

Science-based assessment of animal welfare: wild and captive animals

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Summary

Science-based assessment of animal welfare in wild and captive animals has, during the past ten years, benefited from increased interest in and research into consciousness, emotions, stress and pain. Because it is impossible to make a detailed physiological study in free-living animals, reliance must be placed on behaviour and Darwinian fitness, which have been shown to correlate to welfare. Only in captive animals can more detailed physiological studies be made, and then not without difficulty.

In short, the welfare of an animal is shown to be compromised if the animal exhibits similar behaviour to that of animals whose physiological responses have been confirmed as indicating poor welfare, and if its Darwinian fitness is compromised in similar ways to such animals.

Keywords

Behaviour – Consciousness – Disease – Emotion – Pain – Physiology – Stress.

Introduction

There has been, in recent years, an upsurge of public interest in and concern about the impact of human activities on animals. This concern began as a moral concept concerning the interaction between the needs and desires of people on the one hand and, on the other, their ethical standards, both of which have varied over the centuries and continue to evolve. The debate led to greater scientific interest and attempts to establish measurements of animal welfare, good as well as bad, which are not influenced by what is morally acceptable.

There immediately arose a linguistic problem. Animal welfare can be good or bad, but the translation in French – *'bien-être'* – means well-being in English, and the concept of poor well-being is more difficult to understand.

History

The philosopher Descartes (1596 to 1650) believed that only humans can reason and that animals lack any kind of mental activity. In short, animals were programmed and

had no subjective experience. Descartes said 'they act mechanically like a clock which tells the time – all animal motions originate from the corporeal and mechanical principles', and for many years humans believed that animals were incapable of suffering.

David Hume (1711 to 1776) was one of the first philosophers to say 'animals undoubtedly feel, think, love, hate, will and even reason, though in a more imperfect manner than men'.

Jeremy Bentham (1748 to 1832) strongly supported the contention that animals can suffer.

These of course were only opinions till the scientist Darwin (6) (1809 to 1882) expounded his theory of evolution. His ideas underlie modern biology and in his book *The descent of man* (1871), he wrote: 'we have seen that the senses and intuitions, the various emotions and faculties, such as love, memory, attention and curiosity, imitation, reason, etc., of which man boasts, may be found in an incipient or even sometimes in a well developed condition in the lower animals'.

Science has moved on and – as Professor Marian Dawkins (5), who has studied the welfare of animals for many years,

concluded – it is extremely likely that at least some animals do think in rudimentary ways and experience pleasure and suffering. If consciousness is a biological phenomenon that evolved because it made animals in some way more effective at surviving, then any explanation that ignores consciousness must be missing something very important.

The biologist Professor Frans de Waal (8) argues that opposition to the idea that humans and animals share some characteristics (called anthropomorphism) is really anthropo-denial.

Epistemology – the theory of knowledge, including limitations of knowledge – also has a bearing on the concept of animal welfare. Confusion and arguments arise unless precise definitions are used. Language can avoid or shift responsibility and be at variance with real meaning. The words ‘cull’ and ‘harvest’ are used to replace the more unpleasant word ‘kill’, which has wider and more sinister connotations and makes uniform scientific assessment more difficult. When assessing welfare it is important not to allow oneself to be influenced by the species of animal and the purpose of the interference. An animal that is labelled a pest is already condemned by many people to poorer welfare. The use of words such as ‘happy’, ‘sad’ and ‘love’ to describe animal emotions is described as anthropomorphism by some people. Yet recent research clearly demonstrates the importance of emotions in animals. Beliefs such as ‘wildlife must pay for itself’ can excuse poorer standards of animal welfare for species that have little or no value. The author has witnessed cruel methods of culling unwanted species, such as the use of poisons, that are used and excused because they are convenient and cheap.

Consciousness

Some say that consciousness is a precondition for experiencing emotions. Being aware of being aware is an ability confined to humans and perhaps a few primates, and the behaviour of other animals in emotional states, is automatic, almost instinctual. So can they suffer?

