# Domestic Animal Behaviour and Welfare

4th Edition

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# Preface

All of those who have an interest in livestock production or companion animal management and breeding – including every farmer, pet-owner and veterinary surgeon – need to know about domestic animal behaviour in order that they can carry out their jobs and care for their animals properly. All of these people and all consumers of farm animal products have to consider their moral stance in relation to domestic animal welfare, and require precise information about that welfare in order to do this. This book is a comprehensive guide to the behaviour of domestic animals that provides practical information for those involved with farming, pet animals and veterinary work. It also reviews the scientific information that is available concerning the assessment of animal welfare, and the evaluation of the effects on animals of genetic selection and of different management methods and housing conditions. Such assessment necessarily involves measurement of physiology, disease state and production, as well as behaviour.

Farm animals are very good subjects for behaviour studies, so many important advances in our understanding of fundamental aspects of animal behaviour have come from farm animal behaviour studies. Concepts concerning social structure, behaviour development, learning, cognition, parent–offspring relationships, sexual behaviour and the role of behaviour in coping with adversity have depended greatly on evidence obtained from farm animal studies. Studies of companion animals have also been important in these areas and the rapidly developing field of anthrozoology, which includes interactions between humans and other species, has depended greatly on studies involving pets. If evolutionary questions are being asked, the changes in the species during domestication must be taken into account, but domestic animals have the same range of behaviour as wild animals. It is easy to obtain data about behaviour from farm animals: they are available in large numbers and are often genetically very similar to one another. Companion animals are especially suitable subjects for work on learning, behaviour development and social interactions with conspecifics and humans. Our understanding of domestic animal behaviour and welfare, however, is much enhanced by ideas based on studies of the behaviour of wild animals, laboratory animals and man. The results of work on a variety of species helps us to have an adequate appreciation of the mechanisms underlying domestic animal behaviour.

Precise scientific studies on animal welfare are now sufficient to form an important part of the evidence upon which laws can be based. In these circumstances, those who are learning about, keeping up to date with or legislating upon livestock farming, veterinary medicine or applied biology need a source of information about the current state of our knowledge of domestic animal behaviour and welfare. This text provides that information in a way that is easy for the beginner to understand, but which includes discussion of complex topics and reference to the literature relevant to that area. Hence, as well as being useful to breeders, farmers, agricultural advisors, pet owners, pet trainers and veterinary surgeons, it is suited to a comprehensive university or college course on behaviour science as applied to domestic animals.

This book substantially extends the coverage of the third edition, in that information is provided about the behaviour and welfare of dogs, cats, rabbits, animals kept for fur production, farmed fish, turkeys, ducks and geese. Therefore, all major farmed animals and companion animals are considered. The text revision has been carried out by Donald Broom, with photographs from Andrew Fraser and Donald Broom. After introducing the concepts of behaviour and welfare, behaviour management, animal marking, learning, motivation, evolution and welfare assessment are all considered. There then follow sections on the various aspects of individual, social and reproductive behaviour. The humane control of domestic animals, welfare and disease and the various kinds of abnormal behaviour, are then described. In the final nine chapters, the

welfare of different species is discussed. We should acknowledge scientific pioneers, so the references in the text include those who had key ideas, even if they were published many years ago. The book is illustrated with many photographs and includes a comprehensive bibliography and a glossary.

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## For the Fourth Edition

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# Introduction, Concepts and Methods

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# 1 Introduction and Concepts

The farming of animals has played an important part in the development of human civilization. Food, clothing and transport are obtained by man from a wide variety of species (Broom, 1986a; Messent and Broom, 1986; Clutton-Brock, 1994; Hall and Clutton-Brock, 1995). It is thought that humans have had an even longer relationship with wolves, or dogs as we now call one form of wolf (Clutton-Brock, 1999). This relationship, which may be called wolves domesticating humans just as correctly as humans domesticating wolves (Broom, 2006a), seems likely to have been mutually beneficial to both species, as has other domestication (see Chapter 5). Dogs, cats, other companion animals and many farmed animals have long been treated as companions and viewed with affection by those whose job it was to care for them. Good stockmanship has always involved knowing how to respond to the behaviour of animals when handling them or identifying their problems.

By the start of the 20th century, farm animal use had increased with the expansion of the human population and consumption of animal products. Animals began to be kept in concentrated populations and, prior to 1970, intensive animal husbandry had arrived in the form of close confinement for cattle, pigs and poultry under new husbandry systems. The innovations in management are characterized principally by larger livestock numbers kept together in markedly reduced space. Such conditions have effects on disease transmission and they require considerable physiological and behavioural adaptation by the animals (Broom, 2006a). It has been assumed that the animals could adapt to the environmental restrictions, but both adaptation and failure to adjust have come to be recognizable when welfare is assessed. Substantial new knowledge of the behaviour of livestock under intensive husbandry systems is therefore needed to assess these systems of management. This knowledge can then be applied in the agriculture industry in order to improve production and welfare. Many of the current animal husbandry problems are not soluble by investigation of nutrition, body physiology or disease control, but require investigations of the behaviour of the animals before progress can be made towards a solution.

The attitude of people to the domestic dog (Serpell, 1995) ranges from the animal that is a source of vicious and unprovoked attacks on children, a source of serious pollution of our streets and of serious disease risks, to the animal that is a family member, an archetype of affectionate fidelity and a source of unconditional love. People who use animals as companions, or for some form of work or entertainment, are aware of the behaviour of the animals. In some cases, the behaviour is not what the people want and is viewed as a problem. In other cases the behaviour is the reason why the animal is useful, whether or not this use results in good welfare in the animal. Behaviour can be an indicator of good or poor welfare in any animal. The term ethology means the observation and detailed description of behaviour with the objective of finding out how biological mechanisms function.

The scientific study of animal behaviour has proceeded very rapidly during the last 40 years. Some of the changes in ideas that have occurred during this development are described by Jensen (2002a). There have been substantial recent advances in the precision of behaviour description and the understanding of behaviour organization in relation to physiological and evolutionary processes. Modern techniques in ethology and in experimental psychology mean that we now have a much more extensive knowledge of sensory analysis, motor control, hormonal effects, motivation, body maintenance behaviour in good and difficult conditions, reproductive behaviour and social structure. This knowledge and several other techniques relevant to animal welfare assessment are now being applied to domestic animals.

