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Science, Values and Animal Welfare: Exploring the 'Inextricable Connection'

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ABSTRACT

In conceptualizing animal welfare, it is useful to distinguish among three types of concepts. 'Type l' are single, measurable attributes. 'Type 2' are single attributes that cannot be measured directly but can be estimated by correctly combining various contributing attributes. 'Type 3' are concepts involving multiple attributes which are grouped together because they serve some common function, and whose relative importance cannot be established in an entirely objective way. Individuals who treat animal welfare as a type 1 concept may propose single, objective measures of welfare, such as longevity or levels of stress-related hormones; however, this approach rests on judgements, which are not purely objective, about the relative importance of different factors for an animal’s quality of life. Studies of animal preferences and motivation are sometimes seen as an objective way to weight different attributes according to the animals' own priorities, and thus allow animal welfare to be treated as a type 2 concept. However, numerous technical and fundamental difficulties limit our ability to do this. Animal welfare is best seen as a type 3 concept incorporating multiple attributes, with considerable consensus over certain general principles (eg that a high level of welfare implies freedom from suffering) but with value-related disagreement over how these principles should be applied. Because the various attributes cannot be combined in a purely objective way, science is limited in its ability to determine the 'overall 'welfare of an animal and to compare welfare in disparate environments. Instead of attempting to measure' animal welfare, the role of science should be seen as identifying, rectifying and preventing welfare problems.

Introduction

In an important essay, Tannenbaum (1991) argued that scientists are wrong to treat the scientific assessment of animal welfare as a purely technical issue where the scientific aspects can be conducted independently of ethical considerations. He argued, rather, that there is an 'inextricable connection' between animal welfare and values. The purpose of the present essay is to explore this 'inextricable connection' and its implications for the scientific study of animal welfare.

The link between values and animal welfare can be shown by a simple thought experiment. Let us imagine a list of all possible attributes describing a particular animal which, for sake of argument, has an injured leg and is searching for food. Anatomical attributes would include the animal's height, the thickness of its subcutaneous fat, and the swelling of its injured leg. Physiological attributes would include

its rate of breathing and of secreting digestive enzymes. Behavioural attributes would include its abnormal gait and the whimpers that it emits whenever it uses the injured leg. Now let us divide the list into those attributes that we consider relevant to the animal's welfare and those that are not. Relevant attributes will include the damage to the leg, the whimpers and the abnormal gait. Irrelevant attributes will include the animal's height and the amount of subcutaneous fat, but we might reclassify this last attribute as relevant to welfare if we learned that adequate fat would allow the animal to survive until its injury had healed.

A little reflection shows that in categorizing attributes as relevant or irrelevant to the animal's welfare, we classify them not by scientific discipline (behaviour versus anatomy), nor by bodily system (nervous system versus digestive system), nor by whether the attribute contributes to homeostasis (breathing versus vocalizing). Rather, we consider an attribute to be related to the animal's welfare if we judge it relevant to the animal's quality of life – if it is somehow *good for* or *bad for* the animal. Thus, animal welfare is unlike the many scientific concepts (temperature, viscosity, metabolizable energy) that can be quantified without necessarily invoking any sense of better or worse. Greater or lesser degrees of animal welfare inherently imply something better or worse for the animal (cf Rollin 1992 on 'health'). Hence, to define or conceptualize animal welfare, we involve value notions (see Appendix 1). But can we, nonetheless, find measures of what *is* better or worse for an animal that will command such unanimous acceptance that individuals who differ in their values will still agree on how animal welfare should be assessed?

Three kinds of concepts

To explore this question, let us imagine that a building inspector has been asked to examine a dubious rooming house and report to the local authorities on (1) its height, (2) the weight of sun-bathers that would make the balcony collapse, and (3) the building's overall safety.

The height of the building can be measured directly once we have clarified any ambiguities of definition (eg what parts of the building are to be included) and specified any conditions which may influence the height. Let us refer to properties like height, consisting of single attributes which can be measured directly, as 'type 1 concepts'.

