Pre-publication copy

Broom, D.M. 2011. A history of animal welfare science. *Acta Biotheoretica,* 59, 121-137. DOI: 10.1007/s10441-011-9123-3

A history of animal welfare science.

Donald M. Broom

Centre for Animal Welfare and Anthrozoology, Department of Veterinary Medicine, University of Cambridge, Madingley Road, Cambridge CB3 0ES, United Kingdom

ABSTRACT

Human attitudes to animals have changed as non-humans have become more widely incorporated in the category of moral agents who deserve some respect. Parallels between the functioning of humans and non-humans have been made for thousands of years but the idea that the animals that we keep can suffer has spread recently. An improved understanding of motivation, cognition and the complexity of social behaviour in animals has led in the last thirty years to the rapid development of animal welfare science. Early attempts to define welfare referred to individuals being in harmony with nature but the first usable definition incorporated feelings and health as part of attempts to cope with the environment. Others considered that welfare is only about feelings but it is argued that as feelings are mechanisms that have evolved they are a part of welfare rather than all of it. Most reviews of welfare now start with listing the needs of the animal, including needs to show certain behaviours. This approach has used sophisticated studies of what is important to animals and has replaced the earlier general guidelines described as freedoms. Many measures of welfare are now used and indicate how good or how poor the welfare is. Naturalness is not a part of the definition of welfare but explains why some needs exist. In recent years, welfare has become established as one of various criteria used to

decide on whether a system is sustainable because members of the public will not accept systems that cause poor welfare. The study of welfare has become part of the scientific basis upon which important political decisions are made.

INTRODUCTION

Animal welfare is a term that describes a potentially measurable quality of a living animal at a particular time and hence is a scientific concept. Much of the discussion about animal welfare concerns what humans do about it, or should do about it. Such a question, about what people ought to do, is an ethical issue. The scientific study of animal welfare should be separated from the ethics but no application of the science can occur without understanding arguments about ethical positions. The first section of this paper will therefore refer to morality in relation to animal use. This will be followed by discussions of the history of the welfare concept and of usable welfare concepts now and how they are inter-related. Some links to other moral issues and some future concerns will then be considered.

MORAL ORIGINS AND EARLY WELFARE HISTORY

Animals have always had welfare but what humans know of it has become modified over time, especially recently. The human concepts of what are and are not moral actions have probably changed little over many millennia except that the category of individuals who are considered to deserve to be treated in a moral way has broadened greatly (Broom 2003). Helping others and not harming others are effective strategies, especially for animals that live in long-lasting social groups. Hence moral systems have evolved in humans and other such animals, as explained in more detail by de Waal (1996), Ridley (1996), Broom (2003). Humans have long espoused the view that they have duties to others. As explained in the references quoted, social animals such as humans have evolved characteristics that make them responsive to others in their societies in a way that promotes dutiful preferences and actions. This

deontological position has arisen in every human society and the mechanisms involved have parallels in other animal societies. Other evolved characteristics increase abilities to assess consequences of actions and to evaluate costs and benefits, i.e. some utilitarian decisions.

In some human societies, for example those where the Buddhist or Jain religions dominate, the range of living individuals considered to deserve respect has long been wide. However, in most of the world, ideas about which individuals should be the subject of moral actions (Singer 1994) have changed with: (i) improved communication in the world, (ii) increasing knowledge of the functioning of humans and other animals. People will often avoid actions that could harm others, even if only they know about the action (Gert 1988, Broom 2006). However, they are more likely to refrain from causing harm if those in their social group may come to know about what they have done. As human societies have expanded their contacts, the group that is in moral contact with an individual has changed from the family to the tribe, and has subsequently expanded to include much larger communities. The 20th century communication explosion has resulted in information about the actions of particular people becoming known across the world. As a consequence, it has become harder for harmful actions to be concealed (Broom 2003). The spread of knowledge has also been greatly facilitated.

The level of sophistication of the functioning of individuals has often been a factor in decisions about whether or not they are a subject of moral actions. The ways in which human and other animal brains work was a mystery to all people until information became available from relatively recent developments in neurobiology. Our language has not kept pace with these changes so people make statements about having feelings or knowing something in their heart or in their gut when all are in the brain. The study of behaviour and of how the brain controls it, and of the great similarities in the physiology of all people and a wide range of other species, has been revolutionary in its impact on human attitudes (Dennett 1984). Until recently it was really believed by many people, especially males, that women had very inferior functioning as compared with men, that it was not realistic to compare the cognitive ability of people with brown or black

skin to that of white people and that there was an enormous gap in ability and functioning between humans and other species. A wide range of studies now show these views to be wrong. The group of individuals who are respected, in that harm would not normally be caused to them, has been extended to humans of all nations and races and to many other animal species. To some extent this is a consequence of information that is available from the media. The person watching a television programme and seeing a parrot, or squirrel, or dog, or pig, or sheep, or raven solve complex problems may not in future think of that kind of animal as an object, or as a being of no consequence. That person may well become much less likely to directly harm the animal, or to condone harm by others.

Before there was accurate scientific knowledge, in human societies for which there are detailed records there have been descriptions of animal functioning including their behaviour, physiology and pathology. Very many parallels between humans and other animals were apparent to people and these were described by Greeks, Mayans, Chinese and others (Sorabji 1993). Ideas about non-human animals included recognition of similarities to humans in respect of what would harm them, the complexity of their body regulation systems, the existence of their emotional responses and the range of abilities that they demonstrated to control their environment (Engel and Engel 1990). There have been others who placed emphasis on differences between humans and all other species, as explained by Harwood 1928. However, the Descartes view of animals as automata, with almost no similarity to humans, has probably been used by some people during much of human history. It was often used by those for whom it was convenient as a way of justifying some form of exploitation. Such arguments were also used to justify slavery and other suppression of minorities.

Bentham (1789) stated that the key question about animals was not can they reason but do they suffer? Most people who have lived with or looked closely at animals have assumed that they could do both to some extent. As Duncan (2006) has said, up to the 19th century, this view was very widespread but later there was some reluctance to hold the view because of difficulty to measure the

suffering.. It was based on observation and deduction, i.e. on a scientific approach.