## Behaviour and Animal Production

A major theme of this book is that farm animal behaviour research is relevant and necessary for animal production enterprises to be carried out effectively and economically. The stockman, the farm manager, the animal transporter, the abattoir worker and the designer of animal accommodation and equipment have to be aware of well-established facts and recent research on the ethology of farm animals.

An appreciation of how to handle animals necessitates knowledge of behaviour which, in the past, has just been gradually acquired through personal experience. This information can be taught and is learned more easily if general principles of animal behaviour are known. Feeding behaviour is an example of an important topic for those who have to manage animals. The control of feeding, food selection at pasture or when composite feeds are offered, and learning about food and behaviour in competitive feeding situations are all relevant to intakes and good feed conversion efficiency.

Reproductive behaviour is of great importance to those managing a stock unit. Behaviour assessment is the major method of oestrus detection in dairy cows and pigs. Work on mating preferences and factors affecting libido is of critical importance in the management of sheep, goats, beef cattle and horses where a high proportion of successful matings is desired. Each animal whose offspring production fails, or is delayed, costs the farmer money. The frequency with which maternal behaviour fails in domestic animals and problems with the survival of the young, especially piglets, lambs or calves, can all be reduced by a knowledge of behaviour and consequential improvements in stockmanship.

Wherever animals have to be grouped or decisions have to be taken about the housing and density of animals, information about social behaviour is important. Farm animal management, which leads to fighting, injury or extreme fear, can result in reproductive failure, poor food conversion, reduced carcass value or increased mortality. Such losses can be substantially reduced by knowledge of social behaviour. As pointed out by Broom *et al.* (1995) and Jensen (2002a) through use of ethological knowledge, technical equipment can be designed and management methods can be utilised to work better for the animals.

These very wide-ranging applications of behaviour study to farm animal production, together with the relevance of behaviour work to the understanding of animal welfare, emphasize the importance of including a series of lectures on animal behaviour in courses on animal science, animal production and applied biology.

## Behaviour and Pet Management

Many people decide to buy a pet for themselves or for a child and then discover that the complex being that they have brought into their home requires a wide variety of care and has responses and abilities that the owner may not be able to manage. Owners sometimes reach the stage of having to contend with difficult and embarrassing behaviour before resorting to advice or buying a book that may help them. Behavioural signs may tell you that your cat is sick or that its welfare is poor for some other reason, that your fish is about to die from a lack of oxygen or by being eaten by another fish, or that your dog or horse has interpreted the various signs that you have given to it as a clear indication that it can do what it wants rather than what you want.

The training of companion animals requires knowledge of learning and motivation. People do not have this knowledge unless they have studied animal behaviour or psychology, at least to the extent of reading a good-quality book. Some of those who teach animal training are very knowledgeable about the principles of learning and motivation, as well as having relevant practical experience. However, some of those who appear authoritative to the uninitiated may present incorrect and confusing ideas. It is important that all of those who offer professional advice on animal behaviour are properly trained. The identification of behavioural problems and the ability to propose methods of reducing or eliminating these is another subject where expert, helpful people may be difficult to distinguish from those who are unlikely to help in solving problems. As a consequence, accreditation schemes have been developed, for example by the Association for the Study of Animal Behaviour in the UK and elsewhere. Pet behaviour consultants, like other experts in complex subjects, should be accredited and should not be employed unless they are accredited.

## Behaviour and Veterinary Medicine

The practising veterinary surgeon (referred to in many parts of the world as veterinarian) uses

knowledge of behaviour frequently but, in the past, much of this knowledge has been acquired after formal training is completed, unless an animal behaviour course has been attended. Situations in which such expertise is important include: (i) handling animals; (ii) using behaviour as a sign in diagnosis; (iii) advising on animal husbandry methods; and (iv) dealing with behaviour problems and assessing welfare. Behaviour is also important as a part of the general biology of the animals so it is relevant when considering, for example, feeding responses to adverse temperature conditions, or disease transmission.

The importance to a veterinary surgeon intending to handle an animal, of recognizing the signals that indicate that the animal is about to attack or will kick if handled, are obvious. It is also very beneficial to the veterinary treatment if handling procedures can be modified according to observed behaviour in such a way that the animal is not adversely affected by the handling itself. Poor welfare during veterinary treatment is a major obstacle to success in disease treatment and in retaining client confidence. Studies of behaviour are also especially relevant where it is necessary to move animals from place to place along races, up ramps, into vehicles or into strange rooms (Grandin, 2007). Many domestic animals show behaviour that indicates fear of humans, and it is important to veterinary surgeons and others handling animals that such behaviour is recognized (Beaver, 1994).

The working veterinary surgeon is regularly presented with clinical cases having histories that are symptomatically behaviour-based. In fact, it is common for animal illness to be first manifested behaviourally, such as in loss of appetite, altered activity or diminished body care – for example, in colic and other painful conditions in horses (Mair *et al*., 1998). Clinical veterinary work has a very real and special relationship with pathological behaviour in animals. Those who practise professionally the art and science of clinical veterinary medicine and surgery acquire competence at the interfaces between illnesses and their behavioural signs through years of training, experience and witness. This takes much time and, in future, training in behaviour is essential. Studies of the welfare of animals after veterinary treatment often incorporate neither our knowledge of behavioural nor scientific indicators of welfare (Christiansen and Forkman, 2007) wherever they should do so.

Behavioural signs of impairment and histories of behavioural symptoms give invaluable help to the veterinary clinician in the initiation of a clinical appraisal of the animal's condition. With such orientation, further points are sought out for special investigation and detailed examination. On systematic examination, the behavioural feature of a veterinary problem often presents as a screen over a generalized and mixed array of physical signs of illness. As substantive correlates of the behavioural manifestation are found in physiological and pathological factors, the behavioural picture fades into the background of the clinical problem. Treatment and restorative action then become focused physically on lesions and infections. The behavioural problem thus becomes resolved by a transformation through veterinary medical concepts into an identifiable clinical condition, which can then be given appropriate case management and therapy.

This is an important logical mistake, as the behavioural signs are often a key part of the information used in diagnosis. Sometimes the animal's irregular behaviour does not translate into a physical condition, but this does not mean that the associated pathology is not real. Some disorders are distinguishable only by their effects on behaviour, while others are manifested in a variety of ways.

