Animal welfare involves (1) identification and analysis of the problem as perceived by the animal; (2) what man should do about it. This paper concentrates on the first question which can be addressed tidily by application of logic and scientific method. The second question requires decisions based on less clear-cut matters of ethics and economics. The scientific approach to welfare as perceived by the animal involves (1) definition and analysis of the problem, here encapsulated by the concept of the "five freedoms"; (2) development of objective methods for observation, perturbation and interpretation of welfare state; (3) development of improved husbandry systems and management practices. Examples are presented to illustrate the range of techniques necessary to investigate complex problems of physical and psychological distress. A list of priorities is suggested for welfare research with farm animals.

INTRODUCTION

I am often asked, "Is animal welfare a science?" The simple answer is, "No". Animal welfare, so far as the animal is concerned is a state of body and mind; health, vigour and a positive sense of well-being, or, at least, the absence of distress. So far as man is concerned, animal welfare is a concern; a series of questions to which there are no clear answers, merely compromises based on our own perception of the "right" balance between economics, ethics and expediency.

Faced by the much more precise question, "Can animal welfare be studied scientifically?" I would give a resounding "yes". Indeed, a scientific study of welfare problems is essential to ensure that the husbandry of those animals that serve mankind en masse (i.e. farm and laboratory animals as distinct from pets) is based on a proper understanding of the biological and psychological needs of the species and not unduly distorted by the unrestrained forces of the market place nor the unthinking "good will" of the animal liberators.

It is therefore necessary at the outset to distinguish between (1) the identification and analysis of the problem as perceived by the animal, which is amenable to logic and scientific method, and (2) what man should do about it, which requires decisions based on less clear-cut matters of ethics and economics. The scientific approach to welfare as perceived by the animal must involve all the following stages.

Definition and analysis. A general welfare problem (e.g. that of the battery hen) must be analysed into a series of specific questions that define the interaction between the animal and its physical and social environment. These questions must be formulated in such a way that they are accessible to observation and experiment.

Methodology Each specific question that emerges from the initial analysis requires a series of observations and measurements that establish cause and effect in a way that is free from spurious correlations. These observations should first be made in the "normal" environment under review, then a
controlled system of perturbations to environment and animal introduced to test the observer's initial interpretation of cause and effect.

**Development of improved husbandry systems.** Possible improvements to husbandry systems and management practices that emerge from the scientific study of selected (and therefore restricted) questions relating to animal welfare need then to be evaluated systematically in terms of performance, health, economics and broader welfare issues not included in the original investigation.

**DEFINITION AND ANALYSIS - THE "FIVE FREEDOMS"**

The UK Ministry of Agriculture, Fisheries and Food (MAFF) has produced Codes of Welfare for livestock based on the recommendations of the Farm Animal Welfare Council (FAWC, e.g. Cattle Code, MAFF 1983). These codes consider welfare, in the first analysis, under five distinct headings which have come to be known as the "Five Freedoms" (Webster, 1984).

These are:

- Freedom from thirst, hunger or malnutrition - achieved by readily accessible fresh water and a diet to maintain full health and vigour.
- Appropriate comfort and shelter.
- Freedom from injury or disease - achieved by prevention or rapid diagnosis and treatment.
- Freedom of movement and the opportunity to express most normal patterns of behaviour.
- Freedom from fear.

No husbandry system is perfect and these disparate needs may sometimes conflict. For example, increased freedom of movement in young cattle may increase the incidence of diarrhoea, the more comfortable cow cubicle may also predispose to a higher incidence of mastitis. The concept of the "five freedoms" avoids overemphasis on either behaviour or production traits and inevitably leads to compromises that upset extremists at both ends of the producer-welfarist spectrum who are unwilling to sully their preconceptions with the mud of reality.

Table 1 illustrates the application of the five freedoms to the welfare of laying hens in cages and on free range.