The weight of sun-bathers that would cause the balcony to collapse cannot be measured directly. Rather, it has to be estimated on the basis of various contributing variables such as the design of the supporting structure and the thickness of the beams. Nonetheless, we consider that under a specific set of conditions there should be *a particular* weight that will cause the balcony to fail. Hence, if different people have different ideas about how the estimate should be made, we think of these as more accurate or less accurate approximations to the correct answer. Let us call such concepts - single attributes which cannot be measured directly but which can be estimated by combining contributing variables in an appropriate way - 'type 2 concepts'.

The safety of the building, unlike the height and the maximum loading of the balcony, is not a single attribute but a concept encompassing numerous attributes, including the level of toxins in the air, the slipperiness of the floors, and the soundness of the fire escapes. We regard these as aspects of safety because they serve a common function; that is, they all contribute in one way or another to the health and survival of users of the building. We might try to combine a number of these attributes to create some overall index; for example we might create a fire safety index by awarding five points for each smoke alarm and ten for each emergency exit. However. we recognize the arbitrariness of such measures. We do not consider that there is some correct quantitative expression that represents *the* safety of the building. in all respects and for all users. which we try to approximate by combining variables in a logically or technically correct way. Let us call a concept like safety - a trait involving multiple attributes linked by

some commonality of function - a 'type 3 concept'. (Note that this three-category system is intended as a conceptual short-hand, and is not meant to imply that the categories are always clearly distinct, nor that further subdivision would be inappropriate. For instance. type 3 concepts generally involve a number of type 1 and 2 concepts, and a type 2 concept where most of the variation is attributable to a single contributing variable can, in effect, be treated as a type 1.)

Values are involved in different ways in the three types of concepts. In measuring a type 1 concept, scientists generally try to eliminate the impact of values; we consider it wrong, for example, for an inspector who dislikes a building to give a biased account of its height so that the building will have to be altered. Estimating a type 2 concept, such as the strength of a balcony, is in principle a purely technical matter, but value-related differences may occur if there is uncertainty over the technical issues. The tenants, who want the balcony strengthened, may choose a formula that gives the most pessimistic estimate of the existing strength whereas the landlord, who wants to spare any additional expense, uses the most optimistic. Values are *conditionally* involved in such estimates because the impact of values is conditional on there being insufficient knowledge for the correct formula to be established with certainty. In such cases, science could conceivably eliminate the impact of values by perfecting the technical accuracy of the estimation.

In the assessment of safety and other type 3 concepts, different people are again likely to attach different levels of importance to different attributes. Occupants of the top floor consider better fire escapes to be particularly important; asthma sufferers emphasize the need for clean air; the sun-bathers want a strong balcony. However, these differences do not arise simply because there is insufficient information to establish 'the' technically correct weighting of the various factors. but rather because there is no single, technically correct weighting. In such cases, values are *inherently* involved because there is no entirely objective way to weight the different factors in order to create an overall measure. With type 3 concepts, science may generate information that moves different parties closer to agreement, but science cannot be expected to eliminate the inherently subjective element in judging the relative importance of different attributes.

Conflicts over the assessment of animal welfare often arise because different individuals tacitly disagree on whether to treat welfare as a type 1, type 2 or type 3 concept. Many members of the general public, and a few scientists, seem to treat animal welfare as a type 1 concept, and look for a single, measurable property that will provide an objective assessment. Other scientists treat animal welfare as a type 2 concept - a single attribute in principle. but which in practice is estimated by integrating contributing variables. I will argue that animal welfare should be viewed as a type 3 concept. To do this, I will first argue why it fits this category, and then try to refute claims that might be made in favour of treating animal welfare as a type 1 or type 2 concept.

Animal welfare as a type 3 concept

What we consider good or bad for animals includes a great many attributes, but which attributes are considered relevant, and the relative weighting ascribed to them, obviously reflect what the individual making the judgement considers important. Thus, in discussing animal welfare, a committee chaired by a theologian emphasizes reverence for life, dignity, and diligent human care of animals (Carpenter 1980). An ethologist speaks out against the suppression of animals' natural behaviour (Thorpe 1969). A veterinarian proposes that welfare is often better in confinement agriculture than in extensive agriculture because the animals are freer from disease and attack, and more sure of shelter and nourishment (Taylor 1972). A fiction writer whose novels romanticize freedom and non-conformity considers welfare jeopardized unless cows are free to graze and hens are no longer confined in cages (Anonymous 1989).

