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The Nature of Animal Welfare Science

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Abstract

Veissier I, Forkman B. The Nature of Animal Welfare Science. ARBS Annu Rev Biomed Sci 2008;10:T15-T26. The societal concern for animal welfare stems from the acknowledgement that they are sentient beings, whether their sentience makes morally unacceptable any act that would increase their suffering (utilitarian point of view) or animals deserve rights because of their sentience (animal rights point of view). Several definitions of animal welfare have been proposed, based on common sense, mechanisms, or operational indicators. These definitions should not be interpreted as uncertainties about the existence of the concept but rather as different aspects of the same concept. Whatever the definition used, research on animal welfare attempts to answer the following questions: To what extent are the animals used by humans capable of emotions? How does an animal perceive its environment? How can we assess the level of animal welfare in a given situation? What are the impacts of the ways we treat animals on their welfare? To answer these questions, animal welfare scientists borrow methodologies and theoretical frameworks from various disciplines, mainly behavioural sciences, including not only ethology but also experimental psychology, animal cognition, or stress physiology. The focus is not on the description of animal behaviour or stress responses but rather on the understanding of how animals experience their world. Hence the recent developments issued from psychology, studying cognitive bias or relations between cognition and emotions. Animal welfare science can be considered as a new behavioural science, applied to societal concerns about our relations to animals, with specific research questions and methodologies inspired by other disciplines.

Keywords: animal welfare, behaviour, ethology, cognition, welfare assessment

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1. Animal Welfare: Moral Issues Put in Practice

The proximity between man and (some) animals led to the adoption of rules to protect animals in the XIXth century (*e.g.* the Loi Grammont 1850 in France and the Cruelty to Animals Act 1876 in the United Kingdom). These first texts protected animals against cruelty from humans (although not in all circumstances). During the XXth century, animal welfare became a prominent societal concern, whereby not only cruelty but also poor care became prohibited. The underlying drive was certainly that animals were recognised as sentient beings. In many countries animals are now recognised by law as sentient, and the concept of animals as sentient beings that need be protected is included in the European Amsterdam Treaty (European Union, 1997).

According to the philosophical theory of utilitarianism from Bentham (Canto-Sperber, 1996), more specifically applied to our treatment to animals by Singer (1990), an act is morally right if it increases the overall happiness and decrease the overall suffering of individuals – if animals are sentient then their happiness and suffering should be taken into account. The acknowledgement of feelings in animals by scientists was made clear in the annex from Thorpe in the Brambell report (Brambell, 1965). Nevertheless, the concept of emotions or feelings in animals was received with scepticism by many scientists (discussed by Duncan, 2006), who argued that such concepts cannot be studied scientifically: "What these arguments show, however, is that we cannot *prove* that consciousness – either self- or feeling-consciousness – exists in animals (in *any* animal)" (MacPhail, 1998; see also Kennedy, 1992). Nevertheless, some scientists took a more flexible attitude, taking for granted that some sort of feelings could exist in animals and they then looked for evidence of such feelings. For instance, Fiorito (1986) argued that "when defined operationally as a physiological response induced in an animal by stimuli painful to humans, and resulting in a protective stimulus avoidance response, pain is amenable to testing with non-human subjects" and Bateson (1991) proposed that "despite [these] difficulties, the criteria that lead to the judgement that a man is in pain can be generalised with substantial measure of agreement to other animals". Similarly, recent studies of animals' emotions have used theoretical frameworks developed in humans to characterise what animals can feel (Desiré *et al.,* 2002).

Other philosophers proposed not to base attitudes towards other individuals, including animals, on their capacity to suffer. Their approach is based on deontology, *i.e.* rights attributed to individuals. According to Feinberg (1980), individual rights should be attributed to animals that have *interests*, where interest is used in the sense of "urge, wants, impulses, even unconscious tendencies and directions of growth". Feinberg specially values things that are objects of some demand from the animal. Although some methodological problems remain, studies based on the use of demand functions to measure what price an animal is ready to give to obtain a given situation are essential to assess animals' motivations and thus can shed light on what need to be done to protect animals or ensure their rights (Dawkins, 1983; Holm *et al.,* 2007). Unfulfilled motivations are likely to induce suffering or at least stress (Mason *et al.,* 2001). Hence, in practice, it is likely that the utilitarian view and the position from Feinberg may lead to similar attitudes to animals, that is the same practices may be judged acceptable vs. unacceptable.