WELFARE: 1960s to 1980s

In the 19th century and the 20th century up to the 1960s, knowledge about biological functioning increased greatly. By the end of this time, scientific disciplines such as ethology and neuroscience started to become accepted within the scientific community. However, this did not mean that the information was widely known. Unfortunately, in many countries, the division between scientists and non-scientists and the fear of science among those narrowly educated in non-scientific disciplines resulted in ignorance of these biological developments amongst those who came to have influential positions in some parts of government and industry.

In 1964 Ruth Harrison's book "Animal Machines" was published and pointed out that those involved in the animal production industry were often treating animals like inanimate machines rather than living individuals. As a consequence of this book, in 1965 the British government set up the Brambell Committee, a committee chaired by Professor F. Rogers Brambell, to report on the matter. One of its members was W. H. Thorpe, an ethologist in Cambridge University. Thorpe emphasised that an understanding of the biology of the animals is important and explained that animals have needs with a biological basis, including some needs to show particular behaviours, and that animals would have problems if there were frustration of those needs (Thorpe 1965). This view came to be written in the Brambell Report as the "five freedoms". The concept of freedom has some logical and scientific difficulties, as explained below (Broom 2003). Bill Thorpe was my Ph.D. supervisor. He asked me in 1965 to comment on some material used by the Committee. This was a tape recording of hens in different housing conditions. Thorpe asked whether it was possible to deduce anything about the welfare of the birds from the sounds that they made. Although some deduction might now be made (Zimmerman et al 2003), these tapes did not allow any at that time. However, the Brambell Report has had great influence in many countries.

In the 1960s, the emphasis of discussions was on what people should do, i.e. on animal protection rather than on animal welfare. In the 1970s and early 1980s, the term animal welfare was used but not defined and not considered scientific by most scientists.

A development of major importance to the emerging concept of animal welfare was research by ethologists and psychologists on motivation systems. The writings of Neal Miller, Robert Hinde, David McFarland and others in the 1950s to 1980s helped ethologists to understand control systems and how animals came to take decisions (Miller 1959, Hinde 1970, McFarland and Sibly 1975). A review of Broom (1981), a book entitled "Biology of Behaviour", pointed out that the animals described in it were presented as sophisticated decision-makers in almost all aspects of what they did. This view contrasted greatly with the then widespread but subsequently discredited view of animals as automata driven by "instinct". Key research by Ian Duncan and David Wood-Gush (Duncan and Wood-Gush 1971,1972), explained the motivation of animals whose needs were not met so the animals were frustrated. These authors and Barry Hughes explained the biological basis of needs (Hughes and Duncan 1988, Toates and Jensen 1991). Also at this time, there was work on the evolution of behaviour including sociobiology (Wilson 1975), many of whose proponents considered motivation to be of little interest and domestic animals as quite unsuitable subjects for biological research. Some of those who worked on motivation at that time changed to applied ethology studies and particularly to animal welfare, e.g. Broom, M. Dawkins, Duncan, D. Fraser, Ladewig, Matthews, Vestergaard and Wiepkema. At the same time, the scientific use of the term stress was being questioned. Its use by Hans Selye was clearly ambiguous and, as J. Mason pointed out (Mason 1968, Dantzer and Mormède 1979), to some degree erroneous in that the HPA and SAM physiological mechanisms were presented as general to all situations when they are not. Some people used the term stress to mean HPA axis activity whilst others used it for any stimulation. Broom suggested (1983, see also Broom and Johnson 1993) that it should be limited to adverse or potentially adverse effects with fitness reduction as the criterion. This

view was supported by Dantzer, von Holst (D), Moberg, Mormède and Toates but was ignored by medical and most physiological researchers.

Another view challenged in the 1970s and 1980s was the idea that domestic animals were completely modified by man and therefore scarcely biological and not comparable with their wild equivalents. Glen McBride studied a population of feral chickens on an island off Australia (McBride et al 1969). David Wood-Gush studied another domestic fowl population and, later with Alex Stolba, a group of sows kept in fields with trees (Wood-Gush and Stolba). Per Jensen, encouraged by Ingvar Ekesbo, carried out a detailed study of modern domestic pigs in woodland conditions. (Jensen 1986) The conclusion from all of this work was that the behaviour of these farm animal breeds was scarcely distinguishable in many respects from that of their wild ancestors. Another view, subsequently found to be largely incorrect, was that of Hemmer (1983) that domestic animals have less brain-power and much less complex behaviour than their wild ancestors. A wide range of experimental studies on learning have shown, for example, that sheep and cows recognise many individuals and sheep have units in their brains which make this possible (Kendrick and Baldwin 1987, Kendrick et al 1995, 2001), young cattle can show an excitement response when they learn something (Hagen and Broom (2004), and pigs can use information from mirrors after a few hours of experience with a mirror (Broom et al 2009). The major way in which domestic animals have been changed by human selection is that they are now very different from their ancestors in that they can have some tolerance of human proximity and an ability to breed in restricted, suboptimal situations (Price 2002).

At this time, most of the animal welfare researchers were in zoology or animal production departments in universities and research institutes. Although not often aware of the wide range of welfare topics, many veterinarians were aiming to benefit the animals and improve animal welfare by trying to cure or prevent animal disease. Some of these used their clinical knowledge to ensure that the health of animals was properly considered in evaluation of welfare whilst others carried out experimental work. Veterinarians who contributed to more general aspects of animal welfare science included Andrew Fraser, Ingvar Ekesbo, Henrik

Simonsen, Robert Dantzer, Roger Ewbank, Barry Hughes and John Webster. Andrew Fraser was one of the founders of the Society for Veterinary Ethology (later the International Society for Applied Ethology), which is the major scientific society for animal welfare science. He was also editor of the journal then called “Applied Animal Ethology” and now called “Applied Animal Behaviour Science” which is the most important journal for scientific papers on animal welfare. The journal “Animal Welfare” has also been of major importance in more recent years.

Much of the discussion about the use of animals, until relatively recently, centred on whether or not they should be killed. Philosophers and the public were often concerned with the ethics of killing animals for human food, human clothing, scientific research or as unwanted pets (Regan 1990, Fraser 2008). This is an important ethical question but it is not an animal welfare issue. The animal welfare issue is what happens before death, including how they are treated during last part of their lives, often the pre-slaughter period and then the method by which they are killed. However, as Haynes (2008) points out, there is a danger in this position if it results in the ethical question of whether or not it is acceptable to kill and animal being ignored or inadequately considered.

