soy may pose health risks to the consumer (especially allergenicity), that the use of herbicides should be banned and that consumers should have a choice, which means segregation of the crops, labelling of the products and a clear supply of gmo-free products. Those are the discussion topics, or in other words 'the consumer concerns'.

In the next chapters an attempt will be made to get the right picture of the consumer, the consumer concerns and consumer demands (Chapter 4). The results of a number of consumer surveys were collected, studied and framed together. The most important surveys are mentioned in the References. They form the basis of this article.
In addition a written survey was conducted among 50 European consumer organisations and 10 animal welfare organisations. The results are presented in Chapter 5. Chapter 6 contains the general conclusions.

## 4. A mosaic of surveys

In this Chapter the results of various consumer surveys that were conducted on genetic modification of plants and several surveys which (partly) have genetic modification of animals as subject, will be discussed.
Consumer attitudes towards genetic engineering and breeding technologies are complex, often ambiguous and diverse. First of all, different applications can trigger a wide range of reactions. Secondly, variations in social and cultural background may also lead to adverse reactions. This means that talking about "the consumer" is not very fruitful. It is necessary to clarify how consumer groups can be distinguished and in addition try to find out how those different groups react to genetic engineering in general and genetic engineering of farm animals in particular.

### *4.1. Consumer typology*

There have been many attempts to classify or categorise consumers. In this article we look at two different classifications. The Dutch professor Meulenberg from Wageningen Agricultural University. made the first one (Meulenberg, 1996). The second one was reported by Leslie Gofton et al in the "Studies on the socio-economic impact of Biotechnology (Gofton *et al.*, 1998).
In his report 'Market and Consumer', Dr. M.T.G. Meulenberg developed the following 'seven pure consumer types':

1. *The environmental friendly consumer:* has a preference for fresh products, from biological (organic) agriculture and has an ambivalent attitude towards technology;
2. *The nature and animal friendly consumer:* is interested in animal welfare, nature conservation and ethics;
3. *The health consumer:* is primarily interested in his personal health, goes for products with specific traits like low calories, rich in …, and health protecting or health improving agents;

4. *The convenience consumer:* chooses for snacks, ready to eat meals (microwave), easy and fast to prepare meals at home, take away meals or eating out;
5. *The hedonistic consumer:* prefers (exotic) specialities, delicacies, refined products with added value, eating out in the better restaurants;
6. *The variation seeker:* chooses for diversification in meals and ingredients, takes ready to eat meals as well as spends long hours in the kitchen to prepare a special dinner;
7. *The price conscious consumer:* does his own cooking, chooses ingredients with the best price quality ratio (in relation to his income).

If all consumers could be categorised like this, life would be easy for marketers and policy makers. In the practice there may only be a limited number of consumers that fully fit the description, whereas large numbers move between the categories at will. An additional complication is that incidents (BSE, swine fever, etc.) may create panic reactions amongst all categories and cause (often temporary) switches in categories.

Still, the categorisation can be helpful when assessing the possible impact of new products or technologies. At least one can more or less predict what the reaction could be from one or several of the groups. For example, genetic modification of pigs aimed at creating very docile, fast growing animals with extremely lean and very cheap meat, might appeal to the groups 4, 6 and 7, but definitely not to 1, 2 and 5. If the meat was also extremely low in cholesterol it might also appeal to 3.

For breeders, farmers and retailers it is important to know how big (in numbers) the various groups are and how big their influence is in the media and in society as a whole.

To assess that in detail is outside the scope of this article, but should be tackled when making decisions for future developments.

A different classification, used in the survey ‘Studies on the socio-economic impact of Biotechnology’ (Gofton *et al*., 1996) is the triplet ‘Triers’, ‘Refusers’ and ‘Undecided’. This study focuses on the acceptability of biotechnology in relation to food products, with special reference to farmed fish.

The smallest group they identified is those of the *refusers*. They will refuse any product made with genetechnology.

Slightly larger was the group of *triers.* Within this categorisation the authors found two noticeable typologies. The first is the ‘enthusiastic’ trier who is more predisposed to the perceived benefits of technology in general, and the belief that it has a role in economic and personal progress.

The second type of triers was typified as those with low incomes and traditional dependence on price. They have a rather fatalistic view of the world around them. But if the price is right they will try hightech products anyway.

The third and by far largest group is those of the *undecided*. Within this group, many influences will impinge upon the process of product acceptance. They assess the perceived benefits and risks of hightech products and compare them with alternatives on the market. But then, even when a technology or product is accepted, it does not guarantee purchase.

Combining the two systems is a bit tricky and should be read with some predisposition. The refusers are to be found in the groups 1 and 2 of Meulenbergs categorisation. And the groups 4, 6 and 7 could be the undecided. Groups 3 and 5 might try gmo products.

***4.2. Some results of the survey 'Studies on the socio-economic.....(Gofton et al, 1996)'***

In this study surveys were made (by telephone) in 6 European countries and in the pre-stage of the project focus discussion groups were set up in every country.

The outcome of the quantitative part, the telephone survey, corresponds largely with comparative surveys like the Eurobarometer (1997), see paragraph 4.6., and will not be discussed in this article.

In the discussion groups 'Method of Production' was one of the focus points. The outcome of the discussion showed that methods of food production are an important attribute for many of the discussants. However, despite the perceived importance of the production method to the discussant, it was not necessarily salient in the purchase decision. The production method often takes a secondary role to higher-level product attributes such as price and quality. For example, gene technology was generally perceived as the antithesis of organic farming. However, if organic produce does not meet expectations, the purchaser will look to non-organic products to meet their demands.

Nevertheless, many discussants expressed concerns that the existing foods they consumed were perhaps not as natural as they would like to think.

When it comes to the 'acceptance of genetically modified farmed salmon' the outcome of the discussions lead to the following percentages of 'willing' or 'not willing to try'.

| Acceptance of GM farmed fish | % |
|---|---|
| Definitely will try | 9 |
| Probably will try | 16 |
| Might try | 30 |
| Probably will not try | 25 |
| Definitely will not try | 20 |

Easily identifiable are the consumers who refuse outright any suggestion of buying any GM product (20%). These consumers reject the technology for reasons of perceived dangers to the environment or their own or societies health. They are the typical 'refusers'.

The other group, the triers (9%), represents a typical pioneer's characteristic. Although their choice could be based on insufficient information, they perceive the new technology or product as extending choice and thus are willing to give it a try.

The third group, the undecided (71%) forms a majority. In general, they have a weak understanding of the (gm) technology and uncrystallised attitudes towards it. According to the authors their attitudes are likely to be influenced by the nature of the modification and the nature of the product being modified and of course the price. But they could also be influenced by the refusers or the triers. For a small group the flavour is a very decisive argument. In their perception the flavour of wild salmon is superior and whenever available this will be their first choice (this corresponds with the 'hedonistic' consumer from Meulenberg).

The author's conclusion of this part of the study: there is a need for product by product research to identify the factors affecting consumer acceptability of gm foods.

A more general conclusion to the studies as a whole reads as follows:

1. There appears to be a well-defined group of straightforward ‘refusers’ in regard to genetically modified food products, including fish. This corresponds to a large extend with consumer types 1, 2 and 5 of Meulenberg.
2. A relatively small group of ‘triers’ may have a positive attitude towards genetically modified food products in general. Meulenberg types partly 4 and perhaps 7.
3. The majority is ‘undecided’. Their attitudes and purchasing behaviour may easily be influenced by: other groups, price quality ratio, media attention, incidents, etc..
   Meulenberg types 4, 6 and 7

### *4.3. A small selection of other surveys*

In 1995, Prof. Steenkamp of the Wageningen Agricultural University did a survey amongst Dutch consumers on the animal welfare issue (N=500). The question was: which aspects are decisive when buying meat.

From this survey he distilled the following graph:

| Quality | % |
|---|---|
| Sensory quality | 35.9 |
| Easy to prepare | 28.4 |
| Speciality | 21.6 |
| Natural production (includes animal welfare) | 14.1 |

He compared the outcome of his findings with surveys from Belgium, Spain and Greece. In this comparison animal welfare was down to place thirteen on a 17-point scale. Good quality, fresh, healthy and tasty were on top of the list.

Italy

In 1995 the RSPCA (UK) did a survey (N=1000) in Italy on the consumption of veal (European Brief, 1995). The main question of this survey was: *what the public in Italy thinks about veal production and consumption.* The answers read as follows:

- What are the main reasons for consumption: taste 32%, healthy 21%.
- Are you aware of the veal crate system: heard of it 22%, people concerned after getting the story 70%.
- General attitude towards animal welfare issues: acceptance of veal produced in more animal friendly manner 70%, prepared to pay a higher price 71%

France

The same survey (N=950), with the same questions, was conducted in France. The French answered as follows:

- Reasons for consumption: taste 51%, variety diet 33%, healthy 11%.

- Awareness of the veal crate system: heard of it 70%; concerned about it 35% (percentage did not alter after extra information).
- General attitude towards animal welfare issues: colour of the meat is important, under 50% are likely to change their eating habit.

<u>Eurogroup for animal welfare</u>

"Public attitudes in France, Great Britain, Spain, Italy, Germany on egg purchasing and labelling" (MORI poll, June 1998, N=1000). Below, some parts from the survey (Eurogroup for Animal Welfare, 1998). One of the main questions was whether the labels stood for battery eggs or free-range eggs. In fact they were all battery eggs. Whereas the majority of the respondents thought they were free-range eggs:

Confusion about labelling

| Country | Label | Wrong answer/ Don't know % |
|---|---|---|
| Britain | Farm Fresh | 81 |
| | Good Country Eggs | 88 |
| France | Oeufs Fermiers | 97 |
| Germany | Eier Frisch vom Bauernhof | 96 |
| | Bauerneier | 96 |
| Spain | Heuvos Fresco | 75 |
| Italy | Fresche | 76 |
| | Extra | 84 |

Willingness to pay more for free range eggs
(up to 35% more, except Spain, not more than 1-20%)

| Country | Willing to pay more % |
|---|---|
| Spain | 78 |
| Germany | 79 |
| Great Britain | 77 |
| France | 60 |
| Italy | 57 |

<u>Survey summary:</u>

- The public is prepared to pay more for free-range eggs.
- The labelling of eggs is unclear and causes confusion about the way in which the eggs have been produced.
- A majority in each country feels that eggs from battery cages should be labelled as "battery eggs".

The Eurogroup concludes that there is serious evidence that the public awareness regarding the welfare of animals in food production is increasing and that people are willing to pay more for free range, welfare-friendly produced eggs. The figures seem to support this conclusion, but it is likely that a fair number of respondents gave the political correct answers.

The Consumentenbond survey (Van Genderen, 1997) shows the following results: 47% of the respondents always buys free-range eggs, 19% regularly and 16% sometimes. The Dutch egg wholesalers claim that the market for free-range eggs is about 30-35% of the total sales. So the conclusion is that a large majority of the consumers is potentially interested in free-range eggs, but only a relatively small percentage is actually buying them.

### *4.4. Consumer attitudes*

In the survey "Consumer Behaviour Towards Meat" (Becker, 1998), the topic of attitudes was viewed in the light of the question whether it is possible to identify a correlation between consumer attitudes towards the origin of meat, animal welfare, the status of meat and so forth, on the one hand, and the intensity of meat consumption on the other.

In the interviews, conducted in six European countries, respondents were confronted with a series of general statements concerning food and meat, which they had to rate separately according to their choice. Below you will find a small selection of those statements and the answers.

The first statement was *"I would never serve a meal without meat for visitors".* With the exception of the Irish (big meat eaters) and to some extend the Italians, the respondents disagreed fairly strongly. The Swedish disagreed most strongly, which corresponds with low average meat consumption in Sweden. At the same time, the majority of the respondents in Sweden, Spain and Ireland agree with the second statement *"meat is an essential part of a meal".*

This is partial contradictory to the above mentioned outcome, but it shows that, although most consumers can imagine serving a meal without meat, many feel that meat is essential food.

*II prefer to buy meat from animals which I know have been treated well",* was the third statement. Nearly 90% of the respondents agreed strongly or slightly with this statement. Ireland and Sweden ranked highest (92%). Next came Germany and Italy (88%), Spain (87%) and finally United Kingdom (84%). More or less the same figures can be found for the statement, *"We should have more respect for animals".*

This brings the researchers to the conclusion that, since in each country, information on animal welfare is seldom available for a specific meat product, the respondents seemed to refer more to a general vague interest in animal welfare rather than to their actual purchasing behaviour.

### *4.5. The consumer and genetic modification of animals*

Most of the surveys come to the same two conclusions: the general public is poorly informed about genetic modification (plants and animals) and tends to be very sceptical about the application. But, as Sandøe and Holtug (1998) write in their article on ethical aspects: "it would be a mistake to believe that the scepticism of ordinary people arises simply from a lack of factual knowledge". The Eurobarometer (1997) on Biotechnology underlines this statement with a simple graph which shows that in countries where the factual knowledge is low (e.g. Portugal), people are less concerned than in countries with a reasonable informed population (e.g. Denmark).

The survey "Publiek en genetische manipulatie (*Consumer attitudes towards genetic manipulation)* (Koopman *et al.*, 1998)*,* contains two chapters that are of interest to this article. One chapter deals with the question which groups in society have a lot of influence regarding decisions about genetic engineering. First the respondents were asked which group had the most influence and secondly they were asked which group should have more influence. The results are as follows (first the percentage

what people expect and between brackets what seems more desirable): scientists 90% (65%); companies 75 (25); government 70 (90); media 40 (21); NGO's 28 (61); general public 20 (70).
It is quite clear that people think that scientist, the media and the companies have too much influence on the decisions. Government, the general public and the NGO's should have more influnce.
The chapter deals with the genetic modification of animals. In general, a mere 50% is against genetic modification. When it comes to the more detailed questions there is a slight shift. In favour of higher milk production is 17%, whereas 77% is against it. Production of medicines through the milk of genetically modified animals is acceptable to 41% and exactly the same percentage is against it (the rest don't know). The production of donor organs for xenotransplantation is favoured by 46% and only 37% are against. But, if animal welfare is at stake 82% is against.
People tend to 'vote' different when the benefit of the modification is adherent. Like the modification of animals for the production of humane medicines or in the future perhaps tissues and organs for xenotransplantations. Another Dutch survey (Smink, 1998) shows that a small majority (52%) would approve the modification of cows for the production of lactoferrins (medicine) through the milk. But the same trait just for the benefit of a higher milk production was rejected by over 75% of the respondents.

The Consumentenbond survey (5) amongst 2.500 members (representative selection out of 650.000), shows the following figures (N=1872, 75%):

- g.m. of animals for medicinal purposes: 9% fully acceptable, more or less acceptable 35%, more or less unacceptable 19%, unacceptable 33%, don't know 4%.
- g.m. of animals for production purposes: 3% fully acceptable, more or less acceptable 12%, more or less unacceptable 23%, fully unacceptable 60%, 2% don't know.

In this survey the members were also asked which aspects are decisive when buying meat:

| Decisive | price % | Freshness % | Housing of animals % | Killing mode % | Meat exterior % | Environm. aspects % |
|---|---|---|---|---|---|---|
| Never | 6 | 1 | 39 | 64 | 1 | 34 |
| Sometimes | 25 | 3 | 42 | 24 | 5 | 43 |
| Regularly | 40 | 16 | 15 | 9 | 28 | 17 |
| Always | 29 | 80 | 4 | 3 | 66 | 6 |
| Average* | 2.9 | 3.7 | 1.8 | 1.5 | 3.6 | 2.0 |

*4 points scale: 1=never, 4=always
Freshness (3.7), exterior (3.6) and price (2.9) are clearly the most important aspects.