Regan (1992) limits rights to those animals that are *subject-of-a-life*, *i.e.* animals that develop some sort of a plan for their own life, being conscious of themselves and forming ideas about the future. While Feinberg attributes to animals light rights, *i.e.* the rights to be in good health, to be able to move freely and to be protected against pain and deformity, Regan postulates that animals as subjects-of-a-life have an intrinsic value and their life must be protected (Larrère, 1999). Finally, Larrère (1999) considers that there exists a social contract on man and domestic animals. This tacit contract imposes that man treats well animals that live under his responsibility, that he has the duty to assure their protection (against predators, adverse conditions or diseases), their feeding, and their reproduction. In turn domestic animals have the rights for security, health, feeding and reproduction.

The objective of the present paper is to analyse how the science of animal welfare can help put in practice moral issues linked to the treatment of domestic animals, whether we take a utilitarian view

or an animal rights one, as the one from Feindberg or Larrère. Although we acknowledge the value of animals' life, we think that Regan's views are very far from being put in practice in animal husbandry. Most farm animals are killed at some time whether this is the goal for which they are raised (*i.e.* meat production), the benefits from the carcasses of animals from which meat is not the primary production is necessary for a balanced economy (*i.e.* dairy animals), or because it is not possible to maintain animals alive after their production period for economic and technical reasons (*e.g.* for laying hens). Hence we believe that a strict animal rights view prohibits farming animals and thus make the science of their welfare unnecessary.

2. Animal Welfare Science Basics: The Definitions

There exist many definitions of animal welfare in the literature (reviewed by Fraser, 1995). Stafleu *et al.* (1996) distinguish three categories of definitions: lexical definitions, explanatory definitions and operational definitions.

First, lexical definitions, such as those given by dictionaries, provide the common meaning of welfare. This common meaning is likely to reflect the primary drives for the concerns about animal welfare. For instance, in the Brambell report (Brambell, 1965), released at the beginning of the growing public concern on how we treat farm animals, welfare is considered as a " wide term that embraces both the physical and mental well-being of the animal." (p. 9 of the report). Similarly Hughes (1976a) defines welfare as "a state of complete mental and physical health, where the animal is in harmony with its environment" where *physical* refers to biological needs and good health, and *mental* refers to subjective feelings. As discussed by Stafleu *et al.* (1996) the concept of harmony fits a utilitarian view (since mental health can embrace absence of suffering and positive feelings) but might also fit to an animal right one, with norms for human-animal relationships be defined (*e.g.* ensure the good health of animals reared by humans). In general, lexical definitions are short and broadly accepted by all public. However, they are too vague to be applied directly in research. In addition, although common sense attributes emotional states to animals, some scientists reject the idea that animals have mental states or feelings or consider that these cannot be studied (see discussion by Bekoff, 2008).

Second, explanatory definitions focus on mechanisms underlying welfare. In a way they provide a theoretical framework for lexical definitions to be used in research. Explanatory definitions of welfare can be that welfare is a state where:

- The animal adapts to its environment without overtaxing its capacities, while stereotypies, modification of adrenals' activity etc. are considered as signs of the environment overtaxing the animal (Broom & Johnson, 1993). Coping is then used to describe the efforts made by the animal to adapt to the environment.
- The animal can fulfil its needs and wants (Stafleu *et al.,* 1996) while on the opposite stress can be defined as the state where the feed-back caused by the animal's attempts to adapt to its environment is not sufficient to eliminate the motivation that triggered these attempts (Jensen & Toates, 1997).

Third, operational definitions mention the parameters by which animal welfare shall be assessed. For instance, Hurnik (1990) states that longevity is an integrative parameter of animal welfare while Barnett & Hemsworth (1990) consider that a prolonged 40% increase in blood cortisol reflect poor welfare. Typically such definitions provide tools for research. But they cannot stand alone and need to refer to broader definitions (such explanatory definitions) for the parameters chosen to be validated (*e.g.* the fact that increased blood cortisol levels increase under stress justifies its use as a welfare indicator). However, the reference to an explicit definition of animal welfare is rarely given by the authors using welfare parameters.