THE HISTORY OF THE ANIMAL WELFARE CONCEPT

In the 1980s, it was accepted by most biologists and veterinarians that animals and their response systems are subject to challenges from their environment. These challenges include pathogens, tissue damage, attack or threat of attack by a conspecific or predator, other social competition, the complexity of information processing in a situation where an individual receives excessive stimulation, a lack of key stimuli such as a teat for a young mammal or those associated with social contact for a social animal and a lack of overall stimulation. In general, an inability to control interactions with their environment causes problems for humans and other animals (Mason 1968, 1971,Weiss 1971,. The Brambell Committee did not define welfare in their report but, following some generally

accepted views of the functioning of animals and also the writings of Lorca, Barry Hughes (1981) proposed that the term animal welfare meant that the animal was in harmony with nature, or with its environment. This is a biologically relevant statement and a precursor of later views but it is not a usable definition. Being in harmony is a single state so it does not allow scientific measurement. The key question is how much the individual is in harmony. The term welfare was being used more and more in science, in laws and in discussion about the effects of the treatment of laboratory, farm and companion animals. Hence there was a clear need for a scientific definition.

Broom (1986) presented this definition of welfare. "The welfare of an individual is its state as regards its attempts to cope with its environment." In a series of publications (Broom1988, 1991a,b, Broom and Johnson 1993), a number of points relating to this definition, including those below, were emphasised. Coping means having control of mental and bodily stability (Broom and Johnson 1993). Welfare can be measured scientifically and varies over a range from very good to very poor. Welfare will be poor if there is difficulty in coping or failure to cope. There are various coping strategies with behavioural, physiological, immunological and other components that are coordinated from the brain. Feelings, such as pain, fear and the various forms of pleasure, may be part of a coping strategy and feelings are a key part of welfare. The system may operate successfully so that coping is achieved or may be unsuccessful in that the individual is harmed. One or more coping strategies may be used to attempt to cope with a particular challenge so a wide range of measures of welfare may be needed to assess welfare. Coping with pathology is necessary if welfare is to be good so health is an important part of welfare.

A key point of agreement amongst animal welfare scientists in the early 1990s and later has been that animal welfare is measurable and hence is a scientific concept (see review of the ideas of Duncan, Dawkins, Broom and others by Fraser 2008). However, Broom's definition has been referred to by some as a functional definition and contrasted with the feelings - related definitions of Ian Duncan (see also Broom 2008). Duncan argued that welfare is wholly about feelings (Duncan and Petherick 1991, Duncan 1993). This view was shared by

some other people but a commoner position was that of Marian Dawkins (1980, 1990) who stated that the feelings of the individual are the central issue in welfare but other aspects such as the health of that individual are also important. At the same time, those with a medical or veterinary background sometimes presented the view that health is all, or almost all, of welfare. All of Broom's papers and books discussing the welfare definition referred to feelings but as a part of welfare. The arguments for the evolution of feelings as part of animal functioning are explained by Cabanac (1979), Broom (1991b, 1998, Broom and Fraser 2007) and Panksepp (1998). Even in recent times, the myth that Broom's definition is functional, rather than encompassing suffering and other feelings, has been perpetuated (e.g. Dwyer and Lawrence 2008). The idea that feelings are completely different from other biological mechanisms when individuals are trying to cope with their environment is not biologically sound. When coping is successful and problems are absent or minor, welfare is good. Good welfare is generally associated with feelings of pleasure or contentment.

Like bad feelings, such as pain or fear, good feelings are a biological mechanism and this mechanism has evolved (Cabanac 1992, Keeling and Jensen 2002). 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).. Suffering occurs when one or more negative feelings continue for more than a few seconds (Broom 1998). There are problems with a definition of welfare that only refers to feelings. Feelings are just one part of an animal's repertoire of coping mechanisms. Although the brain condition which results in a feeling may have first arisen accidentally, most feelings now occurring are a result of natural selection and are adaptive. Although feelings are an important part of welfare, welfare involves more than feelings, for example: an individual with a broken leg but asleep, an addict who has just taken heroin, an individual greatly affected by disease but unaware of it, an injured individual whose pain system does not function (Broom 1991b, 1998).

A few veterinarians were involved in animal welfare research in the 1980s, as mentioned above, and the paper on assessing pain and distress in laboratory

312 animals by Morton and Griffiths (1985) had substantial influence. However, at
313 this time most veterinarians did not consider animal welfare as a scientific
314 discipline that should be taught to veterinary students and that was relevant to
315 those in practice. Many thought that only veterinarians knew about animal
316 welfare and that almost all of welfare was treatment of or prevention of disease.
317 Animal behaviour and brain function were thought to be of minor importance to
318 veterinary work. These views had close parallels with the medical profession in
319 which those who studied behavioural or mental problems were often considered
320 peripheral to the major tasks of human medicine. Vets, medics and scientists
321 were unwilling to refer to animal feelings (Panksepp 2005). Research biologists
322 in universities did not think of the study of animal welfare as a science. They
323 often viewed it as an impediment to research and were only grudgingly aware of
324 the concept of the 3Rs, reduce, replace and refine presented by Russell and
325 Burch (1959). Despite the fact that many important biological systems have the
326 function of attempting to cope with difficulties in life, the study of welfare has
327 not been greatly valued in the scientific world and welfare scientists are not
328 thought of as significant contributors to science.

329

330 USABLE ANIMAL WELFARE CONCEPTS AND HOW THEY ARE INTER-RELATED

331

332 Adaptation

333 It may be helpful to relate the welfare terminology to the concept of adaptation.
334 How well can our domestic animals adapt to the conditions that we impose upon
335 them? Can wild animals adapt to our impact on them? When referring to
336 individual animals, adaptation is the use of regulatory systems, with their
337 behavioural and physiological components, to help an individual to cope with its
338 environmental conditions (Broom 2006a). Animals can adapt better if their
339 needs are met. What are the limits to adaptation? The idea that there are limits
340 has been widely accepted in biology (Mount 1979, Moberg 1985) but resisted by
341 some involved in animal production. An individual attempting to cope may fail to
342 do so. For example, it may be difficult or impossible to cope with: extreme

external temperature, pathogen multiplication, or high predation risk or difficult social conditions. Body state may be displaced to outside the tolerable range and death may follow. An individual may adapt to an environmental situation with difficulty, in which case the welfare is poor. For example, if an individual is adapting, or has adapted, but is in pain or depressed. Coping usually means that all mental and bodily systems have functioned so that the environmental impact is nullified. Hence "to cope" is more than "to adapt". Adaptation does not necessarily mean good welfare.

