STAYING GOOD WHILE PLAYING GOD – THE ETHICS OF BREEDING FARM ANIMALS

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Abstract *Animal Welfare 1999, **8:*** 313-328

Modern genetics has given us some very efficient tools with which to alter the characteristics of animals. To date, farm animal breeders have mainly used these tools to increase productivity. Thus, each new generation of farm animals matures faster, yields more milk, or produces more meat or eggs, than the previous one. Despite these apparent benefits, modern farm animal breeding has had severe negative consequences, including effects on the quality of the animals' lives and biodiversity. The aim of this paper is to discuss the goals and consequences of farm animal breeding within an ethical context. First, a description of what has happened to broilers and dairy cattle as breeders have pursued the goal of ever more efficient production is given. Second, the ethical values that ought to underlie future breeding schemes are discussed. It is suggested that there are in fact two very different ethical approaches: the 'quality of life-based' approach and the 'preservationist' approach. A view combining elements from both approaches is advanced. Finally, an example is given of how it is possible, in practice, to pursue an ethically defensible breeding goal without compromising production efficiency.

Keywords: *animal welfare, breeding, ethics, genetic selection*

Breeding as an ethical issue

People have bred animals since prehistoric times. The earliest farm animals were tamed wild beasts, but human intervention changed the selection pressures on the animals and gradually domesticated animals evolved. Theories of how breeding can affect the characteristics of offspring date back to ancient times. Until this century, however, humans have not really been able to use breeding as a means to change animals at will. So although breeding in the past has had tremendous effects on domesticated animals, humans were not really in control of what was going on.

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This situation completely changed with the rediscovery of Mendelian genetics at the beginning of this century and the development of molecular genetics over the last few decades. We now possess some very efficient tools with which to change animals intentionally. Since the 1930s these tools have increasingly been used to make animal production ever more efficient. However, the pursuit of this goal has had negative effects both on biodiversity and the quality of the animals' lives. This has given rise to an urgent need to clarify morally acceptable ways of using the tools delivered by animal genetics. With greater control comes a higher degree of ethical responsibility. As long as we are incapable of understanding what we are doing we cannot be blamed. 'Ought implies can', as the moral philosophers say. Conversely, when we can make a difference, we ought to. So, when we can reasonably predict the consequences of our actions we must take on the burden of ethical responsibility.

The future of domesticated breeds is in our hands – whether we like it or not. Even retrogressive options, such as to retain the status quo or to revive old breeds, would be decisions *we* take. We have to face the question of how to use (or not use) the god-like powers bestowed upon us by modern genetics. In this paper we discuss what ethical goals ought to underlie the breeding of farm animals. Furthermore, we suggest how to move towards realizing these goals. First, however, we describe what has happened to broilers and dairy cattle as breeders have pursued the goal of more efficient production.

Goals and consequences

Until recently, the main aim of farm animal breeding was to improve production and efficiency. This is most noticeable among intensively reared livestock, such as the broiler chicken, in which, until recently, 50 per cent to 70 per cent of the selection pressure was used to obtain rapid juvenile growth. Genetic selection in dairy cattle and laying hens has centred on milk and egg production traits, respectively; whereas domesticated pigs have been bred for characteristics such as enhanced growth rate, feed efficiency, and more recently, litter size.

These goals are laudable because, other things being equal, their achievement will optimize the use of resources, minimize the cost of consumables, and reduce negative environmental consequences. However, they have also led to undesirable and ethically problematic changes. Some of the indirect consequences of narrow selection goals concern the welfare of the animals; others relate to the loss of biological and genetic diversity. In the following sections these issues are discussed, using as examples the breeding of broilers and dairy cattle.

Breeding of broiler chickens

The growth rate of broilers has increased dramatically as a consequence of genetic selection. Intense selection for growth has resulted in modern broilers growing almost three times as fast during the period of maximum growth as the breed they were derived from 40 years ago (Figure 1). In the last decade alone, the weight of a 42 day-old broiler has increased by 17 per cent to 1980g, and in the same period the amount of feed used to produce 1kg of chicken has dropped by 7 per cent (Det Danske Fjerkræraad 1998). In comparison, egg-producing strains kept under similar conditions will (at the same age) weigh one-third of the weight of broiler chickens (Gerken & Jaenecke 1997).

This substantial increase in the growth rate of the broiler chicken has, perhaps not surprisingly, resulted in a number of side-effects, of which the most common are various types of leg weakness. These include tibial dyschondroplasia (TD; abnormal development of the growth plate of tibia), femural head necrosis, dislocation of the hock-joint, longitudinal rotation of tibia, and curled or crooked toes (Sørensen 1992).