Stafleu *et al.* (1996) consider these three types of definitions as three interconnected levels, *e.g.* the disharmony can result from the animal not coping with the environment and this in turn can be objectively assessed with indicators such as the prevalence of stereotypies, illness, corticosteroid levels etc. Stafleu *et al.* (1996) also argue that from lexical to explanatory and then operational definitions,

animal welfare becomes a more assessable concept by means of scientific indicators while the links with the moral aspects at the origin of the concern for animal welfare are progressively lost. In addition, science-society dialog may be difficult while digging into technical vocabulary such as cortisol level or specific diseases etc. as lay person may not understand the reasons for such indicators and may feel that science is in some way hiding the truth. We argue that such losses in moral concerns are not necessary, but that clear concepts and an increase in information shall help maintain the link between moral concerns and operational definitions.

Animal welfare is typically a multidimensional concept, embracing aspects such as good health, biological fitness, absence of suffering, and positive experiences (Fraser, 1995). The relative importance of each dimension in regard to the others cannot be completely determined by science. As a matter of fact, when considering only one separate aspect of animal welfare, like access to nest for laying hens, it is possible to design experiments, *e.g.* using operant conditioning, in order to assess the strength of that animal's motivation (Cooper & Appleby, 2003). By contrast, it seems very hard to know how an animal would rank very different aspects of welfare, such as good health and the possibility to express behaviours, because these aspects occur on very different time scales. There are however attempts to assess *e.g.* the long term mood of the animal (see below). Welfare "incorporates numerous attributes linked by their involvement in the quality of life of animals, and with an inherently subjective element in judging their relative importance" (Fraser, 1995). We would like to go even further by stating that:

- The choice of attributes that are considered relevant for animal welfare (whether very important or less important) are also morally based. In a utilitarian view, where feelings predominate, pre-pathological states of an illness, where animals are not aware of that risk for their health, are not relevant for animal welfare (discussed by Duncan & Petherick,1989). By contrast, in a deontological view considering that farm animals have the right to be in good health, pre-pathological states may be of prime importance, as claimed by Moberg (1987).
- The thresholds for considering that results provided by an indicator reflect poor welfare cannot generally be based only on science (Sandoe *et al*., 2004). Science can provide trends and in some case "dose-dependant" laws but very often no clear-cut yes/no answer. For instance, science can show that the prevalence of mastitis in dairy cows increases with milk yield but cannot decide what percentage of cows affected by mastitis is the maximum acceptable.

Science cannot answer questions about what ethical stance to take, nor about what is an "acceptable level of suffering". Given a specific definition of animal welfare, science can however provide answers on *e.g.* the naturalness of a behaviour, animal preferences, and levels of stress or suffering experienced. Scientific knowledge should therefore provide a basis for societal debates about animal welfare by a better understanding of what matters to animals.

3. Animal Welfare and Behavioural Sciences

Within animal sciences, welfare is addressed for a large part by researchers studying animal behaviour. Although health is an essential component of animal welfare, pathologists rarely refer to welfare when designing experiments or interpreting results (Curtis *et al*., 1985). This is presumably due to the facts that: i) animal welfare refers to the animal taken as a whole, as in behavioural sciences; and ii) the final issue is whether animals feel something bad or good about their general state (or in case of pre-pathological states whether they might feel bad in the near future). It is not possible to ask direct questions to animals, as done in *Quality of life* questionnaires in humans (Smith *et al*., 1999), hence one has to observe behavioural changes to detect such negative vs. positive affects. In this section, we will discuss whether the classical sciences of animal behaviour can help answer questions concerning animal welfare. We will not describe all disciplines and their branches but focus on three of them: behaviorism, ethology, animal cognition, that we feel are essential to understand how animal welfare science built on them.

