Staying good while playing God – Looking after animal welfare when applying biotechnology

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Animal breeding was, until the beginning of the twentieth century, a relatively uncontrolled activity based mainly on the animal's physical appearance. The early animal breeders did not really have the knowledge and tools to predict and control what they were doing. This changed in the first half of the twentieth century, when Mendelian genetics was applied in farm animal breeding. Later, the second half of the twentieth century saw the development of new forms of animal biotechnology such as the freezing of semen, embryo transfer, in vitro fertilization, gene transfer and cloning – all of which allow scientists and breeders even greater control over future animals.

With greater control comes greater responsibility and, in modern democratic societies at any rate, a higher degree of accountability. Certainly the new technologies prompt a range of ethical questions concerning animal welfare, biodiversity and human interference with nature. In this paper focus will be on the effects of breeding and other forms of biotechnology on animal welfare. In the first section it will be described how modern breeding and biotechnology has developed. In the second section consequences for animal welfare will be presented and discussed. Finally in the last section there will be a brief discussion of some of the ethical issues raised.

New ways of changing animals

The main breakthrough in the development of more advanced breeding practices came at the beginning of the twentieth century with the re-discovery of Mendelian genetics. With this new basis for understanding the heritability of different traits it became possible to design future generations of domestic animals using measurements of the genetic potential of possible breeding animals. From the beginning and for a long time this approach was mainly used in the breeding of farm animals.

The genetic potential of animals came to be measured by looking at the performance of their ancestors, siblings and offspring rather than looking merely at the performance of parent animals. Furthermore, advanced biometric models were put to use to estimate the genetic potential of possible parent animals. Breeding animals were now selected by referring to breeding goals – that is, goals that define the relative weight of the various traits that the breeders are trying to enhance. The fact that it is possible, generation after generation, to achieve progress on a breeding goal is based on the biological insight that relevant genetic properties vary among offspring. By always breeding on from the best-performing animals it is possible, over a number of generations, gradually to improve average performance.

For many years the main focus in the breeding of farm animals has been on production traits. Examples of such traits include milk yield in dairy cows, the number of eggs laid by laying hens, and growth and feed conversion in meat animals. The results have been staggering. For example, between the early 1960s and the late 1990s the time needed to produce a slaughter-weight broiler fell from 80 to 40 days, and the required feed consumption halved (Havenstein *et al*. 2003). Over the same period, milk yield in most dairy cow breeds have more than doubled (Christensen 1998). Admittedly, these achievements derive in part from improved management practices. However, to a large, and still increasing, extent they are the outcome of genetic changes brought about by systematic farm animal breeding.

More recently, modern biotechnologies have also been used by breeders in their work with some farm animals. The technologies in question belong to what is called reproductive biotechnology, which aims to control (and often accelerate) the process of breeding. The first technology of this kind to be developed was artificial insemination (AI) in cattle. This allowed reproduction to take place without natural mating. In the 1950s a technique for freezing semen ensured that AI would become even more significant, since frozen semen could now be stored over a longer time and transported to a geographically wider area and, if necessary, across national boundaries.

Similarly, technologies have been developed to enable female animals to produce more progeny than they would naturally. These include superovulation, which allows several embryos/eggs to be produced per selected donor, and embryo transfer, which enables the breeder to shuttle embryos to surrogate mothers. Such technologies have been of particular interest to cattle breeders, because in cattle there are long intervals between generations; each cow normally produces only one calf per year.

One of the more spectacular forms of biotechnology so far has been the kind of animal cloning that took off with the sheep Dolly, born in 1996. Dolly was in a radical sense fatherless. She originated from a cell taken from the udder of her biological mother.

This cell was inserted into an unfertilised sheep egg from which the nucleus had been removed. It was manipulated so that it fused with the ‘egg-mass’ to form an embryo. The embryo was then inserted into a foster mother who went through a normal, albeit closely monitored, pregnancy, resulting in the birth of Dolly – the first mammal to be cloned from an adult animal.

So far cloning has not been used to any significant extent in the breeding of farm animals. The main interest in the technology has come from scientists involved in research. Here there is a particular interest in the potential of combining cloning with another form of modern biotechnology: genetic modification.. Using transgenic techniques, scientists can move genes across species barriers, e.g. introducing genes of human origin into a mouse or a rat. In this respect genetic modification goes well beyond what has so far been possible in conventional breeding.

