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Welfare Assessment and Relevant Ethical Decisions: Key Concepts

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Abstract

Broom DM. Welfare Assessment and Relevant Ethical Decisions: Key Concepts. ARBS Annu Rev Biomed Sci 2008;10:T79-T90. Animal welfare is the subject of rapidly increasing concern in most countries in the world and this concern is resulting in changes in the ways in which animal users keep and treat animals. The welfare of an individual is its state as regards its attempts to cope with its environment. This includes the state of all coping systems, including those responding to pathology, various behavioural and physiological responses and processes in the brain. Welfare includes health and the extent of positive and negative feelings. The statement that welfare means being in harmony with nature is not a definition of welfare that is usable in welfare assessment, whilst the view that welfare includes the extent to which the animal might be in that state in nature is incorrect. It is misleading to suggest that this definition of welfare is a functional one rather than one that refers to suffering and other feelings because feelings are a part of animal functioning. Assessment of welfare must take account of the wide variety of coping systems and coping strategies used. A range of measures of behaviour, physiology, brain function, immune system function, damage, strengths of preferences, etc. is needed. The ease or difficulty of coping should be interpreted within the framework of the abilities and needs of the animal. Ethical decisions about animal welfare generally involve a deontological approach, specifying actions that should never be taken, and a consequentialist approach in which costs and benefits are balanced but neither of these approaches is adequate by itself.

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1. What Is Meant by Welfare?

Welfare is a term which is used about animals, including man, but not about plants or inanimate objects. If, at some particular time, an individual animal has no problems to deal with, that individual is likely to be in a good state that would be associated with good feelings and indicated by a particular body physiology, brain state and behaviour. Another individual may face problems in life such that coping is difficult or not possible. *Coping implies having control of mental and bodily stability* and prolonged failure to cope results in failure to grow, failure to reproduce or death. Individuals are likely to show some direct signs of their potential failure to cope or difficulty in coping and they are also likely to have had bad feelings associated with their situations. (Broom, 1986). *The welfare of an individual is its state as regards its attempts to cope with its environment.* The origin of the concept is how well the individual is faring or travelling through life (Broom, 1991a,b, 1998, 2006a; Broom & Johnson, 2000). The term environment in the definition of welfare means, for an individual, something that could have an effect from outside that individual, or for any particular response system, something that could have an effect from outside that system. Potentially damaging challenges may come from outside the body, e.g. pathogens, causes of tissue damage, or attack by conspecifics, or from within it, e.g. anxiety, boredom or frustration, perhaps because of lack of key stimuli or lack of overall stimulation. Other impacts of the environment may be positive and lead to better welfare.

It is generally accepted by animal welfare scientists that the concept of welfare refers to the measurable state of the individual on a scale from very good to very poor. Since welfare can be poor, it is not logical to speak of preserving, ensuring or compromising welfare.

Welfare measurements should be based on knowledge of the biology of the species and, in particular, on what is known of the methods used by animals to try to cope with difficulties, on signs that coping attempts are failing and on indications of success in coping. The measurement and its interpretation should be objective. Good welfare often involves good feelings and poor welfare involves bad feelings. Indeed feelings are biological mechanisms, which are an important part of coping methods. Pain, fear, achievement pleasure, sexual pleasure, etc. are adaptive and have evolved as a result of natural selection like other biological mechanisms (Broom, 1998).

The statement by Hughes 1981, following the writings of Lorca, that welfare means being in harmony with nature has a link with the definition of welfare above as coping with the environment can be thought of as being in harmony with it. However, being in harmony is a single state and could not vary so it is not a definition of welfare that is usable in welfare assessment.

The Brambell Report (1965) pointed out that farm animals would be likely to have problems if the conditions provided for them frustrate aspects of natural behaviour. However, as Dawkins (1998) has explained, this does not mean that animals should be provided with all that they might encounter in nature. Exposure to predators, starvation and disease clearly do not lead to good welfare. Neither does it mean that when considering an animal in a particular state, welfare includes the extent to which the animal might be in that state in nature. Fraser (1999) discussed the views of the public about animal welfare and described one area as being how natural the system or conditions are. However, he did not advocate including degree of naturalness in the definition of welfare or its assessment. The state of an individual as regards its attempts to cope with its environment is dependent on the biology of the animal and natural conditions have affected the evolution of coping mechanisms but it is incorrect to say that degree of naturalness per se is a component of welfare.