Stress

For most people, stress implies the effects of a challenge to the individual that disrupts homeostasis resulting in adverse effects. It is not just a stimulus which activates energy releasing control mechanisms. Stimuli whose effects are beneficial would not be called stressors by most people. Also, for most people, situations which activate the hypothalamic - pituitary - adrenal cortical axis, but whose effects are useful to the individual, would not be called stressors . A definition of stress that is in line with the general public usage of the word is "Stress is an environmental effect on an individual which overtaxes control systems and results in adverse consequences, eventually reduced fitness"(Broom and Johnson 1993, following Broom 1983). There is no good stress. During the development of individuals, stimuli that result from somewhat difficult situations can be useful experience but these are best not referred to as being stressful.. Whenever there is stress, welfare will be poor but welfare could be temporarily poor without any lon=lasting adverse effect so without stress.

Needs or freedoms?

Motivational systems have evolved. They enable individuals to ascribe priorities to certain actions, as well as to determine the timing of actions (Broom 1981). This facilitates adaptation. A need is a requirement, which is part of the basic biology of an animal, to obtain a particular resource or respond to a particular environmental or bodily stimulus (Broom and Johnson 1993). The need itself is in the brain. It allows effective functioning of the animal. It may be fulfilled by physiology or behaviour but the need is not physiological or behavioural. There are needs for resources, such as food, water or heat but there are also needs to carry out actions whose function is to attain an objective (Hughes and Duncan 1988, Toates and Jensen 1991). For example: a pig rooting in soil or manipulating material such as straw or twigs, or a hen dust-bathing to keep feathers in good condition, or a hen or a sow building a nest when about to give birth or lay an egg. The idea of providing for "the five freedoms", first suggested in the Brambell Report in 1965 but not quite in line with Thorpe's concept of needs, is now replaced by the more scientific concept of needs. The list of freedoms just provides a general guideline for non-specialists. Animals have many needs and these have been investigated for many species. This is the starting point for reviews of the welfare of a species. A list of needs has been the starting point for Council of Europe recommendations and E.U. scientific reports on animal welfare for over 20 years. The freedoms are not precise enough to be used as a basis for welfare assessment. This is now an out-dated approach that may still be useful as a preliminary guideline but should not be used if scientific evidence about needs is available. The 12 factors presented by the Welfare Quality programme are a better guide than the five freedoms but a list of the needs of the particular animals under consideration, based on published scientific evidence, is more useful.

How do we find out from animals what they need? What is preferred? How hard will the individual work for a resource? An example is work with rats that are given a choice of floors. One measure is which floor they choose but more information is obtained if the rats have to work in order to get to the floor of their choice. A rat can readily learn to lift a weighted door and the amount lifted gives an indication of its strength of preference for the resource.

Terminology used in motivational strength estimation includes the following (Kirkden et al 2003). A resource is a commodity or an opportunity to perform an activity. The demand is a measured amount of action which enables resource to be obtained. The price is the amount of that action required for a unit of resource. Income is the amount of time or other variable limiting that action. The price elasticity of demand is the proportional rate at which consumption or demand changes with price. The consumer surplus is a measure of the largest amount which a subject is prepared to spend on a given quantity of the resource. It corresponds to an area beneath an inverse demand curve. A example of the use of this methodology is the work of Mason et al (2001). The key question was to ascertain the strength of preference of mink, a partially aquatic species, for various resources including water in which they could swim. The mink were trained to perform operants to reach: an extra nest, various objects, a raised platform, a tunnel, an empty cage and a water pool to swim in. The swimming water was given very high priority by the mink.

Obligations or rights?

How should we describe what should or should not be done to other individuals? Most people would say that we all have obligations not to harm others. From the other perspective, it might be said that each other individual has a right not to be harmed by us. However, assertions of rights and freedoms can cause problems (Broom 2003). We should describe the obligations of the actor rather than the rights of the subject. If we keep or otherwise interact with animals we then have obligations in relation to their welfare.

WELFARE PROBLEMS, ASSESSMENT AND DECISIONS

Effects on animal welfare which can be described include those of:

disease,

injury,

starvation,

beneficial stimulation,

social interactions - positive or negative,

other forms of success in actions,

housing conditions - positive or negative,

deliberate or accidental ill treatment,

human handling - positive or negative,

transport,

laboratory procedures,

various mutilations,

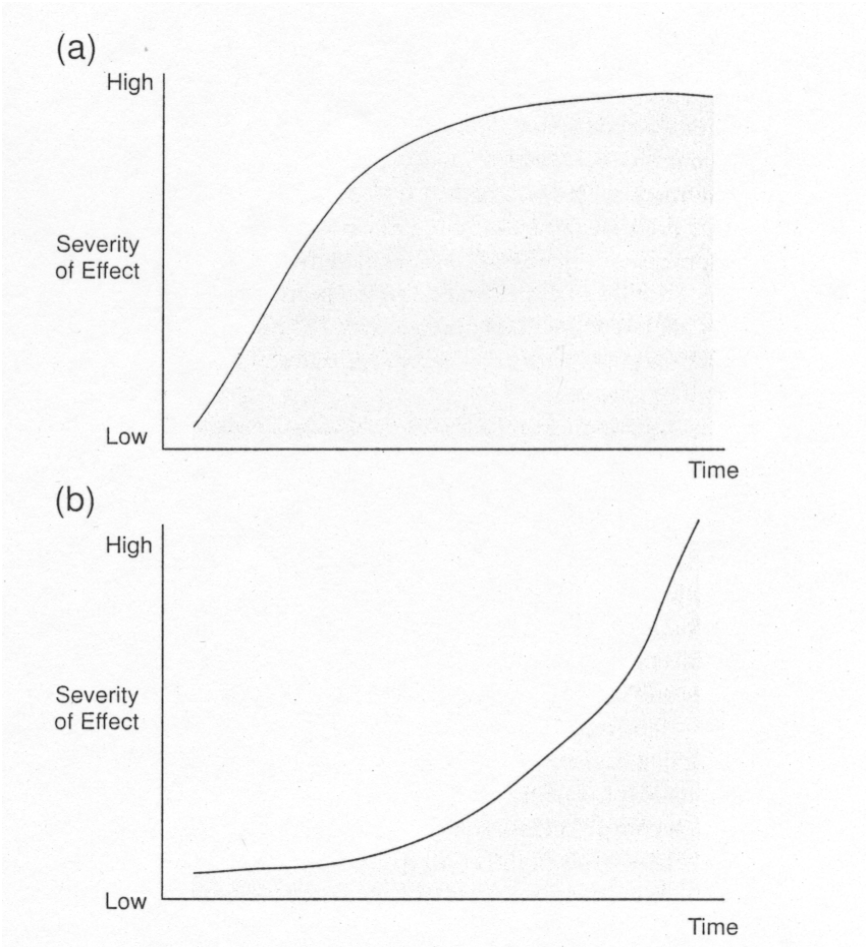
veterinary treatment - positive or negative,