The presentation of the evidence in Table 1 is obviously too brief. To give a single example, it is inadequate to describe physical comfort in cages as poor. This is merely shorthand for a more complete critique which would include:

- Lack of perches leading to foot deformities.
- Lack of space for grooming and other aspects of normal maintenance behaviour.
- Insufficient activity predisposing to osteoporosis, fractures and "cage layer fatigue" (Martin, 1987).
Table 1: Welfare of Laying Hens in Cages and on Free Range

<table>
<thead>
<tr>
<th></th>
<th>Battery Cage</th>
<th>Free Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition</td>
<td>adequate</td>
<td>adequate</td>
</tr>
<tr>
<td>Comfort, thermal</td>
<td>good</td>
<td>variable</td>
</tr>
<tr>
<td>physical</td>
<td>poor</td>
<td>generally good</td>
</tr>
<tr>
<td>Hygiene and infectious</td>
<td>usually good</td>
<td>variable, parasitism (coccidiosis, etc.)</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain and injury</td>
<td>deformed feet</td>
<td>general good</td>
</tr>
<tr>
<td></td>
<td>osteoporosis</td>
<td>predators</td>
</tr>
<tr>
<td></td>
<td>bone fractures</td>
<td></td>
</tr>
<tr>
<td>Fear</td>
<td>rare</td>
<td>predators</td>
</tr>
<tr>
<td>Behaviour, frustration</td>
<td>common</td>
<td>rare</td>
</tr>
<tr>
<td>abnormalities</td>
<td>common</td>
<td>cannibalism</td>
</tr>
</tbody>
</table>

One of the chief "attractions" of the free range system as seen by those customers who wish to eat their eggs with a clear conscience and producers wishing to serve that market is the freedom to range out of doors, the assumption being that this is natural and therefore good. More complete analysis as to why a hen may, or may not, elect to go outdoors involves questions concerning her motivation to feed, nest or simply explore and her reluctance to stray too far from a place of security. Wild jungle hens hurry from bush to bush during the daytime, protected from predators in the sky and roost in branches at night, protected from predators on the ground. In most commercial free range systems in Europe birds leaving their houses are exposed, in the interests of welfare, to an "open field", a situation used by experimental psychologists as a classic test of fear (Gray, 1976). Hence "agaraphobia" in Table 1.

The welfare lobby in Europe has not yet given much attention to extensively managed species such as the sheep exposed to malnutrition, parasitism, the chronic pain of foot rot, fear and injury from predators but free to perform natural behaviour patterns like panic and flight. These problems do not escape criticism after application of the five freedoms which therefore provide a check list to assess the best and worst points of all systems, intensive and extensive and point to priorities for research and development.

METHODOLOGY IN WELFARE RESEARCH

The first essential for welfare research is to abandon the word "stress". Selye's (1950) description of the general adaptation syndrome (GAS) involving an adrenocortical response to almost any significant environmental stimulus has taught us a lot about the pituitary-adrenal axis. What little it had to offer to our understanding of welfare has long since been exhausted because of its lack of specificity. The GAS can be triggered by (e.g.) hunger or the excitement of feeding, heat or cold, fear or pleasure. Welfare is a complex state of body and mind dependent on a range of physical and psychological stimuli from the external and internal environment. These separate stimuli and responses to these separate stimuli need to be
distinguished by the application of a range of physiological and psychological tests; there is no "magic marker".

Full health and vigour is fundamental to good welfare. In many, but not all cases this is also synonymous with optimal productivity and welfare can be improved by conventional animal or veterinary science, e.g. the development of a new vaccine. There are, however, several exceptions to this rule. In my opinion, the two most important priorities for research are the problems of chronic pain and psychological distress.

Probably the most worrying examples of chronic pain that have arisen as a direct consequence of increased productivity are the orthopaedic disorders of broiler chickens (Duff, 1986). These are problems which the poultryman would wish to eliminate by feeding or breeding, if possible, and so reduce production losses. At present, however the economic cost of these disorders is less than the economic cost of controlling them by radical alterations to husbandry. In strictly economic terms, they are an acceptable tax on the system. Problems of lameness in high-yielding dairy cattle are open to the same criticism.

