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The effects of production efficiency on animal welfare *

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Summary

The efficiency of animal production, both in economic terms and in individual animal production, has improved dramatically in recent years and this improvement is generally beneficial for human consumers. In some ways, however, these changes have resulted in poorer animal welfare. Particular effort has been directed towards increasing growth rates by high levels of feeding, increasing food conversion efficiency and managing or modifying animals so as to obtain special products. Ways of achieving these objectives have included improved nutrition, manipulation of growth regulators and modifers, changes in housing and daily management, conventional breeding and genetic manipulation. Examples of consequences of aiming for fast and efficient growth are: leg problems, changes in disease incidence, changes in the proportion of muscle to circulating capacity, increased survival of harmful genes and parturition problems. Special products may necessitate management, e.g. for white veal, or breeding, e.g. for prolific wool production, which causes problems for the animal. Efficient production with good animal welfare must be the aim for the future if the animal production industry is to be publicly acceptable.

Keywords: animal welfare, animal production, animal breeding, growth promoters, somatotrophin, genetic engineering

Introduction

In the last 40 years there has been a considerable increase in the efficiency of animal production. This has resulted in lower food prices for consumers and hence has been economically beneficial to them but it has sometimes resulted in severe problems for animals. Where such problems exist, the practices which lead to them would be judged as morally wrong by the majority of the general public. Those consumers who are aware of the animals' problems sometimes refuse to buy the products and a situation of this kind is bad for the image of the industry. Indeed, in recent years in many European countries, poor welfare of farm animals, together with adverse impacts on the environment and worries about undesirable residues or other components in human food, have contributed to a worsening of the public image of the animal production industry. One result of this has been a decline in animal production consumption, especially when increasing affluence is taken into account, whilst another has been a reduction in the sympathy of governments towards their national agricultural industries.

* Keynote address

The effects on animals of improved economic efficiency in animal production systems and, more specifically, the effects of greater efficiency in individual animal production, are discussed below. The likely effects of future developments in animal production are also considered. First, however, it is necessary to consider the concept of animal welfare and what measurements can be made which allow us to assess the welfare of animals.

The concept of animal welfare

An individual may have no problems in its interactions with its environment, or it may have to resort to much use of methods for trying to cope with difficulties and may fail to cope. The welfare of an animal is its state as regards its attempts to cope with its environment (Broom, 1986). Welfare will vary on a range from very good to very poor, and the extent to which welfare is good or poor can be assessed scientifically. Indicators of what results in good welfare include strong preferences which can be demonstrated in experimental studies and an absence of any sign of problems for the individual. There are many indicators of poor welfare (Table 1); it is necessary to use several of these in any study because there is a range of different coping methods and a variety of different consequences of failure to cope (Broom, 1988, 1991b; Fraser & Broom, 1990). In many cases, welfare becomes poor because the individual lacks control over its interactions with its environment, and wherever there is suffering, welfare is poor (Wiepkema, 1987; Broom & Johnson, 1993). These concepts are discussed at greater length, and the definition used here compared with other definitions, by Broom & Johnson (1993).

Table 1. Indicators of poor welfare

Reduced life expectancy
Reduced ability to grow and breed
Body damage
Increased disease incidence
Immunosuppression
Physiological attempts to cope
Behavioural attempts to cope
Behaviour pathology
Self narcotization

General economic efficiency and welfare

Very many changes in animal production systems have been introduced to reduce the overall costs of the enterprise and to increase the net profitability. Some of these are exemplified in Table 2(a) and each of these is followed by an example of possible consequences which are associated with poor welfare. Efforts to reduce labour and building costs per unit of product can result in individual housing of calves, sows, etc.

in conditions which allow insufficient exercise, room to groom, foraging behaviour, and social interaction. Hens which are easily managed when in battery cages have social companions but lack room for exercise and have weak bones as a consequence (Knowles & Broom, 1990). Pigs kept at high stocking densities with little opportunity for exploratory and manipulative behaviour are more likely to show tail-biting and show a higher cortisol response to challenge with adrenocorticotrophic hormone (Meunier-Salaun et al., 1987).

Improvements in economic efficiency may be directly associated with improvements in the welfare of animals, so not all changes have results like those listed in Table 2(a). If changes are made which improve the welfare of dairy cows, these very often increase output per unit of food input. Measures taken to reduce mortality rates of calves, lambs or piglets are beneficial, both in economic terms and in respect of the welfare of the young animals. Hence it would be quite wrong to say that greater profits mean worse welfare, only that any risk of poorer welfare should always be taken into account if a new system or variation in a system is under consideration.