Interesting also is the question on factual knowledge:
do you know that……….

| | Yes | no |
|---|---|---|
| Chicken feed standard contains medicines | 47 | 53 |
| From all chickens (free range and battery) part of the beak is cut off | 48 | 52 |
| Horns are cut away from all young farm animals (cows, sheep, goats) | 37 | 63 |
| Although forbidden, many meat animals are administered growth enhancers like hormones | 91 | 9 |
| Modern biotechnology is the same as genetic manipulation | 64 | 36 |

### *4.6. The Eurobarometer (Eurobarometer, 1997; Durant et al., 1998)*

The Eurobarometer on Biotechnology is probably the most cited report when it comes to assessing the impact of modern biotechnology (genetic modification) in the food production and the market. The Eurobarometer is periodically repeated, providing an opportunity to chart shifts in opinion since earlier surveys in 1991 and 1993.

A comparisson of the outcomes of the three consecutive Eurobarometer surveys shows that the number of 'optimists about the technology' is dwindling (Nielsen, 1997). In 1991 the percentage of optimists was 51%. The percentage of pessimists was 11%. In 1996 the percentage of optimists had

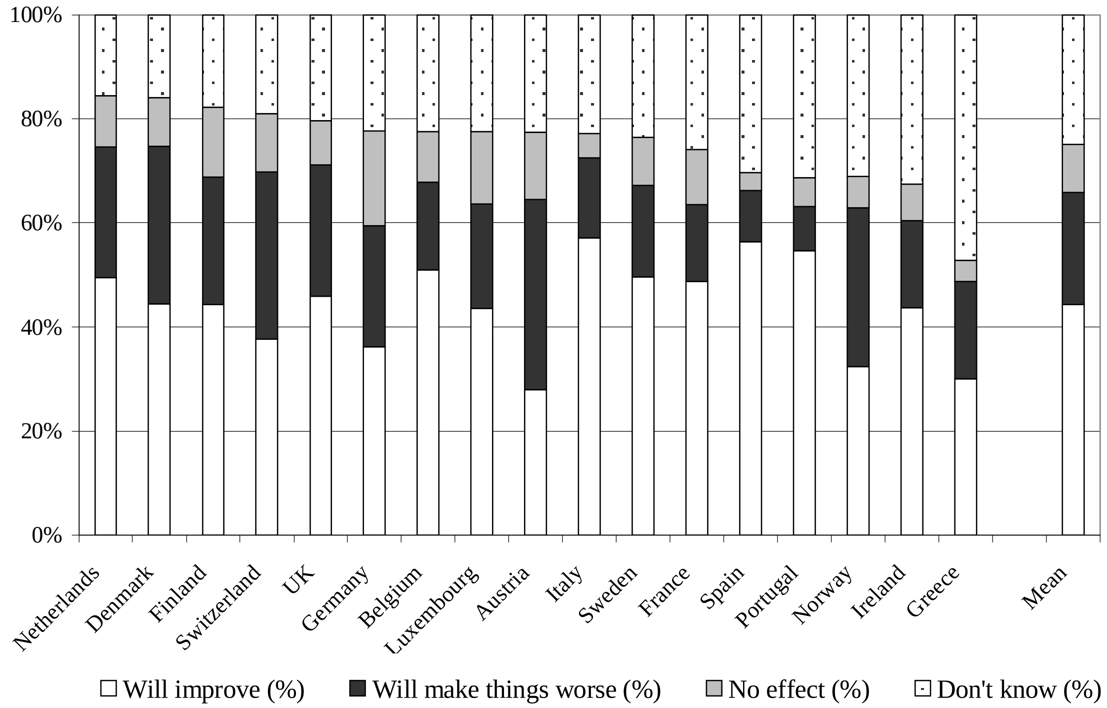



**Figure 1: Results by country of the question: 'Do you think biotechnology or genetic engineering will improve quality of life, make things worse or will make no difference? (Eurobarometer, 1997)**

dropped to 44% and the number of pessimists had grown to 21%.

An analysis of the beliefs about the effects of genetic engineering in general can explain differences in attitudes between countries (Figure 1). The results seem the contradict the idea that increased knowledge will create a more rational, thus positive attitude towards genetic engineering. There is even reason to conclude the contrary: the more people know, the less they seem to like it. Especially for applications in animals, agriculture and food, high levels of knowledge correspond with low levels of acceptance (Durant *et al.*, 1998). However, John Durant thinks it is not solely the level of knowledge that defines the general attitude of the public. Public expectations of biotechnology are generally highest in those countries where the technology has been applied the least, such as Spain, Greece and Portugal – and vice versa.

Nielsen (1997) thinks the large number of “undecided” (no effect, don’t know) in all the European countries might represent realism on the part of the public, rather than ignorance (Nielsen,). An “intuitive” public understanding of “declining marginal utility” might explain the public expectations to biotechnology. The public seems to understand that the consequences of modern biotechnology are uncertain because they depend on the politics of regulation and on market attitudes to applications. It states*: “The classical argument that beneficial technological innovation will diffuse in society stand to be contradicted or falsified by a persistent and widespread mobilisation of opinion against the technology. And the antipathy may be all the more effective because of its dual nature.*

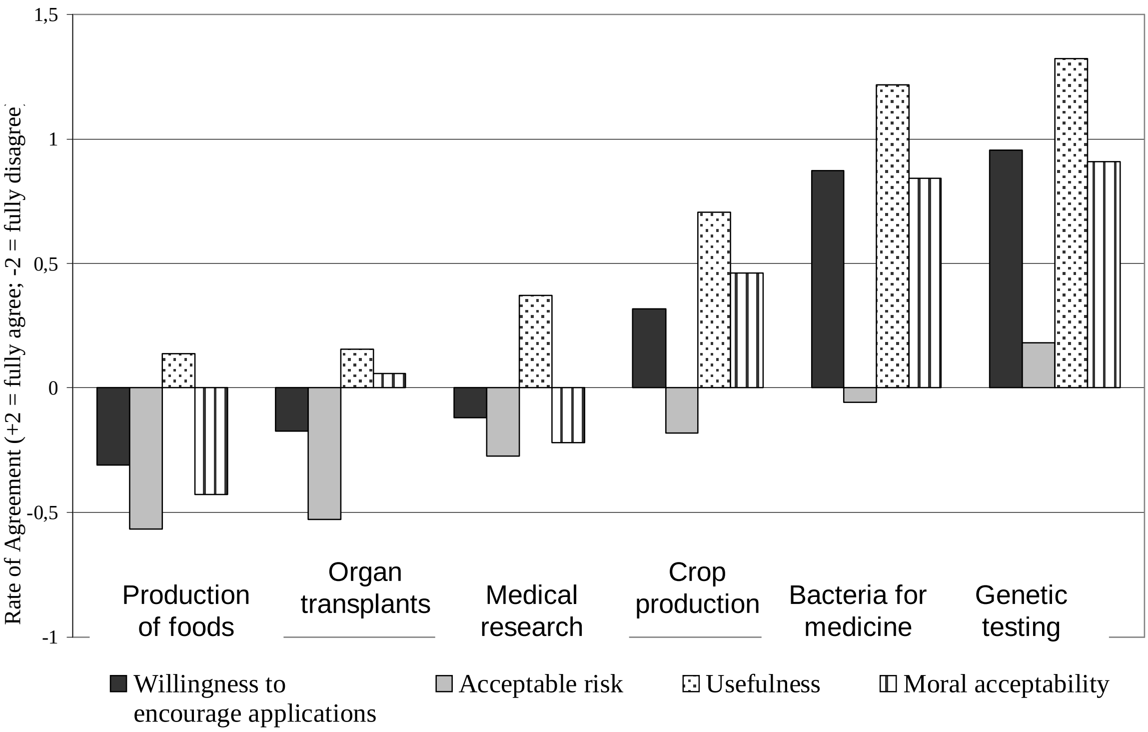
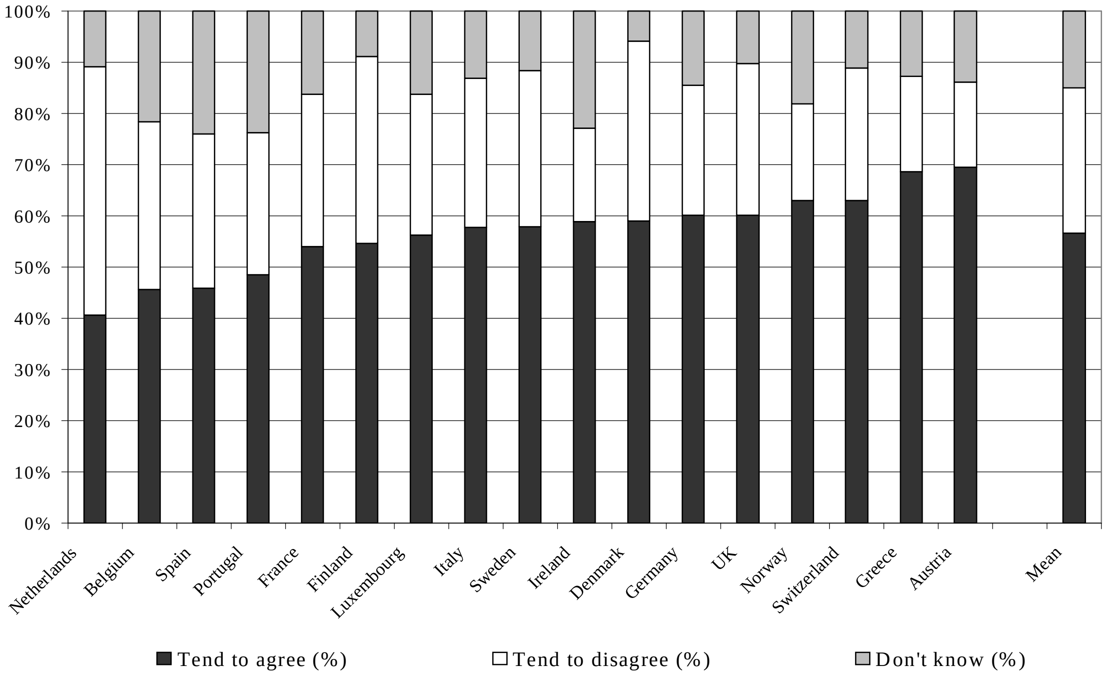



**Figure 2: Responses to questions about encouragement of further development, acceptablity of risks, moral acceptability and perceived usefulness (Eurobarometer 1997, average for all countries)**

*There is a profound difference between preserving the old order, and hesitating in the face of future risks. Until those in biotechnology recognise that, changing public  attitudes will continue to be a source of perplexity."*




Another analyses of the Eurobarometer was made by a team of researchers working as part of a Concerted Action of the European Commission (DG XII) in 1997. They conclude that large sections of the European public seem deeply ambivalent about much of modern biotechnology. The prevailing focus of this ambivalence appears to be moral, a collection of anxieties about unforeseen dangers that may be involved in a range of technologies that are commonly perceived to be 'unnatural'.  Their conclusions are best illustrated in Figure 2. The willingness for encouragement of further development of an application, which could be considered an indication for the level of acceptance, depends upon the nature of the application. The differences can be explained from a combination of the factors risk, moral acceptance and usefulness: Low perceived risk, moral acceptability and perceived benefits/usefulness correspond with more positive attitudes towards the applications.

A final general remark concerns the situations in which opinions tend to be quite polarised. Figure 1 shows this is the case in most countries: equal groups with  outspoken positive and negative opinions and an often rather large group that has no clear opinion (yet) or does not know. The members of the most positive and negative groups are not very likely to change their minds. New developments, incidents, the media and opinion leaders can make the people that do not have an outspoken opinion shift to either the group. It is practically impossible to forecast the moment, the direction and extent of such shifts.

One question in the Eurobarometer survey focussed specifically on plant and animal breeding: 'Only traditional breeding methods should be used, rather than changing the heriditary characteristics of plants and animals through modern biotechnology' showed the following reactions.

Figure 3: **Responses to question: 'Only traditional breeding methods should be used, rather than changing the heriditary characteristics of plants and animals through modern biotechnology' (Eurobarometer 1997, by country)**

**5. Survey amongst consumer and animal welfare organisations**

Although the influence that consumer and animal welfare organisation have on the factual purchasing habits of consumers is limited, they certainly do have influence on the public perception in regard to meat quality, meat (animal) production systems and animal welfare systems. Through their lobbyists they also influence the legislative process. This means that it is important to breeders and producers of animal products to take into consideration the demands those organisations put forward in regard to the whole production chain (from feed to food).

The Consumer and Biotechnology Foundation (C&B) did a survey that consisted of two parts. The first part was made up with questions regarding the interest (consumer) organisations have in the subject of animal breeding, keeping of animals and the quality aspects of animal food production. The second part focussed on three future scenarios which were put forward to them.

On 10 December 1998 a questionnaire was sent out to 50 consumer organisations and 11 animal welfare organisations. The questions were related to a number of scenario's in regard to the future of farm animal breeding. On January the 7th 1999 a reminder was sent to the same addresses.

On the 3rd of February 1999 13 completely filled out questionnaires have been received. So the score is 21%.

The questionnaires received came from:

1. De Verbruikersunie, a Belgian consumer organisation
2. The Farm and Food Society, a British organisation of family farmers
3. Talis/Aequalis, a French animal welfare association
4. EKPIZO, a Greec consumer organisation
5. GAIA, a Belgian animal welfare organisation
6. Verein für Konsumenteninformation, Austrian consumer organisation
7. Kuluttajaliito, Finnish Consumer Association.
8. ADDA Association, Spanish animal welfare organisation.
9. OCU, Organizacion de Consumidores y Usuarios, Spain
10. CLCV, a French Consumer Organisation
11. Eurogroup for Animal Welfare, Brussels, Belgium
12. National Consumer Research Centre, Finland
13. Dutch Society for the Protection of Animals, Den Haag, the Netherlands

This ads up to the following conclusions:

- a questionnaire is perhaps not the best way to get information from this type of organisations, or
- the subject is of minor importance to those organisations.

### *5.1. Review of the answers Questionnaire part 1, general questions*

The first question was about the involvement of the organisation in the subject of animal breeding and or the sale of animal products. Of the consumer organisations 2 are actively involved, 2 are not actively involved and 3 have some involvement. Of the animal welfare organisations 5 are actively involved and one answered with “some involvement”.

One of the most important general questions was: “Do you consider animal breeding and live stock production important consumer issues?” The answer was a clear “yes” from 12 out of the 13 respondents. This needs no further discussion. Next they were asked to be more specific on the various aspects of live stock production. The ethical aspects of animal breeding are considered to be important consumer issues by 4 consumer and 6 animal welfare organisations. Two consumer organisations thought it to be of some importance and one did not answer the question.

The question about the ethical aspects of animal keeping (factory farming) resulted in almost the same score, respectively 5, 6 and 2.

The safety of animal products is an important consumer aspect according to all respondents, as is the use of growth promoters. The irradiation of meat (or other animal products) and the genetic modification of farm animals are also important consumer issues. Strikingly, one consumer organisation thought both subjects to be of minor importance to consumers as long as the safety of the products was guaranteed.

Some conclusions from this part of the questionnaire:

The two consumer organisations that said ‘no’ to the first question are not actively involved in the subject, but nevertheless do test animal products en publish about it. One of the two organisations also answered ‘no’ to question number two, which is a bit strange as later on they do agree on most of the aspects from question 3.

The overall conclusion is that consumer and animal welfare organisations are rather unanimous in their answers. They do agree on the fact that animal breeding and live stock production are definitely ‘consumer’ issues, including the more specific aspects of animal production.

### *5.2. Reviews of the answers Questionnaire part two: scenarios*

In this part of the questionnaire, after a short general introduction, the organisations were confronted with three possible scenarios for the future in farm animal breeding. In brief the scenarios read as follows:

A) conventional path: more or less a continuation of the current system, with emphasis on perfect animals and products for a reasonable price.