A particularly pronounced disagreement occurs between agriculturalists and animal protectionists over the welfare of farm animals reared in confinement. Animal protectionists have traditionally sought to protect animals from harmful human actions (abuse, experimentation, cruel sports), but have tended not to interfere with hardships caused to animals by nature. Farmers, in contrast, have traditionally protected animals from hardships imposed by nature (disease, predation, harsh weather), and have tended not to question the impact of handling by humans (castration, branding, confinement). This difference is reflected in what the two groups consider important for animal welfare, with farmers attaching more importance to adequate shelter, nutrition and protection from predators, while animal protectionists are more concerned about rough handling, crowded housing and painful husbandry procedures. Hence the two groups approach confinement rearing of animals, which tends to protect animals from certain natural hardships while imposing certain man-made ones, from opposite view-points.

In these various cases, the disagreements stem not from different scientific theories or from disagreements about the facts of animal life, but rather from differences in values - specifically from differences in what individuals feel is important for the quality of life of animals. Scientific study might narrow the gap between differing positions; for example, new physiological findings might convince animal protectionists that the lower incidence of disease in a hygienic swine barn is a benefit that should not be dismissed lightly, or behavioural research might convince farmers that animals find certain forms of restraint more aversive than had been assumed. Thus information generated by science may help to reduce value-based differences in people's ideas about animal welfare. However, knowledge alone cannot logically refute or confirm values (see Appendix 1). We cannot expect scientific findings to eliminate value-based differences by, for example, proving whether liberty is *more important than* health, or establishing objectively whether freedom from coccidiosis is *better than* freedom of movement. Hence, animal welfare resembles type 3 concepts as it incorporates numerous attributes linked by their involvement in the quality of life of animals, and with an inherently subjective element in judging their relative importance.

Animal welfare is not a type 1 concept

An alternative position is that the welfare of an animal can actually be determined in such an objective manner that value-based disagreements would be eliminated. One way of achieving this would be to find a single, measurable attribute (like the height of a building) which would adequately and objectively quantify the welfare of an animal. Several measures, although not necessarily proposed in these terms by their originators, are possible candidates.

In a thoughtful essay, Hurnik (1993) has argued that the longevity of animals is 'an objectively measurable parameter' that serves as an 'indirect indicator of quality of life.' Humik argued that an animal's quality of life is directly related to the satisfaction of the many 'biological needs' that are important for survival, health, and comfort. He noted that needs differ in their importance to the animal, but that discovering the true weighting that should be attached to each need is difficult if not impossible. Hornik proposed that the more adequately the animal's needs are satisfied, the longer it may be expected to live. Hence longevity, in effect, integrates the satisfaction of the more important and less important needs over the life of the animal, and thus eliminates the errors that people might make in judging the relative importance of different factors.

Despite the merits of Hurnik's proposal, there are substantial difficulties in drawing conclusions about animal welfare from information about longevity. For example, animals are most likely to die when very young or very old; hence. a factor that greatly influences longevity may be important for the animal during one of these two critical times but not during the majority of the animal's lifespan. This is a *technical* difficulty - one which might be overcome by additional experiments or more refined measures; in this

example, we might determine how different factors influence longevity at different stages in the animal's life. However, there are also *fundamental* difficulties. In particular, in using longevity as an indicator of quality of life, we are assuming that the factors that are truly important for an animal's quality of life are those that promote the length of its life. Does this follow logically from basic principles of biology? Animals have. of course, been shaped by natural selection to favour environments and perform behaviours that promote their survival. but they have also been selected to mate, give birth and rear young, and under some circumstances they pursue these activities at considerable cost to their own longevity (Lessells 1991). Thus, when animals live their lives according to predispositions shaped by natural selection, longevity is an important consideration but not the only one. Furthermore, in the environment in which they evolved, behaviour such as chasing prey and building nests presumably contributed to the longevity of foxes and mice, and these animals may be equipped with strong motivation to perform such behaviour. However, we are often concerned about the welfare of animals in artificial environments where such activities may no longer be important for longevity, yet the animal may be no less motivated to perform them and greatly frustrated if the activities are prevented. In this respect longevity may have become uncoupled from certain factors that are important for quality of life.