Some authors have suggested that my definition of welfare is a functional one rather than one that refers to suffering and other feelings (e.g. Dwyer & Lawrence, 2008). This was never the case and it was clearly explained (Broom, 1991b) that when welfare is defined in this way, feelings are included

as an important part of it. The evidence for the evolution of feelings and for feelings as a part of animal functioning is explained briefly below and by Broom (1998, 2003) and Broom and Fraser (2007).

In origin, welfare refers to how the individual is faring or going through life whilst well-being is how the individual is. Welfare is generally considered a more precise term but the two words are often used interchangeably. Welfare is the word used in modern European legislation. Some other languages have only one word that can be used to translate either welfare or well-being. The words which are equivalent to welfare in other languages, and which are used in identical legislation, include: Wohlbefinden and Wohlergehen in German, welzijn in Dutch, bien-être in French, bem-estar in Portuguese, bienestar in Spanish, benessere in Italian, velfaerd in Danish and dobrostan in Polish.

Poor welfare is often associated with lack of control over interactions with the environment of the individual, *i.e.* with difficulty in adapting. The life of most mammals and birds includes many occasions when coping is done better if the animal uses high-level cognitive skills. Hence we need to study sophisticated coping methods, *e.g.* predicting, based on experience, that the pain will go away. If the animals with the highest levels of cognitive ability have the greatest potential for coping, pain may be worse for simpler animals than for complex animals (Broom, 2006c).

2. Welfare and Adaptation

In order to use animals in a human-orientated environment, and to ensure that the welfare of those animals is good, we need to know about the abilities of animals to adapt. *At the individual level, adaptation is the use of regulatory systems, with their behavioural and physiological components, to help an individual to cope with its environmental conditions* (Broom, 2006b).

3. Welfare, Needs and Freedoms

When attempting to determine what is an appropriate environment for an animal, most scientists involved in welfare research would agree with Appleby (1997) that a range of components of that environment, each of which is to some extent variable, should be considered. The environment is appropriate if it allows the animal to satisfy its needs. Animals have a range of functional systems controlling body temperature, nutritional state, social interactions etc. (Broom, 1981). Together, these functional systems allow the individual to control its interactions with its environment and hence to keep each aspect of its state within a tolerable range. The allocation of time and resources to different physiological or behavioural activities, either within a functional system or between systems, is controlled by motivational mechanisms. When an animal is actually or potentially homeostatically maladjusted, or when it must carry out an action because of some environmental situation, we say that it has a need. Hence, *a need is a requirement, that is part of the basic biology of an animal, to obtain a particular resource or respond to a particular environmental or bodily stimulus* (Broom & Johnson, 2000). These include needs for particular resources and needs to carry out actions whose function is to obtain an objective (Toates & Jensen, 1991; Broom, 1996, 1997). Needs can be identified by studies of motivation and by assessing the welfare of individuals whose needs are not satisfied (Hughes & Duncan 1988a,b; Dawkins, 1990; Broom & Fraser, 2007). Unsatisfied needs are often, but not always, associated with bad feelings whilst satisfied needs may be associated with good feelings. When needs are not satisfied, welfare will be poorer than when they are satisfied.

Some needs are for particular resources, such as water or heat, but control systems have evolved in animals in such a way that the means of obtaining a particular objective have become important to the individual animal. The animal may need to perform a certain behaviour and may be seriously affected if unable to carry out the activity, even in the presence of the ultimate objective of the activity; for example, rats and ostriches will work, in the sense of carrying out actions which result in food presentation, even in the presence of food. In the same way, dogs need to chew on something, even if satiated with food, pigs need to root in soil or some similar substratum (Hutson, 1989), birds need to preen and dust-bathe (Vestergaard, 1980), and many birds and mammals need to build a nest before giving birth (Brantas, 1980; Arey, 1992). In all of these examples, the need itself is in the brain so it is

not logical to refer to it as being solely physiological or behavioural. A need may be satisfied only when some physiological imbalance is prevented or rectified, or when some particular behaviour is shown.