genetic change by conventional or other breeding.

Welfare indicators are described by Broom and Fraser (2007). There are differences between welfare indicators for short-term and long-term problems. Short-term measures like heart-rate and plasma cortisol concentration are appropriate for assessing welfare during handling or transport but not during long-term housing. Some measures of behaviour, immune system function and disease state are more appropriate for long-term problems. Welfare over longer periods is sometimes referred to as quality of life. This term is much used by clinicians but it means welfare over a period of more than a few days (Broom 2007b).

Over any time-scale, measures of intensity of effect on welfare have to be related to the duration of the state. When welfare is evaluated, the relationship between its intensity (the word severity is sometimes used where the effect is negative) and duration should be taken into account. Fig 1 was initially drawn to exemplify poor welfare during killing methods(Broom 2001b) but the principle is the same for positive effects..

Legend Fig.1 The measured intensity of good or poor welfare is plotted against time for two examples. (a) might be an animal being killed by a method involving prolonged pain and other poor welfare, (b) might be an animal killed by a method that has a much more rapid effect (After Broom 2001b).



Axis labelled Intensity of Effect (not severity)

Where there is an adverse impact in Fig. 1, the area under the intensity against time curve is the magnitude of poor welfare. Where the impact is positive, magnitude of good welfare is the area under the curve.

NATURALNESS AND WELFARE

Where does naturalness fit with the concept of welfare? Fraser (1999) pointed out that when members of the public talk about animal welfare, their ideas include the functioning of the animals, the feelings of the animals and the

naturalness of the environment. The feelings, referred to by Fraser and others, fit comfortably into Broom's definition of welfare as they are an important component of coping mechanisms and of biological functioning. Rollin (1990, 1995), Fraser et al (1997) and Fraser (2008) have advocated that "animals should be able to lead reasonably natural lives" and have referred to the importance of understanding animal needs. However, they did not say that naturalness contributes to a definition of the concept of welfare or should be part of welfare assessment. The state of an individual trying to cope with its environment will necessarily depend upon its biological functioning, or put another way, on its nature. Natural conditions have affected the needs of the animal and the evolution of coping mechanisms in the species. The state of an individual trying to cope with its environment will depend upon its biological functioning. Natural conditions have affected the needs of the animal and the evolution of coping mechanisms in the species. The environment provided should fulfil the needs of the animal but does not have to be the same as the environment in the wild.

LINKS BETWEEN ANIMAL WELFARE AND OTHER MORAL ISSUES

In recent years, public pressure in relation to codes of practice, laws and the enforcement of laws have increased in all countries concerning: human health, animal welfare and the impact on the environment. In Europe, one of the big pressures for laws etc. in these areas has been the view that it is uncivilised to allow people to become sick, animals to be treated badly or the environment to be damaged. A system or procedure is sustainable if it is acceptable now and if its effects will be acceptable in future, in particular in relation to resource availability, consequences of functioning and morality of action. Animal welfare is one of the criteria used by the public when deciding whether a procedure or system is acceptable so it is a necessary consideration for sustainability (Broom 2001a, 2002, 2010). For consumers and producers of animal products, the concept of quality has broadened. Good quality now means good in taste and also sustainable, especially: acceptable in relation to human health, animal welfare

and environmental impact. The French 'Label Rouge' scheme has led the way in this (Ouedraogo 1998). The proportion of French consumers who buy only on price is thought to have dropped to 25%.

The term welfare, although not applicable to inanimate objects or plants, is relevant to all animals because they have an ability to detect and respond rapidly to the impacts on them of their environment, usually via the functioning of their nervous system. Whilst the responses of more complex animals are controlled by often complex processes in their brains, those of simpler animals are also part of attempts to cope with the environment. We can assess and consider the welfare of any animal. Separate question are which animals should be protected and to what degree should they be protected? For most people, animals with awareness are thought to be worthy of more protection. 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, 2007a). People have long appreciated the sentience of various domestic and other animals and have often thought of them as an example to follow or a friend who would help, rather than just as a resource object. However, a rabbit is viewed differently according to whether it is: a family pet, a laboratory animal, an animal kept for meat production, or a wild animal that eats your crops. This is not scientifically sound. A rabbit is a rabbit and each one feels pain or has cognitive function.

Health refers to what is happening in body systems, including those in the brain, which combat pathogens, tissue damage or physiological disorder. Health is the state of an individual as regards its attempts to cope with pathology (Broom 2000, 2006b-). With disease challenge, as well as with other challenges, difficult or inadequate adaptation results in poor welfare. Health is an important part of welfare . Examples include osteoarthritis in cats and dogs and sole ulcer in cows.

RECENT AND FUTURE ANIMAL WELFARE CONCERNS

There remain some areas of confusion amongst the public and amongst scientists who do not specialise in the area, in relation to what animal welfare is. In contrast, there is a substantial degree of agreement among welfare scientists. Points (i) to (vi) below are areas where there may be some confusion. (i) For some people the concepts of protection of animals and animal welfare are confused. However, the first is a human action and the second is a characteristic of an animal. (ii) The ethical issues about whether or not animals should be killed for human benefit are sometimes perceived to overlap with the concept of welfare but they do not. The term euthanasia is often misused as it should be limited to meaning that an animal is killed for its own benefit. (iii) The concept of health as a key part of welfare rather than a separate topic is misunderstood by many, including medical and veterinary specialists who may not be familiar with the meaning of welfare. (iv) The evolution of animals in their natural environment has led to them having certain needs that must be met for welfare to be good, and good conditions for animals will allow them to function in a natural way, i.e. a normal biological way. However, as discussed above, naturalness is not a component of the definition of welfare. (v) The dignity of an individual is a human concept that may be applied to non-human animals but there is no evidence that other species have such a concept. It may be used as an argument for treating animals well but it is nothing to do with welfare. (vi) The integrity of an animal, in the sense of its wholeness, has some biological basis and is sometimes used to criticise removal of, or change in, any part of an animal including its genotype. The use of such arguments may reduce the likelihood of poor welfare but the concept itself is not connected to welfare. Some of these areas of confusion will become less common as knowledge of welfare and its scientific study becomes more widespread.