If the premise - that those factors that are truly important for quality of life are those that promote long life - cannot be derived or demonstrated using scientific principles, is it nonetheless a judgement so universally accepted that no one could reasonably deny it? Clearly not. A dog owner, having to choose between letting the dog run loose or remain indoors, may reasonably judge that the animal's quality of life is improved by freedom even though the animal is more exposed to disease and injury (which might shorten its life) when roaming freely. If prisoners on average live longer than owners of small aircraft, few would argue that this necessarily indicates greater quality of life. In short, the use of longevity as a global indicator of animal welfare rests on certain judgements, which cannot be claimed as purely objective, about what is important for the quality of life of animals.

A second candidate as a global indicator of an animal's welfare stems from the observations of Cannon (1929) and Selye (1950,1956) that certain physiological changes help to prepare the body for a wide range of challenges. Selye found that a variety of what he called 'stressors', including physical restraint, exposure to cold and injection of harmful substances, produce several characteristic bodily changes. Selye theorized that the activation of the anterior pituitary and adrenal cortex, with increased secretion of the hormone ACTH and glucocorticoids, had (in the words of Mason 1968) 'a unique, pre-eminent, and nonspecific' relation to stress. Thus it appeared that activation of this system would reflect both challenges to biological functioning and unpleasant psychological states. Animal welfare scientists have been strongly influenced by Selye's hypothesis; for example, Barnett and Hemsworth (1990) have proposed that a sustained 40 per cent increase in plasma-free corticosteroids constitutes a criterion for impaired welfare.

The generality of the link between glucocorticoid secretion and adverse conditions has been questioned from several perspectives. Most importantly, it now appears that the nonspecific nature of the glucocorticoid response to bodily challenge has perhaps been misconstrued. Work by Mason (1968) and others (see Dantzer & Mormede 1983; Moberg 1985) has shown that increased glucocorticoid secretion in response to various stressors (eg cold, heat, fasting) occurs mainly because the experimental situation evokes an emotional reaction in the animal. If the emotional reaction is eliminated, then the increased glucocorticoid secretion in response to adverse environments may not occur. This may explain why glucocorticoid secretion appears to lose its link to adverse conditions in some longer-term studies. For example, Ladewig and Smidt (1989) found that the altered secretory patterns of cortisol in bulls had returned to normal levels after four weeks of tethering in uncomfortable stalls despite other evidence of continued discomfort (see also Rushen 1991). Furthermore, increased glucocorticoid output is not

specific to unpleasant situations but can also occur after exposure to novel environments, exercise and such presumably pleasant activities as mating and nursing (see Dantzer & Mormede 1983; Moberg 1985; Rushen & de Passille 1992). Hence it appears that not all forms of adversity increase glucocorticoid secretion, nor that increased glucocorticoid secretion necessarily indicates adversity. Based on these considerations Moberg (1992) proposed that we 'abandon any attempt to identify a single biological end-point that is characteristic for all stressors.'

Longevity and glucocorticoid levels (along with other variables such as measures of productivity, immune competence and reproductive success) are examples of broadly based measures influenced in various ways by factors arguably important for animal welfare. Such measures have important roles to play in the study of animal welfare, but none provides the single, objectively weighted measure of all relevant factors that would allow us to treat animal welfare as a type 1 concept. More fundamentally, as noted by Mason and Mendl (1993), as long as there are conceptual disagreements about what animal welfare entails, it will of course be impossible to achieve consensus that any single measure adequately reflects all of the contributing variables and accords to each its correct weighting. Hence, for both technical and fundamental reasons, animal welfare cannot be treated as a type 1 concept.

Animal welfare is not a type 2 concept

An important difference between the safety of a building and the welfare of an animal is that the animal itself has certain interests. If we could discover the balance of factors that the animal itself chooses, perhaps this would be *the* correct weighting of the various contributing factors, just as the actual breaking point of the balcony is the correct answer that different estimation procedures try to approximate. With this approach, we might imagine that animal welfare could be treated as a type 2 concept.

Scientific attempts to understand the animal's own priorities have developed rapidly over the past 20 years after the pioneering work of B O Hughes in testing animals' preferences for different environments (eg Hughes 1975, 1976a). In one early example, Hughes and Black (1973) housed hens in cages where they could move freely between compartments with different types of flooring. Based on the time the birds spent on the different alternatives, Hughes and Black (1973) concluded that the birds showed a significant preference for a particular flooring product. From such simple experiments, tests of environmental preferences have evolved rapidly (Fraser *et a11993)* and continue to contribute insights relevant to animal welfare.