The idea of specifying the freedoms that should be given to animals was put forward in the Brambell Committee Report (Brambell, 1965). These were freedom from: (i) hunger and thirst, (ii) discomfort, (iii) pain, injury, or disease, (iv) fear and distress, and freedom to express normal behaviour by providing sufficient space, proper facilities, and company of the animal's own kind. This list of freedoms has been a useful general guideline but animal welfare science has progressed rapidly since that time and there is now good evidence for most domestic species as to their needs. There is now little point in listing the freedoms because the species needs are a much more accurate way to decide upon what should be provided to ensure good welfare. In addition, the concept of freedoms that must be provided for is suspect because, like the concept of rights, it can be misused (Broom, 2003).

4. Welfare and Health

The word "health", like "welfare", can be qualified by "good" or "poor" and varies over a range. However, health refers to the state of body systems, including those in the brain, which combat pathogens, tissue damage or physiological disorder. Welfare is a broader term covering all aspects of coping with the environment and taking account of a wider range of feelings and other coping mechanisms than those that affect health, especially at the positive end of the scale. *Health is the state of an individual as regards its attempts to cope with pathology.* Hence "health" is encompassed within the term "welfare", and indeed is a very important part of welfare.

Although people regularly refer to poor health, they sometimes use the word health to mean absence of illness or injury in the same way that people refer to welfare when they mean good welfare. In precise scientific use, health should refer only to states varying from very good to very poor and "preserving health" should be "preserving good health".

Health is a part of welfare and hence disease always has some adverse effect on welfare. There can also be effects of welfare in general on likelihood of disease because specific aspects of health may be made worse when welfare in general is poor (Broom, 1988; Broom & Kirkden, 2004; Broom, 2006a). The sequence could start with infectious disease that then causes poor welfare. Alternatively, inadequate housing conditions or transport in bad conditions could lead to poor welfare and hence to increased disease susceptibility. If animals became diseased as a consequence, this would result in worse welfare than that caused directly by the conditions.

The general conclusions about the inter-relationships between welfare improvement attempts and disease are: firstly, that disease is an aspect of poor welfare and many actions will be of benefit in both respects. Secondly, that the possible trade off between reduced immunosuppression and increased disease transmission risk should be carefully considered in all attempts to improve welfare. Thirdly, that there are differences between production- or system-related diseases and dangerous infectious diseases. Whilst we have quite a lot of information about the former, the latter should also be borne in mind when developing new systems for housing and managing animals. Our overall aim should be to improve welfare in total and we should always include consideration of the effects on individuals of any disease that they might contract (Broom, 1992, 2006a).

5. Welfare and Stress

The word stress should be used for that part of poor welfare that involves failure to cope. If the control systems regulating body state and responding to dangers are not able to prevent displacement of state outside the tolerable range, a situation of different biological importance is reached. The use of the term stress should be restricted to the common public use of the word to refer to a deleterious effect on an individual (Broom & Johnson, 2000). A definition of stress as just a stimulation or an event that elicits adrenal cortex activity is of no scientific or practical value. A precise criterion for what is adverse for an animal is difficult to find but one indicator is whether there is, or is likely to be, an effect on biological fitness. *Stress is an environmental effect on an individual that over-taxes its control systems and results in adverse consequences, eventually reduced fitness* (Broom & Johnson, 2000; see also