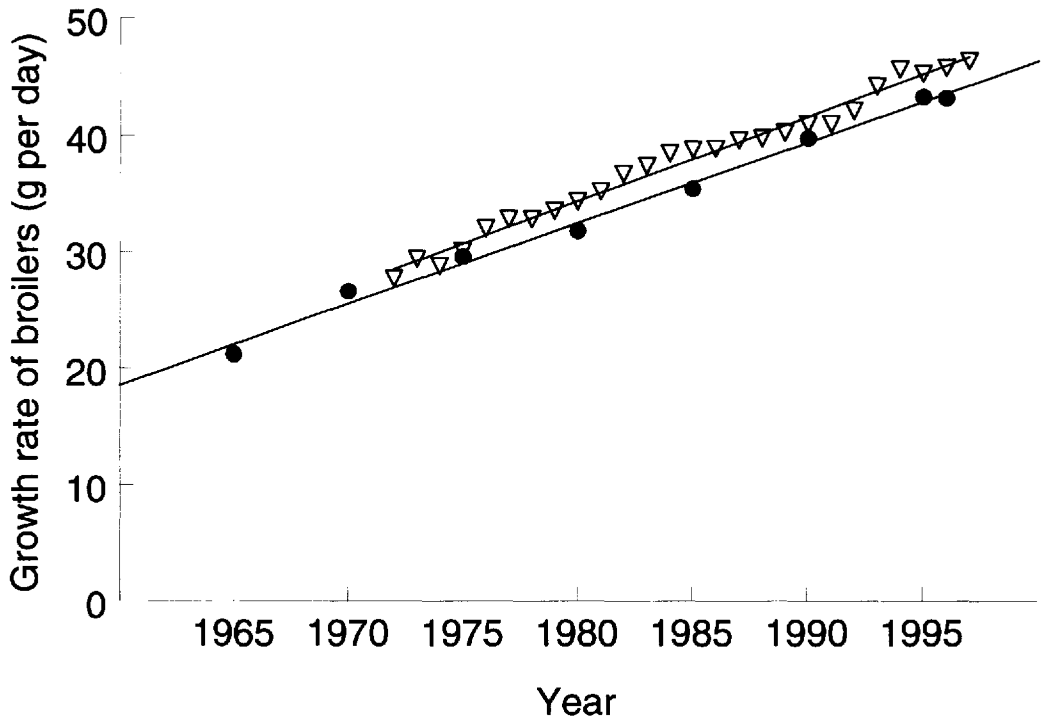

Figure 1 **Development of broiler growth rate (slaughter weight/growth period) over the years in The Netherlands (●) and Denmark (▽). The slopes of both regression lines are 0.7 (g day^{-1} year^{-1}). Data from Rauw *et al* (1998), Landsudvalget for Fjerkræ (1980; 1990), and Det Danske Fjerkræraad (1998).**

Kestin *et al* (1992) have developed a scoring system with which to gauge the locomotive ability and gait of broilers. Integer gait scores between 0 and 5 are given on the basis of the broiler's ability to walk a short distance: a score of 0 represents the perfect gait as performed by the majority of layer-type birds, and a score of 3 is given to birds with obvious gait defects affecting their ability to move about. These birds will often prefer to squat when not coerced into moving, and their manoeuvrability, acceleration and speed are affected. The score of 5 is given when a bird is incapable of sustained walking on its feet. Even if it is able to stand, locomotion can only be achieved with assistance of the wings or by crawling on the shanks (Kestin *et al* 1992).

Using the gait scoring system, 22 per cent of commercial broilers at the age of slaughter (42 days) were found to have leg problems affecting their ability to move (ie a score of 3 or over; Figure 2; [Kestin *et al* 1994]). The deterioration of gait with age seen in broilers is closely linked to the rapid growth of these birds, as is illustrated in Figure 3, with the lowest

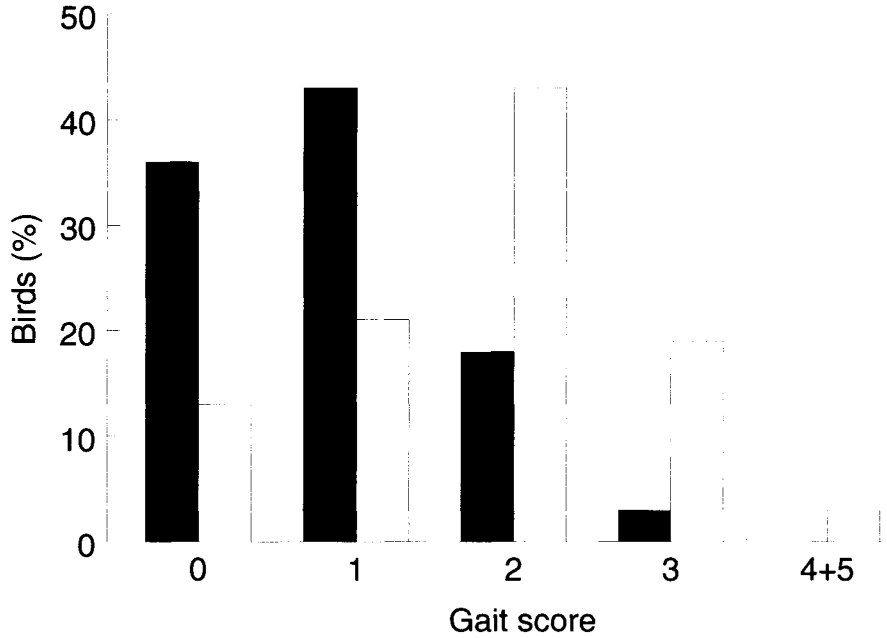

Figure 2 **Distribution of gait scores for commercial broilers at 28 days (solid bars) and 42 days (open bars). Data from Kestin *et al* (1994).**