A necessary prerequisite for the recognition of abnormal behaviour, whether as a sign of pathogen presence or as an indicator of poor welfare which is not due to a pathogen, is a knowledge of normal behaviour. The normal behaviour for a species can be described during a behaviour course, but requires practical experience in order that it can be understood well.

If a horse is seen to be pacing in its stable and kicking at its belly, this is identifiable as a sign of colic, but someone with no experience of horse behaviour would not recognize it as such. More subtle signs, such as the partially hunched posture adopted by a sheep with abdominal pain, require clear observation of both the normal and affected animals (see Chapter 22).

Expertise in behaviour and the assessment of animal welfare are areas where the veterinary surgeon is expected to be able to give advice. Behaviour problems that affect the practicalities of managing animals are also frequently presented to the veterinary surgeon for solution. One area of general behavioural knowledge that helps in the explanation of such problems, in both farm and

companion animals, concerns the ways in which early experience affects behaviour development. Another area is learning. The veterinary surgeon should be able to advise on how to avoid behaviour problems and what training or other procedures to utilize in order to deal with them. The preparation that is required in order that every veterinary student has an adequate knowledge of the fundamental principles and veterinary application of animal behaviour is a course of lectures in the subject and reference to specific techniques and literature at various points in the clinical part of the course.

## Animal Welfare: Science Assessment and Moral Judgement

Domestic animals have to contend with a complex environment and they have a variety of methods for attempting to cope with it. That environment includes physical conditions, social influences and predators, parasites or pathogens that may attack the individual. The coping methods include physiological changes in the brain, adrenal glands and immune system and, linked to some of these, behavioural changes. Some factors that affect an animal may result in it having great difficulty in coping. It may fail to cope in that its fitness is reduced and either it dies or it fails to grow, or its ability to reproduce is reduced in some direct way. 'The welfare of an animal is its state as regards its attempts to cope with its environment' (Broom, 1986c). Hence welfare is a characteristic of the individual animal, which varies on a continuum from poor to good. The attempts to cope and the results of failure to cope can be measured taking account of a wide variety of coping mechanisms, including positive and negative feelings and those minimizing pathology. Hence welfare can be assessed in a precise, scientific way using a variety of indicators.

Animal welfare science developed rapidly in the 1980s and 1990s and it has been important to separate the science from moral judgement. The assessment of welfare can be carried out in an objective way that is quite independent of any moral considerations. Mortality rate, reproductive success, extent of adrenal activity, amount of abnormal behaviour, severity of injury, degree of immunosuppression or level of disease incidence can all be measured. Our knowledge of each of these welfare indicators has improved rapidly in recent years as people with backgrounds in zoology, physiology, psychology, animal production and veterinary medicine have investigated the effects of difficult conditions on animals.

Much remains to be learned, but we are already in a position to apply recently gained knowledge to comparative studies on farm animals of different systems of management, designs of housing, methods of handling or transportation, and procedures in operations or in slaughter. This knowledge can also be applied to the care of companion animals. In addition to measurements of poor welfare, it is possible to investigate the preferences of animals and the value that they place on various resources or other aspects of their environment. Such studies and a wide range of work on the basic biology of animals give information about the biological needs of animals. If these are not met there will often be indicators of poor welfare that can be measured but, in some circumstances, we have not yet acquired the expertise to evaluate adverse psychological effects on animals.

When scientific evaluation of welfare has been carried out, there remains the moral question of how poor welfare should reach before it is regarded as unacceptable. This is an issue where the farmer, the veterinary surgeon, the welfare research worker or the member of the general public are equally entitled to have an opinion. One person might say that a certain degree of poor welfare in an individual domestic animal is acceptable, given the human requirements involved, while another might consider that degree of poor welfare to be unacceptable. Moral positions in such matters have changed as people have come to know more about the complexity of animal organization, the sophistication of animal behaviour and the degree of similarity between domestic animal species and man.

Both recent research and media coverage of such research have contributed to this change of attitude. The feeling that humans have a moral obligation to ensure that the welfare of animals that are kept is never very poor has become widespread. The idea that, when decisions are taken about methods in animal husbandry, animals should be considered as individuals and their responses to their environment should be evaluated and understood, is now held by many in the agriculture industry, by those who care for companion animals and by those in the veterinary profession. This is an important part of the subject of veterinary ethics (Tannenbaum, 1989).

In the early years of consideration of what constituted poor welfare, people tended to think especially of pain as a reason why welfare would be unacceptable. Such a case is shown in Fig. 1.1, an example of a situation where there would be pain. However, long-term problems such as starvation (see Fig. 1.2) or having to live in housing where needs are not met, are now considered as at least as important.

## Questions about Behaviour

There are two kinds of question that can be asked when trying to understand a particular behaviour. The first of these is: 'How does it work?' The answers to this question refer to the mechanisms underlying the behaviour that cause it to occur at the time of observation and with the form in which is seen. What changes are occurring within the body of that animal that result in the movements that are shown? Some of these changes are physiological processes which we know quite a lot about, such as those involved in sensory reception, impulse conduction along nerves or muscle contraction. Changes within the brain involving emotional variables, learning, decision making and control of actions have been extensively investigated. Although we still have much to discover about them, there have been significant developments in knowledge in recent years.

**Fig. 1.1.** This duck is likely to be in pain because of the crossbow bolt shot into it. The duck is held by a RSPCA inspector (photograph courtesy of RSPCA).

**Fig. 1.2.** This Old English Sheepdog was emaciated, weak, flea-ridden and very keen to eat and drink (photograph courtesy of RSPCA).

The second kind of question about behaviour is: 'Why does it happen?' The answers to this question refer to the way in which this behaviour has arisen in the species under observation. In order to try to appreciate how the pattern and use of a behaviour have evolved, it is necessary to consider what the selective advantage of the behaviour is. Put another way, in what way will the effects of a gene that affects behaviour promote the spread of that gene in the population? In practice, 'why?' and 'how?' questions are linked because questions about evolution depend upon a knowledge of the mechanism underlying a behaviour, and questions about causation are often helped by an understanding of the evolutionary origins of the system. For both kinds of questions we need to consider behaviour in relation to the general biology of the animal.