Most cloned and genetically modified animals are used in basic research and as disease models. Genetically modified animals have been produced to investigate the function of genes and gene products, and to create animals that mimic human diseases such as cancer or Parkinson’s Disease. The aim is to facilitate research into the diseases and test possible treatments. In this area of investigation cloning is used mainly as a tool to produce genetically modified animals and to study abnormalities in reproduction. Another potential use of genetic engineering is to create animals which serve as bioreactors that produce biological compounds not naturally occurring in them (so-called “pharm animals”). Typically a gene of human origin is introduced in the animal genome. This may enable the animal to produce a specific protein, often in its milk, that can then be used in the production of a particular medicine.

There is no doubt that modern breeding practices and the various reproductive technologies reviewed above have delivered significant benefits across a wide range of applications. Since the Second World War farm animal breeding has ensured that animal products are produced evermore efficiently, and this has contributed to the significant drop in the relative price of meat and other animal products. Whether this should be considered a positive development from an ethical perspective is a matter for debate.

Furthermore, the application of biotechnology to animals delivers an important set of tools for biomedical research. The hope is that this kind of research will enable researchers to find new ways to prevent, cure and alleviate serious human diseases, although for the most part this remains to be seen. Here again there is room for ethical debate.

Although modern animal breeding and recent developments in biotechnology deliver benefits, they also introduce problems – not least for the animals involved. These problems will be considered in the next section.

Problems caused by animal breeding and biotechnology

The main goal of farm animal breeding has so far been to increase the productivity of farm animals. Pursuit of this goal may as a side-effect lead to a higher occurrence of health-related welfare problems in farm animals. The breeding of dairy cattle for higher milk yield and breeding of broiler chicken for faster growth serve to illustrate this.

Over the last hundred years milk yield in dairy cattle has increased substantially. In Denmark the average milk yield has risen from approximately 2,000 kg to more than 9,000 kg per cow per year, thanks partly to improved management and partly to intensive breeding. This development can be seen as positive from the point of view of human standards of living. It may also be viewed positively from a resource perspective, since the pollution per kg milk produced may be less when production involves a smaller number of animals. However, it has become evident that excessive focus on raising milk yields leads to animal health problems. Thus on average cows get more mastitis and digestive disorders, and there are increased problems with reduced fertility and calving performance.

The huge acceleration in the growth rate of broilers has been secured largely by modern selection techniques. The time required for broilers to attain commercially desirable weight has, as a result, been cut substantially. But as an unintended side-effect the birds now suffer from severe leg problems. In a Danish study conducted in 1999 (Sanotra 1999), it was reported that nearly one third of the birds had a significantly reduced ability to walk normally. There is every reason to believe that this impairment is painful for the birds. A number of other problems also seem to be connected, directly or indirectly, with accelerated growth. For example, the parent animals used to produce eggs from which broiler chickens are hatched endure strict food restrictions under which they are permitted to eat only about half of what their appetite motivates them to eat. The resulting feeling of hunger may reduce their welfare, but in the absence of this restriction the animals become obese, with dramatic negative effects on both animal welfare and production.

The genetic correlations between production and health traits are typically unfavourable in the sense that the genes that bring increases in productivity introduce dispositions to disease and other health problems. Even so, carefully designed breeding programmes might allow breeders to improve health and increase production at the same time. In Scandinavia dairy cattle breeding programs were initiated in the 1980s which promote both production and health traits. Recently this approach to cattle breeding has spread to other countries. In response to public concern, companies involved in broiler breeding have in recent decades invested considerable resources in breeding for leg-health, and data from 2005 from one of the world's two main broiler breeding companies seem to indicate that there has been a significant reduction in leg problems in the birds.

However, because of widespread negative correlations between health and productivity, no breeding goal will at the same time deliver maximum improvements in animal health and welfare and maximum increase in productivity. Thus in farm animal breeding it will always be necessary to balance human benefits and the costs to the animals involved.

So far, genetically modified animals have mainly been used so far in biological research and as disease models. Usually the goal of modification is to produce animals that either under- or over-express certain genes, or that express a mutated, disease-causing human gene. In all these cases body function in the organism is in some way disrupted. In principle, modifications can involve any part of the animal genome, and the effects on the animal's phenotype range from those that are lethal to those that have no detectable effect on the health of the animal. It is therefore difficult to generalise about the welfare effects of genetic modification.