Broom, 1983, 2006b). Using this definition, the relationship between stress and welfare is very clear. Firstly, whilst welfare refers to a range in the state of the animal from very good to very poor, whenever there is stress, welfare is poor. Secondly, stress refers only to situations where there is failure to cope but poor welfare refers to the state of the animal both when there is failure to cope and when the individual is having difficulty in coping. It is very important that this latter kind of poor welfare, as well as the occasions when an animal is stressed, is included as part of poor welfare. For instance, if a person is severely depressed or if an individual has a debilitating disease but there is complete recovery with no long term effects on fitness then it would still be appropriate to say that the welfare of the individuals was poor at the time of the depression or disease. In the circumstances in which people have referred to some stress being good, the effect is not stress but is stimulation that is useful experience in the maintenance or development of individuals. There is no stress that is good and the terms “eustress” and “dystress” are redundant. If an experience is difficult to cope with but beneficial in the long-term, the welfare of the individual is poor at the time of coping difficulty but no stress occurs.

6. Welfare and Feelings

The subjective feelings of an animal are an extremely important part of its welfare (Dawkins, 1990, 2004; Broom, 1991b; Duncan & Petherick 1991; Fraser, 1993). *Suffering, which occurs when one or more negative, unpleasant feelings continue for more than a few seconds*, should be recognised and prevented wherever possible. When managing animals, we should endeavour to promote feelings of contentment and happiness in animals. However, whilst we have many measures that give us some information about injury, disease and both behavioural and physiological attempts to cope with the individual's environment, fewer studies tell us about the feelings of the animal. Information can be obtained about feelings using preference studies and other information giving indirect information about feelings can be obtained from studies of physiological and behavioural responses of animals. *A feeling is a brain construct, involving at least perceptual awareness, which is associated with a life regulating system, is recognisable by the individual when it recurs and may change behaviour or act as a reinforcer in learning* (Broom, 1998).

As discussed above, feelings are aspects of an individual's biology that must have evolved to help in survival (Broom, 1998), just as aspects of anatomy, physiology and behaviour have evolved. They are used in order to maximise its fitness, often by helping it to cope with its environment. It is also possible, as with any other aspect of the biology of an individual, that some feelings do not confer any advantage on the animal but are epiphenomena of neural activity (Broom & Johnson, 2000). The coping systems used by animals operate on different time scales. Some must operate during a few seconds in order to be effectual, others take hours or months. Optimal decision-making depends not only on an evaluation of energetic costs and benefits but on the urgency of action, in other words the costs associated with injury, death or failure to find a mate (Broom, 1981). In the fastest acting urgent coping responses, such as avoidance of predator attack or risk of immediate injury, fear and pain play an important role. In longer time-scale coping procedures, where various risks to the fitness of the individual are involved, feelings rather than just intellectual calculations are amongst the causal factors affecting what decisions are taken. In attempts to deal with very long-term problems that may harm the individual, aspects of suffering contribute significantly to how the individual tries to cope. In the organisation of behaviour so as to achieve important objectives, pleasurable feelings and the expectation that these will occur have a substantial influence. The general hypothesis advanced is that whenever a situation exists where decisions are taken which have a big effect on the survival or potential reproductive output of the individual, it is likely that feelings will be involved. This argument applies to all animals with complex nervous systems, such as vertebrates and cephalopods, and not just to humans. Feelings are not just a minor influence on coping systems, they are a very important part of them.

In circumstances where individuals are starting to lose control and fail to cope, feelings may exist. These feelings might have a role in damage limitation which is functional. However they might also occur when the individual is not coping at all and the feelings have no survival function then. Extreme suffering or despair are probably not adaptive feelings but an observer of the same species

might benefit and a scientist might use indications of such feelings to deduce that the animal is not coping.

If the definition of welfare were limited to the feelings of the individual, as has been proposed by Duncan and Petherick (1991), it would not be possible to refer to the welfare of a person, or an individual of another species, who had no feelings because of being asleep, or anaesthetised, or drugged, or suffering from a disease that affects awareness, or of a species lacking the brain potential to have sufficient awareness for feelings. A further problem, if only feelings were considered, is that a great deal of evidence about welfare like the presence of neuromas, extreme physiological responses or various abnormalities of behaviour, immunosuppression, disease, inability to grow and reproduce, or reduced life expectancy would not be taken as evidence of poor welfare unless bad feelings could be demonstrated to be associated with them. Evidence about feelings must be considered for it is important in welfare assessment but to neglect so many other measures is illogical and harmful to the assessment of welfare, and hence to attempts to improve welfare.