However, as noted by Duncan (1978) and Dawkins (1980), preference testing by itself does not indicate the degree of importance that the animal attaches to the preferred option. Depending on what alternatives are offered, both the preferred and unpreferred options may be perfectly acceptable or both may be seriously deficient. This concern led to attempts to measure the strength of animals' motivation to obtain preferred options or to avoid unpreferred ones. For example, after earlier work had shown that hens generally prefer litter ahead of wire floors, Dawkins and Beardsley (1986) attempted to determine the strength of the preference by requiring hens to perform a task in order to gain access to litter.

There are significant concerns about the influence of experimental procedures on the results of such studies. It is natural for hens to find food by pecking and to enter a new area by walking. If we require a hen to peck a key in order to activate a motorized barrier and thus enlarge its cage (Lagadic & Faure 1987), can we trust the result as a true reflection of the hen's motivation to gain additional space, or is the link between pecking and access to space just too foreign to the hen? Other seemingly' unimportant procedural variables can affect the results in unexpected ways. In experiments by Hutson (1988), sows could perform an operant response to open a box that contained lkg of straw. Because the sows did little of this behaviour, even during the time before farrowing when they normally build nests, Hutson

concluded that the sows had little motivation to use straw. However, in experiments by Arey (1992), sows could perform an operant response for access to a pen furnished with 18kg of straw and the animals demonstrated strong motivation for this reward as the time of farrowing approached. Arey (1992) suggested that the discrepancy in the conclusions of the two studies was due to procedural differences: specifically that 1kg of straw, as offered in Hutson's study, was too little to be functionally significant to the sows.

Tests of motivation strength may help to identify how important an animal considers a particular resource in isolation, but can we ask animals to indicate the *relative* weighting that they attach to different benefits? To do this Dawkins (1983) developed a procedure to 'titrate' one motivation against another. Dawkins trained hens to enter two cages from a common choice point. One cage contained litter (to permit dust-bathing) but no food, while the other contained food but no litter. The hens were then required to choose between the two cages after different periods of food deprivation. In principle this procedure should allow us to say that a hen's motivation to dust-bathe is, under the given conditions, about as strong as its motivation to eat when it has been without food for a certain number of hours. Here the possible impacts of procedural variables become even more daunting, as the instrumental behaviour (the behaviour by which the animal makes its choice) needs to be appropriate (and, arguably, *equally* appropriate) for both kinds of resources being compared (Dawkins 1990).

One response to such complications is an approach that blends motivation testing with a concept borrowed from economics. As summarized by Dawkins (1990), economists observe that for certain goods an increase in price has little effect on the amount purchased by consumers. Such goods are said to have inelastic demand and are sometimes called necessities. For other commodities, consumption declines as price increases. These are said to have elastic demand and are sometimes called luxuries. In studies with animals a commodity such as food can be provided in response to some work that the animal has to perform, such as pecking on a key, and this 'cost' of the commodity can then be varied experimentally. Dawkins argued that commodities that are very important to the animal will show relatively inelastic demand. Thus by establishing demand curves we should be able to make a better judgement of the importance that the animals themselves attach to food, companionship, bedding, exercise and other features. The approach is ingenious and logical, but there are substantial difficulties of technique and interpretation as outlined, for example, by Dawkins (1990), Dantzer (1990), Mench and Stricklin (1990), and Shettleworth and Mrosovsky (1990).

Thus we see, in a sense, four generations of a research paradigm, proceeding from straightforward environmental preference testing, to tests of motivation strength, then titration of one motivation against another and finally attempts to establish demand elasticity. Each stage arguably increases our ability to treat animal welfare as a type 2 concept, but the difficulties of technique and the unpredictable impacts of procedural variables become more daunting. We can conclude that it is technically difficult to identify, from such ingenious experiments, the weighting of various costs and benefits that animals truly prefer, but there are also more fundamental objections (described for example, by Duncan 1978; Dawkins 1980, 1990; Fraser *et al* 1993) to using this approach to make animal welfare a type 2 concept.