Table 2. Improved economic efficiency in the animal production industry: welfare

a.	*Examples of changes designed to improve general economic efficiency*	*Example of problem for animal*
	Easier feeding and management	Individual housing
	High stocking density	More disease
	Fewer animal care staff	Problems missed
	Less veterinary time per animal	Disease etc. not treated
	Fewer, larger, faster abattoirs	Longer journeys, poorer care
	Special markets, e.g. white veal	Confinement, anaemia
b.	*Examples of changes designed to improve efficiency of production per animal*	*Example of problem for animal*
	Improved nutrition for growth	Growth too fast
	Improved nutrition for energy partitioning	Muscle : bone ratio wrong
	Reduced energy expenditure by animals	Confiment
	Growth promoters	Leg problems
	Growth promoters from bioengineering	More production-related disease
	Embryo transfer	Parturition problems
	Conventional breeding	Harmful characteristics
	Transgenic animal use	Biological system changes

Some animal production systems are not in themselves very efficient, but a high-value product may encourage housing and management practices that have some adverse effects on the animals. For example, the production of paté de foie gras involves force-feeding of geese, and the production of white veal involves using both iron-deficient diets, with consequent anaemia, and confinement in small crates with consequent behavioural and physiological indicators of poor welfare (Broom, 1991b).

Efficiency of production per individual animal and welfare

Although the topic discussed in the previous section is important, it has already been widely considered, so most of this paper is devoted to the productivity of individual animals. Increases in the productivity of individual animals have been the principal subject of animal production research, and the world at large has much reason to be grateful to those studying breeding, nutrition and disease reduction for the benefits which have accrued from their efforts. However, we need to use such knowledge wisely and to consider in every case whether we have come too close to some biological limit. There are biological limits to the body size which can be supported by a given design of skeleton and to the distance which oxygen can diffuse in a given tissue and yet reach a required concentration in the cells. If individuals bred and reared in a particular way are generally unable to cope with the environments commonly encountered, then a biological limit has been reached. Have all of the animals the ability to adapt to the rates of metabolism and growth which are now expected of them? Table 2(b) shows some of the changes which can result in poor welfare. Many of the changes can be associated with more than one of the problems listed.

Breeding

Whenever animals have been bred to obtain a particular objective, there has been the possibility that the main effect or side effects would cause problems for the animals. Clear examples of this are seen in dog breeds in which the animals have breathing difficulties, deafness, skin folds which impair sensory function, or increased susceptibility to some disorder. One example of selection causing or exacerbating problems in a farm animal is the Merino sheep. Selection for high-density fine wool has resulted in an animal whose skin is folded more than that of most sheep and whose wool is very dense. A minor consequence of this is that shearing is somewhat more likely to involve cuts in the skin unless the shearer is careful. A much more important consequence is that moisture is more likely to be retained, especially in the ano-genital area, and there is a greater risk of fly-strike, where *Lucilia* and other blowflies lay eggs in the area and the body of the sheep is eaten by the larvae. Another welfare problem, which is worse in Merinos than in most other sheep breeds, is that resulting from the poorer maternal behaviour in the breed.

Selection for double muscling in cattle has caused some problems directly. Some strains of Belgian Blue cattle produce calves that are too large for normal parturition to occur safely. Severe problems can result at parturition; alternatively there is a necessity for Caesarean section, a substantial operation which should be avoided if possible. Such genetic lines should not be continued.

A much commoner consequence of farm animal breeding programmes concerns animals that have the potential to grow fast and efficiently. If these are fed in such a way that their maximum growth potential is realized, they reach a size at which some problem occurs. Selection for large breast muscles in turkeys has reached a point where full-grown male turkeys are often unable to mate. If they attempt to mate, whether or not they are successful, injuries to the females may ensue. Hence artificial insemination is normally used. Most of those not concerned directly in the animal production industry find it unreasonable that almost all members of a widely used breeding line are unable to perform a normal biological function like mating, and consider that turkeys that can mate should be used. It is also of interest that broiler breeders are anxious to point out that their male birds are able to mate. Other examples of poor welfare resulting from a combination of breeding and feeding for fast growth are discussed in the following section.