In some areas of animal welfare research it is difficult to identify the subjective experiences of an animal experimentally. For example it would be difficult to assess the effects of different stunning procedures using preference tests. Disease effects are also difficult to assess using preference tests. There are also problems in interpreting strong preferences for harmful foods or drugs. However, research on the best housing conditions and handling procedures for animals can benefit greatly from studies of preferences which give information about the subjective experiences of animals. Both preference studies and direct monitoring of welfare have an important role in animal welfare research. Welfare assessment should involve a combination of studies providing information about coping.

7. Welfare Assessment

The assessment of welfare should be quite separate from any ethical judgement but, once an assessment is completed, the information produced can be used to take decisions about the ethics of a situation. If we need to assess quality of life, we should use quantitative welfare assessment methods where possible. People's assessment of welfare may vary considerably unless established methods are used. A key question to be addressed is how good is the welfare from the animal's perspective?

The general methods for assessing welfare are summarised in Table 1 and a list of measures of welfare is presented in Table 2. Most indicators will help to pinpoint the state of the animal wherever it is on the scale from very good to very poor. Some measures are most relevant to short-term problems, such as those associated with human handling or a brief period of adverse physical conditions, whereas others are more appropriate to long-term problems. These measures of welfare are not "subjective" measures and it is possible to assess quality of life by the use of such measures and not just by asking the subject questions. Subjective measures in humans may be incorrect or inconsistently correct. However, those who use the methodology used in medical research on welfare/quality of life and those who assess the welfare of non-human animals have much to learn from one another (see Lutgendorf, 2001 and other papers in that book). For a detailed discussion of measures of welfare, see Broom and Johnson (2000).

Table 1. Summary of Welfare Assessment^a

General Methods	Assessment
Direct indicators of poor welfare	How poor is it?
Tests of avoidance	What is the extent to which animals have to live with avoided situations or stimuli?
Tests of positive preference	To what extent is that which is strongly preferred available?
Measures of ability to carry out normal behaviour and other biological functions	How much important normal behaviour or physiological or anatomical development cannot occur?
Other direct indicators of good welfare	How good is it?

^a modified after Broom (1999a)

Table 2. Measures of welfare^a

Physiological indicators of pleasure
Behavioural indicators of pleasure
Extent to which strongly preferred behaviours can be shown
Variety of normal behaviours shown or suppressed
Extent to which normal physiological processes and anatomical development are possible
Extent of behavioural aversion shown
Physiological attempts to cope
Immunosuppression
Disease prevalence
Behavioural attempts to cope
Behaviour pathology
Brain changes
Body damage prevalence
Reduced ability to grow or breed
Reduced life expectancy

^a From Broom (2000)

Some signs of poor welfare arise from physiological measurements. For instance increased heart-rate, adrenal activity, adrenal activity following ACTH challenge, or reduced immunological response following a challenge, can all indicate that welfare is poorer than in individuals which do not show such changes. Care must be taken when interpreting such results, as with many other measures described here. The impaired immune system function and some of the physiological changes can indicate what has been termed a pre-pathological state (Moberg, 1985).

Behavioural measures are also of particular value in welfare assessment. The fact that an animal avoids an object or event, strongly gives information about its feelings and hence about its welfare. The stronger the avoidance the worse the welfare whilst the object is present or the event is occurring. An individual which is completely unable to adopt a preferred lying posture despite repeated attempts will be assessed as having poorer welfare than one which can adopt the preferred posture. Other abnormal behaviour such as stereotypies, self-mutilation, tail-biting in pigs, feather-pecking in hens, or excessively aggressive behaviour in dogs indicates that the perpetrator's welfare is poor.

In some of these physiological and behavioural measures it is clear that the individual is trying to cope with adversity and the extent of the attempts to cope can be measured. In other cases, however, some responses are solely pathological and the individual is failing to cope. In either case the measure indicates poor welfare.