However, in some cases genetic modifications have a real impact on welfare. These cases can be divided into two main categories: those involving intended, and those involving unintended, genetic change. Welfare problems stemming from intended genetic change are hard to avoid, since the very point of inducing the change is to affect the animal. For example, a mouse carrying the human Huntington's disease gene will be prone to suffer welfare problems as it develops the disease, including rapid progressive loss of neural control leading to premature death (Naver *et al*. 2003). By contrast, unintended genetic changes are the upshot of two factors: the present inaccuracy of the technology and our insufficient understanding of the function of different genes in different organisms. Both of these factors operate to create the rather unpredictable nature of genetic modification at the phenotypic level.

Turning to cloned animals, the current success rates of animal cloning are very low (3-5%), and of the few individuals born, many suffer from impaired health. Here, a wide range of problems include reproduction abnormalities, malformation of organs and immunological dysfunctions (Vajta & Gjerris 2006).

Looking after animal welfare – And other ethical issues

It is not yet clear to what extent the welfare problems currently associated with animal cloning and other biotechnologies can be avoided through technological or methodological improvements, but it is likely that at least some unintended welfare problems will be reduced as the technologies and our scientific understanding develop. However, in one way breeding and biotechnology seem merely to add more of the same kinds of problem and concern that are already found in various forms of animal use. Production-related breeding and biotechnology make it possible for farmers to put more pressure on animals and produce ever more efficiently. When it comes to laboratory animals, breeding and biotechnology enable researchers to develop new animal models – for example, animals born with dispositions to develop certain diseases. And when it comes to companion animals, breeding is used to develop animals that meet human desires, such as the desire to own a dog of charming or endearing appearance.

Looked at in this way, breeding and biotechnology appear to give rise to the very same kinds of ethical dilemma that relate to other forms of animal use. In general, the dilemma is one in which there is, on the one hand, a human need, interest or preference, and yet, on the other hand, pursuit of the relevant human aim comes at a cost – a cost carried principally by the animals in terms of welfare problems.

Of course different people may based on different ethical points of view have different opinions on how to strike that balance. Some people will based on a contractarian perspective always give priority to human interests, others may inspired by an animal rights approach always give priority to animal protection and many will probably take a middle position, inspired by a utilitarian perspective, and try to balance human interests and the concern for animal welfare in a fair-minded way. (For a more full discussion see Sandøe and Christiansen 2008).

However it is important to be aware that there is more to the ethical discussion concerning breeding and biotechnology. Besides problems relating to the welfare of affected animals, breeding and biotechnology may also have a negative effect on biodiversity. In its nature, intensive selection tends to lead to losses in genetic diversity, since very often a limited number of genotypes of particularly high breeding value are concentrated upon and put to heavy use. This danger is particularly great in dairy cattle, where artificial insemination enables a few bulls to have offspring all over the world. Already, less productive local breeds are being replaced by high-yielding and thus more profitable breeds, and as a result genetic diversity is lost. Interestingly, however, it is desirable to protect biodiversity from the point of view of production: since it is not known what genes will be needed for future breeding goals, the preservation of genotypes may serve as a sort of insurance for the future. Of course, local breeds also have value as part of cultural heritage.

Moreover, ethical discussion may involve more than just weighing human benefits against costs to animals and effects on biodiversity. An example may serve to make that point: Some time ago poultry breeders in Israel managed to breed featherless broiler chickens for use in poultry production in countries with a very warm climate. From a human-centred perspective this may seem to be a very useful and ingenious step to take. The use of these chickens would allow savings to be made in feedstuff (that would otherwise be required for the growth of feathers) and reduce or remove the cost of plucking at slaughter. Even though this is disputed, it can also be argued that there is no problem for the welfare of the birds as long as they are only used in warm areas where they don’t need feathers to maintain their body temperature. However, many people will probably still object to the breeding of featherless chickens, because they see it as a wrong-doing to the animal, or as wrong in itself, to make such drastic changes to a natural feature of birds.

Some people feel that limits should be placed on researchers’ interference with nature. This feeling can be defended in two rather different ways. It can be claimed either that we should refrain from interfering with nature because we cannot accurately foresee the consequences of what we are doing and may therefore bring about some kind of disaster, or alternatively that we should leave nature as it is because untouched nature has a value of its own.

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