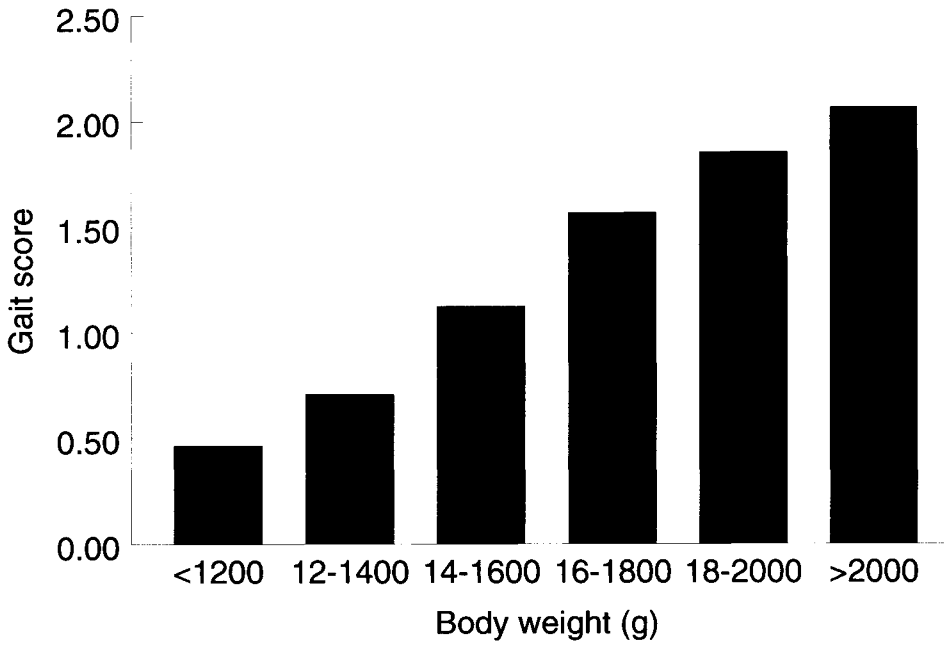

Figure 3 **Mean gait score for different weight groups of commercial broilers at 35 days (P Sørensen personal communication 1998).**

gait scores obtained by the least heavy birds at a given age. Similar results were obtained by Kestin *et al* (1992), but they found a substantial drop in the liveweight of birds with gait scores of 4 and 5. This was interpreted as a consequence, rather than cause, of the immobility and the concomitant inability to compete with other birds for food and water. Recent studies on the effect of changing various factors in the chickens' environment have demonstrated that the use of feeding techniques where the chicken is allowed to eat a few times only per day substantially improves walking ability, while factors like length of photoperiod had little or no effect on walking ability at the end of the normal growing period. (Sørensen *et al* 1999; Su *et al* 1999).

The heritability (h^2) of tibial dyschondroplasia (TD) is relatively high ($h^2 = 0.33$; Ducro & Sørensen [1994]), and so TD would appear to be susceptible to genetic treatment. Selection against TD has been carried out for some years now by the major broiler breeding companies (eg Nicholson [1998]). However, the gait of broilers does not appear to have improved to the same degree as the decrease in TD would predict, leading to concern that other types of leg disorders are the major cause of problems, or that these disorders are increasing in the broiler population.

Leg weakness significantly alters the behaviour of broilers, with activities such as walking, standing and running reduced to minimal levels in broilers with a gait score of 3 (Weeks & Kestin 1997). Urrutia (1997) lists other consequences of fast growth in broilers, such as 'sudden death syndrome' (cardiovascular failure) and hypertrophy of the right ventricle in the heart caused by tissue hypoxia. In addition, the fast growth necessitates severe food restriction in the parent stock, down to 25 per cent of *ad libitum* intake (Savory *et al* 1996), to ensure an acceptable reproductive performance and to prevent metabolic disorders. Thus, as a consequence of the genetic changes, the birds may be expected to experience pain or stress at different stages of their lives. This is clearly an ethical problem.