Disease, injury, movement difficulties and growth abnormality all indicate poor welfare. If two housing systems are compared in a carefully controlled experiment and the incidence of any of the above is significantly increased in one of them, the welfare of the animals is worse in that system. The welfare of any diseased animal is worse than that of an animal that is not diseased but much remains to be discovered about the magnitude of the effects of disease on welfare. Little is known about how much suffering is associated with different diseases. A specific example of an effect on housing conditions that leads to poor welfare is the consequence of severely reduced exercise for bone strength. In studies of hens (Knowles & Broom, 1990; Norgaard-Nielsen, 1990) those birds that could not sufficiently exercise their wings and legs because they were housed in battery cages had considerably weaker bones than those birds in percherries where there was enough space to exercise. Similarly, Marchant and Broom (1996) found that sows in stalls had leg bones only 65% as strong as sows in group-housing systems. The actual weakness of bones means that the animals are coping less well with their environment so welfare is poorer in the confined housing. If such an animal's bones are broken there will be considerable pain and the welfare will be worse. Pain may be assessed by aversion, physiological measures, the effects of analgesics (*e.g.* Duncan *et al.*, 1991) or by the existence of neuromas (Gentle, 1986). Whatever the measurement, data collected in studies of animal welfare gives information about the position of the animal on a scale of welfare from very good to very poor.

The majority of indicators of good welfare that we can use are obtained by studies demonstrating positive preferences by animals. In operant tests a cost is imposed upon access to the resource by requiring the subject to perform a task. Performance of the task requires time and effort, which could otherwise have been spent doing other things. The task may also be unpleasant to the subject. In choice tests, a cost is normally imposed instead upon consumption. The animal must divide time between consuming the resources.

An indicator of the effort which an individual is willing to use to obtain a resource is the weight of a door which is lifted to gain access. Manser *et al.* (1996), studying floor preferences of laboratory rats, found that rats would lift a heavier door to reach a solid floor on which they could rest than to reach a grid floor. Where the demand for a resource is measured at a range of prices (Fig.1), the importance of the resource is indicated better by the consumer surplus than by the price elasticity of demand (Kirkden *et al.*, 2003).

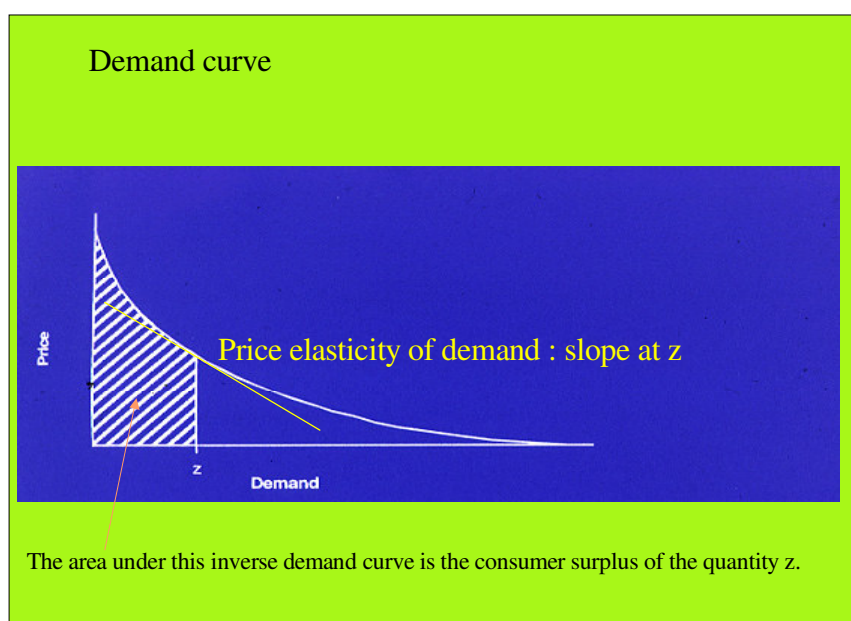


Figure 1. The consumer surplus and the price elasticity of demand are illustrated on a demand curve that might be produced by evaluating the demand shown by an animal carrying out an operant response for a resource at different prices.