Dr Gerald Edelman (10) who received the Nobel Prize for physiology and medicine wrote: ‘there is something special about consciousness: conscious experience arises as a result of the workings of each individual brain. It cannot be studied under direct observation, as the physicist’s objects can be studied. Thus, studying consciousness presents us with a curious dilemma: Introspection alone is not scientifically satisfactory, and though people’s reports about their own consciousness are useful, they cannot reveal the workings of the brain underlying them. Studies of the brain proper cannot, in themselves, convey what it is like to be conscious. These constraints suggest that one must

take special approaches to bring consciousness into the house of science. Everyone knows what consciousness is: it is what abandons you every evening when you fall asleep and reappears the next morning when you wake up.’

The acceptance that the brain is the organ of consciousness is a relatively recent achievement. Neural processes have been, and are being, examined by electroencephalography and magneto-encephalography, which measure small electrical potentials and electric currents. Positron emission tomography and functional magnetic resonance imaging can assess changes in brain metabolism and blood flow with great accuracy in the living brain at work. The response times are in thousandths of a second. Another method of studying areas of the brain is through the effect of lesions. A lesion of a restricted portion of the cerebral cortex has never been shown to cause unconsciousness, though such a lesion may cause focal deficits in conscious experience. For example, damage to one area may abolish the ability to see colour, and to another area may reduce the ability to perceive moving stimuli.

Dr Le Doux (18), a neuroscientist, has observed that following the removal of the entire cerebral cortex, cats still exhibited characteristic signs of emotional arousal as well as autonomic arousal.

Much of the brain’s activity is unconscious. For example, speech is the product of unconscious processes. People do not plan the structure of a sentence when speaking – there isn’t enough time.

Finally, it is important to realise that human and animal brains are organisationally and structurally similar. In all vertebrates the brainstem houses neuronal structures that regulate sleep, wakefulness and dreaming as well as attentional and arousal functions. This is understandable when one accepts Darwinian evolution. The closer humans are to other species genetically, the closer the similarity in brain anatomy. Humans and chimpanzees share about 98% of their deoxyribonucleic acid, humans and mice about 90%. The sensory nerves enter the dorsal segments of the spinal cord and the motor neurones exit the ventral segments in all vertebrates. This conservation of structures is not unexpected in vertebrates, but conservation in cellular functions extends to non-vertebrates.

Dr Le Doux (18) studied in great detail the emotion of fear in animals, particularly rats, as well as humans. He views emotions as biological functions of the nervous system. Emotion, he contends, does not refer to something that the mind or brain really has or does – it is only a label for a complex process. The brain, for example, does not have a system dedicated to perception. The word simply describes in a general way what goes on in a number of specific neural systems. Le Doux also found that the brain systems that generate emotional behaviours are highly conserved

through many levels of evolutionary history. Within the animal groups that have backbones and brains, the neural organisation of particular emotional behavioural systems is broadly similar across species. When one of these evolutionary old systems, such as the one that produces defence behaviours in the presence of danger, is functioning in a conscious brain, emotional feelings like being afraid are the result. Emotional responses are for the most part generated unconsciously. Emotional feelings and emotional responses are effects caused by the activity of a common underlying system, which is similar in animals and people.

If an anxious rat has no control of a situation, it may groom, fight or chew. In zoos, animals pace and circle endlessly.

A frightened animal displays characteristic behaviour. It becomes more vigilant, may want to hide, may urinate and defecate, or may freeze. However, stressed animals often appear to damp down behavioural responses to avoid attracting attention. So the best measures of such stresses are corticosterone levels in rats, cortisol in dogs and cats and humans, and blood pressure and heart rate.

Fear conditioning occurs in nearly every animal group examined. A classic experimental fear conditioning is one that can be induced by using a sound and mild electric shock to the foot of the rat. The research showed that only the damage to the amygdala removed the susceptibility of the rats to fear conditioning to the sound. The amygdala plays an important role in emotional behaviour. Emotion exerts a powerful influence on declarative memory and other thought processes. A person can have an emotional feeling without being conscious of the stimulus. Similar types of studies have been done on other mammals and the conclusion is that when it comes to detecting and responding to danger, the brain simply has not changed much in evolutionary terms. In other words, the fear reactions in rats are very similar to the fear mechanisms in humans.

Connections from the amygdala to the cortex allow the amygdala to influence attention, perception and memory in situations where people are facing danger. In other words, the amygdala has a greater influence on the cortex than the cortex has on the amygdala, allowing emotional arousal to dominate and control thinking. Although a person's thoughts can easily trigger emotions by activating the amygdala, humans are not very effective at deliberately turning off emotions by de-activating the amygdala.