Poultry meat birds: consequences of breeding and fast growth

In common with other farm animals which are bred and fed for fast growth and slaughtered at an age that is relatively early in relation to their life expectancy, broiler chickens tend to increase in body size faster than the rate at which their legs develop. Leg conditions that arise frequently in the fastest-growing broiler chickens include tibial dyschondroplasia and femoral head necrosis. A different kind of problem associated with fast growth in certain conditions is a dysfunction of the cardiopulmonary system called ascites, which involves the accumulation of fluid in the abdomen. Any of these pathological conditions cause the bird to be less active than it would normally be. Chickens that sit down for long periods are likely to get hock burns or breast blisters if the litter upon which they are standing has much accumulated faecal material and is at all damp. If stocking density is high, even mildly affected birds may have to spend much time sitting, and both hock burns and breast blisters are common in chicken carcasses. A worse consequence of leg weakness is that birds that are not able to stand up may be trampled and killed by the many other birds which are all around them. If a cow was unable to stand and was trampled to death by other members of its herd, the farmer who allowed this to happen would be condemned by fellow farmers, members of the public and probably also by the enforcers of the laws in most countries. However, the same fate for the broiler chicken elicits less condemnation. This is not logical or humane. It is impossible to avoid occasional mortality in a broiler unit, but there should be regular, effective checks so that weak individuals can be removed and humanely killed.

Questions which remain about leg problems in poultry concern their frequency and how painful they are to the average bird. A study by Kestin et al. (1992, in press) used a scale of measures of the extent of walking difficulties in broiler chickens kept at 12, 16 or 22 birds.m^{-2}. At 4 wk of age, almost all of the birds had only mild abnormalities of gait if they had any at all (Figure 1), but by 7 wk of age, the frequency of leg problems was clearly higher and there were significant differences between the stocking densities in that there were more severe walking difficulties in the birds kept at the higher densities.

A study of pain in adult male breeding turkeys, which often have leg problems, was

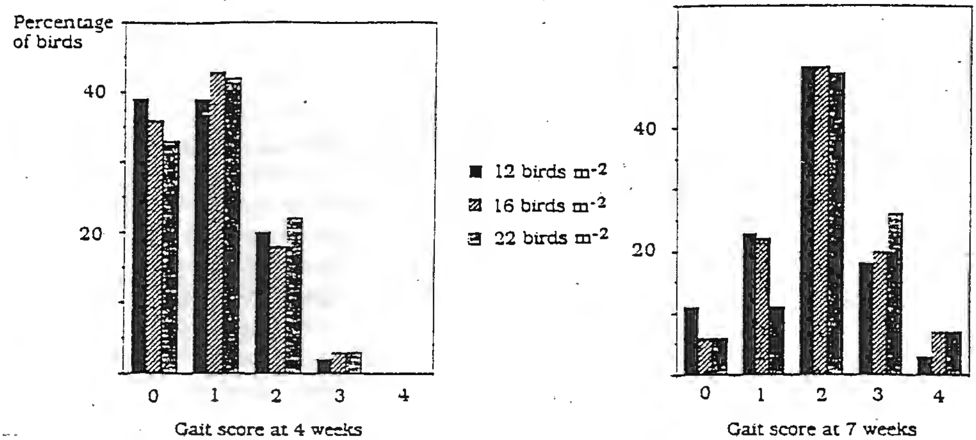

Figure 1. The extent of walking difficulties in 4- and 7-week-old broiler chickens at stocking densities of 12, 16 and 22 birds.m^{-2}. Gait scores: 0, no problem; 1, slight defect; 2, greater defect; 3, moving to resources affected; 4, severe defect, walking just possible; 5, incapable of walking. (Data from Kestin et al., in press.)

carried out by Duncan et al. (1991). The normal activities of the turkeys and the responses of the birds in a test situation involving the possibility of approach to females were measured in normal full-grown males given a saline injection as a control, and in these same birds after they had been given the analgesic drug betamethazone.