The third general method of welfare assessment listed in Table 2 involves measuring what behaviour and other functions cannot be carried out in particular living conditions. Hens prefer to flap their wings at intervals but cannot in a battery cage whilst veal calves and some caged laboratory animals try hard to groom themselves thoroughly but cannot in a small crate, cage or restraining apparatus.

In all welfare assessment it is necessary to take account of individual variation in attempts to cope with adversity and in the effects which adversity has on the animal. When pigs have been confined in stalls or tethers for some time, a proportion of individuals show high levels of stereotypies whilst others are very inactive and unresponsive (Broom, 1987; Broom & Johnson, 2000). There may also be a change with time spent in the condition in the amount and type of abnormal behaviour shown (Cronin & Wiepkema, 1984). In rats, mice and tree shrews it is known that different physiological and behavioural responses are shown by an individual confined with an aggressor and these responses have been categorised as active and passive coping (Holst, 1986; Koolhaas *et al.*, 1983; Benus, 1988). Active animals fight vigorously whereas passive animals submit. A study of the strategies adopted by gilts in a competitive social situation showed that some sows were aggressive and successful, a second category of animals defended vigorously if attacked whilst a third category of sows avoided social confrontation

if possible. These categories of animals differed in their adrenal responses and in reproductive success (Mendl *et al.*, 1992). As a result of differences in the extent of different physiological and behavioural responses to problems it is necessary that any assessment of welfare should include a wide range of measures. Our knowledge of how the various measurements combine to indicate the severity of the problem must also be improved. It is also important to understand the strategies used by animals in various coping situations as these may be different from those used by humans. An example is the response to severe pain in sheep and some other prey species, in which it is not adaptive to show obvious behavioural responses (Broom & Johnson, 2000).

As a consequence of the high proportion of coping mechanisms that involve the functioning of higher centres in the brain, some welfare assessment should involve brain function measures (Broom & Zanella, 2004). Whilst welfare applies to any animal, animal protection laws generally refer to sentient animals. *A sentient being is one that has some ability: to evaluate the actions of others in relation to itself and third parties, to remember some of its own actions and their consequences, to assess risk, to have some feelings and to have some degree of awareness* (Broom, 2006c). Our expanding view of what constitutes moral behaviour has led to more animals being protected by legislation (Broom, 2001a, 2003, 2006c).

In situations in which an animal has a chronic clinical condition, or a particular training procedure is used, or an animal's reaction to a kennel is to be evaluated, the welfare of that animal can be assessed using a combination of measurements. A clinician may be able to use a variety of observational methods to estimate the welfare but accurate measurement using a suitable array of welfare indicators will give more reliable results and should be used. Where the severity of any poor welfare is assessed, the overall effect on the welfare is a function of duration and severity. In Fig. 2, the area under the curve is the value required (Broom, 2001b).