At the beginning of the XXth century, psychologists decided to study animal behaviour in a purely "objective" way, following the large scientific trend of positivism. Watson defined behaviour as

any adaptive response that an organism, generally possessing a nervous system, produces in reaction to stimuli from the environment, with both eliciting stimuli and body responses being objectively observable (Watson, 1913, cited by Campan, 1980). In this vein, the study of behaviour consisted in placing animals, generally rats, in an environment totally controlled by the experimenter, often cages. The black box approach used advocated studying inputs to the animal and outputs from the animal (in terms of behaviour). What happened in the animal was considered to be impossible to study, and there was no mention of affects. Thanks to specific arrangements of stimuli, experimenters aimed at animals producing a given response to obtain a reward, or avoid a punishment, a procedure called operant conditioning. Although behaviorism cannot help us understand animal affects, hence their welfare, we will see further in this paper that the methodology developed (operant conditioning) can be used to study animals' motivation and investigate what stimuli may affect them.

In reaction to behaviorism, criticized as the *white rat psychology,* zoologists develop their own framework to study animal behaviour, later called ethology. Tinbergen and Lorenz observed animals in natural environments, or at least in an environment where they were free to move in (Campan, 1980). They focused on innate behaviours and set four main issues to be addressed by ethology (Tinbergen, 1963):

- the function of a behaviour,
- the evolution of the behaviour,
- the causation of the behaviour,
- the development of the behaviour.

Contrary to claims from behaviorists, Lorenz believed that internal and external factors interact, and that they in some cases may be responsible for behaviours that occur independently of external stimuli. In his hydraulic model, he considered that some energy accumulates with time and is released in the form of behaviour when a certain stimulus is present and/or a threshold is attained (Lorenz, 1950). However what this energy consisted of remained unclear. One can view this energy in the form of some hormones that act on the brain to modify outputs, *e.g.* behaviours. Mental processes are still in a black box and again affects are considered out of study because not observable. Nevertheless, ethology can help us see how animals see and interpret the world. Current research in the biology of animal behaviour is dominated by behavioural ecology, with an increased focus on the function of behaviour and its evolution. In this regard, the biology of behaviour has moved further from proximal causes, hence further from questions concerning animal welfare.

While behaviorism was a very important school of thought in psychology it was not the only one. Psychologists, as for example Tolman, helped lay the ground for cognitive psychology by arguing that it was possible to study mental processes in animals and humans (Tolman, 1932, cited by Toates, 1986). Main topics addressed in cognitive psychology were categorisation, memory, language, and problem solving. They used experimental situations such as maze and also more natural environment. These studies broke through the black box of animals' mind, making it a grey box. Nevertheless, the problems to what animals were subjected were very much designed according to humans and may not be relevant for animals' real life. See for instance the language studied as the ability for parrots to reproduce and combine human words (Pepperberg, 1981) which, although very intellectually stimulating, cannot really tell us how parrots communicate with each other and construct their social life. There is however a number of researchers who are combining cognitive research with biology, investigating *e.g.* the spatial memory in hoarding birds (Shettleworth, 1990).

Among the behavioural sciences, ethology seems closer to animal welfare because it sees animals for what they are spontaneously. Cognitive ethology emerged from the fusion of classical ethology and animal cognition. Mental abilities of animals are studied in rather natural conditions. As a framework, the four Tinbergen's questions may then be applied to cognitive abilities of animals (Jamieson & Bekoff 1993). Bekoff & Allen (1997) further note that the views of people in favour of cognitive ethology are consistent with animal rights, as animal experience is considered as worthy in itself. Cognitive ethology made a break through animal mental abilities however, these seems to be seen more in terms of *cold cognition*, trying to understand how animals reason, but not tackling directly the issue of animals'

affects, which are central to welfare. So as mentioned by Toates (1997), "applied ethologists considering welfare issues are in a strange situation: they are required to create much of their own pure ethology".

Animal welfare science need to attempt to answer the following questions:

- To what extent are the animals used by humans capable of emotions? In other words, what affective states can they feel? This knowledge would greatly help choose the animals we decide to give moral consideration to, at least from a utilitarian and a "Feinberg right" attitude;
- How does an animal perceive its environment? In other words, what are the situations which are perceived negative vs. positive, or what are the elements animals like vs. dislike? Again, this would be particularly pertinent from a utilitarian view;
- How can we assess the level of animal welfare in a given situation? Here not only mental state but also physical state might be incorporated;
- What are the impacts of the ways we treat animals (during their life or at slaughter) on the welfare of these animals?
- What recommendations can we make as to improve animal welfare?