Behaviour, like physiology and anatomy, is part of the general functioning of an animal. The various aspects of life can be classified into functional systems that include behaviour as a component (Broom, 1981). These are: (i) obtaining oxygen; (ii) osmoregulation; (iii) temperature regulation; (iv) cleaning the body surface; (v) feeding; (vi) avoiding chemical hazards; (vii) avoiding physical hazards; (viii) predator avoidance; and (ix) reproduction. Behaviour often serves more than one

function – for example, exploration and establishing social relationships may be relevant to almost all of them, so they become objectives in themselves. The role of behaviour in each of these functional systems is discussed in detail in this book, but the key to understanding the behaviour of an animal is an appreciation of how resources are apportioned and decisions taken about which activity to show and when.

The study area that deals with decisions about the timing and nature of changes in behaviour is that of motivation. This important subject is essential to an understanding of all aspects of behaviour and also to questions about animal welfare. Many welfare problems result from frustration or environmental unpredictability, and a knowledge of motivational state is needed in order that these can be recognized.

When trying to answer questions about how behaviour works, investigatory methods are used in which the experience of an animal is controlled and its effects are assessed. Some such studies are carried out during the development of the individual. Learning occurs when some experience modifies later behaviour (see Chapter 3). Learning has an effect on all aspects of life, so some reference must be made to it in discussions of every aspect of behaviour, and therefore it is relevant to the material in every chapter of this book. All systems develop in animals as a consequence of interactions between the genetic information in the animal and influences from the environment of that genotype. Since all behaviour depends on the genetic information in an animal and environmental factors will always affect the expression of genes, it is not useful to try to distinguish between instinctive or innate behaviour and that which is environmentally determined. The interesting questions concern how differences in genotype and in the environment result in differences in behaviour. Behaviour genetics and the processes occurring during behaviour development are both exciting topics that will be discussed in this book.

The various questions posed above are answered here, but with especial reference to the requirements of those who need to know about the management, housing, veterinary treatment and general biology of domestic animals.

## The Sensory Worlds of Domestic Animals

Humans are particularly aware of information from vision and from the narrow range of sounds associated with speech. However, apart from taste, which humans can use with precision, olfaction is of less importance than in our domestic mammals. We are atypical mammals because, for most, olfaction is a major source of information about the surrounding world. Smells are often relatively long lasting and can continue after the source has departed. They exist in enormous variety and can be detected with great sensitivity, so they are used for recognition and assessment of foods, animal species, animal individuals and even animal mood changes by most animals, including the mammals and fish mentioned in this book. Birds are generally less olfactorily oriented, but use vision and hearing in sophisticated ways.

In order to understand the behaviour of the members of any domestic animal species, we need to consider their sensory world and especially the role of odours. We should also be aware of their differences from humans in the range of detection and sensitivity using each sense. Rodents can hear sounds of above 60 KHz while humans hear little above 15 Khz (see Table 1.1). Dogs can also hear higher-pitched sounds than can humans, hence the use of dog whistles that are ultrasonic for the human ear. Animals can be severely disturbed by sounds that humans cannot hear. Some fish can hear and be disturbed by sounds that are very low frequency in comparison with the human range. Birds and some other animals can detect low-frequency vibrations when standing on land or another solid surface because of the sensory corpuscles in their leg joints. Reports of animals responding to an approaching tsunami provide evidence of the ability of these animals to detect and respond to the low-frequency sound that a tsunami would produce. Birds also have the ability to resolve complex sounds with components close together in time much better than can humans. Hence, elaborate bird songs or calls appreciated by other birds may sound like a buzz to humans.

Potentially detectable visual stimuli vary in the brightness, wavelength, plane of polarization and pattern of light. Birds and fish can use all of these aspects when evaluating their visual environment. Humans and some other mammals do not detect plane of polarization so cannot see the many polarized light patterns, for example those of a great variety of flowers and insects (Broom, 1981). Poultry and fish kept for farming or as pets, as well as seeing colours, may see complex polarized light or ultraviolet (UV) patterns in objects that appear

**Table 1.1.** Hearing and sound frequency in humans and some domestic animals (from Heffner and Heffner, 1992).

| Species | Lowest frequency detected (Hz) | Greatest sensitivity (KHz) | Highest frequency detected (KHz) |
|---|---|---|---|
| Human | 31 | 8 | 17 |
| Dog | 68 | 8 | 40 |
| Cat | 50 | 8 | 70 |
| Ferret | 36 | 12 | 45 |
| Horse | 55 | 2 | 33 |
| Pig | 40 | 8 | 40 |
| Sheep | 125 | 10 | 40 |
| Cattle | 24 | 8 | 40 |
| Goat | 70 | 2 | 40 |
| European rabbit | 120 | 16 | 60 |
| Brown rat | 400 | 8 | 68 |
| House mouse | 3000 | 16 | 80 |
| Domestic pigeon | 8 | 3 | 6 |
| Mallard duck | 100 | 2 | 6 |
| Turkey | 200 | 2 | 6 |

white or plain to humans. Domestic mammals have limited or no ability to discriminate light of different wavelengths, so are largely or partly colour-blind (Piggins, 1992). The basic ability of vertebrate animals to discriminate visual patterns made up of blocks or lines is similar, but there are differences in ability to resolve the grain of patterns. For example, sheep can resolve a grating of lines with 13 cycles per degree, while humans can resolve 40 cycles per degree (Sumita, 2005). The light sources used by humans may vary in the extent and kind of brightness fluctuation as well as in the variable mentioned above, and these fluctuations are detected and lead to preferences, e.g. in chickens (Kristensen *et al.*, 2007).

The visual and auditory world of domestic animals is a little different from that of humans, and we need to take account of that when we try to appreciate what it is that the animals of a particular species are responding to. Humans discriminate better than domestic animals in some visual and auditory modalities but worse in others. Some visual patterns cannot be seen by humans and some sounds cannot be heard. The situation in which this is particularly important is when a stimulus leads to poor welfare in animals but the people who are causing it are unaware of it. For example, high-frequency sounds that are inaudible to humans may be extremely unpleasant to some rodents, birds or dogs. We now know that some electronic switches and heating equipment cause noises that are very aversive to several non-human species (Sales and Pye, 1974). The frequency range for hearing in humans and some domestic animals is shown in Table 1.1.