B) welfare path: emphasis on animal welfare, moderate production levels, but resulting in higher consumer prices.

C1) high tech path: emphasis on maximum production levels and efficiency, special product traits and fairly low prices.

C2) high tech path: emphasis on maximum production levels and efficiency, special product traits and fairly low prices, including the use of biotechnology and cloning.

The organisations were questioned in detail on all possible aspects and choices in respect to the three scenarios. To start with the scenarios, C1 and C2 are definitely rejected by 10 out of the 13 organisations. Only one consumer organisation is willing to discuss it to some extend. Two organisations did not answer this question. The Scenarios A and B are more or less acceptable. For Scenario A the score was acceptable 6, not acceptable 2, to some extend 4. Scenario B scored respectively 7, 1 and 4.

Which of the following breeding technologies are acceptable to your organisation?

1= no problem; 2 = acceptable; 3 = acceptable for product quality and healthy products; 4 = only acceptable for welfare and disease resistance; 5 = not acceptable; 6 = don't know.

| Technique | 1* | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Reproduction: | | | | | | |
| Artificial insemination | 2** | 4 | | 1 | 3 | 1 |
| Freezing of semen | 2 | 4 | | | 3 | 2 |
| Heat induction | | 1 | | | 5 | 4 |
| Embryo Transplantation | 1 | 1 | | | 6 | 3 |
| Ovum Pick-up | | 1 | | | 6 | 4 |
| In Vitro Fertilisation | 1 | 1 | | 1 | 5 | 3 |
| | | | | | | |
| Cloning: embryo splitting | 1 | | | | 9 | 1 |
| Cloning: nuclear transfer | 1 | | | | 9 | 1 |
| Sperm sexing | 1 | | | 1 | 4 | 5 |
| Embryo sexing | 1 | | | | 6 | 4 |
| Monosexing (fish) | | | 1 | | 6 | 4 |
| Inter specific hybridisation (fish) | 1 | | | | 7 | 3 |
| Triploidisation (fish) | 1 | | | | 8 | 2 |
| Cytogenetics (fish) | | | | 1 | 6 | 3 |
| | | | | | | |
| Selection: | | | | | | |
| Gene mapping | 1 | 3 | | 1 | 3 | 2 |
| Marker assisted selection | 1 | 2 | | 1 | 2 | 4 |
| Genetic. Modified animals | | | | | | |
| With DNA introduced from The own species | 1 | | | 1 | 8 | 2 |
| Transgene animals (DNA From other organism) | | | | | 10 | 2 |
| Transgene animals for Xenotransplantation | | | 1 | | 8 | 3 |

* = rating, ** = number of respondents

### 6. Discussion and conclusions

#### *6.1. Discussion*

In 'Agrarisch Dagblad' of 24 December 1998, an article was published under the heading '*Ballot paper or cashier ticket'* (Vullings, 1998). The major statement of author Jan Vullings reads*: "The public goes shopping with two hats on. As good citizens they like to follow the lamentations of the animal protection organisations about the so-called abuses in animal keeping. But as soon as this good citizen enters the supermarket, he no longer acts as critical consumer. He looks at the cashier ticket instead of the ballot paper. A double standard. And it is just this double standard that wreaks havoc on the farmer'.*

This article describes the problems the farmers have with the demands for safe, healthy, welfare friendly and environmentally sound products: *"Demands aired mainly by the consumer and animal welfare organisations. It is no problem to the farmers to deliver those products, but it has a price. And as long as the consumer is not willing to pay a fair price and keeps looking for cheap foods nothing will change".*

Apart from this ‘double standard’ amongst consumers it is obvious that the whole situation in regard to animal production systems is highly polarised, with a fairly large segment of the population ‘undecided’. The latter may, depending on incidents and media attention for the subjects, develop a more polarised attitude. This development will depend on a great number of factors. One factor is the influence groups with more extreme attitudes in the field of animal production systems may have on the debates and the legislative system. Another factor is the type of application and the perceived benefits to the consumer. Also the media could play an important role in the process. Highlighting incidents, the headings of articles and the general ‘tone’ could create a very negative image to new developments like genetic modification and cloning. On the other hand, a more positive attitude from well trusted sources like consumer and animal welfare organisations could create a more positive attitude amongst the ‘undecided’.

In Chapter 2 it was presumed that the genetic modification of animals will trigger a discussion on animal products at large (breeding, housing, product segregation, labelling) as an analogy with the introduction of gmo-crops.
The question is: does the studied literature support this hypothesis? To be honest, a clear yes or no is not possible because of lack of clear data. The reason for this is that most of the material was on the genetic modification of plants and the material on animals focussed primarily on animal products and not on the breeding of animals.
On the other hand, some surveys give at least some indication that there is reason for a cautious approach of the matter. The SWOKA survey (Smink, 1998) indicates that, at least in the Netherlands, a large portion of the respondents is weary about the genetic modification of animals for improved production traits. Only a small majority would accept the genetic modification if the benefit was clear, i.e. the production of life saving medicines for example. A result close to the outcome of the (also Dutch) Consumentenbond survey (Van Genderen, 1995). And in the case of the gm-farmed-salmon (Becker *et al*, 1998) a mere 55% of the respondents said that they would or might try the fish. Which leaves 45% saying no.
The weariness of large numbers of consumers will undoubtedly lead to a debate on the genetic modification of animals. But what shape this debate will get remains to be seen.
By parity of reasoning the question whether genetic modification of animals is an issue that concerns consumers (Question 2) is more or less answered. In addition, the results of the questionnaire amongst the consumer and animal welfare organisations show clearly that the genetic modification of animals is definitely an aspect that concerns them. And they are the organisations that may set the stage for a debate.
The question whether it is possible to distinguish between different purposes of the modification, can only partly be answered. Again the SWOKA and Consumentenbond surveys (Smink, 1998, Van Genderen, 1995) give an answer: yes, consumers do look at the type of modification and the purpose. If the benefit to society is seen as important, less opposition can be expected as is the case when this benefit is not so obvious or absent. And on basis of the Eurobarometer there is little reason to expect really fundamental differences in this aspect between the EU member states.

Question number 4, is it possible to have a fruitful dialogue between breeders and the public, is most difficult to answer. The soy-case has taught us that the introduction of gm-products, without any consumer benefit and no communication and dialogue, will backlash on the sector. On the other hand, no one can guarantee a smooth introduction of genetic modification of animals, for whatever purpose, by having such a dialogue.

From the questionnaire, how limited the response may be, we can learn a few things. First of all, as said before, genetic modification of animals does concern the consumer and animal welfare organisations. Which means that the average consumer will hear about it. Also, the animal welfare organisation, and to a lesser extend the consumer organisations, opt for scenario number two. This is the scenario in which the breeding is focussing on animal welfare and health aspects. Some consumer organisations are in favour of reasonable priced, good quality and safe end products and do not have such clear-cut ideas of how to reach this goal. Although, the genetic modification of farm animals does not have their preference. Remains the question whether the average consumer is prepared to pay the price for welfare friendly products.

### *6.2. Conclusion and recommendations*

When introducing new, sophisticated techniques like genetic modification of animals, the following should be taken into account:

- the benefits of new product(s) or techniques should be evident and clearly demonstrated to the general public.
- there seems to be little public support for the genetic modification of farm animals.
- the genetic modification of farm animals for medical purposes seems to be more acceptable to the general public than for production purposes. However, a large scale destruction of gm-farm animals, or the use of carcasses from gm-animals for feed and/or food purposes may easily trigger a discussion on the sector as a whole.
- segregation of the products derived form gm-animals and labelling of the end product will give the consumer the opportunity to choose.
- general consumer concerns are to be taken serious and tackled with openness and, whenever possible the will to comply with those concerns (demands) in terms of R&D.
- in order to become familiar with those consumer concerns and to create a future scenario, which has support in society, an open pro-active discussion should be started at an early stage. The breeders should preferably base their policy on the outcome of a dialogue with the consumer and animal welfare organisations

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# Discussion

*regarding presentations by John McInerney and Arie van Genderen*

***Dave Burt – UK***

I like to suggest an alternative interpretation of consumer views on the use of genetics in animals. Rather than concerning of consumers about welfare, I would suggest that it has more to do with perceived food safety. For example, there is a perception on Tracy and other genetically modified farm animals, a perception, whether it is true or not, that eating a genetically modified organism is not healthy. So nobody cares about the animals welfare.

On the other hand it is OK to use a genetically modified organism for medical purposes. So: they do not care, but if these cure faster. I propose the opposition has not to do with animal welfare. It is food safety. Would you like to comment on that?

***Arie van Genderen***

I more or less agree with you. In many aspects, if you look at genetically modified plants safety aspects are the first things people are concerned about. As for animals, I expect, safety would come first. And then animal welfare. The article in the proceedings supports your statement.

***Nanke den Daas – The Netherlands***

My question relates to the consumers' perception of animal breeders. Whether, although all animal breeding organisations do not want to use, or still discuss about using genetically modified animals, the public perception is that there *are* genetic modified animals? Do we have information on this, whether the public perception is so ambivalent? And, if that is the case, should we then fight that perception by saying no, we do not? Or should we say yes, we do but we do it in such and such a way?

***Arie van Genderen***

The perception that there are modified animals is already rather widespread. The man in the street does not distinguish between farm animals and pharmaceutical animals. You could try to fight that perception, but I do not think you will succeed.

I can not find scientific evidence to support this, but it is my feeling. I have been having a lot of discussion about this subject in the last three years, and everybody is convinced that the discussions on genetic modification of animals will spread on all the animals. Farm animals or not.

***Nanke den Daas – The Netherlads***

So this is like the speaker said this morning: what is true is what is believed.

***Arie van Genderen***

In most cases, yes. That is the reason why we, as an organisation, and all the other consumer and welfare organisations have an obligation to the public to get the facts right. That is not the same as convincing the public that they have a wrong perception.

***Peter Bradnock – UK***

Could you reconcile about consumers being most interested in the price of the products?

***Arie van Genderen***

My experience in a lot of discussions in the Netherlands on this part of the discussion  is that the consumer is aware of the production system and wants to buy safe, ethically sound products. Also end products. Free range eggs etcetera. There is an awareness among the public. Also the awareness is growing, but still it is only a very small proportion of the public.

I am afraid this proportion might still grow a little more, but as soon as economy goes down a bit, we are back were we started: at price. I am rather pessimistic about it.

***J.P.M. Schenkelaars – The Netherlands***

Coming back to the perception of the public that animal farms are already being genetically modified. I would like to remind this for the discussion where the animal breeding industry would like to go for the high tech path producing biopharmaceuticals. If you choose for that option, you will go definitely to genetic modification. If you are looking for livestock for meat production or milk production, as in the in the diagrams shown this morning, only in the low cost path transgenesis would be useful. So, I mean it is really not to ethical breeders at this moment to decide whether they want to join life science industry to go also for the fourth high tech path. If breeders decide not to breed for pharmaceuticals, then they have an option to explain to the public: “We are only breeding for food production”. Then you can make definitely clear that you are not going to use genetic modification. This is also a strategic option within your reach at the moment.

***Jan Merks***

This point should come back to the general discussion too. It gives an overview of a lot of aspects we are dealing with nowadays.

***Jean Paul Renard - France***

Is there a kind of hierarchy regarding the species of farm animals for the consumer or is there no hierarchy between animals?

***Arie van Genderen***

I have seen surveys where it was suggested that there is a hierarchy. The higher ranking the animal is, the more concerns there are. Mice are lower in the hierarchy than cows, or monkeys.

# Farm animal breeding and the law

*Christine Noiville*[1]

Industrial property on farm animal inventions has become clearer in Europe since the recent adoption of the E.U. patent directive. In many respects, the situation is satisfactory, since a patent is a useful tool. It confers a 20-year monopoly to the inventor of a new and useful product or process, as long as it is disclosed to the public. As such, a patent is a fair return to innovators and an incitation to technical progress. This paper analyses the impact of new patent law on farm animal breeding and selection. It first examines what is patentable in farm animal breeding technologies and products. It then turns to the potential problems that may be associated with such patents. In the final section, the paper examines if animal welfare, a concept that is gaining a growing legal importance, may put special constraints on future breeding work.

## I. An equitable return for farm animal breeding innovations

European Patent law requires that any invention be novel, inventive and has industrial applicability. The invention has also to be a patentable subject matter (not excluded by patent law) and must meet the requirements concerning enabling disclosure (a person skilled in the art may actually reproduce the invention) and clarity (the language must be comprehensible). Since most of these requirements could not traditionally be met with animals, European patent law excluded animal varieties and most methods of producing animals.

With scientific and legal evolution, things are far more favourable today. It is now possible to patent a gene and its application in an animal, an animal itself and methods of breeding.

### A. Patents may be granted on technical processes for the production or selection of animals

#### *a) Production methods*

The rule is that patents cannot be granted for essentially biological processes for the production of animals, but microbiological or other technical processes are patentable.

It is logical that essentially biological processes for the production of animals are not patentable, because they consist entirely of natural phenomena. No one can be granted an exclusive right on traditional, widely used methods like crossing or interbreeding.

Conversely, microbiological processes ("any process involving or performed upon or resulting in microbiological material") are patentable, as well as other technical processes. As soon as a process incorporates a stage that cannot naturally occur, this is considered to be technical and can be protected. The question of whether a process is "essentially biological" (non-patentable) or "essentially technical"

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(patentable) is therefore one of the degree of technical intervention by man in the process and its impact on the desired result. When, in a process for the production of animals, biological as well as technical elements are present, one has to find out where the core of the invention lies. If human intervention plays a determining - and not only supporting - role in the invention, if it plays a significant part in controlling the result to be achieved, if the quality of this intervention is more than routine manipulation of a known and naturally occurring biological event, if the result of the process is substantially different from those provided by natural phenomena or classical breeding processes, then the human intervention is seen as decisive and the process considered as patentable.
In this context, 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.

***b) Marker-assisted selection methods***

Apart from this new kind of method, a large number of processes do not "produce" new animals but help to select animals with desirable traits: marker assisted selection, DNA genotyping, genetic fingerprinting, ovum pick-up, etc. As none of these methods are "processes for the production of animals", they only have to satisfy classical patentability requirements. But two things must nevertheless be kept in mind. Firstly, they must not be "methods for treatment of animal body by surgery or therapy" nor "diagnostic methods practised on the animal body", because they would then be excluded from patent law (which will not be the case for most current methods). Secondly, using DNA information for the choice of a breeding animal does not make the animal genetically modified; only the use of the process by laboratories or breeders will give the right to a royalty payment.

**B. Patentability of animals**

Inventors generally seek a stronger protection than process patents and try to have animals as such patented as well. The E.U. patent directive confirms that such a protection is possible. Each new animal, as long as it is also inventive and applicable in industry (which will be the case either if the animal is used for milk or meat production or if it is raised for the production of organs or therapeutics), is patentable as such. This is the case for genetically modified animals (transgenic, knockout, etc.) in which part of the DNA has been technically changed in a way which would not occur by natural processes. Should a patent be granted on the animal as such, no one can reproduce it - whatever the technical mean used - without being authorized by the company or the researcher holding the patent.
Some have feared that the patentability of new animals would nevertheless be hampered by the exclusion of animal varieties. As a matter of fact, for historical reasons, both EPC and the E.U. directive exclude animal varieties from patentability. But it is far from being a source of legal insecurity. The main reason is that inventions currently developed in the biotechnological field may be applied not only to a particular variety, but also to a whole higher taxinomical degree. For example, a company that discovers a coding gene for a substance increasing muscular growth or a new cloning technique can apply this

invention to any animal. The exploitation of the invention is not only possible in the form of an animal variety, like a cloned charolaise. The company will then claim exclusive rights over any cloned or transgenic non human mammal as exemplified in the patent, not only over a "cloned charolaise". Once the invention is applied to varieties - charolaise, holstein, etc. - by breeders, the company will be entitled to collect royalties.