The last three questions fit both a utilitarian and a animal right view since both the affects of animals and what is necessary to assure them a good life (health, comfort, …) are taken into account.

Specific methodologies must be developed to assess positive and negative states of animals in order for the above questions to receive appropriate answers. These will be discussed in the next section.

4. Animal Welfare Science in Practice: The Methods

There are two distinct fields of research that are of interest in animal welfare science. The first is how to assess the welfare of an animal in its present situation. The second field of research is what resources are necessary for an animal to have good welfare, resources in a broad sense including both physical and behavioural aspects.

4.1. Assessing animal welfare

People who live in proximity with an animal believe they know when this animal is happy, scared, sad, angry, etc. and for the owner of a pet there is no doubt that this interpretation is correct. However, for a long time scientists have been reluctant to use such terms in their publications, because they sound anthropomorphic (Kennedy, 1992). Alternative methods have therefore been developed.

Approaches to animal welfare often start with taking the physiological needs of the animals into account, *e.g.* feed, water and temperature. These are often measured by looking at the production results, if the animal is growing as it should, or alternatively producing milk or eggs this is often taken as an indication that this measure of welfare is fulfilled. A recent and more subtle approach is to use measures of developmental stability (also known as fluctuating asymmetry) to determine whether the needs, primarily physiological needs, are fulfilled (Knierim *et al.,* 2007).

A second important variable is the health of the animals, and it is often considered that a sick or infected animal has poor welfare. As we discussed above, this will however depend on the person's definition of welfare since there are subclinical infections which will probably not affect the behaviour or mental state of the animal. These two aspects, meeting the physiological needs and health, are often considered to be prerequisites for welfare rather than welfare measurements in themselves (Dawkins, 1980).

The third type of measure tries to measure the hedonic state of the animal in a more direct way. There are several different approaches taken here. One possibility is to use the spontaneous behaviour of the animal. This may be distress signals, *e.g.* vocalizations to determine the level of acute pain or stress, as has been done to determine whether piglets feel pain at castration (White *et al,.* 1995; Weary *et al.,* 1998). Another alternative is to look for abnormal behaviour such as stereotypies or redirected behaviour (*e.g.* belly-nosing in piglets – Dybkjaer, 1992; cross sucking in calves – Jensen, 2003). The occurrence of abnormal behaviour is often considered to be an important marker for unfulfilled needs (Mason, 1991). Under experimental conditions physiological measures indicative of stress are often

used (*e.g.* glucocorticoid levels - Mormede *et al.,* 2007; heart rate variability - Borell *et al.,* 2007). While physiological measures are good for determining the level of arousal of the animal they are less so for determining the valence of the emotion (Mormede *et al.,* 2007) and need thus be associated with behavioural measures, such as approach vs. avoidance.

4.2. Assessing the need for resources

A more controversial aspect is the resemblance of the behaviour or environment of the animals to its natural habitat. This is a variable which is typically thought to be of high importance by consumers (Evans & Miele, 2007), but seems more controversial to scientists working in animal welfare (Fraser, 1995). New ideas for how to improve animal welfare often begin with an analysis of the natural behaviour of the animals however, as in the example of perches for hens (McBride *et al,.* 1969), or pen-designs for farrowing sows (Stolba & Wood-Gush, 1984). The motivation of animals to obtain such natural environments or the consequence of these environments on animal behaviour, production or health shall nevertheless be assessed.