The neuroscientist Dr Damasio (4) believes that having feelings is one of the main jobs the brain does. He sees them as an integral part of the decision-making processes of the brain.

Also important is the mind/body interaction and disease. The brain and the immune system are continuously signalling each other, often along the same pathways. New molecular and pharmacological tools can help identify the intricate network that exists between the immune system and the brain. Emotional stress has a considerable effect.

In summary, these examples show clearly that emotions are an integral part of the brain function in all mammals and are not dependent on awareness arising first. The emotion arises and we then become aware of it.

Most people accept that animals can suffer fear. Animals also suffer grief and sadness, concern or anger, the absence of joy, and frustration. An example of grief was that of a female chimpanzee that died of old age. Her son stayed near the corpse grabbing the hands, trying to pull her up. He slept near the body. He showed signs of depression. In the days that followed he kept returning to the body and tried to remove the maggots. In ten days he lost a third of his weight. Finally, when the corpse was removed and buried, he sat on a rock and died. Post mortem examination showed no cause of death.

Pain

Research in the 1970s showed that in man and those mammals that have so far been examined, there are distinct receptors responsible for the perception of pain. They have been called nociceptors. They are simple in appearance and non-corpuseular. They are served by axons that are either non-myelinated or poorly myelinated. There are two types of nociceptors: one responding to pricking or pinching (mechanical), and one responding to temperature changes in the skin (thermal), although this nociceptor does also respond to intense mechanical stimulation. The nociceptors are insensitive to low intensity mechanical or thermal stimulation and respond only to those levels of intensity that are potentially damaging to cells and may cause cell death.

Activation of the non-myelinated axons is associated with slow aching, burning and purely localised pain of long duration, while the poorly myelinated axons are associated with sharp, well-localised pain.

A peptide (a primitive protein) called bradykinin is released in the termination of afferent nerves following thermal injury. It is also present in blisters raised by heat or chemical irritants like nettle stings. If it is injected into an artery it will override the effect of local anaesthesia to cause extreme pain. Bradykinin is also found in an area in the dorsal horn of the spinal cord in those parts that respond to the stimulation of nociceptors. Bradykinin is released by nerve endings or special cells close to the nerve endings when they are damaged.

Another peptide called substance P is involved in the transmission of pain. When bradykinin is released at the nerve ending, substance P is released at the first synapse in the spinal cord. Experiments have shown that substance P is a powerful stimulant to the neurons in the dorsal horn and acts selectively in those cells that respond to noxious stimuli. This pain-transmitting peptide is present in all mammals so far examined.

The presence or absence of substance P provides a pharmacological test for pain-transmitting elements in a nervous system. It occurs in all mammals so far tested, as well as in birds, frogs and in the brains of trout and some other species of vertebrate fish.

In addition to nociceptors and the afferent nerves to the brain, there are what have been called 'sleeping nociceptors' or 'silent afferents', which are found in the skin, joints, and viscera of rats, cats and monkeys. They are called 'sleeping' or 'silent' because they do not 'fire' immediately when tissue is injured, but increase in sensitivity in the hours following inflammation.

Pain can be felt in many ways: aching, burning, sharp and so on. Colic can make an animal writhe, while fractures and arthritis demand immobility. Pain can be useful because it makes the animal take action to prevent destruction of any part of the body. Free-living wildlife has, through natural selection, become adapted to the injuries that can happen. For example, prey animals are adapted to being preyed upon. A prey animal that escapes a predator soon returns to normal activity. If the animal does not escape, it is quickly killed. Animals are not, however, adapted to injuries caused by humans such as steel-jawed traps, snares and bullet wounds. Pain can be useful, although sometimes it seems meaningless.

Stress

In 1936, when Hans Selye was studying the effects of a chemical he was injecting into rats, he found consistent changes, namely peptic ulcers, atrophy of the immune systems and enlargement of the adrenals. But the control group, which had been injected with saline solution, exhibited similar changes. Further studies revealed that the physiological response was due to the handling and injection. Selye used the term 'stress', which he took from engineering. Since then a great many studies have been undertaken, and a dozen or so hormones and the inhibition of others are now known to be involved. The response to stress is simply an attempt by the individual to preserve its well-being. For all practical purposes, stress can be said to occur when an animal encounters physical or emotional conditions that disturb its normal equilibrium. Scientists argue that stimuli with which the

animal can cope are essential to keep the coping process in good working order, and the dividing line between what is beneficial and what is harmful varies for each individual.