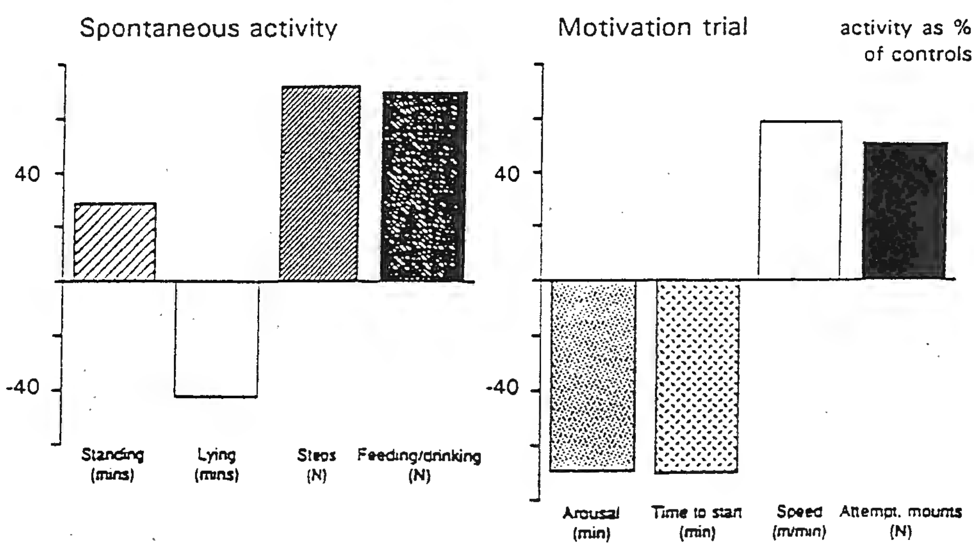

Figure 2. Activity of male turkeys 56 to 60 wk old injected with analgesic drug (betamethazone) relative to males receiving a control injection. (From Duncan et al., 1991.)

The difference between these sets of measures is shown in Figure 2, which clearly demonstrates greater activity and both faster and more efficient responses in the test situation if the analgesic had been administered. These results strongly suggest that the average full-grown male breeding turkey suffers from pain in its legs.

It would appear that the welfare of very many broiler chickens at the end of the rearing period and breeding male turkeys is particularly poor. Clearly the industry must remedy this situation.

Pigs: consequences of breeding and fast growth

The most noticeable problem of pigs kept for meat production is that during handling and transport to slaughter a few die, rather more are obviously adversely affected and many have some degree of pale, soft, exudative meat. The leaner breeds tend to have greater problems in this respect, for example many Landrace strains are worse affected than Durocs. Pigs of modern breeds are considerably larger than their wild boar ancestors, and work by Dämmrich (1987) shows that selection for muscle block size has had consequences which help to explain the mortality or less adverse effects which occur when pigs exercise vigorously. Table 3 shows that Landrace pigs have much larger muscle fibres than wild boar have. This is especially true of the Type II fibres, which are larger than the 5000 μm fibre area which Dämmrich considers to be the limit above which capillary-to-fibre distance is too great for adequate metabolite removal. In these large fibres, lactic acid will accumulate. A further consequence of pig breeding is that Landrace have a much higher proportion of anaerobic Type IIb fibres, so even more lactic acid production and accumulation occurs (Table 4). Finally, heart strain is more likely in modern breeds because the heart is smaller in relation to body weight: 0.21%

Table 3. Mean size of pig muscle fibres (M. longissimus dorsi, pigs 200 d old, entries are cross-sectional area in μm^2). At fibre areas of more than 5000 μm^2, capillary-to-fibre distance is too great for adequate metabolite removal, so more lactic acid accumulates (From Dämmrich, 1987)

Fibre	German Landrace	Wild boar
Type I	4995	2030
Type II	7335	2500

Table 4. Types of pig muscle fibres (M. longissimus dorsi, pigs 140 d old). More lactic acid accumulates in Landrace (From Dämmrich, 1987)

Fibre	Metabolism	German Landrace (%)	Wild boar (%)
Type I	Aerobic	8	6
Type IIa	Both	20	49
Type IIb	Anaerobic	72	45

of the body weight in a Landrace but 0.38% in a wild boar (Dämmrich, 1987). Pigs selected for relatively fast growth have more leg problems than animals not thus selected.

Production level and welfare in dairy cows

The combination of selection for fast growth and high levels of feeding can cause leg joint problems in beef cattle. There are also indications of a relationship between levels of nutrients fed and a variety of indicators of poor welfare in dairy cows. Cows that are pushed hard energetically are more likely to fail to breed, to get mastitis or to become lame. Manson & Leaver (1989) showed that a higher protein level in the diet of dairy cows was associated with a greater incidence of lameness. The reduction in the life expectancy of dairy cows now in comparison with that which they had 30 yr ago is often commented upon by farmers. Data from a study by Agger (1983) on cows sent to rendering plants in Denmark because they had died or had been killed on the farm and were not fit to go to a normal abattoir, are shown in Figure 3. This reveals that the life expectancy of a cow halved between 1960 and 1982. Some of this effect could be a consequence of a more vigorous culling policy by 1982, but this is not likely to be the explanation of a substantial part of the change.