We can measure animals' preferences or aversions for different aspects of the environment and then see if these resources are available to the animal, *i.e.* use a resource based measure. There are two major methodologies used for determining the needs of animals, the preference test, and the operant conditioning test. In the preference test the animal is offered a choice between two resources, *e.g.* two floor types or two light intensities, and time spent on each alternative is registered as the choice of the animal (Hughes, 1976b; Kristensen *et al.,* 2007). The advantage of this approach is its seeming simplicity. The approach only gives a relative measure however, *i.e.* both floor types might be very bad with one just slightly better than the other. In an operant conditioning task on the other hand, an animal is trained to associate access to a resource with a task. The effort required (*e.g.* number of lever presses) is then varied and an estimate for how valuable the resource is for the animal can be acquired (Dawkins, 1990). This methodology can be made quite complex with live-in environments (so called "closed economies") in which the animal is required to work for access to a large variety of resources (Cooper & Mason, 2000). The needs and preferences most often investigated with these methodologies are psychological or behavioural needs, *e.g.* need for swimming water for mink (Cooper & Mason, 2000), rooting material for pigs (Jensen & Pedersen, 2007) or perches for hens (Olsson & Keeling, 2002). Because the different methods have different strengths and weaknesses it is important to compare the results from more than one technique to determine *e.g.* preferences. A recent example of this is a review on pigs' preferences for different rooting material that encouragingly came to the conclusion that there is a very good correlation between the different methods; in this case time budget studies, operant conditioning studies and preference studies (Studnitz *et al*., 2007).

5. The Future of Animal Welfare Science

Traditionally the area of animal welfare and applied ethology have emphasised the importance of objectivity of its measurements – perhaps because when dealing with welfare assessment it is easy to be accused of anthropomorphising.

One of the arguments against anthropomorphising and extending phenomena such as emotions or consciousness to animals has been the difference in brain architecture (at least in relative proportion of the different parts of the brain) between us and other animals (*e.g.* Kennedy, 1992; Rose, 2002). Another argument that has been put forward is that phenomena such as emotions or cognitive processes are inherently subjective and cannot therefore be studied directly.

As the science of neurobiology develops, new discoveries concerning the function, and functional correlates, of the different parts of the brain in different species are being discovered, *e.g.* the reclassification of the brain structures in the avian brain (Reiner *et al.,* 2004) This has led to an increased willingness to accept arguments by analogy as proposed by *e.g.* Sherwin (2001): "we observe whether an animal responds to a putatively negative stimulus in a similar way to ourselves, and if it does, we assume the animal's experience must be analogous.".

The argument by analogy has not always been accepted. As late as in 1985 a young infant in the USA "had holes cut on both sides of his neck, another cut in his right chest, an incision from his

breastbone around to his backbone, his ribs pried apart, and an extra artery near his heart tied off". The infant was awake throughout and only paralyzed with a curare compound. He died a month later. When the mother asked about the operation the anaesthesiologist said that "it had never been demonstrated to her that infants feel pain" (Lee, 2002). In a study some 10 years later more than 6% of the mothers were still not sure if the infant could feel any pain at all (Berthier *et al.,* 1996).

The same discussion on whether other young animals feel pain has been discussed in conjunction with the practice of castration. The responses of piglets to castration, sham-castration and castration with anaesthetics has led researches to agree that piglets can and do feel pain at castration (Wemelsfelder & van Putten, 1985; White *et al.,* 1995; Weary *et al.,* 1998). At present a very similar discussion is taking place concerning whether fish can feel pain (Rose, 2002; Sneddon *et al.,* 2003; Rose, 2007). There are even suggestions to extend the argument by analogy to arthropods (Fiorito, 1986; Sherwin, 2001; Barras, 2007).

As with the development in neurobiology, new findings in the area of cognitive psychology and cognitive neuroscience are changing the emphasis in the field of animal welfare, and offering new tools to investigate mental states, *e.g.* moods or emotions, in animals.

There are three especially promising approaches: the use of appraisal theories, the study of cognitive bias, and of anticipatory behaviour.

Appraisal theories stipulate that (human) emotions result from the evaluation of a triggering situation by the individual facing that situation. Desiré *et al.* (2002) proposed to study the emotions of non-human animals by transposing to them the frameworks developed by appraisal theories. According to these theories, emotions arise from a combination of rapid evaluations of the environment, on the basis of few discrete criteria such as the novelty of a situation, its controllability, or correspondence to expectations. For instance a situation perceived as novel, potentially aversive and out of control induces fear whereas anger appears in similar but controllable situations. Using this framework Greiveldinger (2007) concluded that sheep are able to feel surprise, fear, joy, frustration, anger, and presumably shame vs. pride. The studies using appraisal theories are mainly focused on short term responses, *i.e.* emotions. The repetition of specific emotions, especially negative emotions, is likely to affect mood, a more stable internal state that influence the way the environment is interpreted.