One of the most dramatic differences in sensory appreciation that exists between humans and the animals that we keep is that between humans and fish. While fish respond to visual and auditory stimuli, their worlds are much more complex than just those two sensory modalities. The world of fish also includes that resulting from lateral line organs, electric receptors and olfaction, which is considered in the next section. The lateral line provides information about localized and general pressure changes. If an individual comes close to a fish, the fish detects it efficiently in complete darkness and without any sounds being involved. The newly arrived animal causes localized pressure changes that are transmitted through the water to the lateral line organs passing down the side of the fish. A moving but non-living object also initiates such changes and, when the fish swims up to a solid object like a rock, plant or the side of a tank, it readily detects the increase in pressure caused by the damming effect when water is compressed between the fish and the object. Fish can move around their environment without colliding with solid objects and without using vision, hearing or olfaction.

An approaching fish is likely to be detected by another fish long before it affects the lateral line organs because of its electrical output. All fish have some degree of electrical receptivity and some are

outstandingly sensitive to electrical changes. For many years the function of the ampullae of Lorenzini under the skin of the head of a dogfish, a set of fluid-filled interconnected vesicles, was unknown. It then became clear that these were electric organs. When a muscle contraction occurs it produces an electrical charge in the immediate environment. The air dweller does not detect it because of the poor conductivity of air. However, most animals in the world live in water and the water dweller can be affected by the muscle contraction because water conducts electricity very much better than does air. Fish that live in water with poor visibility – perhaps because of suspended matter – are the most likely to have efficient electroreceptors that allow them to detect the approach of a live animal whose muscles are contracting. However, all fish have some ability in this respect. Sensitivity to electrical change is quite different from the ability to produce electrical fields, which is possessed by a very small number of fish with specialized muscles whose function is not to contract but to produce a large electrical output.

Olfactory communication is very important for most living animals, including all domestic mammals and fish. As explained by Manteca (2002), the olfactory mucosa of a dog is 75–150 $cm^2$ in area, as compared with that of a cat, which is 20 $cm^2$ and that of a human, at 2–10 $cm^2$. In terms of receptors, the dog has 200–300 million while the human has 5 million and the cat is intermediate. The region of the brain that analyses olfactory information, the olfactory bulb, is much bigger in dogs than in humans and, while in humans only a small proportion of inspired air is passed over the olfactory mucosa, in dogs the majority of inspired air is subjected to olfactory analysis. A further difference between dogs and cats is that, while dogs can detect odours without auxiliary movements, cats perform the flehmen movement (see below), in which the mouth and nose apertures are opened widely to maximize the olfactory epithelium contact with the odour under investigation.

The human or other animal walking down a path is readily detectable by a following dog. Dogs can detect extremely small quantities of the complex mixture of odoriferous substances carried by every animal. A droplet of material from a moving animal will leave a pattern of deposit that allows the follower to identify the individual and to calculate the direction of movement. Dogs can track animals with an efficiency that is extraordinary to us humans. Dogs can also discriminate between different individuals of the same species and can pick out an individual human's armpit odour sample from an array of other such samples, even distinguishing between identical twins (Sommerville *et al*., 1990, 1993; Settle *et al*., 1994). A dog can identify a human from a urine sample and may be able to distinguish a diseased individual from an individual who is not diseased (Williams and Pembroke, 1989; Church and Williams, 2001; Broom *et al*., 2005). The sensory world of our domestic animals is sufficiently different from ours that we should consider carefully what it is in any circumstance where we are trying to provide for or to manipulate the behaviour of a domestic animal.

## Pheromones

A pheromone is a substance produced by one animal, and carries information to other individuals by olfactory means. Humans respond to olfactory information, even if they are unaware that they do (Stoddart, 1990). Experimental studies have shown that, in humans, synchronization of oestrus, preferences for places to sit in a dentist's waiting room, the duration of telephone calls at a public telephone and attention to photographs of members of the opposite sex can all be influenced by exposure to pheromones. However, it is clear that responses to odours play a much more substantial part in the life of most animals. The world of a dog, pig, cow or tilapia is, in substantial part, an olfactory one. Odours remain in places where individuals of the same or different species have been. Frightened individuals leave a different odour from calm individuals, sexually active individuals have different odours from those who are sexually inactive and there may be differences between more aggressive or more friendly individuals and those who are less aggressive or more friendly. Every individual can be distinguished from every other individual. For a review of the role of pheromones in behaviour see Wyatt (2003).

There is variation amongst species in the sources of pheromones. Some animals have scent glands within which the secretion of specific chemicals occurs. Often, these secretions are held for some time so the final composition and odour of glandular products depends upon bacterial action. Many different substances will be present in the odoriferous product. Other sources of pheromones are

body products such as urine, faeces and saliva. The effects of pheromones may be the rapid initiation of action, as in alarm pheromones, or the production of sustained behavioural responses.

The important effect of pheromones is the stimulation of olfactory centres in the brain, so pheromone detection depends on macrosmatics, which is the possession of keenness of smell to an extremely high degree. Most animals' olfactory centres are more differentiated than are those of man, who is microsmatic, and the olfactory portion of the telencephalon of cattle and sheep is about 20 times larger than that of the human.

A special organ, apparently involved with pheromone reception through its mucous membrane, is the vomeronasal, or Jacobson's, organ (Meredith, 1999). This organ is an olfactory receiver in the form of a pair of blind-ended tubes located within the nasal cavity and linked to the roof of the mouth. It is connected to the centres of olfaction in the brain with its own mechanism of conduction and its own reactive behaviour. It is instrumental in an olfactory reflex act, which is known as flehmen. In flehmen, the head is elevated and extended, the upper lip is curled up with the mouth slightly open and the nostrils constricted. The flehmen reaction (Fig. 1.3) indicates that the male is testing the urine of the female. The concentration of pheromones can reflect levels of sex hormones in the individual and, in this case, the male is monitoring the oestrous state of the female. Oestrus synchronization in female mammals can result from common olfactory urine checking. Male urine can also provide olfactory information about hormone levels. Urine is used as a territory marker in some mammalian species, such as badgers, and some animals mix faeces, urine and scent gland products in acquiring a distinctive individual odour.

**Fig. 1.3.** Flehmen in a stallion. This reaction is shown in response to the odour of a mare in oestrus and has the result of bringing the pheromone in contact with the vomero-nasal organ (photograph courtesy of A.F. Fraser).