Stressors, the stimuli causing stress, can be divided into somatic and psychological types.

Somatic stressors include such things as injuries to soft tissues and/or bones, poisoning and intoxication with pollutants, hunger and malnutrition, intense thirst, severe extremes in temperature, and acute and chronic disease states.

Psychological stressors include sudden and violent alarm, fear, apprehension, anxiety and frustration. These can be either very rapid stressors that cause extreme disturbance, or they can be prolonged, producing much less intense mental strain but quite considerable stress in the long run. In wild animals for example, the stress of the chase and capture by humans, with the concomitant fright and terror, together with the restraint and handling and transport can cause intense degrees of stress. However, continued low-grade stress in confinement is just as serious in the long run.

When the animal is suffering stress, the hypothalamus stimulates the pituitary to produce adrenocorticotrophic hormone (ACTH), which in turn stimulates the adrenal glands to release corticosteroids. These corticosteroids have a number of major actions, as follows:

- a) they affect carbohydrate metabolism and stimulate the production of glucose
- b) they stimulate the breakdown of tissue protein
- c) they stimulate the production of glucose from fat
- d) they promote the retention of sodium chloride ions
- e) they increase sensitivity of the blood vessels to adrenaline
- f) they affect the blood cells and lymphatic organs, producing an increase in a number of circulating neutrophils, thrombocytes and erythrocytes
- g) they affect the kidneys, increasing the rate at which urine is formed
- h) they maintain the capacity of muscles to function longer than they might otherwise do
- i) they affect brain excitability
- j) they increase gastric acid and pepsin secretion, and therefore are prone to cause ulceration of the bowels
- k) they have potent anti-inflammatory effects
- l) they affect antibody reactions
- m) they are immune suppressive.

Chronic stress can damage health by causing atrophy of healthy tissues and cardiovascular changes, which can damage the heart, blood vessels and kidneys. Tissue repair is curtailed and there is reduced fertility.

Sapolsky (26) studied captive baboons, *Papio hamadryas*, where the primary sources of stress, as with humans in modern society, are psychological and socially generated rather than physical. Sapolsky concludes that attitude counts, that stress-related physiology is remarkably sensitive to the psychological filters of the individual.

Khansari *et al.* (17) reviewed the effects of stress on the immune system, a new interdisciplinary research area called psychoneuroimmunology. The limbic system is the major central system involved in neuroendocrine and emotional responses to stressors, and it is an important connection between the hypothalamus and the cerebral cortex. There are more than 15 neurotransmitters and hormones that affect the immune system, of which about half are suppressors and the remainder enhancers. The processes are complex and the impact of stress is bio-directional on a feedback system.

The biological responses to stressors are varied. There is no single response, but rather a wide range of responses that vary between individuals and are greater in those of an anxious disposition. In other words, some individuals cope better than others.

Fraser and Broom (11) suggest that the Darwinian fitness of an animal may be used to evaluate whether an animal is coping. This approach has advantages in that evaluation does not depend on specific mechanisms that restrict the concept to certain taxa or classes of stimuli. Hofer and East (12) suggest that a Darwinian approach is essential for any theory of stress in biological conservation. An animal needs to evaluate challenges to mental and bodily stability and then act to restore homeostasis. Hofer and East define stress as an environmental effect that reduces or is likely to reduce the Darwinian fitness of the organism, which in practice is linked to fecundity, survival and age at first breeding – see Sibley and Calow (28). Hofer and East (12) believe that using a reduction in Darwinian fitness to define stress has a number of advantages: the approach has universality, does not require specific mechanisms that are restrictive, and recognises that animals employ a variety of mechanisms to cope.

Impacts on welfare

It is useful to list briefly the major examples of the impact of humans on wildlife.