**C. Patentability of animal genes**

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.

One thing which must be well understood is that 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.

One can see that European patent law will duly reward research efforts in the farm animal breeding sector and that ideas sometimes expressed by companies and breeders - appropriation by a patent of "mere conventional breeding practices", impossibility to patent new animals because of the "animal variety" exclusion - are wrong. But it is now necessary to focus attention on the potential risks of the new patent law in the practice of breeding.

**II. Potential problems associated with patents in farm animal breeding**

This part of the analysis is naturally more speculative. This is only the beginning of a patent registering period, which makes it difficult to have a general view of who possesses what and what are the strategies adopted. The opportunities of delivered or claimed patents for major innovations in breeding are still unclear. The impact of new technologies will depend on the way these technologies are marketed, and at what price. Will they be embodied in G.M. animals as such or in processes, like vaccines? In some cases, there may be a direct choice available between these alternatives, depending on economical and acceptability factors.

Three problems have nevertheless been identified: a risk of competition between patentees and traditional breeders; a potential problem attached to broad patents on products or processes; application of the "farmer's privilege" and traceability of patented animals.

**A. Risk of competition between the patent holder and traditional breeders**

A simple example will help understand the situation. A company gets a patent on a genetic modification process making cows resistant to mastitis infection. Obviously, this invention will present an economic interest for him only if it is applied to bovine varieties. The company will then claim protection for "any transgenic cow resistant to mastitis infection" and will be entitled to collect royalties for any commercialization of any bovine variety genetically modified as exemplified in its patent. The company may then sell the genetically modified animals, without any authorization from the developer of the traditional varieties used. The latter won't be able to fight it and won't obtain any return from it since traditional breeding practices are not protected under any intellectual protection law.

Traditional breeders are becoming aware of this potentially unbalanced situation and are beginning to organize some form of protection of their breeding work. A first type of protection is currently organized through sales agreements: by using sales contracts, breeders intend to allow biotechnology companies to take advantage of their breeding practices only if the companies buy the varieties. A second type of protection is to get animal varieties protected under tradenames: several breeders in the pig sector are currently trying to protect new pig varieties by a trademark.

Neither of these two types of protection really appears satisfactory. The first one implies a constant and difficult control of the use of breeds. In fact, the breeder will sell breeds to farmers, some of them reproducing the breeds. Even though farmers generally commit themselves not to sell breeds to anybody, there is a risk that such a situation may arise. The breeder cannot do anything, neither to effectively prevent such releases, nor to fight against the patent holder who will modify and commercialize the breed since he is not a counterfeiter. Protecting animal varieties by trademarks does not work much better. Actually, trademarks only protect a name: by being the only one to use this name, the company gets a competitive position on the market. But trademarks do not protect the genetic improvement realised by breeders. Should a biotechnological company apply its invention to the variety and sell the genetically-modified variety, the breeder could not oppose it, even though his variety is protected by a trademark. From a legal point of view, a better system would be to create intellectual property rights for animal varieties. Certainly, such a project comes up against several difficulties, like the legal definition of varieties. But in any case, such rights would provide better protection than the two types seen above.

**B. Patents and effects on research and development in animal biotechnology**

Theoretically, patents promote innovation and stimulate industry and academia to constantly pursue innovation. But as far as biotechnological inventions are concerned, it has been feared that patents may hamper the research and development of new innovations, for patents in this field are sometimes very broad.

***a) Research exemption***

It must be recalled, nevertheless, that patent law has a "research exemption" rule, whose goal is precisely not to block fundamental research. Any breeder or any company has a free access to patented animals or genes and may experiment in order to develop a new application of the gene or to perfect a protected method. But as its name suggests, research exemption is only valid within the confines of research. As soon as the breeder or the company develops an invention closely related to the patented one (for ex. a new application of a patented gene) and wants to commercialize it, he may be obliged to get the authorization of the patentee. The latter is not obliged to grant a license and may prevent the second invention from being commercialized. Such a position is uncomfortable, for the current trend in biotechnology is to deliver broad patents conferring wide monopolies. In this field, the risk that an invention be dependent on another one is therefore high. Is this also the case in animal biotechnology?

***b) Effects of broad claims***

Although the few wide patents found today in this field particularly concern animals used as experimental models or bioreactors, there are also some examples of wide patents regarding breeding of farm animals. For instance in aquaculture, one patent claims "all transgenic fish" expressing a growth hormone gene. Wide claims are also numerous in patents covering animal genes, such as genes encoding bovine prolactin, porcine growth hormones or salmon growth hormone, which already seem to be protected by a large number of potentially overlapping patents. A first inventor has a patent on the gene and its use, which is described in a relatively abstract manner ("the muscular growth regulation function operated by the myostatin gene"). A second inventor holds claims on a more specific part of the same gene for a more specific application ; a third one...etc.

In some of the above examples, the wide monopoly is legitimate because if the inventor was only protected for what he actually achieved - a specific transgenic salmon or a specific gene - anyone could freely carry out his invention by using a slightly different gene performing the same activity or by crossing the patented gene into a different species. The patent would therefore be commercially worthless. From a business perspective, wide claims are therefore essential to obtain effective control of breeding technology. But with regard to the future of research and development in this field, important questions must still be answered. For example, should insertion of a growth hormone gene into a pig always be a basis for claims over other farm animals, even if the effectiveness of the transformation techniques on these other strains may not be known at the time of patenting? In a similar vein, in a research sequence moving from a relatively abstract idea - for ex. "a fish gene having an antifreeze function" - to detailed implementation - a more precise description and application of this gene -, who should have what rights? As a matter of fact, excessively wide monopolies can prevent the useful improvement of inventions. Several patent-law directions should be considered by patent offices and courts, such as a strong non-obviousness principle and a reasonably limited scope of patent claims.

***c) Patents on biotechnological processes***

Fears are more concrete here because of the numerous patents on animal breeding and reproduction inventions, many of which are already distributed in the form of processes and some are licensed, so that effects on the breeding sector are easier to anticipate.

Some of these patents apply to specific and quite narrow situations (cloning of bovine embryos, method of producing transgenic pigs, process of culturing avian embryos, etc.) but others are broad patents on basic processes of animal breeding. For example, several broad patents cover basic approaches to the production of transgenic animals, such as a patent on genetic transformation of zygotes. Above all, a similar situation of broad patents exists in the field of marker-assisted selection tools. Here, a growing number of patents - especially in the pig sector - protect methods of detecting genetic mutations or genetic variations in functional genes that directly influence production traits, for example pigs that are resistant to stress or more likely to produce larger litters or to develop less intramuscular fat.

As the first generation of patents with a real impact in the animal biotechnology field, such patents have sometimes caused concern in the animal selection sector. The owners of these patents are in a position to require royalties from a very large number of persons working in the pig sector and the patent may be very difficult to bypass because of the broad monopoly. For instance, a Canadian company holds a patent on a "mutant RYR1 gene" and a method of identifying said gene in a pig. Claims are drafted in such a way that any method to determine the presence of the mutation is protected by the patent. Any improved process proposed by another company would be considered counterfeiting, which is all the more inconvenient when the requested royalties seem high. In these areas, it may be necessary to support public sector research and to explore ways to develop intellectual property arrangements in order to ensure that these techniques are available to the whole breeding sector at fair commercial conditions. This is particularly important for patents on methods of detecting diseases such as mad cow disease. In such situations, it would seem necessary to make adjustments to the patent system, which could rely upon a compulsory licensing mechanism tailored to this problem of broad patents.

**C. "Farmer's privilege" and traceability of genetically modified animals**

With the farmer's privilege, which is an exemption from traditional patent law, the E.U. directive tries to establish an equitable solution whereby both the farmer and the patentee will benefit from the invention.

***a) The exemption***

As far as he is concerned, the farmer appears to have the legal right to mate the patented animal and to perpetuate offspring without royalties. As long as it is for an agricultural purpose (milk, slaughter...) and not for a commercial reproduction purpose, it is not an act of infringement to reproduce a patented transgenic farm animal through breeding, to use such animal in the farming operation, or to sell such animal or the offspring of such animal. Though it is still difficult to know whether this exemption will be worthwhile for the farmer - because little is known on the genetic drift of transgenic animals - such a rule will be important especially for small farmers who intentionally reproduce animals.

Acting as a breeding company, however (selling the germ cells, semen or embryos of a patented animal) is considered to be commercial reproduction and is forbidden, as it is in direct commercial competition with the patentee. The patent holder has the legal right to forbid such use of his invention or to claim royalties. Nothing is clear, however, about application of the derogation, which is left up to the different countries' responsibility.

***b) Application of the derogation***

Firstly, states will have to specify exactly what the exemption means: does "pursuing of the agricultural activity" include the reproduction, by a farmer, of a patented transgenic sheep producing a therapeutic molecule in its milk? Does "livestock" include aquaculture fish? Secondly, states will have to take a position on a more fundamental issue: the control of transfers of genetically-modified, patented animals between farmers.

In fact, although this may vary according to the species, patented animals will be dispersed from farm to farm. For example, in the beef cattle sector, transfers between farms are frequent and types of use are varied (bulls sold for immediate slaughter, for breeding purposes, etc.). Logically, the patentee should then sell breeding stocks with a side contract specifying the requirement to indicate any transfer of semen, embryos or animals. He could then monitor each transfer of patented animals, identify transfers for "commercial reproduction", test each animal and check which ones carry the patented genetic modification, and finally ask for royalties. But such monitoring seems highly difficult: is it realistic to expect farmers to become involved in such patent enforcement? Is a monitoring of sales and collection of royalties possible given the large volume of sales and numerous changes of ownership? Facing such difficulties, the patentee may find that policing to collect royalties is unnecessary and that marketplace solutions present the most efficient method of allocating the cost of enforcement. He may carry out no monitoring and claim no residual rights to fees but merely sell the animal for a higher price.

Today, national authorities tend to let companies and patentees find such marketplace solutions. Their first reaction is to transcribe the farmer's privilege "a minima", without any special rules, and to let things evolve as regards choice of companies commercializing G.M. animals. But such a solution may not be satisfactory, for two reasons. Firstly, a "pricing policy" could make the cost of the patent prohibitive and ruin the usefulness of the farmer's privilege, whose idea is to prevent, for practical but also for economic reasons, the payment of excessively high prices. Secondly, although patent law does not itself require any monitoring of animal transfers and uses, such monitoring may soon become mandatory since traceability requirements are emerging in the field of GMOs, in order to prevent ecological consequences or sanitary risks and to establish separate channels - genetically/non genetically modified animals and food derived from them - leaving the consumer free to choose. In the same way as it is already enforced in the bovine sector, traceability may oblige those concerned to organize the close monitoring described above, instead of simply choosing "pricing policies". For this reason, it appears necessary for States to participate, alongside breeders and farmers, in a global reflection on the articulation of patentees rights, farmer's privilege and traceability issues (which system, who pays ?...).

## III. New breeding technologies and animal welfare

As seen above, the development of new breeding technologies is supported by the law. But at the same time, it may be limited for reasons of animal welfare, a concept which is gaining a growing legal importance and which could put special constraints on future breeding work.

### A. Such a constraint is already reflected in patent law itself.

As such, patent law does not create any welfare or ethical problems. A patent only constitutes intellectual (not real) property. Moreover, a patent is only a monopoly for commercial use but does not make the invention acceptable to society. Even if a patent has been granted, the use of the invention may require authorization. Conversely, a ban on patenting does not prevent development and use of inventions that could make an animal suffer. Nevertheless, in accepting patenting, the patent directive makes a strong choice in favour of the development and use of biotech. inventions. It has therefore become necessary to put limits in the text. As far as animals are concerned, "processes for modifying the genetic identity of animals, which are likely to cause them suffering without any substantial benefit to man or animal, and also animals resulting from such processes" are not patentable. More broadly, "inventions shall be considered unpatentable where their commercial exploitation would be contrary to public order or morality". Any application for patent in the animal field will be subjected to a systematic ethical assessment. It will then need to have a clearly stated purpose so that its justification can be assessed by patent examiners.

Welfare is not the only concern expressed by the E.U. directive, which also expresses a more philosophical concern - the identity of animals - about the mixing of human and animal genes or the creation of outrageous chimeras. But welfare nevertheless gets a determining role that may hamper patentability. The patent examiner must find out which human benefits are at stake and in cases where animal welfare is adversely affected, find out whether the "costs" in animal welfare will outweigh any reasonably expected human benefits. Inventions fighting against animal diseases and developing healthier animals would probably be patentable even if there is no clear human benefit. On the other hand, transgenic animals with enhanced productivity are a benefit, but some of them are subject to so many health disorders or discomforts that they may not be patentable.

Though the directive's measures are mere guidelines still open to interpretation by patent offices, it illustrates a very new legal trend. Traditionally, patent law has been considered as merely technical: novelty, non-obviousness and industrial applications were the only criteria determining patentability, public order and morality being very rarely applied as an exclusion. The directive illustrates a new trend where ethical matters - although subjective - and especially welfare matters may partly determine the protection of new animal inventions. It is likely that such a trend foreshadows a broader legal evolution, where animal welfare puts increasing legal constraints on breeding and selection.

### B. Animal welfare may become a legal constraint for the future of breeding

Dealing with welfare in patent law only is not entirely satisfactory. Unpatented methods and animals may still develop freely, outside welfare considerations. Besides, patent law's primary objective is to stimulate the development of biotechnological inventions, so that in cases where negative effects are not clearly established (for ex. in vitro production of bovine embryos which could lead to problems with offspring), patent law will rarely use the so-called "precautionary principle" and wait for clearer justifications. And lastly, patent law considers welfare at quite a late stage in the development of inventions, while it would be more logical to think about it earlier. Welfare issues should primarily be dealt with elsewhere, in the current legal framework of breeding licenses.

This is not really the case today. Most rules on animal welfare apply to experimentation or farming practices (bad treatment, etc.) and do not put special constraints on breeding work. When a breeding program is approved by national authorities, there is generally no legal obligation to consider its welfare implications. In most European countries, the development of new transgenic animals will be assessed for its ecological and human health effects, for its zootechnical aspects and the genetic input it provides, but rarely for its consequences on welfare, this aspect being a matter of "moral conscience" for the breeders.

But for three combined reasons, it is anticipated that welfare will soon become a legal imperative in this area too. Firstly, welfare has become a key concept in law, which is more and more legally binding and more and more widely interpreted, beginning to extend to issues like adaptation to the environment, normal behaviour, not breaching the identity of species, and even to breeding and selection goals. A recent case brought before the European Court of Justice thus questioned the ethics of breeding Belgian-blue cows, which generally need caesarians to deliver. Secondly, even if welfare problems are not limited to biotechnology - which sometimes may indeed help to preserve farm animal welfare -, biotechnology has amplified the need for a global reflection on what is or is not desirable in the breeding sector. Thirdly, because the techniques are new and often lack public support, biotechnology has a propensity to push towards new and generally strict regulations, calling for an assessment of risks and opportunities.

With biotechnological developments, recommendations and regulations of animal breeding have multiplied over recent years. Many national administrations or committees are thinking about the direction breeding programs should take in terms of desirability, according considerable importance to welfare considerations (cf. French CNAG and English Farm Animal Welfare Council). For example, some reports suggest that broiler breeding companies now put emphasis on reduced leg problems and that turkey breeders are producing a less aggressive strain of turkeys which do not require beak trimming. The Danish Ethical Council also made a statement on the breeding of animals that are prone to birth difficulties, stating that performing caesarian sections is not a welfare problem in itself but it is unacceptable to continue breeding animals that are expected to need this procedure.