There will continue to be areas of discussion amongst animal welfare scientists. For some, all coping systems should be considered when assessing welfare. For others, only those involving feelings should be considered. The importance of

566 trying to assess feelings will continue to be common ground for welfare
567 scientists (Dawkins 1993, Panksepp 1998, Mendl et al 2004, Paul et al 2005,
568 Broom 2010) but better methodologies for all aspects of welfare assessment will
569 be developed. One recent and significant development in animal welfare science
570 has been the substantial increase in attempts to assess good welfare in a
571 scientific way. This has become feasible because of increased acceptance of the
572 validity of measuring positive feelings in animals. Studies like those of Boissy et
573 al (2007) and Mendl et al (2009) are increasing our understanding of animal
574 welfare and pointing to new methods in the future.

575 Another development in relation to welfare concepts and applications is the
576 measurement of welfare on farm or other places where animals are used.
577 Welfare outcome indicators that can be used by veterinary inspectors, farmers
578 and others have now been worked out with considerable precision (Welfare
579 Quality 2009 a,b,c). It is likely that further progress will be made with measures
580 of pain and other aspects of welfare for use by animal welfare scientists.
581 Assessments are now being made of the risk of poor welfare and the probability
582 of benefits to welfare (Smulders and Algers 2009).

583 The numbers of animal welfare scientists is increasing rapidly. The subject is
584 now being taught in all European countries and the number of university courses
585 on animal welfare in Brazil has increased from one to over 60 in 15 years. The
586 diversity of animal welfare science is increasing and the expansion is likely to
587 continue. The decision by the American Veterinary Medical Association to
588 promote the teaching of the subject in all American veterinary schools will have a
589 substantial effect.

590

591 References

592 Agenäs, S., Heath. M.F., Nixon, R.M., Wilkinson, J.M. and Phillips, C.J.C.

593 2006. Indicators of undernutrition in cattle. *Animal Welfare,* 15, 149 – 160.

594

595 Bentham, J. 1789. *An Introduction to the Principles of Morals and Legislation.*

596

597 Boissy A., Manteuffel G., Jensen M.B., Moe R.O., Spruijt B., Keeling L.J., Winckler C.,
598 Forkman B., Dimitrov I., Langbein J., Bakken M., Veissier I., Aubert A., 2007.
599 Assessment of positive emotions in animals to improve their welfare. *Physiology*
600 *and Behavior*, 92, 375-397.

601

602 Broom, D.M. 1981. *Biology of Behaviour.* Cambridge: Cambridge University Press.

603 Broom, D.M. 1983. The stress concept and ways of assessing the effects of stress
604 in farm animals. *Applied Animal Ethology,* 11, 79.

605 Broom, D.M. 1986. Indicators of poor welfare. *British Veterinary Journal* 142,
606 524-526.

607 Broom, D.M. 1988. The scientific assessment of animal welfare. *Applied Animal*
608 *Behaviour Science,* 20, 5-19.

609 Broom, D.M. 1991. Animal welfare: concepts and measurement. *Journal of*
610 *Animal Science,* 69, 4167-4175.

611 Broom, D.M. 1991. Assessing welfare and suffering. *Behavioural Processes,* 25,

612 117-123.

613 Broom, D.M. 1998. Welfare, stress and the evolution of feelings. *Advances*

614 *in the Study of Behav*ior, 27, 371-403.

615 Broom, D.M. 2000. Welfare assessment and problem areas during handling and transport.
616 In *Livestock handling and transport*, 2nd edn., ed. T. Grandin, 43-61. Wallingford: C.A.B.I.
617
618 Broom, D.M. 2001. The use of the concept Animal Welfare in European conventions,
619 regulations and directives. *Food Chain 2001*, 148-151, Uppsala: SLU Services.

620 Broom, D.M. 2001. Coping, stress and welfare. In: *Coping with Challenge: Welfare*
621 *in Animals including Humans.* (Ed). D.M. Broom, 1-9. Berlin: Dahlem University
622 Press.

623 Broom, D.M. 2002. Does present legislation help animal welfare?
624 *Landbauforschung Völkenrode,* 227, 63-69.

625 Broom, D.M. 2003. The Evolution of Morality and Religion (pp.259). Cambridge:
626 Cambridge University Press.

627 Broom, D.M., 2006. Adaptation. *Berliner und Münchener Tierärztliche*
628 *Wochenschr*ift, 119, 1 - 6.

629 Broom, D.M. 2006. Behaviour and welfare in relation to pathology. *Applied Animal*
630 *Behaviour Science,* 97, 71-83.
631
632 Broom D.M., 2006. The evolution of morality. *Applied Animal Behaviour Science*,
633 100, 20-28.

634 Broom, D.M. 2007. Cognitive ability and sentience: which aquatic animals should
635 be protected? *Diseases of Aquatic Organisms,* 75, 99-108.

636 Broom, D.M. 2007. Quality of life means welfare: how is it related to other
637 concepts and assessed? *Animal Welfare,* 16 suppl., 45-53.

638 Broom, D.M. 2008. Welfare assessment and relevant ethical decisions: key
639 concepts. *Annual Review of Biomedical Science,* 10, T79-T90.

640 Broom, D.M. 2010. Animal welfare: an aspect of care, sustainability, and food quality
641 required by the public. *Journal of Veterinary Medical Education,* 37, 83-88.
642
643 Broom, D.M. 2010. Cognitive ability and awareness in domestic animals and decisions about
644 obligations to animals. *Applied Animal Behaviour Science* 126, 1-11.
645
646 Broom, D.M. and Fraser, A.F. 2007. *Domestic Animal Behaviour and Welfare, 4th*
647 *Edition.* Wallingford: CABI.