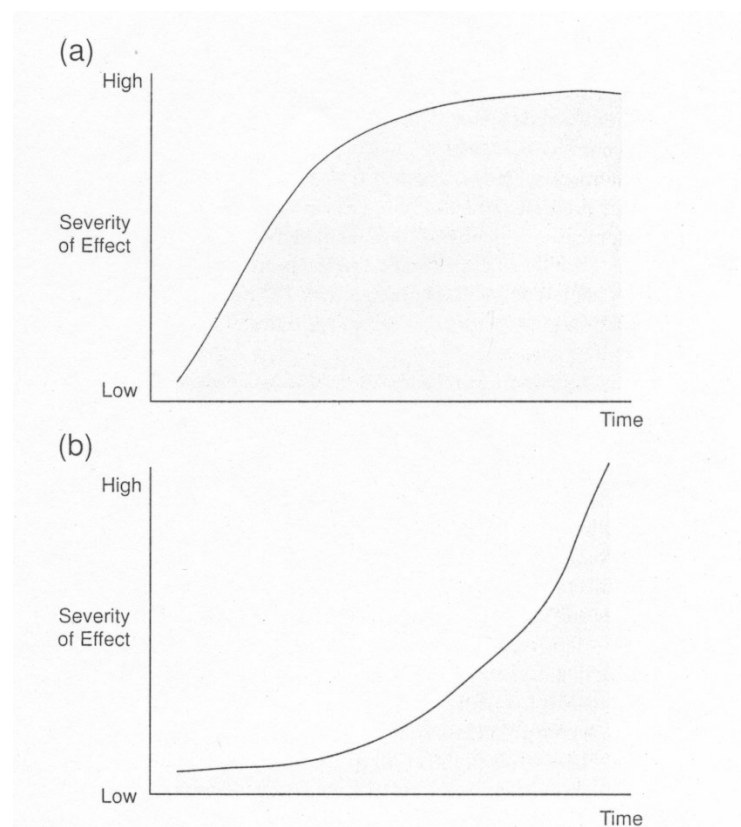


Figure 2. Where measures of poor welfare indicate the severity of the effect on the animal, the area under the curve when severity is plotted against duration gives a useful overall estimate of the extent of poor welfare. The maximum severity is the same in 2a and 2b but the extent of poor welfare is much greater in 2a (after Broom, 2001b).

8. Ethics and Using Animal Welfare Science

The collection and analysis of data by animal welfare scientists should be carried out in an objective way that is independent of any ethical view about the outcome of the research. After the results have been obtained, scientists, like any member of the public, may make judgements about what should be done.

The ethical approach of those considering what to do about situations where animal welfare is poor may be deontological or utilitarian. The idea that we have duties towards individual animals that we use is widespread and leads to views that there are certain harms to animals that should never be perpetrated. Using a utilitarian or consequentialist approach, however, any harms to individuals may be balanced against benefits that accrue because of the action. In practice, many decisions involve a mixture of the two approaches as some actions are avoided whilst others are subject to cost-benefit analysis.

9. Concluding Remarks

Welfare depends on extent of adaptation, a variety of coping methods and how well needs are met. Welfare encompasses health and any stress or feelings. Feelings are biological mechanisms and are part of coping methods. Like some other coping methods, feelings involve high-level brain activity as well as simpler physiological functioning. Although many aspects of welfare involve feelings, not all of welfare is about feelings. Many feelings are not easy to evaluate and there are occasions when feelings can be misleading or absent when welfare, and hence quality of life, is being assessed.

Some coping involves prediction and other complex brain abilities. Animals with better brains probably cope better. Established methods in welfare assessment, including measures of strength of preference and scientific measures of abnormal behaviour, physiological responses and clinical condition, should be used to evaluate welfare in clinical and other situations. Terminology should be used precisely in this area of science, medicine and veterinary medicine.

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11. About the Author

Donald Broom (M.A., Ph.D., Sc.D.), the world's first Professor of Animal Welfare, has held the post at Cambridge University's Department of Veterinary Medicine since 1986. His Centre for Animal Welfare and Anthrozoology have developed concepts and methods of scientific assessment of animal welfare, publishing over 500 papers on cognitive abilities of animals, the welfare of calves, pigs, chickens, laboratory animals, zoo animals etc. in relation to housing and transport, behaviour problems of pets, attitudes to animals and ethics of animal usage. He has lectured on animal welfare in 37 countries, served on UK (FAWC and APC) and Council of Europe committees and has been Chairman or Vice Chairman of EU Scientific Committees on Animal Welfare since 1990. At present he is Vice Chairman of the European Food Safety Authority Scientific Panel on Animal Health and Welfare. He also chairs the O.I.E. group on Welfare of Animals during Land Transport. Amongst his eight books are *Stress and Animal Welfare* (Broom & Johnson 1993/2000, Kluwer), *Coping with Challenge : Welfare in Animals including Humans* (Broom ed. 2001, Berlin: Dahlem University Press), *The Evolution of Morality and Religion* (2003, Cambridge University Press), and *Domestic Animal Behaviour and Welfare*, 4th edition, (Broom and Fraser 2007, CABI).