Legal rules have also been set up by the Council of Europe, which tend to take welfare into account when setting up a new breeding program. In particular, a measure has been systematically introduced in each amendment of the European Convention for the protection of animals kept for farming purposes, and now appears in some Community law texts. It says that "no animal shall be kept for farming purposes unless it can be reasonably expected, on the basis of its genotype or phenotype, that it can be kept without detrimental effects on its health and welfare". A transgenic swine whose genetic modification provokes arthritis or a featherless hen intended for rearing in cold conditions, cannot be "kept", which means a fortiori that they are not to be developed.

In national laws, some dispositions are even more explicit. For example, the German Tierschutzgesetz enables the authorities to take into account suffering caused to surrogate mother animals in IVF or embryo transfer techniques. In Denmark, the law on animal protection offers the Ministry of Justice the possibility to prohibit the application of biotechnology for production of animals in the agricultural sector, particularly for welfare reasons. The Netherlands recently passed a law imposing a mandatory license for each project on genetically modified farm animals. Under that text, no animal may be modified unless the Minister of agriculture grants a license on the basis of health and welfare.

**C. No general ban for welfare reasons but a case-by-case assessment**

Even if stricter or looser regulations may emerge at first in different countries, nothing suggests in the present evolutions that new farm animals or breeding techniques, taken as a whole, will be banned by the law. Rather, they will probably be subjected to a "yes, but" approach, which implies that new selection techniques are not per se unacceptable but that their use should be regulated and each project assessed. A case-by-case assessment of each breeding project may be performed under the current licensing procedures, in the early stages of the program rather than once the new farm animal line has been established. Every breeding project would then be subjected to a cost-benefit analysis, as exemplified in current patent law. Indeed, current welfare regulation itself is generally driven by such a cost-benefit analysis. Pain, suffering and distress must be avoided, but when they are "necessary" and "unavoidable", they may be accepted as long as they are kept to a minimum. In order for a breeding project to be acceptable, each breach of welfare would then have to be justified and proportionate.

# Discussion

*regarding presentation by Christine Noiville*

***J.P.M. Schenkelaars – The Netherlands***

I am always quite curious about how far the technical progress is. Especially in the United States there are enormous legal fights between companies on patents etcetera.

In what sense could this also be a constraint or, in other words, how much does a patent add to research and development and production costs? Is there any study on these kind of aspects?

***Christine Noiville***

Traditionally patents really stimulate innovation. This is the aim of this legal tool by giving 20 years monopoly to the inventor, who is the only one who can commercialise the invention in this period. Patent really promotes innovation. That is the aim. In general everybody says that it works quite well. You are right that in the biotech field there have been many fears about the consequences of patents. One of the reasons is that in this area patents are quite broad. They give very wide monopolies and probably for several reasons.

The first one is that they are pioneer inventions in a new field. The first one who occupies the field in some way is the person who receives the widest monopoly. An other reasons comes from the techniques themselves, which maybe be applied to very different contexts. These may be reasons why there are such wide monopolies. I made a research in the animal biotechnology field to see if you have in this field examples as the one you have in the plant biotechnology sector. You are right when you take patents like the Agrossitus patent. The Agrossitus firm has a patent for all genetically modified cotton or soybeans. If you look at the claims of the patent, as it has been delivered in the U.S., you see that all transgenic cotton or all transgenic soybean is protected by this patent. I did not find this kind of patent in the animal biotechnology field. You have yet many patents, which seem rather wide. You also have potentially overlapping patents but not such broad patents as the Agrossitus patent. However, you are right: such broad patents could give real problems for technical progress. If the first one is the one who has the monopoly and other ones can not work in the same field, because whatever they develop it will not be patentable. This is a real problem.

Now, to your question: is there a precise study on the effect of patents in the biotechnological field since 5 or 10 years?

I have never heard of it, nor seen any. But governments are convinced that these patents are good and that we must go in this situation. Which is partially right, but not entirely. The idea of my presentation was to say: biotech patents, okay. But we should think about potential problems that may rise in the near future. Even if we do not see them now, or even if governments do not see them now.

# General discussion

The general discussion starts claryfying that the workshop is part of a project funded by the European Commission. The aim is to promote discussion, and not to give a position of the industry nor anyone else.

***Luca Buttazzoni***

I like to add that the work on patenting of Christine Noiville gives a very good idea and a summary of all the discussions we have had on the issue of patenting.

The patent directive allows a farmer to use a patented animal for agricultural purpose, but not for commercial reproduction activities. Do you think the occasional selling of one or two animals to neighbours is just a reproduction activity and not a commercial reproduction activity?

***Christine Noiville***

Yes, I agree. The criteria today is *commercial reproduction activity*, but this is all we can say today. The EC decided to take a very simple position on that issue leaving to the different member countries the opportunity to explain exactly what they intend to do with this farmers' privilege. Today it is difficult to say more on this issue.

***Gerard Albers – The Netherlands***

Regarding the presentation of Peter Sandøe, he said that it was very difficult to find literature on the subject of ethical issues from outside the UK, Holland and Germany. An American article on this subject in a book gave an overview of cultural differences between different areas in Europe set out against the US. The Americans have quite different opinions and views. This is important for our discussion, because there we also have our competition.  In the American view technology is always right, technology is good, technology is beautiful, it brings things forward, it helps the world go round. That are the Americans. In Europe we have a different view. Especially in Northern Europe, there is almost an anti-technology view. We suspect technology, we do not like it. This creates a big difference in the attitude towards the application of biotechnology to animal production. If we look at different issues: safety for humans, animal welfare and animal integrity. In this view; the American go for safety, Central Europe would go for animal welfare. And Northern Europe would add animal integrity to that. That is the overview of cultures around the world. For the discussion of issues the selection between 1) safety of animals for consumer production, 2) animal welfare and 3) animal integrity would be very important. You see, that in the Americas transgenics are not really a big issue. The only issue is to deliver a safe product. If that is suspected, than there is a problem. Can you give your reaction to see this difference between safety, animal welfare and animal integrity to segment the discussion about the ethics?

***Peter Sandøe***

I certainly agree about the distinction between Europe and the U.S. In another publication I have tried to summarise the difference. The Americans always say "why not" – I mean, if you cannot come with a

good reason against something, then it is okay. Europeans say “why”. Europeans say “why?”. You must give a convincing reason, or show that we get something good out of a proposal. As for transgenic crops, unless you convince the consumer that they benefit by getting more healthy food, solving environmental problems and so on, they will not have it. That is what the Eurobarometer says.
This all has to do with deep-running differences. In the U.S. a fortune is being made. People are making the most taking all the business opportunities. Some intellectuals in America even give the impression that it is unethical to leave a business opportunity there without using it! Whereas, in Europe you have a quite different approach. as I have said. So I certainly agree. On the other hand, it is important to be aware that the U.S. debate is complicated and sophisticated. If you look at the literature review, you will see that the very critical bits come from the US. I also agree that everywhere in the world we broadly agree on food safety. There is a pocket about animal welfare, and a even smaller poclet of concern about something called integrity that is mainly located in Scandinavia, Holland and Germany.

***Peter Bradnock – UK***

We have heard about the concerns of society, labelling aspects. Some of them not necessarily having to do with animal welfare. We have also had one comment on the floor from the farming sector that companies actually survive by selling products. Most of the discussion from the speakers seems to be suggesting that perhaps the breeding companies should be considering that their basis goes much further than the ones they sell their products to. If that is the case, than who should we, breeders, be listening to? And then how do we get criteria to formulate breeding goals, breeding programmes? If this goes beyond the customers we normally have, the farmers?

***Peter Sandøe***

If big companies want to stay in the market, they should behave like medical companies. The major medical companies that I know, look much further into the future. They ask what the reaction of the consumers will be, because having the goodwill of the consumers, and doing something that is acceptable, is very important to them. If you are large-scale operators, then probably you ought to think more about the actual consumers than those who buy your products. Just have a policy there.

***Arie van Genderen***

The only way to be successful in biotechnology as far as the consumer is concerned is that you come up with products or specialities that have a very, very clear benefit for the consumer. I have said it before and I keep on saying it for the next few years I suppose. As long as you do not have this clear benefit, the fear for unsafe food or concerns about animal welfare and animal health will prevail.

***Alessandro Bagnato***

Information is very important. It is really important that the consumers know what is the technology involved, and know what are the good and the bad sides of the technology. The technology is not good or bad per se, it is the way how it is used that can be viewed as bad or good. If the information is going to the consumer and to the society, they have indications and the tools to decide what is important for them, a certain application or utilisation of a biotechnology. We are facing an era in which biotechnology would play probably a stronger role.

***John McInerney***

In a sense it is really very difficult to know who you should be listening to. As an academic it is my role to analyse issues of principal, not advise on matters of practice. In my last slide I listed the issues that seem to me still very unclear, e.g. a misinformation of consumers. We talk about what the consumer wants and society wants this. Societies perceptions are highly misinformed and highly variable. It depends on which newspaper you read or which television programme you listen to. There are not clear perceptions about it, I suppose, to perceptions. You know: England ought to win the world cup, I mean that is a pretty clear thing to be unified on.

The trouble is: society does not know its choices. We are gradually learning about animal welfare, but we do not know quite what it is, what the choices are, what the trade offs are. Everyone wants more if it is free. But it is not at all clear what the costs are to the benefits that might come. As an economist I would say: all economic activity is supposed to end up doing what society wants. So society is your customer. But who in society is a question I asked you. Is it consumers only, who are allowed to make the rules? It is not clear what they want. How do you transmit that down a very diffuse information chain? The distance between an animal breeder, who can in some way influence animal welfare in very subtle and often unclear ways to the man in the street. And on the other hand there is some guy who has heard something about it is not right the way they keep animals: the information transmission channel is very poor. I am not sure there is an answer in looking at what society thinks or what we think society thinks. The question is: who is in charge of all this? The industry is probably quite aware of what other kind of political pressures on it are building up with respect to animal welfare. Insudtry has got be conscious of those and start adjusting to them. The rules of the game would change over the next ten years and the position may be very different then. But you can not form strategies to be in the right position in ten years. Like everything in society you have to be moving in the direction of gunfire so to speak without knowing exactly what the best strategy is. That is obviously what you do anyway. This is just a new set of considerations, that have come in on top of the traditional images of production efficiency playing a role in a food secure society. There are different ideas of efficiency coming in.

***Peter Bradnock – UK***

You think the market itself is the true reflection of the wishes in society? If you have the retailers putting pressures there. In market economies like in Europe the market is maybe the best answer to what society wants?

***John McInerney***

That same market has a very important information structure. That is why we interfere in them so much. It is not safe to rely on the market. They can change very rapidly, because markets are just people responding to their current perceptions. If you change people's perceptions you change market behaviour. The market does not know. It is a restricted number of people. The more expenditure you have the more power you have in the market. Therefore it is a value system of people with expenditure power. With ethical issues it is not appropriate to let the decision make by rich people. So, it is ending in the political arena anyway. Here economics gets mixed up with politics.

***Christine Noiville***

The problem that you raise may find a solution on the state level. Probably a good solution would be to create a sort of commission with breeders in it, but also consumers, animal welfare organisations etcetera. As we are trying to do it in the genetically modified crops area. That is the trend which is beginning to be seen by national authorities asking necessary trends.

In the first instance industry and national authorities, on this question of genetically modified crops, had to educate the public, because the public did not know things like that. In the second stage it was thought that one did not have to educate the public but one should give the public information. Now there is a third stage: information is just one part and on top comes negotiating some solutions on a case by case basis: " It is such a crop or such other crop. It gives benefit to the whole society and if everybody is okay to say, well, it is going to be authorised." I think there is a new type of decision like this one, which has to be found at least in these areas of biotechnology. For example in France, last year, we had this kind of new types of decision in the form of a consensus conference. I do not say that it is a panacea. I just say that it is one of the different tools that could be used to get an answer from the public. Even if public representatives is very difficult notion. Who represents the public or what does the public think? Everybody knows it is very difficult to know that.

***Peter Sandøe***

Sometimes I think: maybe I should not ask "Who should I listen to?", but rather "What should I say myself?" I mean, you sometimes have a message that you are trying to market. I think that if you want to be listened to, and taken seriously, then you should have a message yourself. If industry does not have a message it will be a poor listener and a weak influence on opinion. That is why the medical companies, who may be completely cynical, have board of directors with ethical views. They believe that is the only way they can influence the market and opinions about the market.

***J.P.M. Schenkelaars – The Nederlands***

In the plant breeding area the attitude was also: we sell to breeders, they are our customers. With regard to biotechnology they have been confronted with the fact that they have to talk to and deal with the whole society. So you see indeed life sciences companies are indeed talking with environmental organisations, consumer organisations, with retailer organisations, with food processors. Because the food chain is becoming more and more integrated. These kind of discussions are difficult, but they are probably the only way forward. Having a dialogue with stake holders. When you look now at the positions of different stake holders on biotechnology, you see that at least some of the consumer organisations and the animal protection organisations have very firm viewpoints on the issue of biotechnology in animal breeding. They may not be well informed. They may not be right. On the other hand I do not see positions from the animal breeding industry. Then it is very difficult to have a discussion and a dialogue if you do not have already some positions or viewpoints written in a document that you want to distribute all over Europe. You should at least have some ideas about where animal breeders want to go. You can of course test those ideas in a dialogue. It would for me be very special to read a document from FAIP containing an analysis, an inventory of possibilities, an ethical analysis of the issues, the consumer viewpoints and the legal points.

***Anne-Marie Neeteson***

Things are happening this way, because we are at the very start of the discussion. We started the internal dialogue at the same moment when we started the external dialogue. That is why at this stage there is not a clear position from the industry, because we still develop it at the same time when we talk to you.

Having made that choice to include also the external world as from the beginning it is not possible to come already with a clear viewpoint.

***Alessandro Bagnato***

You came back to education. I am working at a University, providing education. In all the discussions today, a common factor is that society is not well-informed on what is going on. Before the "Biotechnology era" breeding companies planned their work just according to farmers needs. Now, with several biotechnologies developing or available, they have to talk also with the public: consumers and society if they should wish to use these technologies. I read this as a request or a need from industry to raise the education at a different level of what has been done until now. This may be a partial lack of Universities that did not extend enough education to a non academic level. In US Universities there is a figure which basic role is to provide education to technicians involved in production, or to public opinion and society and consumers. This discussion is making clear that there is a need for an extended education, at a different broader level of what is today. There is the request of deeper knowledge on the biotechnology topics, more complicated technologies and very important issues for public opinion and consumers.

***Jan Merks***

Maybe I can add as chairman of FAIP and the Steering Committee also the discussion we had on similar questions we raised yesterday in the FAIP annual meeting. What Anne-Marie said is the case. We just started up our own discussions. What also may be part of the answer is that it would probably be possible to give an answer or a clear point of view for a certain country. I think for instance for the Netherlands, it would be possible to come with such a position, but that is not the reason for coming together here today. The reason the industry wants to do that discussion is to have a European viewpoint. We are not active within certain countries. Most of the companies active in breeding are active in different countries, and have to deal with the differences in culture between South European countries and Scandinavian countries, between the United Kingdom or Greece. We want to find a reasonable answer, which has included all viewpoints from other groups and then try to come up with a viewpoint of how animal breeding and industry should handle in the future. This meeting is meant to start up a discussion and to make all people working in this area in the industry aware of that we need to *have* a discussion. Also there is a need that the industry forward their ideas on what could be possible and what is not, and also to give a clear transparency about the thinking, about the way of working.

***H. Lommers – The Netherlands***

There is a concern about modified transgenic animals. A lot of the discussion was on this issue. However, what is the possible gain from them, from an economical point of view in less than ten years? And what will be the possible loss of confidence, and trust in the market and of the consumers, due to transgenic animals?

