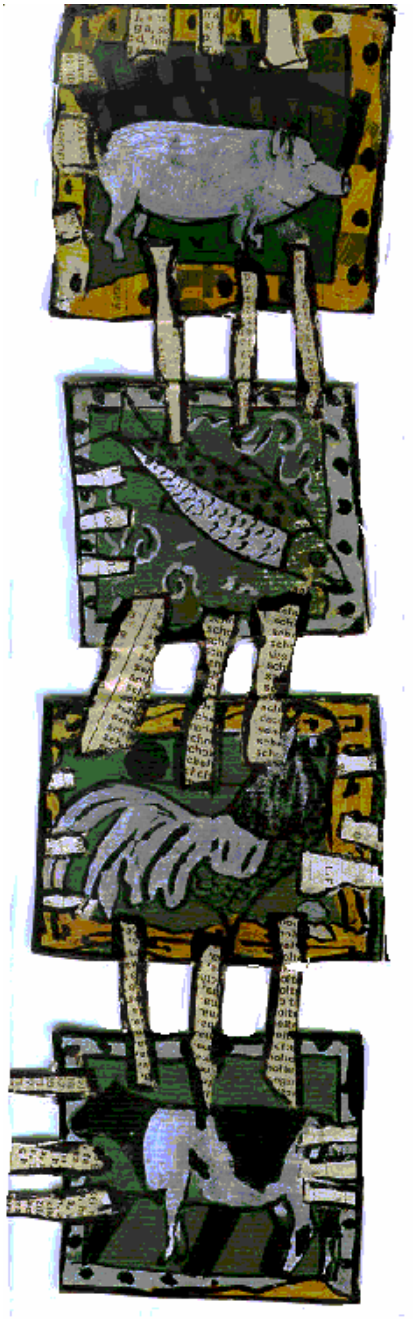
Farm Animal Industrial Platform *(FAIP)*



Ethical Perspectives on Breeding and Biotechnology

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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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