The cognitive bias approach is based on research on humans and how mood in humans affects their interpretation of an ambiguous signal. The general finding is that humans who report that they are in a good mood are more likely to believe that the ambiguous signal is positive than those individuals that are in a negative mood state. Preliminary studies have shown that animals as diverse as rats (Harding *et al.,* 2004) and starlings (Matheson *et al.*, 2008) react in a similar way. Animals that have been stressed are less likely to react to an ambiguous signal as if it was signalling a reward.

The idea of anticipatory behaviour is closely related to that of incentive value theory (Flaherty, 1996), which emphasises that the value of a resource is dependent on other things than the physical properties of the resource itself. In broad terms the anticipatory behaviour approach states that an animal that has an environment with few rewarding resources, *i.e.* a poor environment, will appreciate a new reward more than an animal living in a rich environment (Spruijt *et al.,* 2001). Animals show anticipatory behaviour when expecting a reward and the strength of that behaviour is related to the value of the reward. By measuring the anticipatory behaviour of an animal it should therefore be possible to determine whether its environment is rich or poor (Harst *et al.,* 2003; Vinke *et al*., 2004). By contrast, chronically stressed animals can develop anhedonia and may be unable to show an anticipatory response to a positive event (Van der Harst, 2005).

6. Conclusion

Animal welfare science is an applied science in the sense that it focuses on societal problems rather than being driven primarily by theory. As such it is defined by society, not least because the very thing it aims to study - animal welfare - cannot be defined scientifically. What can be studied scientifically however, are the things which we mean form part of animal welfare (*e.g.* health, pain, mental experiences).

While there can be no "true" definition of animal welfare, it is nonetheless important to have a working definition to be able to move forward. An influential attempt was made by FAWC (1993) when

they formulated the five freedoms. In a similar vein an integrated EU project, Welfare Quality®, has adopted another working definition whereby four main principles (good feeding, good housing, good health, and appropriate behaviour) have been identified as essential to safeguard adequately animal welfare. Within these principles, twelve distinct but complementary criteria have been highlighted. These criteria were derived from the literature and from discussions with stakeholders. They are: the absence of prolonged hunger, the absence of prolonged thirst, a comfortable resting area, thermal comfort, the possibility to move freely, the absence of injuries, the absence of disease, the absence of pain due to management practices, the expression of social behaviours, the expression of other behaviours, a good human-animal relationship, and the absence of negative emotions (Botreau *et al.,* 2007). While the weighting of the different aspects may differ between different definitions of animal welfare it is believed that most major aspects of animal welfare have been covered. Then indicators were defined to check how well a given situation (a farm, a slaughterplant) meets these criteria.

Scientists working in the field of animal welfare do this by using very diverse techniques from different fields of research, from stress physiology (Mormede *et al.,* 2007; Borell *et al.,* 2007), classical ethology (Stolba & Wood-Gush, 1984) and evolutionary ecology (Jensen *et al.,* 1998) to cognitive psychology. Even methods developed by the behaviorism approach, *i.e.* operant conditioning, are often used to determine animals' preferences or aversions (see Section 4.2). New advances in the cognitive sciences led to the work now being done on the mental experiences of animals (see Section 5). At first glance, animal welfare appears at the intersection of diverse disciplines linked to animal behaviour, with one discipline supporting other disciplines to interpret results. For instance, an innate behaviour can be described thanks to an ethological approach, the underlying animal motivation can be assessed by operant conditioning and the consequences of its frustration can be studied by physiological indices of stress (Mason *et al.,* 2001). In addition, animal health needs also to be taken on board as the fulfilment of behavioural needs can impact on health (Jensen & Toates, 1993) and pathologies can lead to modifications of behaviour (Dantzer *et al.*, 2008). However, the study of animal welfare is more than a mere juxtaposition of disciplines due to the specific object studied. Animal welfare science aim not only at describing animals' responses to more or less harsh environments but also, and more importantly, at understanding how animals experience their world, in other words it aims at describing objectively animals' subjectivity (Dawkins, 1980). Therefore, animal welfare science can be considered as a new behavioural science, with specific research questions but methodologies inspired by other disciplines.

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