***John McInerney***

These are very difficult issues. We are very good in calculating the costs of things, because here we can get current data on. We have very little idea of values of things that are developing. The trouble with perceptions of economics is that it gets confused with accountancy. People believe that. Therefore, in a way, it would give economic information to help guide some of these developments. There is a large amount of what we are doing in all technology development, in all progress, in our production systems and the way our society look our way forward. It is very important in this whole area of technology of animal production. As long as we do not get into areas where irreversible damage is caused, you can end up correcting your path.

That is why people are terribly worried about genetic modification: the talk about genes coming out of bottles and so forth. Great figurative images. Making steps which one can not correct and wish one had not taken. If I may compare: maybe people wish we had never developed nuclear energy now, now we look back on it. But we have and we adjust to it. As a social scientist it is difficult to give answers to very specific issues like this. Man are taking confidence in the fact that human societies are very adaptive. What ever happens, we adapt to it somehow. I do not think we have to try and have answers to a lot of these things on beforehand. I think that responsible industry so long as it is aware of what the major problem in society is, leaves its bit of the action forward, without being just reactive to what consumer might be or feeling they have got to be knowing in advance before decisions can be made. I do not think we have to worry about being all that precise, it is difficult to do empirical work on it and get information that is worth having.

***Anne-Marie Neeteson***

We heard a new question about what could be gained in the next ten years with transgenics and cloning. Directly gained? There would not be very much within the next ten years. Only DNA technologies, but that is it. On the other hand, if these technologies will develop in the medical field and in other fields, if we do not keep a close look at it, there might be certain areas that will give beneficial outcome, that will be acceptable to society within 15 years. If we do not understand anymore what is happening in that field, then we would also loose track on that. So we should observe and understand what is happening there, and base decisions on knowledge and on what is the demand in the market society. That is why we have to have as well a discussion and also we have to develop our knowledge about new technologies.

***Jan Merks***

If you look at the inventory from the consumer viewpoint, or if you look to animal breeding from an ethical point of view, you can ask the industry whether it is worth to go for a transgenic pig, cow or sheep or even fish for meat, milk, for eggs. The statement could be the industry does not go in that direction with regard to milk, eggs or meat.

***Graham Plastow – UK***

In terms of genetically modified organisms it is a very dangerous time to be saying technology does not have any role to play of distance. We really do not have the tools to do genetic modification on animals or to do genetic modification in a way that consumers get products that are acceptable. There are problems: problems for our industry, and problems which the consumer would like us to solve, which can be approached by using transgenics. At least in the future. So the timing is wrong to make any decisions about not using these technologies. It is not the time to do it.

***Peter Sandøe***

Europabio, the European Biotechnology Industries, recently published core ethical values that they decided on a group of values. They say these are our values, the values of our members. Some of these are very basic. It is a start. Their approach in the discussion about human cloning and their view was similar to your view about transgenic animals. At the time being it is not useful and there are problems with it. But we do not know what we will be doing in the long run. Why not say that: at the time being we think it is stupid, it is unsafe and unethical to use it without any kind of knowledge. But we do want to conclude it, because we can see certain good perspectives. That will also be a statement.

***Graham Plastow – UK***

That is exactly the stand we try to bring forward with the platform. No use now, this is impossible. But if you have genetic modification which reduced the use of antibiotics that would make food safer could be the sort of application that would be much more acceptable than the present state where people just see gm soy or crops growing faster.

***Merja Markkulla - Finland***

We should be very careful. We do not know about the developments in the future, nor the possible benefits. If it would be banned to use transgenic technology, it means that we are banning possible benefits. They may be harmful but surely we all *know that right now we simply cannot manage them*.

***Conclusions***

***Jan Merks***

Each of us heard a lot of ideas from several directions. There were a lot of questions that brought the discussion at a higher level. Today we have had a very good exchange of opinions with regard to animal breeding and reproduction. That was the purpose of today: to start up a good discussion on animal breeding and reproduction in a way that we make it more transparent to society. Of course, due to the presentations and the questions that were raised, you may conclude that we even end up with more questions than we came here with this morning. That is always the case, if you have a good discussion. You only solve old problems but find out that there are more problems to be solved and that is what discussion is for.

We have had very good and informative questions today. At the same time we have to start to think about the answers to those questions. Should we come up with core ethical values in which farm animal breeding and reproduction industry? A question which should be addressed too by the industry is whether they decide not to co-operate towards farm animals which are being used for pharmaceutical production, but stick to what they have been doing up to now: produce, apply their genetics and reproduction in a way for producing farm animals, for milk, meat and eggs.

Today we are not addressing a national problem, but trying to make an answer at the European level. We are becoming more and more one Europe. Especially in our activities we should have a discussion not within countries but across the country boarders, to make sure that the answers are valid for Europe and not for a small area in Europe. People are changing very fast. People in an area may have an opinion and next week have developed to another opinion.I think the movement of people nowadays across Europe makes clear that opinions of people within Europe are mixing up more and more. It underlines that we should address our discussion in an European way, not in an national way.

# Discussion Resume

Discussion in four sessions succeeding the presentations at the workshop of 3 June 1999, and in a final general discussion.

**Presentation by Alessandro Bagnato and Anne-Marie Neeteson**

Three different scenarios (conventional path, alternative path, low cost path) related to possible breeding goals and the involvement of different bio-technologies were presented.

The discussion at the beginning was focused on sustainability, especially on the association of the low cost path and non sustainable agriculture that was presented as a provocative relationship. The discussion focussed on the definition of sustainability and the different aspects that might contribute to its definition and interpretation: i) undesirable side effects in high producing animals (e.g. health problems), ii) biodiversity, iii) variability in food products and production.

Furthermore, possible interactions of the different paths were discussed: each path can benefit from others.

Other paths were proposed by the audience, one specifically related to advanced bio-technologies for non-food products. The authors of the presentation raised two major points: 1) Are animal breeders interested in raising animals for non food purposes? 2) In principle their technologies can be used from organic farming or low cost production systems to high production systems, being merely a tool and not per se a production path as such.

The audience discussed about the production of non food animals, e.g. for pharmaceutical products or organs for xenotransplantation. The request for non food animals is already addressed to breeding companies today. Should the animal breeding industry be involved in this? Are animal breeding organisations ready to decide at this moment or do they wish to discuss more about it? Clearly, there was a need for further discussion.

Another remark was related to differences between countries in the EC (North-South). This is a reality affecting the markets, they are different. Furthermore, other economical, societal, ethical, environmental, or food safety constraints can affect the possibilities of developments and applications of bio-technologies.

**Presentation by Peter Sandøe**

An overview of the available literature on the ethical perspectives of breeding and bio-technologies, together with various concerns, the ways to handle them, and cultural differences was presented.

A first comment was that the breeding industry produces what the farmer desires and that it should involve societal needs as well. The internal discussion in the breeding industry about breeding goals has to face both reality and the future. Animal welfare being a topic, the breeding industry has to face, it is better to start a dialogue with society making the problems clear. If there is dialogue there can be a solution to a problem, much better than ignoring societal concerns and becoming unpopular. The chance and opportunity to make the industry reality understandable and to show to the society that

industry is making modest and sensible progress can move public opinion to support it and to find ways for new solutions. This is seen, by an ethicist point of view, as the only feasible strategy.
The way forward in the hands of the industry is to care about the ethical problems. Industries who denied any problem, had to admit it later. Having started a good dialogue they could have avoided it, and this would have been more constructive.
A remark was made that sometimes it is not possible for industry to change their production system. In the case of forbidding the farrowing cages in pigs, companies are being forced to do something that pushes them out of business. Again the ethicist point of view is that if there is no dialogue the regulations are imposed without the possibility for producers to let understand what is vital for them. The two empirical hypotheses to reach a societal acceptance are either to have a dialogue or stay though.
Animal integrity and human concerns are two topics in the ongoing discussion. Animal welfare can be obtained with different strategies and for different aims. Going for welfare and explaining the reasons make that respected even by people aiming at animal integrity first, because they can see one is taking an ethical stand, not just being arrogant.
Cloning is an activity not well accepted by public opinion because they do not understand the reason and the consequences of that. Because of all the media noise the explanation why Dolly was cloned out of Tracy could not get through.
Just adding cloning, or just using cloning in tomorrows' farm animal breeding and reproduction industry is almost of no use. It is adding only very little. And due to the present cost it is even more expensive than not using it.
There was a consideration on the public opinion about scientists working in biotechnology and on the present level of knowledge of biology and ethical issues in society. More and better biology and phylosophy education would be a prerequisite for good public discussions on DNA and genes.

**Presentations by John McInerney and Arie van Genderen**

An alternative interpretation of the consumer point of view with regard to the use of biotechnologies in animal breeding is that consumers pay more attention to food safety than to animal welfare. Transgenic animals are well accepted for medical purposes: they can provide faster cure and this is what society cares about. However, the consumption of the meat of these animals might give associations with medicines and damage the image of meat produced by farm animals in the agricultural food production chain.
The perception of the consumer on the existence of genetically modified animals is rather widespread. There is *no* distinction between farm animals and animals for pharmaceuticals in public perception. Although there is no evidence for such an affirmation, the discussion on genetically modified animals never distinguishes between the two categories mentioned before.
Nowadays consumers are aware of the production system and want to buy safe, ethically sound products. The awareness is probably growing a little but as soon as economy goes down a bit, public will go back at price.
The higher ranking the animal is, the more concerns for genetic modification there is. Mice are lower in the hierarchy than cows, or monkeys.

**Presentation by Christine Noiville**

In the biotech field there is a lot of fear about what a patent can cover, because they can be quite broad and provide wide monopolies for many reasons: pioneer invention in a new field, techniques applied in very different contexts. Nevertheless such broad patents could give real problems for technical progress, because if one has the monopoly other ones are not interested to work in the same field: whatever they develop it will not be patentable. There is not yet a precise study on the effect of patents in the biotechnological field after five or ten years.

**General discussion**

The presentations are not representing opinion of industry, or any one else, but aim to stimulate discussion on a topic of great interest to society

Patenting is a very important topic involving farming, especially for the directive on the protection of biotechnological inventions with regard to the farmer's privilege.

It is important to bear in mind that the societal points of view of the US and Europe are very different with respect to technology.

Most of the discussion suggested that perhaps the breeding companies should consider that their basis goes much further than simply the farmers who buy their products. That being the case, than who should the breeders be listening to, how should they get criteria to formulate breeding goals and breeding programmes? It is really very difficult to know who breeders should be listening to. The discussion concentrates on information and messages received from society, the customer of the animal breeder, how the information chain is working and how this will probably change in the very near future.

Then it was observed in the discussion, that the market itself is the true reflection of the wishes in society. Again the discussion touches topics like which strategies should breeders take to deal with the necessities of society (a concensus conference was mentioned as a workable option); there is a strong need for discussion and information, and that this process must be as much transparent as possible to public.

The meeting did not express a clear viewpoint of the industry, because industry is at the very start of the discussion. The possibility of core ethical values of industry was mentioned, and the need for more education in ethics and societal awareness in breeding and reproduction education was concluded.

What would be the direct interest in modern biotecnology is a further topic of discussion raised to the attention of the audience. Particularly the discussion develops on the minimal expected contribution of genetically modified organisms and advanced techniques like cloning in the animal breeding sector compared to what we have and will achieve with traditional breeding.

**Conclusion**

The workshop has started up a discussion on farm animal breeding and reproduction in a way that it is made more transparent to society. New questions were raised, one of them being whether the farm animal breeding industry should get involved with producing for the pharmaceutical industry, or stick to producing food like it has done until now.

Furthermore, it became clear that the discussion should continue, and that it needs to take place not nationally, but at the European level, taking into account the global situation.

# Appendix 1

## Reproduction and selection technologies

*Raffaella Finocchiaro[1], Alessandro Bagnato[1], Pierrick Haffray[2]*

### ARTIFICIAL INSEMINATION (AI) AND SEMEN TECHNOLOGIES

***Introduction***

Artificial insemination (AI) has been used for fifty years, in different species and breeds, including humans. In 1780, Lazzaro Spallanzani, an Italian physiologist, was the first who used this technique to obtain pups from his dog. Nowadays AI is the most important reproduction biotechnology for the genetic improvement in domestic animals. A few selected males produce enough spermatozoa to inseminate thousands of females per year. Methods have been developed for semen collection, semen freezing and insemination in different species (cattle, sheep, goat, swine, poultry, rabbits, horses, dogs, cats, and a variety of laboratory animals). Only healthy and selected males are used; therefore males are always tested for disease and typed for identification before using them. The major advantages of AI are 1) genetic improvement: excellent animals can be used more often and more efficiently, 2) control of diseases: a) instead of males, their semen is transported, b) extermination of venereal diseases, 3) availability of accurate breeding records (Salisbury, 1978; Foote, 1980; Colenbrander et al., 1993; Perret, 1997; Cunningham, 1999).

**Description of the technique:**

***Collection of semen and preparation***

For the collection of semen in mammals an artificial vagina is used. Amantea first applied this in dogs (1914). The artificial vaginas differ according to the species. The volume of sperm produced varies according to species, age, season, behaviour and libido. A bull produces 5-15 ml, a ram 0.8-1.2 ml, a boar 150-300 ml, a cock 0,2-0,5 ml and a turkey 0,25-0,4 ml (Foote, 1980; Hartigan, 1995; Surai & Wishart, 1996). Sperm is collected at body temperature. After collection it must be kept in a water bath at 37°C, in order to maintain its initial quality and fertilising ability. After the collection semen gets evaluated for quality (volume, motility, and concentration). Rapid and effective evaluation of the collected samples is necessary in order to preserve semen quality. Ejaculated sperm does not survive for long periods, unless various agents (extenders) are added. Extenders provide nutrients as a source of energy; they protect sperm cells during rapid cooling and freezing; and they increase the volume of the semen so that it can be used for multiple inseminations. Usually, extenders contain egg yolk, heated milk or a combination of the two as basic ingredients. Semen is diluted at specified rates so that the volume of frozen or fresh semen used in insemination will contain sufficient spermatozoa to give high probability of conception. The technique has proved to be successful for cattle: from an ejaculate of a bull it is

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possible to obtain 300 frozen doses containing on average 10.000.000 spermatozoa. A ram produces 15 doses and a boar produces 10 doses per ejaculate. Semen collection in poultry takes place by massaging a cock on belly and back. The semen is collected in an ampoule with an extender at 15°C. Diluted sperm, preserved at 5 to 7°C, can be used until 48 hours after collection. A cock produces 7 to 20 doses per ejaculate (van 't Hoog, 1997). Semen collection in fish farming takes place in massaging flanks of males. The volume of semen collected varies from 0,1 ml /kg in turbot and silurid species (oligospermic) to few ml/kg in salmonids, sea bass, sea bream and cyprinids to 10 to 20 ml/kg in sturgeons. Sperm can be stored at low temperature (0 to 4°C) between a few hours to a few days depending on species (Billard, 1992). In some species (catfishes, sex reversed males of salmonids, oysters), sperm needs to be extracted from the testicles by dissection in specific extenders after slaughtering of the males.