Pain is a subjective sensation and most pain studies tend to involve man. Studies with animals are usually concerned with the mechanics of nociception which describe how the messages are transmitted but not how the animal feels. Techniques are available, however for a proper study of pain as a production disease in farm animals. In the case of broilers, for example this must include:

1) study of pathological changes in bone and joints in relation to genetics, nutrition and environment (e.g. Duff, 1988);

2) measurement of pain thresholds in conscious birds in relation to early development and related pathology (e.g. Nolan et al, 1987);

3) measurement of spontaneous and enforced behaviour in relation to early development and related pathology;

4) effect of analgesic drugs on 2 and 3.

The problem of psychological distress is enormously complex and does, of course, constitute the main body of what is usually thought of as welfare research. Most of this concentrates either on fear or the denial of natural behaviour in intensive husbandry systems.

There are several psychological tests which can be used as reasonably specific indices of fear in animals (Gray, 1971). In poultry tonic immobility is a particularly sensitive response that appears to quantify the intensity of fear associated, e.g. with transportation (Cashman et al, 1989). However here, as always, fear is too complex a response to be explained away by a single measurement.

Once can, without an excess of anthropomorphism, at least speculate that an environment that denies almost all activities beyond eating, resting and restricted grooming may induce sensations of frustration, boredom, perhaps anger and the development of abnormal patterns of behaviour to an extent dependent on the cognitive abilities of the species under investigation.

There are many proven, objective methods available for the study of such problems. I shall cite only four.
1. Comparison of the behaviour patterns of animals in "natural", barren and enriched environments; development of abnormal behaviour patterns or stereotypies (Fraser & Broom, 1990).

2. Measurement of the motivation, and strength of motivation of animals to achieve or avoid specific features of their environment. Dawkins (1983) has pioneered an elegant extension of basic economic theory to this study. In essence she asks animals how much things matter by measuring the price they are prepared to pay (usually in the form of work) to achieve or avoid things. For a laying hen, for example, a nest box is price-inelastic or a necessity. Toilet facilities, such as a dust bath, tend to be price elastic or more of a luxury.

3. Measurement of the extent to which individual animals differ in their motivation to explore the environment in the absence of a guaranteed reward, the correlation of this with the development of stereotypies when this desire is frustrated and changes in awareness and motivation following the development of stereotypies. Jonathon Cooper and Christine Nicol in my department are currently investigating this problem using mainly the bank vole (Clethrionomys glareolus) but also pigs and horses. The disturbing impression given by this work is that stereotypies may help an animal to cope with a barren environment but only after its awareness of that environment has become distorted and its responses deranged. This is uncomfortably close to a definition of madness.

4. Use of mood-altering drugs to interpret motivation, normal and abnormal behaviour (Cronin et al, 1985).

There are countless publications which report observations of farm animal behaviour. The experimental analysis of the psychology that determines animal behaviour is still in its infancy but many of the approaches developed in recent years suggest that it can be advanced with the same rigour as more conventional animal science and will provide a sound objective basis for improvements to farm animal welfare. However, what actually gets converted into practice will, of course, require political decisions since compromises will have to be made between the ever-present irreconcilables, economics, ethics and expediency.

DEVELOPMENT OF IMPROVED HUSBANDRY SYSTEMS

The development of improved husbandry systems is based on the conventional approaches to research and development in animal science but starts from different premises. Conventionally, husbandry systems have been evaluated simply in terms of output, efficiency and quality of product. The development of a welfare-improved system starts from an evaluation of alternatives in terms of the five freedoms. Having decided upon a "least worst" system or systems the conventional sciences of nutrition, physiology, epidemiology, etc. are applied to ensure that it works as cost-effectively as possible.