Breeding of dairy cattle

The annual milk yield of dairy cows has been increasing since records began (Figure 4). Until the mid-1980s, most of the increase in milk yield was the result of improved management, and, in particular, better application of nutritional standards and improved quality of roughage. Since then, the worldwide distribution of semen from bulls with high genetic merit for production has greatly increased the rate of genetic progress. Recently, methods for combining data from several countries have been developed, and the genetic evaluations from Interbull (The International Bull Evaluation Service) are based on data provided by 18 countries, for five dairy cattle breeds (Wickham & Banos 1998). Today, dairy bulls with high genetic merit for production traits are used worldwide. According to Wickham and Banos (1998), the five most heavily used Holstein-Friesian sires accounted for 50 per cent of all breeding bulls born in 1990 across the 18 countries that contributed to the Interbull evaluations of 1997.

Genetic selection for high and efficient milk production has led to a reduction in the number of cattle breeds from which milk is produced. A total of 217 dairy cattle breeds can be found in 26 European countries; 72 of these breeds are endangered, and 80 per cent of the European milk production originates from only 54 of the 217 breeds (Martyniuk & Planchenault 1998). Around 90 per cent of the UK dairy herd today are of the black and white breeds, and they produce around 95 per cent of the milk (Simm 1998). Similar trends are seen in Denmark, where three breeds currently account for 97 per cent of the dairy cow population, and the Holstein-Friesian breed alone accounts for 70 per cent (Figure 5). This tendency for a few breeds to dominate the population has led to concerns about the loss of

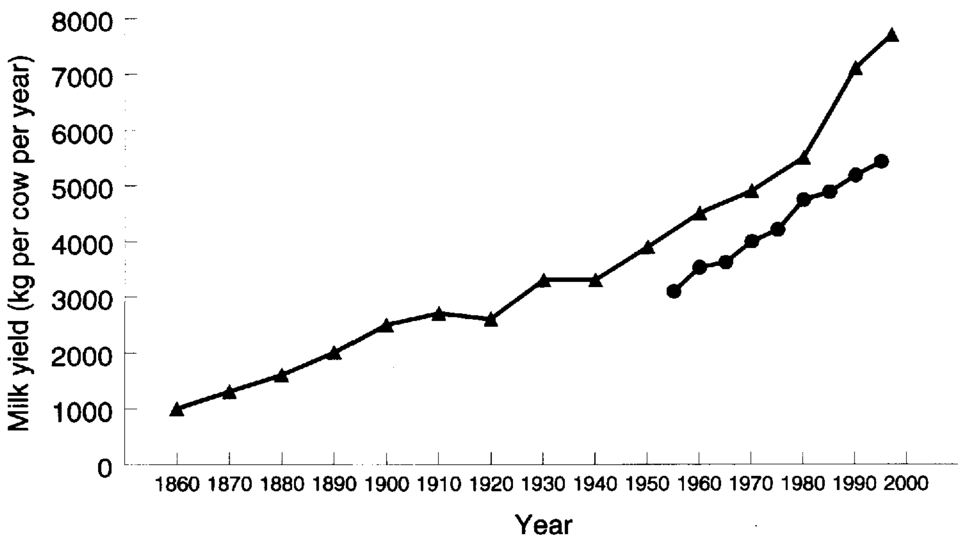

Figure 4 Average milk yields of dairy cows in Denmark (▲) and United Kingdom (●) over the years. Data from L G Christensen (1998 personal communication) and the UK Milk Marketing Board (1994).

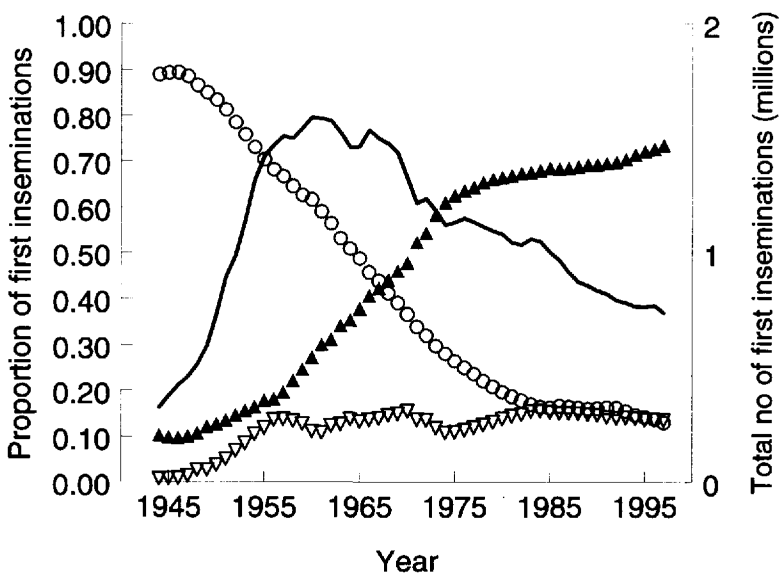

Figure 5 A measure of the size of the cow population (total number of first inseminations [—]) for three dairy breeds in Denmark, and the proportional distribution of first inseminations for Red Danish (O), Danish Holstein-Friesian (▲), and Jersey (∇).

biological diversity, as older, so-called unimproved, breeds of livestock disappear or are in danger of doing so (Avon 1990).