***Freezing of Semen***

Sperm can be frozen in all the species. The use of frozen sperm is limited to conservatory purposes and preservation of genetic resources (Maisse, 1996). At the beginning, mainly fresh or cooled (5°C) semen was used in AI. After Polge and co-workers (1950) discovered the protective effect of glycerol during freezing, the technique evolved to the use of the frozen semen. This technique is used in cattle and sheep. Before freezing, a mixture of semen and extenders are kept for almost six hours at 5°C. This enables sperm cells to spread uniformly into the extenders. Then semen is packed into small “plastic” containers (straws or pellets). Straws contain 0,25 to 0,5 ml of semen extended for bulls and 0,5 ml for ram. Pelleted semen is prepared by including some drops of diluted semen (0,1 ml) in a hemispherical structure made in a block of dry ice. Straws are first cooled to 5°C. Then, they are brought down at a controlled rate to -110°C before storage in liquid nitrogen at –196°C. Pellets are cooled quickly to a temperature of –79°C, and then they are transferred into containers immersed in liquid nitrogen at –196°C. Before semen is used, the samples (straw or pellets) must be thawed rapidly by placing them in a warm water bath (30-37°C) for e.g. two minutes. Then they must be used rapidly, because spermatozoa cannot survive for a long time after thawing. Each straws or pellets are marked with the indication of the animal indentification number and the date of processing.

***Insemination or Fecondation***

The semen is brought into the female reproductive tract (cervix or uterus) by a so-called sterile pistolet or catheter. Insemination must take place at the right place and at the best moment in order to enable spermatozoa to meet an ovum. In cattle, rectovaginal insemination is used. A gloved hand is inserted into the rectum of the female and used to locate the cervix. The insemination tube is brought into the vagina and carefully guided into the cervix by means of the gloved hand in the rectum. The technique requires practice and experience. Other techniques are used according to the species. A hen is inseminated in the cloaca by using an insemination pipette. Fertilisation of the eggs from aquaculture species is practised in specific extenders to allow longer duration of sperm motility in order to maximise success of fertilisation in fresh water fish or in sea water for marine fish and molluscs. 3 ml of semen can fertilise 1 litre of eggs (10.000 eggs in salmonids to 1 million eggs in marine species).

***Detection of oestrus***

Accurate timing of insemination is essential for achieving the best conception rate. Usually, the best way to detect the heat is when the females start to mount either male or females. A farmer must control a herd every day, or twice a day (morning and evening). There are many aids for detecting oestrus, such us using vasectomized sires with coloured crayons held on the sternum by an harness, so all of females colour-marked on the rump should be noted during each control. Odours can also be detected by trained dogs or by a 'snuffle boar'. For cows, pedometers placed on the legs can be used, because cows, while on oestrus, are more active than usual (Foote, 1980; Secchiari et al., 1998). Hens get inseminated every week in order to be sure of fertilised eggs.

***Heat induction***

This technique is usually addressed in extensive farming where heat detection is difficult or to synchronise deliveries in particular period of the year (e.g.: sheep and rabbit). In these species heat induction became really important due to its several advantages: 1) programming and concentrating parities taking a look to the market demand; 2) anticipating the first birth, and reducing distance between parities; 3) the chance to use better AI in those species with a seasonal breeding and 4) to increase litter size and improve fertility. To induce oestrus in females particular hormones are used. Administration techniques and hormones vary according to specie and phase of oestrus cycle.

***Differences***

In pigs AI has had a slower start than in cattle, but now it is rapidly increasing. In some countries more than 50% of breeding females are artificially inseminated (Wilmut et al., 1992; Visscher et al, 1998). The introduction of AI in pigs is changing the marketing strategy of breeding companies, from selling live boars to selling semen. The problem in pigs is the short effective life of AI sperms in the sow. Success with AI is highly dependent on good detection of oestrus and accurate timing of insemination. Optimum fertility is obtained when semen is used within 24 hours of collection. With modern long-life diluents semen doses can be stored at 16-18 °C for 2-5 days prior to use. However, over this period a 5-10% drop farrowing rate and a decrease in litter size of up to one pig can be expected (Colenbrander et al., 1993; Meredith, 1995).

Artificial insemination in sheep is not routinely used. Unfortunately, the anatomical structure of the cervix prevents intrauterine deposition of semen by insemination syringe (Cappai et al., 1998). Consequently, cervical artificial insemination with frozen/thawed-semen results in low fertility (Maxwell and Watson, 1996), due to impaired sperm transport through the cervix and the short survival of frozen-thawed spermatozoa in the female reproductive tract (Lighfoot and Salamon, 1970). From a technical point of view most artificial inseminations in sheep selection schemes are realised with fresh semen after oestrus synchronisation by cervical insemination. A common use of frozen semen by cervical insemination does not seem currently possible because of low conception rates. Therefore frozen semen is used only in a few cases for particular mating by intrauterine techniques (Sanna et al., 1994; Maxwell & Watson, 1996).

Artificial insemination in fish is different if compared with others farm animals. Females are manipulated with a little pressure on their belly. Mature oocytes are collected in a proper recipient. Males are massaged directly with their fin back, and spermatozoa collected in the same recipient of the oocytes are. This is a dry method because the gametes are mixed together without adding water: sometimes diluents can be added (Billard, 1992). Oocytes are let to rest for 10-15 minutes and all unfertilised oocytes are removed. Fertilised oocytes are put in an incubator. One hundred per cent of the salmonid, catfish and turbot production uses AI. In other marine fish and molluscs species, in which fertilisation is occuring naturally in the water by mass spawning after releasing of the gametes by the males and the females.
In poultry and more particularly turkeys, AI is used routinely by the breeding companies. In turkeys 100 % AI is applied.

***Sperm sexing***

The procedures is based on the identification of the minimal difference in DNA contents (about 3%) between X and Y spermatozoa using a flow cytometer (Pinkel et al., 1982; Cran, 1992) In mammals, the larger X-chromosome carries more DNA than the Y-chromosome and percentage differences are reported to be 3.0, 3.6, 3.8, 3.9, 4.1, and 4.2 for rabbit, swine, cattle, dog, horse and sheep respectively (Johnson, 1992). The potential application of sperm determination in farm animal can be seen in a reduction of costs, (e.g. to obtain heifer calves for dairy replacements or bulls for beef production) and therefore elimination of supernumerary male embryos in particular in export programmes and use of fewer female recipients (see embryo transplantation), all this will bring a big economic advantage.

**Monosexing and Triploidism in Fish farming**

In fish farming, males often have the disadvantage to mature before achieving the commercial size desired by the consumer (trout, charrs, carp, bass, bream, turbot, halibut). This maturation decreases the level of lipid in the meat, decreases growth and increases weakness. The opposite occurs in some other species such as tilapia and catfishes. In 99% of the animals (invertebrates, batracians, reptils, fishes), the phenotypic sex of the males or the females can be managed by external factors (temperature, density, social relation, hormones), particularly in hermaphrodites species that change sex naturally during their life or present simultaneously the two sexes (sea bream, groupers, oysters, scallops). This is used to manage the sex in order to produce monosex fry, in most of the case female, without any hormonal treatment of the animals eaten by the consumer. Such type of treatment is recognised by the EU regulation Directive 96/22/CE of 29 April 1996). Most of the European and American trout production, the Korean and Japanese hiramé productions are based on this technique. Field trials are in progress in Atlantic salmon, in common carp in Israel and in other marine species.

Almost ninety nine per cent of the animals (crustaceans, batracians, reptiles, molluscs) and 100% of the plants consumed by humans (weat, rice, banana, onion, sugar, tea, paprika, lemon, coconut, coffee, potato, etc.), except for mammals and birds, polyploids are observed in wild populations of fish and molluscs. Triploids present gonad or gametic sterility depending on their sex. In the 80's, research has proposed standardised processes to induce triplody by thermal or hydrostatic treatments practised few minutes after the fertilisation (Chevassus, 1987). This type of genotypes are proposed by scientists to prevent contamination of wild populations by escaped population from farms, an original situation if compared to other domesticated animals for which wild ancestors have disappeared. Triploidisation, by preventing the maturation of the females avoids the decrease of meat quality (colour, lipid content) and allows diversification of the aquaculture production with fish of bigger sizes for smoking, filleting and processing that could not be achieved if sexual maturation occurred or in oysters without maturing gonads. Today 10.000 mt of triploids of rainbow trout are farmed in Europe. 80 % of the US oyster reproduction is triploïds and the first mt are tested in Europe. Ecological and quality reasons pushed the generalisation of this technique in the next future for the interest of the society.

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**EMBRYO TRANSPLANTATION (ET)**

**Introduction**

Embryo transplantation (ET) has been used during the last twenty years in different livestock species such as horses, cattle, sheep, goats and pigs. The main benefit of ET is the increase in number of offspring per female, thus increasing the reproductive rate of females and their contribution to the breeding programme. Next to this, the breeding efficiency within the herd is improved. For ruminant breeders the economic benefit from the sale of animals with high genetic value is an important advantage. Further, for all species, ET permits an easier and more rapid exchange of high genetic material between countries, and reduces the cost of international transport by flying embryos rather than shipping live animals. ET can limit the transport of live animals between farms, thus decreasing the risk of infectious diseases. Especially in pig production this offers possibilities for the safe exchange of genetic material down the breeding pyramid. The technique can also be used for the storage and the expansion of a rare genetic stock. ET is fundamental for all new biotechnologies used today in animal breeding. A disadvantage of ET is the high cost of the technique, varying from one country to another, but are always high. Therefore this technique is usually used for breeding animals (Ruane, 1988; Woolliams & Wilmut, 1989; Polge, 1995; Nicholas, 1996; Wilmut, 1996; Cunningham, 1999).

**Description of the technique**

The technique consists in the recovery of embryos, usually from an elite female (donor) and to transfer them to recipient females. Embryos can be collected non-surgically in horses, cattle, and sometimes sheep and goats. In pigs, the non-surgical collection of embryos is developing rapidly and close to its routine utilisation. The recovery of embryos includes the induction of multiple ovulation by hormonal treatment. This increases the ovulation rate so that simultaneous collection of a large number of embryos per female compared to natural reproduction is possible. The induction of superovulation is almost similar in all the species where ET is used, with the exception of mares. After ovulation, the animal gets inseminated, usually by artificial insemination. A few days later - e.g. 7 days in cattle and sheep, fertilised eggs are collected from the uterus with a sterile catheter. Before transferring embryos to a recipient female, they are evaluated at the microscope according to morphological criteria and only selected embryos can be implanted. Recipient females must be on heat at the same time of the donor females. To synchronise donor and recipient, the procedure used is similar to the one described in the artificial insemination session. In cattle and horses a non-surgical method nowadays is a routine method like the AI method. In goat, embryos are transferred by laparoscopy, but the cervical canal is large enough to permit non-surgical transfer. In sheep, embryos usually are transferred by mid-ventral laparoscopy although in the last years there was an increasing use of laparoscopy. In pigs a surgical method was mainly used until recently; non-surgical embryotransfer in pigs is developing quickly. The main practical problem of ET is the enormous variability of the superovulatory response. The cause of this variability depends, among others, on the specific physiological effects of the hormone treatment. In cows, for example, on average two or three calves born from each recovery. However, the success can vary from zero to more than ten calves.

The technique has a few fundamental stages: selection of donors and recipients, synchronisation of donor and recipient females, superovulation and insemination of donors, collection of embryos, their evaluation and transplantion in recipient females.

***Freezing of embryos***

After collection, the embryos are packed in straws. These straws are immersed into a freezing medium, containing a cryoprotectant for 5 to 10 minutes. Then the straws are transferred into an alcohol bath at –6°C, and after a few minutes of adaptation, cooling passes slowly to a temperature of –32°C. The straws are then transferred directly to liquid nitrogen and stored in a container at the temperature of –196°C. When frozen embryos have to be used, straws are carried out to a temperature of 20-30°C. The cryoprotectant has to be removed. Then the embryos are placed into a normal medium and transferred. Freezing of fish eggs is still impossible even if a short decrease at -4°C give live fry (Lubzens et al., 1996). Freezing of blastomeres of rainbow trout is possible (Leveroni & Maisse, 1998) but their reimplementation still needs experiments. As in other species, cryopreservation of blastomeres or embryos could open new applications for establishing gene banks in the context of aquaculture or ichthyodiversity preservation.

## IN VITRO EMBRYO PRODUCTION (IVEP)

### Introduction

As mentioned before, the ET success rate is highly variable. An alternative to embryo production *in vivo* is to use the ovaries of females to collect oocytes (ovum pick up-OPU). This technique involves three steps: collection and maturation of the oocyte (in *vitro* maturation-IVM), fertilisation (in *vitro* fertilisation-IVF) and culture of the resulting embryo to a stage at which it can be transferred into the uterine horn of a recipient female. Females after puberty can be potential donors of oocytes; donors in the immediate post-partum or in late pregnancy stages are not suitable (Ball et al., 1984; Naitana et al., 1992; Wilmut et al., 1992). IVEP was first developed for laboratory, domestic, primate, avian, and aquatic species. Nowadays, it is a technique used on farm animal species such as cattle, pigs, sheep, goats, rabbits, and equine. In the last decade, IVEP has been used in human too. The first success was on rabbits by Chang (1959). One of the advantages of this technique is the increased possibility of selection through the female line. The commercial application of IVEP depends on the type of embryos produced. In cows, for example, only 30% of cultured oocytes develops into embryos to be transferred (Cunningham, 1999). The disadvantage of this technique is that it can be done only in laboratory and moreover it is a really costly technique.

### Description of the techniques

#### *Oocyte collection and maturation*

The immature viable oocytes can be collected from animals immediately after slaughter by dissection of the ovaries or by simple aspiration from live animals (*ex vivo* ovum pick up- Pieterse et al., 1988; Brackett, 1992; Besenfelder et al., 1998). Due to this technology limitations in female reproduction may be overcome. It is possible to have oocytes from females that do not superovulate such as pregnant or sterile females (Leitch et al., 1995; Galli & Lazzari, 1996). This technique can fundamentally increase the number of offspring produced per donor anima without any hormone treatment. In cattle, for example, it is possible to produce up to 150 embryos per year per female. Genetic improvement rate in a population can be increased thanks to the use of young heifers of 6-8 months of age as parents (shorten generation interval).

Immature oocytes are placed under suitable culture conditions for *in vitro* maturation (IVM). The optimum culture environment requires a temperature not below 39°C and a medium supplemented with foetal calf serum and some hormones. After 22-24 hours, the oocytes turn to the mature stage (Naitana et al., 1992; Galli & Lazzari, 1996).

#### *Fertilisation*

When the oocytes are mature, they must be fertilised (IVF). In cattle, for example, commercial frozen semen is used for fertilisation. The sperm must be separated from the extenders, e.g. by washing or centrifugation on discontinuous Percoll gradients. The latter ensures a high recovery of motile spermatozoa (Lynham & Harrison, 1998). Then the spermatozoa are diluted in a medium, and prepared in microdrops under paraffin oil. The mature oocytes are introduced in the fertilisation medium for 18-24h at 38.5°C. Following fertilisation embryos can be transferred either into a temporary recipient female (rabbit or sheep) or cultured *in vitro,* with or without somatic cells, in a particular medium. Embryos developed in a temporary female recipient have a better sensitivity to freezing and thawing; they behave like embryos recovered from superovulated donors; they can be frozen with the same protocol, and moreover a high pregnancy rate will result after thawing and transfer to the recipient female. If frozen-thawed embryos, cultured in vitro, are used, on the contrary, a lower pregnancy rate is achieved (Galli & Lazzari, 1996). Fish and molluscs eggs are incubated at optimal natural temperature for the development of the embryo. Their transport is possible after the development of the neural and axial systems in Salmonids and all the time in species with planctonic eggs. This has allowed transportation of Salmonids from Europe to Chili by boat and across the Andes Cordilier at the end of last century. As for sperm, this way is used to disseminate genetic material. This is particularly interesting as fertilised eggs can be disinfected to prevent disease risks.

**EMBRYO SEXING**

The possibility to determine the sex of the offspring will have an important influence on the livestock management, productivity and for the genetic improvement of all domestic animals, although more used in cattle. Dairy farmers are more interested in female offspring production. A large number of female offspring guarantees maximum selection through replacement within the herd, resulting in a faster breeding progress. Moreover, sex predetermination reduces the number of recipient female required. After embryos have been recovered from the reproductive tract of a donor female and before they are used for ET procedures, they can be sex determined. The method of embryo sexing is based on the determination of the presence of the Y-chromosome, specific to the male, inside some cells of the embryo. Some cells are removed from the embryo and their DNA analysed to mark a known DNA sequences present in the Y-chromosome (Nibart, 1992; Powell & Wilmut, 1995).