First, the fundamental assumption of these techniques - namely, that animals seek out what is beneficial and avoid what is harmful - applies within limits to benefits and harms that the animal can detect and act upon but not to all benefits and harms. We as humans avoid putrescent food and aggressive dogs because we can detect the potential harm; but when confronted with food contaminated with anthrax or a dog infected with heart worm we may fail to avoid the harm because we cannot detect it.

Second, even where harms and benefits can be detected some choices involve too much complexity or too much uncertainty for the outcome to be predicted. We might wish to know whether a cow will have a

better life when served daily meals in a narrow stall' that is occasionally hot and stuffy, compared to less abundant food in a wooded hillside where temperatures occasionally plunge and where a leg may be broken in a rodent burrow. However, the ultimate fate of the animal in these environments is too unpredictable for the result of a preference experiment to be taken as a genuine reflection of the animal's welfare. Third, even if the outcome of a choice can be predicted, an individual's choices do not always promote its welfare (Duncan 1978). Humans are confronted daily with decisions that affect their welfare: what to eat and drink, how much to rest and exercise, whether to behave aggressively toward a rival, whether to behave sexually toward a potential partner. Humans have the benefit of long lives in which to observe the consequences of their actions, powers of abstract thought that allow them to ponder the future consequences of an action, and a facility with language that allows them to learn from experiences other than their own. Even so, humans often make choices based on short-term impulses that they know to be contrary to their long-term welfare. Can we expect much more of, say, a ten-week-old chicken?

With suitable refinements, the techniques described above clearly have an important role in understanding the preferences and priorities of animals. Preference testing can, for example, help us identify what the animal considers a comfortable pen, a palatable food or a congenial social group. Motivational tests provide insight into how keenly an animal is motivated to obtain a particular benefit at a particular time. Such techniques thus provide information relevant to understanding an animal's welfare, but they do not tell us *the* objectively correct weighting of costs and benefits that would allow us to treat animal welfare as a type 2 concept.

Implications for defining animal welfare

To summarize, animal welfare makes a good fit to a type 3 concept, and available scientific approaches do not allow us (for a mixture of technical and fundamental reasons) to treat animal welfare as a type 1 or a type 2 concept. This conclusion has implications for how we define and conceptualize animal welfare.

A good deal of effort has gone into devising definitions of animal welfare. For example, Broom (1991) defined the welfare of an animal as,

> 'its state as regards its attempts to cope with its environment,' and which 'refers to how much has to be done to cope and how well or how badly coping attempts succeed.'

Carpenter (1980) proposed that,

> 'The welfare of managed animals relates to the degree to which they can adapt without suffering to the environments designated by man.'

And Hughes (1976b) defined welfare as,

> 'A state of complete mental and physical health, where the animal is in harmony with its environment.'

The limitations of these definitions become apparent when we compare them with definitions of other scientific terms such as 'viscosity' (a type 1 concept):

> 'a property of liquids that causes them to resist flowing as a result of internal friction from the fluid's molecules, usually measured by letting the fluid flow through a narrow capillary tube,'

or 'metabolizable energy' (a type 2 concept):

> 'the energy which the animal has available for production of heat, body substances or work,' and which equals 'the difference between the chemical energy in the feed and the chemical energy in faeces, urine and methane.'

Unlike these definitions, the definitions of animal welfare 'broadly describe the area under discussion' (in the words of Duncan & Dawkins 1983), but specify very little about what processes contribute to welfare or how welfare might be measured. This is because with animal welfare, as with other type 3 concepts, the definition focuses on the common function served by the relevant attributes but does not specify which attributes are actually involved. Thus, the above definitions tell us merely that the attributes relevant to animal welfare are those that relate to how well the animal is coping (Broom), how well it adapts (Carpenter), or whether it is in harmony with its environment (Hughes). To be more specific we need to propose what attributes we consider important for an animal to be said to be coping, adapting and in harmony with its environment, and this process involves values. Hence, to conceptualize animal welfare we should attempt not the impossible task of creating technical definitions that eliminate values, but the possible task of making the underlying value-related assumptions sufficiently explicit that we do not mistake value issues for technical ones (see Sandøe & Simonsen 1992).