Broom, D.M. and Johnson, K.G. 1993 (reprinted with corrections 2000). *Stress and Animal Welfare.* Dordrecht: Kluwer.

Broom, D.M., Sena, H. and Moynihan, K.L. 2009. Pigs learn what a mirror image represents and use it to obtain information. *Animal Behaviour,* 78, 1037-1041.

Cabanac, M. 1979. Sensory pleasure. *Quarterly Review of Biology*, 54, 1-129.

Cabanac, M, 1992. Pleasure: the common currency. *Journal of Theoretical Biology*, *155, 173-200*.

Dantzer, R. and Mormède, P., 1979. *Stress in Intensive Husbandry*. Paris: Masson.

Dawkins, M.S. 1980. *Animal Suffering: The Science of Animal Welfare.* London: Chapman and Hall.

Dawkins, M.S. 1990. From an animal's point of view: motivation, fitness and animal welfare. *Behavioral and Brain Sciences,* **13**, 1-31.

Dawkins, M. 2001. In: *Coping with Challenge: Welfare in Animals including Humans.* (Ed). D.M. Broom, . Berlin: Dahlem University Press.

Dawkins, M.S. 2004. Using behaviour to assess welfare. *Animal Welfare,* 13, 53-57.

Dennett, D.C. 1994. *Elbow Room: the Varieties of Free Will Worth Wanting.* Cambridge MA: M.I.T. Press.

Duncan, I.J.H. 2006. The changing concept of animal sentience. *Applied Animal Behaviour Science*, 100, 11-19.

Duncan I.J.H. and Petherick J.C. 1991. The implications of cognitive processes for animal welfare. *Journal of Animal Science*, 69, 5017-5022.

Duncan, I.J.H. 1993. Welfare is to do with what animals feel. *Journal of Agricultural and Environmental Ethics,* **6**, suppl.2, 8-14.

675 Dwyer, C.M. and Lawrence, A.B. 2008. Introduction to animal welfare and the
676 sheep. In: *The Welfare of Sheep,* ed. C.M. Dwyer, 1-40. Berlin: Springer.

677 Engel, J.R. and Engel, J.G. 1990. *Ethics of Environment and Development: Global*
678 *Challenge and international Response.* London: Belhaven Press.

679 Fraser D 1993 Assessing animal well-being: common sense, uncommon science.
680 In *Food Animal Well-being*, 37-54. West Lafayette, Indiana: USDA and Purdue
681 University.

682 Fraser, D. 1999. Animal ethics and animal welfare science: bridging the two
683 cultures. *Applied Animal Behaviour Science,* 65, 171-189.

684 Fraser, D. 2008. *Understanding Animal Welfare: the Science in its Cultural Context.*

685 Chichester: Wiley Blackwell.

686 Fraser, D., Weary, D.M., Pajor, E.A. and Milligan, B.N. 1997. The scientific
687 conception of animal welfare that reflects ethical concerns. *Animal Welfare,* 6,
688 187-205.

689 Gert, B. 1988. *Morality: a New Justification of the Moral Rules.* New York: Oxford
690 University Press.

691 Hagen, K. and Broom, D.M. 2004 Emotional reactions to learning in cattle. *Applied Animal*
692 *Behaviour Science,* 85, 203-213.
693
694 Harrison, R. 1964. *Animal Machines.* London: Vincent Stuart.

695 Harwood, D. 1928. *Love for Animals and how it Developed in Great Britain.*
696 Republished 2002 as *Dix Harwood's Love for Animals and how it Developed in*
697 *Great Britain (*1928, R.Preece and D.Fraser eds.). Lewiston U.S.A.: Edwin Mellen
698 Press.

699 Haynes, R.P. 2008. Animal and human health and welfare. A comparative
700 philosophical analysis *Journal of Agricultural and Environmental Ethics,* 21, 91-
701 97.

702 Hemmer, H. 1983. *Domestikation: Verarmung der Merkwelt.* Braunschweig: Vieweg.

703 Hemsworth, P.H. and Coleman, G.J. 1998. *Human-Livestock Interaction: the*
704 *Stockperson and Productivity ad Welfare of Intensively Farmed Animals.* CAB
705 International, Wallingford, UK.

706 Hinde, R. A. 1970. *Animal Behaviour: A Synthesis of Ethology and Comparative*
707 *Psychology,* 2nd Edition, New York: McGraw Hill.

708 Hughes, B.O. 1982.The historical and ethical background of animal welfare. In:

709 *How well do our animals fare? Proc. 15th Annual Conference of the Reading*

710 *University Agricultural Club, 1981*, ed. J.Uglow, 1-9.

711 Hughes, B. O. and Duncan, I. J. H. 1988. Behavioural needs: can they be explained in
712 terms of motivational models? *Applied Animal Behaviour Science,* **20**: 352-355.

713 Jensen, P. (1986). Observations on the maternal behaviour of free ranging domestic pigs.
714 *Applied Animal Behaviour Science,* **16**:131-142.

715 Keeling, L. and Jensen, P. (2002). Behavioural Disturbances, Stress and Welfare. In: *The*
716 *Ethology of Domestic Animals,* 79-98. (Ed). Jensen, P. Wallingford: CABI.

717 Kendrick, K.M. and Baldwin, B.A. 1987. Cells in the temporal cortex of sheep can
718 respond preferentially to the sight of faces. Science, NewYork, **236**: 448-450.
719
720 Kendrick, K.M., Atkins, K., Hinton, M.R., Borad, K.D., Fabre-Nys, C. and Keverne, B.
721 1995. Facial and vocal discrimination in sheep. Animal Behaviour, 49, 1665-1676.
722
723 Kendrick, K.M., da Costa, A.P., Leigh, A.E., Hinton, M.R. and Peirce, J.W. 2001. Sheep
724 don't forget a face. Nature, 414, 165-166.
725
726 Kirkden, R.D., Edwards, J.S.S. and Broom, D.M. 2003. A theoretical comparison of the
727 consumer surplus and the elasticities of demand as measures of motivational strength.
728 *Animal Behaviour,* **65**, 157-178.