**CLONING (embryo splitting, nuclear transfer)**

Splitting (cutting) embryos at a really early stage creates identical animals. In order to cut embryos, simple equipment is used, such as a hand-held blade. In this way, it is possible to obtain two embryos from one. Embryos can also be cut into smaller parts using micromanipulation. However, this technique is very expensive and the maximum number of identical individuals obtained is four. The embryo splitting technology is now used commercially to increase the number of lambs or calves born following routine embryo transfer or *in vitro* embryo production. Reports for pigs are really scarce and only few identical twin piglets have been generated after transfer of bisected pig embryos (Niemann & Reichelt, 1993). An alternative method of making clones involves the use of another embryo manipulation procedure called nuclear transfer. The first successful nuclear transfer in vertebrate animals was reported in frogs in 1952. Furthermore, it has also been used in domestic animal such as sheep (Willadsen, 1986) and cattle (Prather, 1987). Nuclei (=DNA) are taken from embryos at an early stage (donor). These are transferred, by injection, into unfertilised ova from which nuclei have been removed (Heyman & Renard, 1996; Wilmut, 1996). This technique has been proved in several livestock species:

cattle, sheep, goats, swine and rabbits. This technology has had limited impact however because the adult performance of an embryo is not known and only limited number of clones can be made from a single embryo. (Wells et all., 1998). Splitting or taking the nucleus from an embryo creates not clones but identical twins. A clone is a set of genetically identical individuals, whereas an embryo carries 50% of genes from his mother and 50% of genes from his father (Visscher et al., 1998; Cunnigham, 1999). Wilmut et al. (1997) proposed a different way of nuclear transplantation, in contrast with embryo cloning, adult cloning (from a somatic cell), that can be done with an animal that has already proven its production potential and, theoretically at least, an almost infinite number of clones can be produced from a single animal.

***Description of the technique***

***Cloning from somatic cells***

Wilmut and colleagues took cells from the udder of a 6 years old Finn Dorset sheep and placed them in a culture with a very low concentration of nutrients, so to stop cells dividing. At the same time an unfertilised ovum was taken from a Scottish Black-face sheep. The nucleus (with its DNA) was extracted, leaving an empty ovum cell. So both cells (the nucleus one and the one without nucleus) were placed next to each other and an electric pulse let them fuse into one cell. Then the new cell (fertilised cell) started the division. Six days later, an embryo was implanted in the uterus of another Black-face sheep. After 150 days of gestation, from the Black-face sheep was born a Finn Dorset lamb named Dolly. Dolly was genetically identical to its original donor. Recently, in Italy, a calf was cloned from a leukocyte cell of an adult bull (Galli, 1999, personal communication).

Acceleration of the genetic progress by the diffusion of high genetic values individuals by cell transfer or nuclear transplantation is at research level in fish (Hong & Schartl, 1996). Most of the progress was achieved in model fish like medaka Orezia latipes or zebra fish Brachydanio rerio. ES totipotent cells can be cultivated and stored. Their injection in host embryos or the injection of their nucleus in enucleated eggs is possible. Further research is necessary before this technique can be used by the industry.

Moreover, as in plants, gynogenetic (only from egg) and androgenetic (only from sperm) has been performed in batracians and fish (Rostand, 1934; Purdom, 1969). As in plants, 100% homozygote clones, 100% heterozygote clones and hemiclones, are produced only at a laboratory scale by gyno or androgenesis for more than 10 years. They are particularly interesting in order to identify traits genetically determined by a few genes as quantitative trait loci (QTL – Quillet, 1994; Tanigushi *et al.*, 1994). One of their other possible applications is to develop reference lines (Bongers *et al.*, 1998) to study environmental factors (pollution toxicology), genetically determined diseases (cancer, etc.) in ordere to develop resistant strains or to develop vaccines. The absence of genetic variability of such genotypes could also be used to reduce the variability of the performance in farm animals.

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## GENE MAPPING & MARKER ASSISTED SELECTION (MAS)

### Introduction

Molecular technologies developed in the last decade have permitted to locate several genes of some interest in different species. The purpose of the gene mapping in livestock is to identify and locate the genes along the genome (pigs, cattle, sheep, goats, poultry), in order to identify genes controlling traits of economic interest. Nowadays almost 100% of the mouse genome is mapped (more than 14000 genetic markers). Mapping in humans actually covers 95% of the genome (more than 15000 genetic markers) (Cunningham, 1998). A complete genome map of domestic species will not be available in the near future. However, because a homology exists between mammals, geneticists can benefit from the knowledge of other well mapped species (mouse and human genome). This kind of approach is called comparative genetics (Archibald, 1998; Cunningham, 1998; Georges, 1998).

### Terminology

Individuals are composed of a variety of cells. Inside each cell is the nucleus with a complete number of chromosomes, which differs according to species. Every cell contains two copies of every type of chromosome (chromosome homologous), one coming from the mother and one from the father. A long strand of DNA (deoxyribonucleic acid) which is composed of different sequences of 4 molecules (bases), adenine (A), cytosine (C), guanine (G) thymine (T) make chromosomes. Genes are sequences of bases carrying specific information for the synthesis of a given protein. A gene is a fundamental unit of heredity, which carries the genetic information from parents to their progeny. The genetic differences between individuals come from all the different genes carried in the genome. The genome represents all the genes of an individual. Genes have two or more different forms called alleles, coding for different characteristics (e.g. blue eyes, brown eyes). Each individual carries two alleles, one from the father and one from the mother. The two alleles present at the same locus (the position on the chromosome) can be identical and in this case the individual is called homozygous at that locus. Or they can be different at that locus, then the individual is called heterozygous. In order to better understand the terminology we use an example in humans. If a new born child inherits an allele coding for brown eyes both from the father and the mother he/she will be homozygous - brown eyes. He/she will be able to transmit to his/her progeny only brown eyes. If a baby inherits an allele coding for brown eyes from the mother and an allele coding for blue eyes from the father he/she will be heterozygous and having brown eyes (the brown is dominant over the blue). The progeny will receive the blue allele or the brown one. If the blue allele is inherited and coupled with a blue allele from the other parent the progeny will have blue eyes.
It is estimated that each individual (e.g. human, mouse, or cattle) has about a hundred thousand of genes. Unfortunately genes of economic interest, i.e. genes coding for production traits (milk/meat production), product quality, health traits, fertility traits and heredity diseases, represent a group of genes (polygenes) which add their contribute to have a final single effect. For this reason it is really difficult to identify any single gene that gives its single contribution to a particular trait. The genes or loci which code for these kind of quantitative traits are called “quantitative trait loci” (QTL).

### Genetic markers

In domestic species the genes mapped do not directly affecting productive characteristics, but they may be linked to genes directly affecting desired characteristics. However, if a given gene is located (same chromosome) close to a gene of economic interest it is very likely that these can be inherited together. The mapped and known gene can be used to “mark” the gene of economic interest. For this reason they are called “genetic markers”. These genes are easy to be identified with a laboratory analysis. Very often, there are more then two types of alleles possible at the same locus. This is called genetic polymorphism. The purpose is to locate as many gene markers as possible along the genome, to verify their association to a trait of economic importance and subsequently use this information for the selection of reproducers carrying the favourable allele. Genetic markers used nowadays for the construction of genetic maps are divided into two classes (O’Brien, 1991). The first one are markers associated with gene sequences observed across mammalian species (type I). The types II are markers highly polymorphic but usually they present anonymous DNA sequences. It means, these markers are distributing throughout the genome and their function is mainly unknown. Moreover they don’t have a direct effect on a trait of economic interest, but it might be possible, located close to a useful functional gene (e.g. milk yield trait). They are inherited together (Montgomery & Crawford, 1997; Cunningham, 1998).

The main advantage of molecular markers is that they can be typed on animals of both sexes at any age, e.g. boars can be measured for litter size markers and moreover carcass quality can be measured on live animals (Visscher & Haley, 1998; Fernando; 1998).

**Marked Assisted Selection (MAS)**

The first method discovered for the detection of DNA polymorphism is the restriction fragment length polymorphism (RFLPs) published in 1980 by Botstein and colleagues. Among the new DNA markers discovered the variable number of tandem repeats (VNTRs), are most commonly used nowadays. The genome presents several regions with tandemly repeated sequences (e.g. bovine presents 40% repititive sequences). According to the number of base pairs repeated these markers are called mini- or micro-satellites loci: with more than five bases repeated markers are mini-satellites, with 5 or even less base pairs repeated they are microsatellites. The latter appear frequently throughout the genome and moreover they represent the majority of the genetic markers mapped now for all species.

In the 1990’s this “technique” started to be practically reliable thanks to the development of livestock genome maps based on highly polymorphic micro-satellites DNA markers. The idea of making selection by means of the directly genetic information came earlier in the 1970’s and 1980’s (Soller & Beckman, 1983). This process where marker genes, pointing to the presence of desirable genes, are used is called marker assisted selection (MAS-Mcclintock, 1998; Well et all., 1998). The purpose is to combine all genetic information at markers and QTL with the phenotypic information to improve genetic evaluation and selection. The advantage is that the effect of genes on production is directly measured on the genetic make up of the animal and not estimated from the phenotype. Traditional selection methods will not be replaced by molecular genetics but an integration of the two selection methods could be beneficial to the selection response.

Using genetic markers it is possible to identify earlier in the life of the animal which can be considered of high genetic value and sent to normal ttesting procedures. At present studies are at a really early stage, until now researchers know little about which variants of the genes are desirable.

Development of efficient selection schemes in Atlantic salmon and in trout is in progress in Europe. Multitrait selection on family value will be possible for many other species if research will be able to propose to the farmers selection schemes at lower cost of investment and function. Development of less expensive selection programmes could be achieved by the use of fingerprints to set up marked assisted selection. This will need further research in order to optimise their use and to measure genetic parameters. Some traits are determined by a few genes. Programmes of mapping of these genes are initiated under EU financial support on salmonids in the SALMAP programme. Development of other programmes for other species is of interest to determine genes responsible for disease resistance.

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## TRANSGENESIS

### Introduction

Transgenesis is a technique used for over twenty years, since the first success with mice by Gordon and colleagues (1980), several different transgenics have been inserted into farm animals. Technically gene transfer means the stable incorporation of a gene from another species in such a way that it functions in the receiving species and is passed on from one generation to the next (Cunningham, 1999). The transgenic technique offers several possibilities such as: 1) improve animal production (milk, meat, wool), product quality and disease resistance (reducing cost), 2) produce recombinant proteins in the mammary gland, and moreover 3) create a source of organs to be transferred into human beings (xenotransplantation) (Mcclintock, 1998). In order to produce transgenic animals, several steps are required (see below). For this reason the success rate is not high (1-2%). Therefore the technique is mainly used in mice, sheep and pigs and, very limited in cattle (Cunningham, 1999). Progress has been rather slow mainly because of a lack of basic understanding of gene regulation and gene expression. The research has focused primarily on the alteration of growth and development, but recently has also included the generation of foreign proteins in milk and blood and the increase of disease resistance (Niemann & Reichelt, 1993).

Transgenic technique, nowadays, is less directly applicable, and slower than it was thought at the beginning when it was discovered and proposed. This depends on several reasons: 1) most economically important traits are controlled by multiple genes, which are for a good part unknown today, and therefore hard to be manipulated; 2) the low efficiency of gene transfer in farm animal makes the technology really expensive, therefore preliminary tests are conducted on mice. For this reason results may not be directly applicable to livestock species.

### Description of the technique

The technique widely used to produce transgenic livestock is the pronuclear injection. Hammer and colleagues (1985) generated the first transgenic livestock (rabbits, sheep and pigs) by pronuclear injection. The methods used to create transgenic farm animals are based on those developed in mice by Gordon and colleagues (1981), with some changes according to the species (Eyestone, 1998). To produce transgenic embryos, oocytes are first collected from the oviduct of superovulated females (donor) (see embryo transplantation techniques) and cultured *in vitro*. Oocytes are then fertilised with frozen-thawed sire semen and again collected 18-24 hours after insemination. Once the pronucleus is visible, a given quantity of solution containing 200-300 copies of DNA fragment is injected directly into the pronucleus by means of a fine glass needle. Then the early stage embryo is first cultured in a medium for 6-7 days (cattle) and then transferred into the uterus of a recipient female. The pregnant rate and therefore the calving rate are lower than with non-modified embryos (Eyestone, 1994), probably because of a chromosomal damage or a mutation that can occur during the pronuclear injection. The technique is quite simple; the success depends on the operator, the quality of the injection needles, the quality of the DNA, the quality of the oocytes and the ability to visualise the pronuclei. Once the offspring are born, they must be evaluated to see if the transgene exits in their genome. The PCR procedure is used to check the transgenic integration. This is a process that can duplicate (amplify) any desired DNA sequence. DNA can be obtained either from blood, hair, saliva, semen or milk samples. Later, duplicated segments are separated by electrophoresis; single alleles will appear as single bands and according to the repitition length polymorphism can be detected. The technique basically needs just small amounts of DNA to be analysed (before amplification). Moreover, several individuals can be typed simultaneously.

***Examples***

Several of the protein products of livestock genes have been shown to dramatically affect the performance of farm animals. The best example is the growth hormone (GH). A wide variety of data have shown that an increase in the growth hormone level in meat-producing animals, increases growth rate and feed efficiency and, in dairy animals, increases milk production (Machlin, 1972, 1973; Niemann & Reichelt, 1993 Pursel, 1998). The effects of exogenously added growth hormone on growth rate have been known for more than 50 years since the original studies of Evans & Simpson (1931) and Lee & Shaffer (1934) who demonstrated that extracts from pituitary glands caused a dramatic increases in the growth rates of experimental animals.
The earlier transgenic animal was created using the growth hormone (GH); the first GH transgenic mice were produced in 1982 (Palmitier et al., 1982). These transgenic animals presented an enhanced growth performance: the growth rate increase 4 times and the final body weight increased twice. Later a number of GH transgenic pigs and sheep were created with human, bovine, rat growth hormone (GH). In pigs with bovine GH (bGH), for example, it was possible to see an increase of a faster growth rates and an increase of feed efficiency, and moreover there was a big reduction of fat carcass (Pursel et al., 1989). Unfortunately transgenic pigs presented a variety of health problems: susceptibility to stress, gastric ulcers, and reduced fertility (Pursel et al., 1989; Pinkert et al., 1994). GH transgenic lambs in some studies did not grow faster or utilise feed more efficiency carrying elevated doses of ovine GH (oGH) or bGH, but they were thinner than usual (Murray et al., 1989; Rexroad et al., 1989). Furthermore the absence of body fat could cause a hyperglycaemia and glycosuria (Rexroad et al., 1989, 1991). Moreover these animals presented anatomical abnormalities (Vernon & Pursel, 1998).

Transgenic fish are produced in experimented situations - since the 90's. Increase of growth reported twice in more than 20 experiments of Devlin et al. (1994) report that transgenic Coho Salmon Onchorhynchus Coho were more than 11 times heavier than non-transgenic controls. The production of such type of genotype is not well controlled and many steeps need to be improved before achieving possible farming of transgenics for human food. Many traits could be improved as growth rate, their ability to consume plants, to decreasing of production cost and capacity to resist to diseases. One of the more important problems to consider is that such type of fish can escape and reproduce eventually with wild animals. Sterilisation by triploïdisation, hybridisation or transgenesis or farming in completely closed systems could solve this problem but the main key factor will be the consumer acceptance.

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