To do this it is useful to create a 'hierarchy of propositions', progressing from general principles which may enjoy considerable consensus, to more specific details where consensus is likely to be lacking. A possible framework (see Fraser 1993) groups the issues under the following three principles. First, there appears to be widespread consensus that a high level of welfare implies freedom from suffering in the sense of intense and prolonged pain, fear, distress, discomfort, hunger and thirst (eg Harrison 1964; Carpenter 1980). More specific applications of this principle enjoy less agreement. For example, farmers and animal protectionists may disagree about whether the pain inflicted by castration and branding is sufficiently intense and prolonged to seriously detract from animal welfare.

Second, despite some possible dissent (Duncan 1993), it seems widely agreed that a high level of welfare requires a high level of biological functioning, including freedom from debilitating diseases, injury, malnutrition and reductions in normal growth. Again, more specific issues are less well resolved. For example, does the exclusion of disease in a confined, minimum-disease herd enhance welfare enough to compensate for the curtailment of freedom that the system requires?

A third principle, perhaps less universally accepted, is that a high level of welfare implies that the animals should have positive experiences such as comfort and contentment, and the pleasure of normal activities such as play, exploration and non-aggressive social behavior (see Harrison 1964). The specific application of this principle involves very disparate viewpoints, including disagreement about how spacious and natural an environment must be in order to satisfactorily accommodate natural behaviour.

To say that values are inextricably involved in our concept of animal welfare is not to say that animal welfare is a purely subjective concept, nor that animal welfare requirements should be decided by public opinion poll, nor that the welfare of a given animal depends purely on the values of the human culture in which the animal is kept. These ideas arise from the mistaken notion that concepts are either purely objective and value-free or else purely subjective and not influenced at all by objective considerations. Rather, our conception of animal welfare is influenced by both values and knowledge. We may never understand animals' preferences and priorities so completely that we eliminate all intrusion of human values in assessing animal welfare, but we can learn a great deal about these preferences and priorities. Hence. animal welfare scientists should not sit idly by, waiting for society to decide what animal welfare involves so that they will know what to study. Instead, scientists should develop and use knowledge of animals to help society develop a more sound conceptualization of animal welfare and its ethical dimensions.

Implications for the scientific assessment of animal welfare

In discussions of animal welfare assessment we can draw a rough distinction between two schools of thought, ranging from scientists who speak of 'measuring' animal welfare (eg Broom 1991), to those who consider that different conceptions of animal welfare, including different values, make precise measurement an impossibility (eg Mason & Mendl 1993). Measurement would be an appropriate goal if animal welfare were a type 1 or type 2 concept and hence, at least in principle, a single attribute. If, however, we treat animal welfare as a type 3 concept we must picture it not as a vector but as a collection of vectors in a multi-dimensional space (Sandøe & Simonsen 1992). Hence, as with other type 3 concepts, we do not 'measure' animal welfare; rather we measure those type 1 and 2 variables that are relevant to animal welfare. Many of these can be studied as objectively as other scientific variables, but there is no purely objective way to combine these variables into a measure of the 'overall' welfare of the animal.

This limits our ability to compare welfare in systems that differ in a large number of features. For example, compared to their counter-parts in gestation stalls, sows in outdoor yards have more freedom of movement and cleaner air, but they are also exposed to harsh weather, larger group sizes and increased transmission of certain diseases. Studying a large number of variables (behaviour, physiology, productivity, health) may allow us to argue that one system is on net better than the other because it outperforms the other on most attributes that we consider important. However, a variety of measures is likely to yield a complex picture, with certain important advantages favouring each system (eg Barnett *et al* 1984). Science cannot provide a purely objective way to achieve consensus in such cases (see Sandøe & Simonsen 1992; Mason & Mendl 1993).

In studying other type 3 concepts, such as the health of a person or the safety of a building, overall measurement is rarely the objective. For example, building inspectors do not see their task as 'measuring' the safety of a building or determining whether one building is, on net, safer than another. Rather their task is (1) to identify deficiencies. (2) to propose ways of correcting deficiencies, and (3) to recommend preventive measures so that deficiencies will not become significant. Animal welfare science should follow a similar pattern. Instead of trying to 'measure' animal welfare, scientists should see their task as identifying, solving and preventing animal welfare problems.