729 Koolhaas J M Schuurmann T and Fokema D S 1983 Social behaviour of rats as a
730 model for the psychophysiology of hypertension In: *Biobehavioural Bases of*

731 *Coronary Heart Disease* ed: T M Dembrowski T H Schmidt and G. Blumchen 391-
732 400 Karger: Basel.

733 Lutgendorf S K 2001 Life, liberty and the pursuit of happiness: good welfare in
734 humans In: *Coping with Challenge: Welfare in Animals including Humans* ed: D M
735 Broom 49-62 Dahlem University Press Berlin.

736 Mason, G.J., Cooper, J.J. & Clarebrough, C. 2001. Frustrations of fur-farmed mink.
737 *Nature*, 410, 35-36.

738 Mason, J.W. 1968. A review of psychoendocrine research on the pituitary adrenal cortical
739 system. *Psychosomatic Medicine,* 30, 576-607.

740 Mason, J.W. 1971. A re-evaluation of the concept of 'non-specificity' in stress theory.
741 *Journal of Psychiatric Research*, 8, 323-333.

742

743 McBride, G., Parer, I.P. and Foenander, F. 1969. The social organisation of the feral
744 domestic fowl. *Animal Behaviour Monographs,* 2, 125-181.

745 McFarland, D.J. and Sibly, R.M. 1975. The behavioural final common path. *Philosophical*
746 *Transactions of the Royal Society* B, 270, 265-93.

747 Mendl, M., Burman, H.P., Parker, R.M.A. and Paul, E.S. 2009. Cognitive bias as an
748 indicator of animal emotion and welfare: emerging evidence and underlying mechanisms.
749 *Applied Animal Behaviour Science*, 118, 161-181.
750

751 Mendl, M. and Paul, E.S. 2004. Consciousness, emotion and animal welfare: insights
752 from cognitive science. *Animal Welfare* 13, S17-S25.
753

754 Miller, N.E. 1959. Liberalization of basic S-R concepts: extensions to conflict behaviour,
755 motivation and social learning. In: *Psychology: a Study of a Science,* Vol. II (Ed). Koch, S.
756 New York: McGraw Hill.

757 Moberg, G. P. 1985 Biological response to stress: key to assessment of animal
758 well-being? In: *Animal Stress* ed: G. P. Moberg 27-49 American Physiological
759 Society: Bethesda Md.

760 Morton, D. B. and Griffiths, P. H. M. 1985. Guidelines on the recognition of pain,
761 distress and discomfort in experimental animals and an hypothesis for assessment.
762 *Veterinary Record*, 116, 431-436.

763

764 Mount, L.E. 1979. *Adaptation to Thermal Environment,* 333pp. London: Edward Arnold.

765 Ouedraogo, A.P. 1998. Ethical consumers? Social representations of stock farming in
766 France. *Proc. 32nd Cong. Int. Soc. Appl. Ethol.*, ed. I. Veissier and A. Boissy, 204.
767 Clermont Ferrand: I.N.R.A.

768 Panksepp, J. 1998. *Affective Neuroscience. The Foundation of Human and Animal*
769 *Emotion.* New York: O.U.P.
770
771 Panksepp, J. 2005. Affective consciousness: core emotional feelings in animals and
772 humans. *Consciousness and Cognition,* 14, 30-80.
773
774 Paul, E.S., Harding, E.J. and Mendl, M. 2005. Measuring emotion processes in animals:
775 the utility of a cognitive approach. *Neuroscience and Biobehavioral Review***,** 29, 469-491.
776
777 Price, E.O. 2002. *Animal Domestication and Behaviour.* Wallingford: CABI.

778 Regan, T. 1990. In: Clarke and Linzey (Eds), *Political Theory and Animal Rights.*

779 London: Pluto Press. pp. 176-186.

780 Ridley, M. 1996. *The Origins of Virtue.* London: Viking.

781 Rollin, B.E. 1990.*The Unheeded Cry.* Oxford: Oxford University Press.

782 Rollin, B.E. 1995. *Farm Animal Welfare: Social, Bioethical and Research Issues.*
783 Ames, Iowa: Iowa State University Press.

784 Russell, W.M.S. and Burch, R.L. 1959. *The Principles of Humane Animal*
785 *Experimentation Technique.* London: Methuen.

786 Selye, H. 1956. *The Stress of Life.* New York: McGraw Hill.

787 Singer, P. 1994. *Ethics.* Oxford: Oxford University Press.

788 Smulders, F.J.M. and Algers, B. 2009. (eds) *Welfare of Production Animals: Assessment and*
789 *Management of Risks*. Wageningen: Wageningen Academic Publishers.
790

791 Sorabji, R. 1993. *Animal Minds and Human Morals: the Origins of the Western*
792 *Debate.* Ithaca, NY: Cornell University Press.

793 Toates, F. and Jensen, P. 1991 Ethological and psychological models of
794 motivation: towards a synthesis In: *Farm Animals to Animats ed:* J. A. Meyer and
795 S. Wilson 194-205 MIT Press: Cambridge.

796 Thorpe, W.H. 1965. The assessment of pain and distress in animals. Appendix III
797 in *Report of the Technical Committee to Enquire into the Welfare of Animals Kept*
798 *under Intensive Husbandry Conditions,* F.W.R.Brambell (chairman). London:
799 H.M.S.O.

800 Waal, F. de 1996. *Good Natured*. Cambridge Mass: Harvard University Press.

801 Weiss, J.M. 1971. Effects of coping behaviour in different warning signal conditions on
802 stress pathology in rats. *Journal of Comparative and Physiological Psychology,* 77, 1-13.

803 Welfare Quality 2009. *Welfare Quality assessment protocol for cattle.* Welfare
804 Quality Consortium: Lelystad, Netherlands.

805 Welfare Quality 2009. *Welfare Quality assessment protocol for pigs.* Welfare
806 Quality Consortium: Lelystad, Netherlands.

807 Welfare Quality 2009. *Welfare Quality assessment protocol for poultry.* Welfare
808 Quality Consortium: Lelystad, Netherlands.

809 Wilson, E.O. 1975. *Sociobiology.* Cambridge Mass: Belknap Press.

810 Zimmerman, PH., Lundberg, A. and Keeling, L.J. and Koene, P. 2003. The effect of
811 an audience on the gakel-call and other frustration behaviours in the laying hen
812 (*Gallus gallus domesticus)*. *Animal Welfare,* 12, 315-326 .

813

814