On free-living wildlife

- a) Habitat destruction due to human use, such as farming, dam building, and construction of buildings leading to local over-abundance of animals and conflict with people
- b) management of the environment, such as fencing and its effects on migration
- c) pollution such as polychlorinated biphenyls (PCBs) in marine mammals and dichlorodiphenyltrichloroethane (DDT) on wild birds
- d) spread of disease from domestic to wild animals: for example tuberculosis (TB) in buffalo, *Synceros caffer*, and lions, *Panthera leo*; canine distemper in wild dogs, *Lycaon pictus*; tuberculosis in deer, *Cervus elaphus*
- e) human use of wild animals and parts of their bodies for food, fashion, perfume, medicines (tiger bone), aphrodisiacs (rhino horn), capture and research
- f) deliberate introduction of disease, e.g. myxomatosis in rabbits
- g) deliberate poisoning, e.g. of moles by strychnine
- h) noise
- i) capture
- j) marking for research
- k) fencing; for example, the very long fences in Botswana against which thousands of migrating wild animals die.

On captive animals

- a) Capture
- b) captivity itself
- c) training and taming (dominating animals)
- d) unsocial grouping
- e) research
- f) noise
- g) marking.

Assessment

This explanation of what is known about pain, stress and the ability of animals to experience suffering is necessary, because some people still believe that at least some species do not suffer. Certainly assessment is not easy in free-living wild animals, and species react differently to pain, stress and fear.

The best examples of the different reactions to pain are to be observed in domestic species, which show little or no inclination to hide their weakness.

For example, the horse and the cow exhibit totally different symptoms when they suffer abdominal pain. The horse will throw itself about, sometimes rolling on the ground, pawing at the ground, kicking at its stomach and showing what we would call a painful look about its eyes. The cow on the other hand will stand still, hardly moving at all and will rarely kick at its stomach, with its ears drooping, looking dejected and occasionally moaning.

Dogs and cats may suddenly withdraw from the source of the painful stimulation. They may lick, bite or scratch at the location of the pain. Dogs often become quieter and less alert, with stiff body movements and an unwillingness to move. Dogs may appear restless when pain is severe, and there may be inappetence, shivering and panting. Spontaneous whimpering is more common than barking, and a dog may growl when approached and become vicious when handled. Cats in pain are generally silent but may growl or hiss when approached. They tend to hide, posture becomes stiff, and cats may sit hunched, reluctant to stretch out. A cat in pain may howl and show demented behaviour, with desperate attempts to escape. Cats sometimes pant and have an increased pulse rate and dilated pupils.

In general, free-living wild animals hide symptoms that could make them appear vulnerable to a predator or attack. Prey species like impala and buffalo try not to show weakness. The author has observed such animals limping and even staggering, but generally they are stoical and show little reaction to extensive cutaneous – and even muscle – wounds, and the author has never seen them reacting like cows and horses to internal pain.

Predators will limp and are less stoical. When in pain, such animals will rest a lot and lick wounds. The author has observed a brown bear with toothache and a swollen cheek holding his head to one side, and a polar bear with a cutaneous wound about half a metre long, showing no abnormal behaviour.

Species react differently to fear, as do individuals. Some will hide, others flee and, if escape is impossible, may either turn to fight or freeze. Some species will struggle to escape from a steel-jawed trap and may even chew off a foot to escape, whereas others, like the possum, *Trichosurus vulpecula*, will curl up and appear to be asleep.

Assessment of welfare therefore demands detailed knowledge of normal behaviour. Because physiological examination is not possible in the wild, reliance must be placed on a detailed knowledge of the situations that are known to cause poor welfare.

Poor welfare can arise from pain, extreme or prolonged stress and emotional situations, and often a combination of two or more such factors. A prey animal in a steel-jawed

trap will suffer pain, stress and fear. In social groups of many species, emotional problems arise and this can lead to poor welfare in a captive situation where escape is restricted. For example, the author has witnessed zebra being injured and stressed by a dominant, overly aggressive male from which the remainder of the group could not escape, and has also witnessed this in primates.

As Broom and Johnson (3) point out, the subjective feelings of an animal are a very important part of its welfare; however, recognising and assessing subjective feelings are far from easy. Suffering is the most important aspect of poor welfare, but an animal with a wound that is no longer painful or where there is immuno suppression can also be described as having poor welfare.

Broom and Johnson (3) divide the assessment of welfare into short term – meaning a few hours – and long term. The majority of short-term welfare problems are due to human impacts described earlier. The other causes are environmental and injuries caused by other animals.

One can assume that humans cause poor welfare by creating over-abundance, for example by reducing available space (which rarely occurs without human impact), by snaring, by the spread of zoonotic diseases such as canine distemper in lions, or by injuries such as those inflicted on elephants trespassing onto farmland. Behavioural measures, reproductive rates and mortality are also important in judging the welfare of an animal.