Concluding remarks

This essay, like that of Tannenbaum (1991), was motivated by the observation that some scientists believe, or write as though they believe, that animal welfare can be defined and studied as a purely technical, scientific concept without involving values. I have argued instead:

(1) that our conception of animal welfare inherently involves value notions about what is better or worse, more important or less important. for the quality of life of animals;

(2) that scientific study and interpretation of animal welfare inherently flow from these underlying value notions, and that these value notions need to be made explicit so that value-related disagreements are not confused with technical ones;

(3) that while science provides many ways to identify, solve and prevent animal welfare problems, science cannot 'measure' the overall welfare of animals because there is no single measure, nor any purely objective way of combining different measures, that eliminates value-related disagreements; and

(4) that when systems of animal husbandry differ in a large number of features, science may be unable to show objectively whether animal welfare is, on net, better in one system than another.

Appendix 1

Because the term 'values' has various meanings in philosophy (see Edwards 1967), it is important to be clear on the meaning intended in this essay. For this purpose it is useful to think of statements (or propositions, ideas, etc) as falling on one of three levels. First is the level of knowledge, consisting of descriptive statements by which we try to describe the world as it is, was or will be. As an example, 'Pigs are bigger than chickens.' Second is the level of 'preference values,' consisting of appreciative or evaluative statements by which we report what we like or dislike, consider important or unimportant, enjoy or fail to enjoy. As an example, 'Pigs are better than chickens.' These are called 'values in the broad sense' by Brunk *et al* (1991). Third is the level of 'moral values,' consisting of prescriptive statements by which we prescribe how people ought to behave. As an example, 'We ought to eat chickens rather than pigs.' These are called 'values in the narrow sense' by Brunk *et al* (1991).

Statements at one level may influence, but cannot by themselves logically refute or confirm, statements at a different level. Our knowledge may influence, but cannot logically refute or confirm, our preferences. And both our knowledge and our preferences may influence, but cannot logically refute or confirm, our notions of moral obligation. Hence, new scientific knowledge relating to animal welfare may influence, but cannot logically refute or confirm, what we feel is relatively more or less desirable for animals (preference values) and what we consider to be morally acceptable treatment of animals (moral values).

In the above discussion I have stressed the link between animal welfare and *preference* values. For example, in studying animal welfare we involve preference values because we invoke our notions of what is relatively more or less desirable and important for an animal. Tannenbaum (1991) tends to link animal welfare specifically with *moral* values. For example, he writes of animal welfare as a term 'that refers to what is good for an animal in the sense of what would provide it with the life we ordinarily *ought to* permit or encourage it to live', and he writes that when we give relative weight to different mental states and conditions of existence of animals we rely on our perception 'about how animals *ought to* be treated' (my emphasis). The link is perfectly logical: if we have a moral responsibility for an animal's welfare and if action X is better for the animal than action Y, then we ought to do X, other things being equal. However, in such cases other things rarely *are* equal. What is good for an animal may be bad for the farmer or for food availability or for the environment. Hence, as noted by Sand0e and Simonsen (1992) and Hurnik (1993), values related to animal welfare compete with many other values when we make ethical decisions. Furthermore, many factors, such as warm weather, can enhance the welfare of animals in our care even though we have no obligation to provide these benefits. Finally, the applicability of the term 'animal welfare' should not vary from species to species depending on our ethical obligations; adequate food is important for the welfare of field mice as well as laboratory mice even though we feel no obligation to provide food for field mice. Hence, in conceptualizing animal welfare it is less problematic if we invoke preference values rather than moral values, but recognizing that moral issues are often closely involved.

The view that values are involved in scientific approaches to animal welfare seems, at first, directly contrary to the position of some scientists who, like Broom (1991), maintain that welfare 'can be measured in a scientific way that is independent of moral considerations'. However, many of the points made by Broom are compatible with the arguments presented here. In particular, Broom notes that there are some ethical questions, such as whether the killing of animals is justifiable, that cannot be resolved by scientific study of animal welfare (Fraser & Broom 1990) and that scientists should not try to reduce ethical questions to purely technical ones (Broom 1991). Scientists may be uniquely qualified to report on the degree of suppression of an animal's immune competence, but decisions on *how much* suppression of immune competence is morally acceptable is not a purely technical question that can be answered without recourse to values.

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