New developments in dairy cow management include more frequent milking and embryo transfer. A study of the immediate effects of milking by Royle et al. (1992) showed that heart rate normally increased by about 20 beats.min^{-1} during milking.

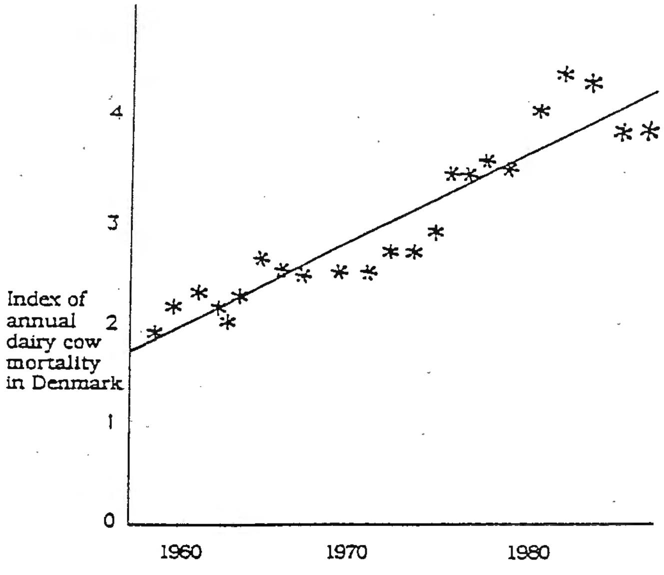

Figure 3. The rate of mortality on farms of dairy cows in Denmark as assessed by entries to rendering plants. This rate doubled over a period of 20 yr, so the life expectancy of a cow halved. (After Agger, 1983)

However, after 7 wk of milking five times per day, the heart-rate increase was still 20 beats.min^{-1} higher at each milking. It appears that cows adapt well to being milked more often, although careful studies of the incidence of teat damage and mastitis are also needed to evaluate the effects of this practice. Embryo transfer in cattle can be carried out without much more disturbance to the animals than artificial insemination and it could sometimes obviate the necessity for transport. However, there is always the risk that, following embryo transfer, too large a calf will develop in a cow and there will be serious problems at parturition.

Genetic engineering

Where any growth promoters are used on farm animals, the risks mentioned above, which are associated with fast growth or larger size in certain body parts, are increased. If the recombinant growth hormones bovine somatotrophin (BST) and porcine somatotrophin (PST) are used, these same risks exist, but it may be that larger quantities of the growth promoter are used, so there are greater possibilities of adverse effects. The structure of the somatotrophin may not be the same as that of the naturally produced form, so there may be some different effects. Reports of studies of BST effects indicate that mastitis and lameness can be increased and conception rates can decline. More antibiotic may be needed and frequent injection can cause problems. If BST is used at a low level rather than to increase maximum production there may be no adverse effects on welfare. These issues are addressed by Willeberg (1993) and Broom (1993). Some studies of the use of PST show that the treated, faster-growing animals have more leg problems than controls (Simonsen, 1993).

Some transgenic farm animals in the future may be genetically modified to increase their disease resistance, so there is better welfare as a consequence of the change. Others may produce within their bodies a small quantity of a substance valuable to humans, e.g. human blood-clotting factor in ewe's milk. This may have no adverse effect on the animal. When attempts are made to increase production, however, there is again a problem as biological limits are approached. Methods of assessing the welfare of treated and modified animals are reviewed by Broom (1993). It is clear that the accelerated change which is possible in such animals necessitates specific legislation to protect the animals. No product of genetic engineering or genetically engineered change in an animal should be allowed to be put into general use unless it has been proven harmless to the treated or changed animal by comprehensive scientific studies of animal welfare carried out throughout the longest commercial life of the animal and continued for at least two generations.

Conclusion

If the animal production industry is to continue to flourish it must be publicly acceptable, and the present situation is unsatisfactory in this respect. One important aspect of this acceptability is that production efficiency must be accompanied by good animal welfare.

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