As an example, I shall describe, very briefly, the approach we have taken to develop alternative husbandry systems for veal calves; alternative, that is, to the conventional European crating system where each calf is kept in a narrow, individual wooden pen such that it cannot adopt a number of normal lying and sleeping postures (Webster et al, 1986). The calf is fed an all-liquid diet with restricted amounts of iron designed to ensure white meat. One commercial alternative (the Quantock system) looked good from an ethological point of view in that the calves were group-reared, able to drink
from a teat whenever they wanted, stand up, lie down, etc. The main drawback to the system (see Table 2) was that it was uneconomic. A ton of milk replacer could rear 5 calves in crates but only rear 4 calves of comparable genotype in yards. Moreover, the health of the calves in this system was no better than in crates.

At the University of Bristol we examined a variety of alternatives. The most effective was Access (Table 2) a variant of the computer controlled sow feeding system. Calves with transponders had access to a computer-controlled feeder where they could get milk in restricted amounts plus a limited amount of dry food which contained sufficient digestible fibre to ensure normal development of the rumen. When average costs of death and disease are taken into account the Access system was the only one that did not lose money (Table 2). A little intermediate technology met all five freedoms and in so doing became cost effective. The UK Government has now passed legislation to prohibit systems of veal production that constrain calves in boxes less wide than body height at the withers and/or deny calves over 2 weeks of age access to some solid food containing palatable, unmilled roughage. Similar legislation has been drafted within the European Community although not yet approved.

Table 2: Comparative Economics of Different Rearing Systems for Veal Calves

<table>
<thead>
<tr>
<th></th>
<th>Friesian/Holstein Bulls</th>
<th>Hereford x Friesian Heifers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boxes Quantock</td>
<td>Quantock Access</td>
</tr>
<tr>
<td>£ per calf purchase:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calf price</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Milk powder</td>
<td>125</td>
<td>153</td>
</tr>
<tr>
<td>Dry food</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Straw, etc.</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Total variable costs</td>
<td>175</td>
<td>233</td>
</tr>
<tr>
<td>Selling price</td>
<td>225</td>
<td>236</td>
</tr>
<tr>
<td>Carcass profit (ideal)</td>
<td>+3</td>
<td>+3</td>
</tr>
<tr>
<td>Less deaths/disease</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Net profit</td>
<td>nil</td>
<td>-27</td>
</tr>
</tbody>
</table>

CONCLUSIONS

PRIORITY FOR RESEARCH AND DEVELOPMENT

Given the constraints on funding for all animal science and the important but not all important priority for welfare within these constraints, may I suggest the following as top priorities for fundamental and applied study with farm animals.

Fundamental studies on welfare perception

1. Development of cognition: investigation of the development of awareness, expectation, empathy and fear as a function of genotype and early experience. Although much of this work must be species-specific, early studies may involve laboratory species.
2 **Frustration:** a study of the motivation of animals to work towards specific goals, reinforcement of that motivation, frustration in the absence of those needs and changes in behaviour and state of mind consequent upon frustration.

3 **Chronic pain:** a physiological, pharmacological and ethological study of the perception of chronic pain run in association with studies of the underlying pathology.

Applied studies on improved husbandry and management practices

1 Development of systems (including robotics) which allow animals more opportunity to make a constructive contribution to their environment and their perceived quality of life.

2. Reduction of transport stress by (i) improving vehicles and handling systems, (ii) preconditioning animals to reduce fear.

3. Control of social problems (e.g. fighting, hysteria) in colony systems for especially pigs and poultry developed in response to demand for alternatives to conventional intensive systems.

The subject of animal welfare is too big to tackle in a short paper except in terms of general concepts illustrated by a few specific examples. Here I have attempted to suggest how we may define the problems, investigate the problems and which problems we should tackle first. Every point I make is open to criticism and alternative interpretation. The only point on which I shall insist is that such criticism and interpretation can be conducted in a scientific manner.

REFERENCES