There is also substantial evidence that genetic selection for high milk yields has led to a decline in health, in terms of increased incidence of mastitis and digestive diseases (Mäntysaari *et al* 1991; Jones *et al* 1994; Lescourret *et al* 1995), more calving problems (Hanset 1981) and more lameness (Alban *et al* 1996). A significantly reduced fertility in dairy cows of high genetic merit has also been demonstrated (Nebel & McGilliard 1993; Pryce *et al* 1999). This deterioration in health and fertility has resulted in an increase in the frequency of involuntary culling (Beaudeau *et al* 1995). The genetic correlations between milk yield and health traits are antagonistic and much stronger than the corresponding phenotypic relationships (Lyons *et al* 1991; Mäntysaari *et al* 1991), reflecting the significant influence of management on the occurrence of disease. The incidence of a number of diseases also increases with parity after the cow has reached her mature yield in her third lactation, which may indicate a cumulative effect of successive lactations (Nielsen in press). Thus, selection for high milk yield will necessarily have negative welfare consequences for the dairy cow. One way of addressing this problem is the use of multiple-trait indices (Veerkamp *et al* 1995; Christensen 1998a, b), an example of which will be discussed below.

Ethical outlooks on breeding

Breeding poses an ethical problem which is different in nature from other ethical problems concerning our treatment of domesticated animals. For example, in discussions of housing conditions for farm animals, the animal types are, so to speak, taken for granted, and the question is simply about *treatment*. In contrast, the questions relating to breeding concern *which animals* are going to exist. The difference can be clarified by considering the sort of moral reasoning that people often apply to breeding issues. Take, for example, a cow that is genetically disposed to encounter birth problems. It is natural to say that it would have been better for this cow had breeding schemes in the past focused more on preventing calving difficulties. However, strictly speaking, it is probably false to say that it would have been better for *this* cow if another breeding strategy had been pursued, because in that case this cow would probably not have existed. Breeding decisions, then, affect the identity of the animals that come to exist – and may, as we shall see, even affect their numbers.

An ethical outlook on breeding must provide guidance on how to evaluate the goals and consequences of different possible breeding schemes. Two kinds of approaches to such evaluation exist (Sandøe *et al* 1996). One is the 'quality of life-based approach'. This specifies what is good and bad for the various parties that may be affected by animal breeding and outlines a principle for weighing the interests of the affected parties in case of a conflict. The other is the 'preservationist approach', according to which breeding schemes ought to preserve the genotypes that already exist (or a subset of these). Key notions in the latter approach are *authenticity* and *biodiversity*. The focus is typically holistic, concentrating on the integrity of breeds as a whole rather than the good of individual persons or animals. A notion such as biodiversity may, of course, also play a role in a quality of life-based approach. However, the motivation and focus will be different. According to the quality of life-based approach, preserving biodiversity is all about preserving resources, biological or recreational, judged to be of importance in securing the quality of life for future persons or animals. In contrast, the preservationist approach looks upon biodiversity as something that is valuable in itself and not merely as a resource.

Probably very few people, if any, adopt the preservationist approach in its pure form. It seems to be generally accepted that human and animal quality of life matter. The real discussion is, therefore, most likely to be between those who take the quality of life-based approach, thereby claiming that *only* well-being matters – and those who think that the preservationist approach is *also* relevant.

The quality of life-based approach can be spelled out in several different ways. Different views falling under this approach vary in two dimensions. First, they may embody different conceptions of quality of life. Roughly speaking, quality of life may be defined in terms of good functioning, including health; it may be defined in terms of pleasure and avoidance of pain; or it may be defined in terms of preference satisfaction (Fraser *et al* 1997; Sandøe 1999). Second, views may differ over the way in which the interests of the affected parties should be weighed against one another. One influential view here is the classical utilitarian view, according to which the aim should be to maximize the total sum of that which contributes to quality of life among the affected parties. Alternative views will focus on those worst off and will for, example, prescribe minimum standards of quality of life for all – standards which must be adhered to even if this means a smaller total amount of that which contributes to the quality of life. (For an outline of the various ethical views, see Sandøe *et al* [1997].)

In the following discussion we shall take as our starting point a classical utilitarian view in the style of Bentham (1789). According to this view, the only concern in setting up breeding schemes should be to obtain the highest possible net amount of pleasure (ie the sum of pleasure minus the sum of suffering) for human beings and animals. (A closely related view, noted above, is preference utilitarianism which defines the good in terms of preference satisfaction instead of pleasure.) Other things being equal, one should aim to breed animals which will be healthy and which are otherwise able to avoid suffering and live a pleasurable life. From a utilitarian point of view, the important thing is how the animal subjectively perceives its situation. Pain and other kinds of suffering detract from the quality of the animal's life, while pleasure in its various forms make a positive contribution.