The two types of scent-producing glands are: (i) sebaceous glands, such as the ventral gland of the Mongolian gerbil, which is used for territory ownership marking; and (ii) apocrine glands. The two types of glands are often mixed in glandular areas. The axillary glands in man produce pheromones whose release is facilitated by both the presence of axillary hair, which provide a larger surface area, and by the action of arm raising. Pigs, ruminants and horses possess specialized gland complexes located in the skin. The skin as the primary protector of the body surface is covered with glands serving temperature control, excretion, lubrication and maintenance of the pH in fending off microorganisms. This, in its totality, produces a specific body odour. In these animals the convoluted type of skin glands, with their apocrine excretions, produce a volatile substance which is moved to the skin's surface and mixed in a product which is particularly suited to contain, or bond, odoriferous substances. The occurrence and location of skin regions that produce odour relate to certain forms of behaviour (Vandenbergh, 1983).

Widely studied glands include those of many insects and mammals. The chin gland of rabbits is used to mark territory, to warn others and to mark young for recognition. Dogs and their relatives have anal glands, and the secretion in the female fox contains about 12 volatile components including trimethylamine and several fatty acids. The chemical produced by bitches inducing sexual behaviour in male dogs is para-methyl hydroxy benzoate. Male wolves and dogs mark their territory using urine, and this indicates who the individual is and, according to elevation from the ground, how big that individual is. Cats have glands on the side of the face and at the base of the tail. These are often coloured differently in tabby and other variably coloured cats; they use these to mark objects in their environment, including their 'owners'. When cats rub their head and tail base against you they may well be merely establishing their ownership of you! Deer have elaborate glands, that of the musk deer containing as much as 120 g of sebum. The tarsal tuft on the leg of the black-tailed deer

has specially adapted hairs that trap volatile substances from the tarsal gland and from urine that is deposited on the tuft (Müller-Schwarze, 1999). The odours from the tarsal gland in this species and from the metatarsal gland in the roe deer (Broom and Johnson, 1980) attract much attention from other members of the species and probably allow individual recognition.

Many wild ruminants are endowed with interdigital glands on all four feet, particularly below the dewclaws. The skin around these interdigital glands is richly endowed with convoluted glands, which produce a mixed secretion of pheromones. It appears that an alarm pheromone is produced and stored there as a colloid. The domestic ruminants have remnants of analogous glands that may still function as sources of specific odours.

Saliva can be involved in chemical communication, and behavioural evidence of this is notable in the pig in pre-mating and nursing situations and in social events in the horse. Experimentally, saliva has been found to play a part in organizing the suckling behaviour of the rat and the aggressive behaviour of mice. Rat pups reportedly engage in long periods of licking and nuzzling the mother's oral region, and this suggests that a chemical mechanism operates via saliva in regulating nursing interactions. Sows and their young piglets show essentially similar nosing of the maternal oral area. Young animals show a tendency to pursue olfactory examination of the mouths of associating adults, and of their mothers' mouths particularly (see Fig. 1.4).

Experimentally, juvenile gerbils were found to respond preferentially to females carrying their littermate's saliva rather than to those carrying non-littermate saliva. Adult male gerbils spend more time contacting the facial regions of recipients carrying saliva from an oestrous female. They exhibited no difference in their contact times with the ventral scent glands or anogenital regions. Social preferences were evident in the behaviour following salivary exposures. These findings suggest that saliva-related cues may act as chemosignals in all stages of social behaviour in gerbils (Block *et al.*, 1981). Such salivary factors probably function in other animals, including farm livestock. Among farm animals many social interactions take the form of nose-to-mouth contacts, in which it is likely that salivary cues of identity, and possible status, are communicated. This has been noted in the horse and sheep and it seems that salivary pheromones may affect social behaviour in animals to extents not appreciated before. Many so-called 'naso-nasal' contacts are in fact found to be nose-to-mouth contacts when carefully studied.

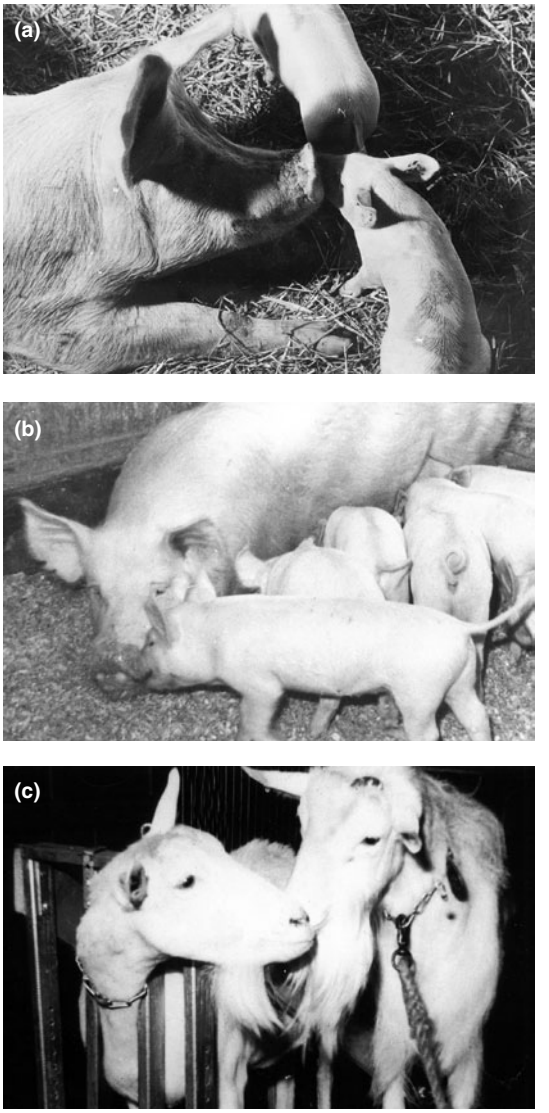


**Fig. 1.4.** Close nose-to-mouth contacts between very young animals and adults and between sexes: (a) sow to her piglet; (b) piglet to mother; (c) female to male goat. This behaviour probably facilitates salivary chemicals acting as pheromones (photographs courtesy of A.F. Fraser).

The production and the effects of pheromones have been noted in the pig (Signoret *et al.*, 1975; Booth and Signoret, 1992). The boar produces a chemical substance called androstenedione, which

appears to have a releaser effect on sows during oestrus so that they show the rigid mating posture more readily after they have been exposed to the male pheromone. The boar's pheromone is apparently produced in the submaxillary salivary gland. There is copious production of saliva, in frothy form, during the natural pre-mating activities between boar and sow. During these activities, nose-to-mouth contacts are clearly shown. Pheromone excretion in the boar also occurs via the prepuce. Proof of this has been shown in large-scale, experimental studies in pig artificial insemination work. Small quantities of boar seminal fluid dropped onto the snout of a sow or gilt showing dubious or incomplete signs of oestrus causes the complete oestrous display to be shown. The boar odour may also have effects on other species such as humans.