On the utilitarian view, human well-being also counts, even though the activity being assessed is animal breeding. Thus, our interests in being able to buy very cheap meat and other animal products should be taken into consideration to the extent that their satisfaction will create more pleasure – either directly or indirectly – by setting free resources for other purposes. This may lead to a conflict of interests between, on the one hand, breeding for rapid growth, increased milk production and other production traits, and, on the other hand, breeding for increased welfare. However, in the more affluent parts of the world, very cheap products are not vital to people. In a country like Denmark, ordinary consumers spend about 10 per cent of their available income on food (Statistics Denmark 1996). A moderate increase in prices of meat and other animal products would, therefore, have only a marginal effect on the proportion of people's income available for other purposes; and since the income is generally high this would not significantly decrease the quality of life of the affected individuals. On the other hand, it is possible to improve the quality of life of the animals significantly at moderate costs. Therefore, when there is a conflict, breeding programmes should, according to the utilitarian view, favour traits related to the quality of animal life rather than productivity raising traits. This argument will probably be acceptable to adherents of various other ethical views. The controversial side of the utilitarian view only becomes apparent when the following two cases are considered: i) where the number of animals is an issue; and ii) where animal well-being is achieved by changing the animals rather than by changing a poor production environment. We shall elaborate on each of these cases in turn.

According to utilitarianism the quality of animal life has ethical significance. However, it is possible to improve the quality of farm animals' lives in two quite different ways: either by improving the living conditions of the affected animals, or by bringing different animals into existence. These two strategies may be compatible or they may conflict. Here is a case where there appears to be a conflict:

Keeping animals in poor environments may reduce the price of the resulting animal products so that more products are bought and, consequently, more animals come into existence. For example, rearing broilers in very intensive production systems has made it possible to sell chicken meat at very low prices indeed, which in turn has resulted in a worldwide boom in broiler production. Whether or not this is a good development for the broilers will, according to the utilitarian view, depend on whether any decrease in the quality of life for the individual broilers will be compensated for by a net gain in the sum of that which contributes to the quality of a broiler's life. Thus, each broiler may experience less net pleasure, but since there are so many more of them the sum total of enjoyable experiences is greater – the net sum of pleasure in one million mediocre broiler lives being higher than the net sum of pleasure in the lives of one thousand free-range chickens. The calculation may or may not turn out this way, of course. (Perhaps modern broilers have a life that is not worth living.) However, many people will probably think that the whole idea of calculating the ethical acceptability of broiler production in this way is perverse, and will, therefore, be sceptical about applying utilitarian principles in these cases (for a general discussion, see Parfit [1984]). However, the criticism is not directed at the quality of life-based approach per se. To accommodate the sceptics this approach can incorporate the idea of a minimum standard of quality of life for each individual animal.

The following example may help to test one's intuitions about the second type of case, ie the case in which animals are being changed to make up for poor production systems. Feather pecking and cannibalism are serious problems in modern egg production where hens are kept in large groups. The hen directs its pecking towards the feathers of another bird, which can lead to severe damage of the plumage and cause wounds. The wounds may attract more pecking from other hens, developing into cannibalism, and the bird may eventually be pecked to death or culled. Apart from the increased risk of cannibalism, feather pecking leads to a reduced quality of life as it is painful to have feathers removed and feather loss is associated with heat loss. This problem has financial consequences too, because the birds will consume more food to combat heat loss, and because any fatalities among the birds will lower overall returns. Attempts to modify the environment of laying hens to eliminate these problems have been largely unsuccessful. To alleviate the problem, day-old chickens are usually mutilated by having the tips of their beaks removed.

However, another solution exists: this involves using blind hens. The blindness in one experimental strain of layers is caused by an autosomal recessive mutation. A study comparing blind and sighted chickens (Ali & Cheng 1985) showed that the blind chickens do not have problems with feather pecking, comb damage or cannibalism. Nor do they seem to have any additional problems measurable by normal standards applied in animal welfare research. Cortisol levels do not differ between the two groups. The blind chickens are able to find food and water. Their food intake is about 25 per cent less than the sighted chickens but their body weight remains the same. This is thought to be due to the reduced activity of the blind chickens in combination with the reduced heat loss of their intact plumage. In addition, the blind chickens produce about 13 per cent more eggs.

Of course, being blind may deprive the hens of some pleasures. However, there is good reason to think that these hens are well adapted to their situation and may find pleasure by many other means. Assuming that the blind hens do not suffer in any other way, it seems clear that, by utilitarian standards, they live a better life than their sighted counterparts. However, many people will think that this is a completely wrong approach to improving animal welfare. One way of adjusting the ethical principles to cater for this thought is by defining quality of life in terms of 'good functioning', as measured by the standards of the species.

Alternatively, one can take in the viewpoint of the preservationist approach. Adherents of this approach would emphasize that we should change the housing systems to fit the animals, not the animals to fit the housing systems. Of course, the preservationist approach also gives rise to critical questions. This view values the preservation of certain existing genotypes. However, sometimes a change in genotype would be an advantage to both animals and humans. How, then, can the preservation of existing genotypes be of value when it is not of value to any of the affected parties? Also, domesticated animals are in a clear sense artefacts — how, then, can one breed be more authentic than another?