Many animals leave olfactory messages by the use of urine or faeces. For example, cats mark defended territories, principally their peripheries, by squatting and depositing urine, depositing faeces in prominent places and scratching objects to leave a visual and olfactory message (Borchelt, 1991; Bradshaw, 1992; Simpson, 1998). Male cats also spray urine on to objects, especially when there are other cats in the close vicinity and they are anxious (Beaver, 2003). In houses, furniture, walls and windows at the periphery where cats have visual access to the outside are often the targets for spray-marking (Pryor *et al.*, 2001).

## Sentience

Animals vary in the extent to which they are aware of themselves (DeGrazia, 1996) and of their interactions with their environment, including their ability to experience pleasurable states such as happiness and aversive states such as pain, fear and grief. This capacity may be referred to as their degree of sentience. '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).

Human opinion as to which individuals are sentient has generally changed over time in well-educated societies to encompass, first, all humans instead of just a subset of humans and then, certain mammals that formerly were kept as companions, animals that seemed most similar to humans such as monkeys, the larger mammals, all mammals, all warm-blooded animals and then all vertebrates. The general public has been ready to accept some guidance about evidence for sentience from biologists who have collected information about the abilities and functioning of the animals. Animals that are shown to be complex in their organization, capable of sophisticated learning and aware are generally respected more than those that are not, and such animals are less likely to be treated badly. However, some people view animals solely on the basis of their effects on, or perceived (extrinsic) value to, humans and have little concern for the welfare of pests, disease carriers or those that cannot be eaten (Broom, 1989a, 1999; Serpell, 1989).

Evidence that has been used in deciding on the animals for which welfare is an important consideration, in addition to similarity to and utility to humans, has included the following: (i) complexity of life and behaviour; (ii) learning ability; (iii) functioning of the brain and nervous system; (iv) indications of pain or distress; (v) studies illustrating the biological basis of suffering and other feelings such as fear and anxiety; and (vi) indications of awareness based on observations and experimental work.

Animals are more complex if they have to contend with a varied environment and, as a consequence, have an elaborate motivational system that allows them to think about the impacts of that environment and then take appropriate decisions. Some kinds of feeding methods demand much brain power, as do aspects of predator avoidance, but the most demanding thing in life for humans and many other species is to live and organize behaviour effectively in a social group (Humphrey, 1976; Broom, 1981, 2003). Animals that live socially are generally more complex in their functioning and in their brainpower than related animals that are not social. The demands on cognitive ability are greater in large social groups than in small groups (Croney and Newberry, 2007). Analysis of the degree of complexity of living possible for members of an animal species is a first step in deciding whether such animals are sentient (Broom, 2007). Without a level of brain functioning that makes some degree of awareness possible (Sommerville and Broom, 1998), an animal could not normally be sentient.

## Welfare Concepts

The scientific study of animal welfare has developed rapidly during the last 15 years. The concepts have been refined and a range of methods of assessment have been developed. Substantial challenges to

animal functioning include those resulting from: (i) pathogens; (ii) tissue damage; (iii) attack or threat of attack by a conspecific or predator; (iv) other social competition; (v) complexity of information processing in a situation where an individual receives excessive stimulation; (vi) lack of key stimuli such as a teat for a young mammal or social contact cues; (vii) lack of overall stimulation; and (viii) inability to control interactions with the environment. Hence, potentially damaging challenges may come from the environment outside the body – e.g. many pathogens or causes of tissue damage, or from within it – e.g. anxiety, boredom or frustration that come from the environment of a control system. Systems that respond to or prepare for challenges are coping systems and 'coping means having control of mental and bodily stability' (Broom and Johnson, 1993).

Coping attempts may be unsuccessful in that such control is not achieved but, as soon as there is control, the individual is coping. Systems for attempting to cope with challenge may respond to short-term or long-term problems, or sometimes to both. The responses to challenge may involve activity in parts of the brain and various endocrine, immunological or other physiological responses as well as behaviour. However, the more that we learn about these responses, the clearer it becomes that these various types of response are interdependent. For example, not only do brain changes regulate bodily coping responses, but adrenal changes have several consequences for brain function, lymphocytes have opioid receptors and a potential for altering brain activity, and heart rate changes can be used to regulate mental state and, hence, further responses.

Some coping systems include feelings as a part of their functioning, for example pain, fear and the various kinds of pleasure, all of which are adaptive (Broom, 1998). Bad feelings that continue for more than a short period are referred to as suffering. Other high- or low-level brain processes and other aspects of body functioning are also a part of attempts to cope with challenge. In order to understand coping systems in humans and other species, it is necessary to study a wide range of mechanisms including complex brain functioning, as well as simpler systems. Investigations of how easy or difficult it is for the individual to cope with the environment and of how great is the impact of positive or negative aspects of the environment on the individual, are investigations of welfare. If, at some particular time, an individual has no problems to deal with, that individual is likely to be in a good state, including good feelings and indicated by body physiology, brain state and behaviour. Another individual may face problems in life that are such that it is unable to cope with them. Prolonged failure to cope results in failure to grow, failure to reproduce or death. A third individual might face problems but, using its array of coping mechanisms, be able to cope but only with difficulty. The second and third 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.

According to Broom (1986c, 1996, 1998) and Broom and Johnson (1993): 'the welfare of an individual is its state as regards its attempts to cope with its environment', and this includes feelings and health. Welfare is a characteristic of an individual at a certain time; the state of the individual can be assessed so welfare will vary on a range from very good to very poor. Welfare concerns how well the individual fares, or goes through life. Some other authors place sole emphasis on feelings when defining welfare (Duncan and Petherick, 1991). Health, like welfare, can be qualified as good or poor and varies over a range. It refers to body systems, including those in the brain, that combat pathogens, tissue damage or physiological disorder. All of this is encompassed within the broader term welfare, so health is a part of welfare.