No attempt will be made here to resolve these large issues, but it can be pointed out that there is room for partial reconciliation. According to both approaches, it is in most cases a good thing to breed animals for improved quality of life. The utilitarian view can be accepted – except for cases where the good of the individual animal is sacrificed to gain a larger net good and for cases where animals are bred so as to change their nature in significant ways. There is, however, no clear definition of what constitutes a significant change in animal nature, but breeding blind varieties of animals that normally see is an example.

The view suggested here may be described as utilitarianism with side-constraints. When breeding animals we should aim to increase the sum of that which contributes to the quality of life of animals (and humans), but the increase should not be achieved at the cost of the individual animal or by depriving the animals of natural abilities, such as being able to see. In the subsequent section we will discuss how this view may be applied in practice, using an example from the breeding of dairy cattle. It is necessary to reconcile ethical demands with the economic imperatives of animal production, as any improvements in the quality of life of the animals will disappear if the resulting production is not competitive in economic terms. Thus, the challenging task is to breed in way that is both competitive and improves the quality of animal life.

Breeding to improve the quality of life for domesticated animals

The necessity of broadening breeding goals has long been promoted by a number of geneticists and other animal scientists (eg Phillips [1997]; Simm [1998]). The rapid and successful selection against TD in broilers is one example of the inclusion of traits which are only indirectly production-related (Kestin, Su & Sørensen unpublished), although this alone does not solve the problems of broilers as outlined above. Selection for multiple and diverse traits is now more common in the dairy industry, with the development of selection indices such as ITEM (Index of Total Economic Merit), which incorporates longevity estimated from genetic correlations to type traits (Veerkamp *et al* 1995); and the selection indices for dairy sires used in the Nordic countries, which directly incorporate health and fertility traits (Christensen 1998b). The question to be answered is: does the use of such broader breeding goals lead to an improved quality of the animals' lives?

One example of successful multitrait selection comes from the Nordic countries, where breeding goals have been formulated to include health, calving performance, and fertility. The marginal net profit of one unit of genetic improvement in each of these traits, and in milk production, has been estimated, and is included as information when calculating the merit index. Thus, the selection criteria in Table 1 illustrating these effects on the expected annual genetic progress per cow are expressed in Danish kroner. When only an increase in milk production is the goal (Production), health and fertility traits decrease. Reducing the rate of increase on the production traits by also selecting for health and fertility traits (Multitrait) leads to an improvement of the latter traits, and results in an overall economic benefit. Putting even more emphasis on traits other than production (Multitrait+) reduces this benefit slightly, but still outweighs the total genetic progress in terms of the profit which is obtainable from selection for production traits alone. Figure 6 shows the predicted effects on the incidence of mastitis requiring treatment as a function of sire index for mastitis resistance. Thus, shifting the breeding goals to include mastitis resistance would significantly decrease the number of mastitis cases in the population.

Table 1 The effects of selection criteria and breeding goals on the expected annual genetic progress per cow, expressed in Danish kroner. See text for details.

	Breeding goal		
Target traits	**Production**	**Multitrait**	**Multitrait+**
Production	106	80	53
Mastitis resistance	-14	7	17
Resistance to other diseases	-6	1	4
Calving performance	0	7	9
Fertility	-6	0	3
Udder and teats	-3	8	12
Total	**77**	**103**	**98**

Antibiotic treatment for mastitis in the Nordic countries can only be carried out by a veterinarian and is, therefore, more expensive than it is in most other European countries and the USA. Hence, the true economic benefit of selecting for mastitis resistance must be calculated as a function of the money saved by the decrease in frequency of mastitis (ie the saved cost of treatment plus avoided loss of yield and involuntary culling due to the disease) and the reduced gain in milk yield relative to selection for increased production. It may also be necessary to take into account the genetic correlation between mastitis and levels of somatic cell counts (SCC), and the economic penalties for high levels of SCC which have recently been introduced in many European countries. The influence of having alternative breeding goals in a modern breeding scheme for dairy cattle is illustrated in Table 2. In this example, 10 years of selection solely for milk yield resulted in an increase of 117 900kg of milk and 12.9 additional treatments for mastitis in a herd of 100 cows (ie an average of 1179kg and 0.129 treatments per cow). It is possible, by using selection indices which combine milk yield and mastitis resistance, to improve both traits simultaneously. If, for example, mastitis resistance is given double weight in the index relative to milk yield, the gain in milk is reduced to 96 400kg, a reduction of 21 500kg compared to selection for milk yield only. The number of mastitis treatments is reduced by 18.4 (ie 12.9 – [-5.5]) per 100