The assessment of welfare (Broom and Johnson, 1993) should be carried out in an objective way, taking no account of any ethical questions about the systems, practices or conditions for individuals that are being compared. Once the scientific evidence about welfare has been obtained, ethical decisions can be taken. Much of the evidence used in welfare assessment indicates the extent of poor welfare in individuals, but it is also important to recognize and assess good welfare, i.e. happiness, contentment, control of interactions with the environment and possibilities of exploiting abilities. Good welfare in general, and a positive status in each of the various coping systems, should have effects which are a part of a positive reinforcement system, just as poor welfare is associated with various negative reinforcers. We need to identify and quantify indicators of good welfare as well as those of poor welfare.

The term 'well-being' is often used interchangeably with 'welfare', but well-being is often used in a looser, less precise way. Welfare is the word used in English versions of modern European legislation. Some other languages have only one word that can

be used to translate either welfare or well-being. The words that are equivalent to welfare in other languages, and that are used in identical legislation, have similar origins: for example, *welzijn* in Dutch, *bien-être* in French, *bem estar* in Portuguese, *bienestar* in Spanish, *velfaerd* in Danish and *dobrostan* in Polish. *Welzijn*, *bien-être*, *bem estar* and *bienestar* are very similar to well-being in origin, but are used by scientists and legislators in much the same way as English speakers use welfare. *Dobrostan* is close in use to welfare as defined in this chapter, and *velfaerd* has a wider meaning but is used specifically in legislation. In German, *Wohlbefinden* and *Wohlergehen* have similar meanings to welfare but *Tierschutz* means animal protection.

Most people who speak of stress refer to a situation in which an individual is subjected to a potentially or actually damaging effect of its environment. However, the usage of the term has sometimes been confusing, as it has been used to mean three different things: (i) an environmental change that affects an organism; (ii) the process of affecting the organism; or (iii) the consequences of effects on the organism. Some people have limited stress to one kind of physiological response mechanism, hypothalamic–pituitary–adrenal cortex (HPA) activity or to mental rather than physiological responses.

However, it was demonstrated by Mason (1971) and in many other studies that several different responses to challenges could occur: HPA activity is temporarily increased during courtship, mating, active prey catching and active social interaction, none of which would be considered to be stressful by the majority of the general public or by scientists. To equate stress with HPA axis activity renders the word redundant and is considered unscientific and unnecessary by most scientists working in the area. Another meaning that has been ascribed to stress makes it largely synonymous with stimulation. If every impact of the environment on an organism is called stress, then the term has no value. Many stimuli that affect individuals in beneficial ways would never be called stressors by most people. 'Stress is an environmental effect on an individual which overtaxes its control systems and results in adverse consequences, eventually reduced fitness' (Broom and Johnson, 1993, 2000). The ultimate measure of fitness is the number of offspring reaching future generations, and there are many different ways in which challenges overtax control systems and have such effects.

The environment of an animal is appropriate if it allows that 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. 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. There are needs for particular resources and needs to carry out actions whose function is to obtain an objective (Toates and Jensen, 1991; Broom, 1996). Needs can be identified by studies of motivation and by assessing the welfare of individuals whose needs are not satisfied (Hughes and Duncan, 1988a, b; Dawkins, 1990; Broom and Johnson, 2000). Unsatisfied needs are often, but not always, associated with bad feelings, while 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 that result in food acquisition – even in the presence of food. In the same way, pigs need to root in soil or some similar substratum (Hutson, 1989), hens need to dust-bathe (Vestergaard, 1980) and both of these species need to build a nest before giving birth or laying eggs (Brantas, 1980; Arey, 1992). In all of these different examples, the need itself is in the brain and is not physiological or behavioural, but may be satisfied only when some physiological imbalance is prevented or rectified or when some particular behaviour is shown.

## Ethics

The deontological approach to the organization of human conduct is one in which the structure is a set

of duties pertinent to all individuals. Hence, the individual should assess what action duty dictates using rational thought and carry out that action.

Consequentialism in ethics implies that the extent to which an act is morally right is determined solely by the goodness of the act's consequences. This approach was extended into utilitarianism by J.S. Mill (1843), who argued that the right act or policy is that which will result in the maximum utility, or expected balance of satisfaction minus dissatisfaction, in all the sentient beings affected.

Although many aspects of utilitarianism are helpful when deciding what is morally right, as a general approach it may be viewed as incomplete (Broom, 2003). Acting in such a way that general happiness or general good is promoted will be entirely desirable in some circumstances, but following such a philosophy implies that decisions are taken only on the basis of the average or overall good of collections of individuals. This view does not take account of the fact that humans and other animals interact with and have concerns for individuals. The mechanisms underlying moral codes are based on effects on individuals as well as on collections of individuals. An example of the flaw in the extreme utilitarianism approach is that, following this approach, an individual could be caused extreme pain or other poor welfare, or could be killed if the overall effect on a collection of individuals was good. This individual might be a dangerous criminal or an entirely innocent person, but should they be tortured, caused prolonged misery or killed? Most people would not wish an innocent person to be killed, however great the resulting good, and those who hesitated on the issue might be swayed toward that view if the person were their neighbour, their mother or themselves.

Criticisms of the utilitarian position have been made by many, including Williams (1972) and Midgley (1978). Those who would consider themselves deontological ethicists would maintain that certain rights, rules or principles take precedence over utility. However, the rights approach also has flaws. Neither a rights-based approach nor a wholly utilitarian approach is adequate to further moral ends, but elements of both deontological and utilitarian approaches are necessary.

Arguments about the importance of freedom to control one's life led to the idea that such freedom is a 'right' which all should have. Strong proponents of a rights structure for determining what are proper actions regard the stated rights as absolute, so they cannot be mitigated by other circumstances. A key issue here is the establishment of what is a right. There are few so-called rights that would be accepted as valid in all circumstances. The oft-proclaimed right to free speech can cause great harm to certain individuals and hence can be morally wrong, in my view, as can the 'right' to drive a car as fast as you wish or to carry a gun. The concept of rights causes many problems. All behaviour and laws should be based on the obligations of each person to act in an acceptable way towards each other person or other sentient individual. Arguments based on obligations are better than any attempts to assert a 'right'. Laws and other such statements should provide guidelines for the behaviour of each person rather than stating what the individual who is the object of an action can demand. For more detailed discussions of all of the issues mentioned in this section see Broom (2003, Chapter 4).

The ethics aspects of animal behaviour research are discussed by Dawkins and Gosling (1992).

## Further Reading


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