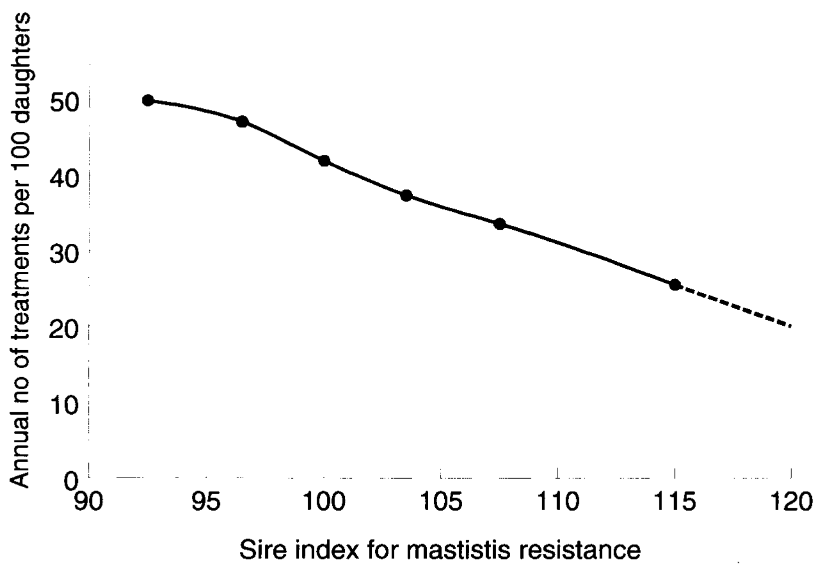

Figure 6 **Predicted effects of sire index for mastitis resistance on mastitis frequency in future daughters of Danish Holstein-Friesians. Graph modified from *Håndbog for Kvæghold 1996–1997* (Landbrugets Informationskontor 1997).**

cows. In this particular case, the loss in milk yield gain after 10 years of selection is equal to 1168kg (ie 21 500/18.4) per avoided treatment for mastitis.

This example illustrates that it should indeed be possible, through genetic selection, to lower the incidence of a disease such as mastitis – a disease which contributes significantly to the suffering experienced by many dairy cows. The added bonus is that such breeding goals do not necessarily lead to a reduction in profitability; and, depending on the cost of treatment relative to milk prices, the relative weighting of such traits in the selection index can be chosen to maximize profits. However, as long as the majority of the dairy bulls tested

Table 2 **The expected effect after 10 years of index selection with varying relative weight on milk yield and mastitis resistance.**

Relative weight on mastitis resistance	Extra kg milk per cow after 10 years (A)	Extra mastitis treatments per 100 cows after 10 years (B)	Kg milk not obtained in (A) for each avoided mastitis treatment in (B)
0.00	1179	12.9	0
0.50	1167	8.8	293
1.00	1128	4.2	586
1.43	1070	0.0	845
2.00	964	-5.5	1168
4.00	514	-19.2	2072
7.94	0	-27.5	2918
10.00	-120	-28.7	3123

in the Nordic countries originate from sires outside Scandinavia, where no estimates for genetic merit for health and fertility traits are available, the Nordic effort to improve these traits is of little consequence (Christensen 1998b).

Rushen and de Passillé (1998) note that animal welfare is portrayed as opposed to animal production far too often; and Smith and Hogan (1998) present the notion that high production levels cannot be achieved unless the welfare of the animal is good. The variation in management skills between dairy farmers is typically large enough to mask any potential correlation, whether negative or positive, between measures of the quality of an animal's life and its production. This is also reflected in the low or non-existent phenotypic correlations between production and health traits, as compared with the relatively high genetic correlations (Pryce *et al* 1998). Broom (1994) calls for production efficiency to be accompanied by good animal welfare.

The advantages of genetic improvement are cumulative and permanent and are usually highly cost-effective and sustainable (Christensen 1998a; Simm 1998). Unfortunately, some of these very advantages have facilitated a rapid increase in growth in broilers and detrimental effects on the quality of life of the animals, especially of restrictively fed broiler breeders, have followed (Savory *et al* 1996). In order to improve the quality of life of animals through genetic selection, the cooperation of breeding experts, geneticists, epidemiologists, nutritionists, ethologists and others concerned with animal welfare problems is required. Sustainable breeding goals, incorporating health and fertility measures, are necessary to at least avoid a decrease in the quality of life of the animals, if not to enhance it.

Conclusions and animal welfare implications

Armed with the techniques of modern genetics, breeders of farm animals can pursue their goals in a very efficient way. However, these same techniques permit us to foresee and control negative consequences, notably negative impacts upon the quality of life of the animals, and this creates an ethical responsibility. When trying to shoulder this responsibility one should be aware that there is more than one ethical perspective from which principled advice may be forthcoming. However, all reasonable ethical approaches commend, within different limits, the breeding of animals with a view to improving their quality of life. There is a need, and ample scope, for multidisciplinary efforts to integrate animal welfare parameters into animal breeding. It may even, at times, be possible to breed in a way that is both beneficial to the animals and economically efficient.

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