The behavioural response to moderate to severe pain in a limb can be easily recognised, but if the pain is elsewhere in the body there may be no obvious symptoms. Animals will avoid using a painful limb and may lick or scratch a wound. They react when a painful area is touched, hold the head to one side if there is pain in the ear, and close a painful eye. Symptoms vary from one individual to another, and with the severity of the pain.

When a proposal for an international standard for trapping animals for fur was made, there was an attempt to develop what was called a trauma scale, on the assumption that injury can be used as an indication of pain and stress. At first, injuries were listed and scaled one to ten according to the severity. Later the classification was changed to what was acceptable and not acceptable (Table I).

Although the length of time in the trap before being killed was usually at least two days, fear and stress were not taken into account.

Drowning traps for beaver *Castor canadensis* were considered to be humane by those proposing the International Organization for Standardization standard. In the end, however, this claim was rejected as drowning was considered to be very distressing to the animals. After

Table I
Trauma scale for acceptable and unacceptable injuries in trapped animals

Acceptable	Unacceptable	Injury
	X	Claw loss – toe
X		Oedematous swelling and haemorrhage
X		Cutaneous laceration < 2cm
X		Cutaneous laceration > 2cm
X		Permanent tooth fracture
X		Minor tendon or ligament severance
X		Minor periosteal abrasion
X		Minor (< 2 cm) subcutaneous soft tissue erosion or maceration
	X	Major tendon or ligament severance
	X	Major (> 2 cm) subcutaneous soft tissue maceration or erosion
X		Joint subluxation above carpus or tarsus
	X	Joint luxation below carpus or tarsus
	X	Joint luxation above carpus or tarsus
	X	Compression fracture/periosteal (major) abrasion
	X	Simple rib fracture
X		Simple fracture at or below carpus or tarsus
	X	Compound/simple comminuted rib fracture
	X	Compound or simple comminuted fracture at or below carpus or tarsus
X		Simple fracture above (dorsal to) carpus or tarsus
	X	Compound or simple comminuted fracture above carpus or tarsus
	X	Amputation of one digit
	X	Amputation of two digits
	X	Amputation of three digits
	X	Amputation of four to five digits
	X	Amputation above digits
	X	Spinal cord injury
	X	Severe internal organ damage (internal bleeding)
	X	Death

several years of debate, the scientific group on pain and distress concluded in 1996 that there is no reliable method of scientifically quantifying pain in animals. Injury scales take no account of fear and stress, because such feelings cannot be identified by the presence of an injury; other factors are involved and pain can arise even if there is no visible injury.

Bateson's (1) paper on the assessment of pain in animals begins with solipsism – the belief that the only

consciousness people know about is their own – and the common assumption that, even if solipsism is rejected, the only way that pain can be recognised in another person is through language. Bateson then observes that descriptive signs of pain can be used, that is non-verbal behaviour such as attempts to escape, raised blood pressure, increased respiratory depth and dilation of the pupils.

The point stressed in his article is that, if it is rational to project onto other humans, it is no less rational to extend the generalisation to other species. He does not attempt to quantify pain in animals.

Ten years on, research into consciousness, emotions and brain anatomy has left no doubt that all vertebrate animals can feel pain and suffer stress and emotional problems.

Assessment of welfare in free-living animals

Behavioural responses

To stress

Behavioural responses are often unreliable because animals try to hide symptoms of lowered fitness. All that may be noticed are increases of displacement activity and changes in feeding habits.

Hunting by humans causes stress as well as fear. For example, shooting cliff nesting birds may increase egg loss due to disturbance, and pursuit hunting such as the chasing of deer, *Cervus elaphus*, by horse and hounds was found to be stressful by Bateson (2). It is well known that sport-hunting (for fun not for food) elephants can make them more nervous and increase the flight distance from humans and vehicles, making photographic tourism more difficult.

Stress induced by pollution such as DDT on birds and PCBs affecting the immune system can only be diagnosed by the pathological changes, on post mortem examination. A good example was the mass die-off of North Sea harbour seals, *Phoca vitulina*, in 1988. PCBs are thought to have lowered the immune response of the seals to infection with a phocine distemper virus, and about 18,000 seals died (7).

Hofer and East (12) mention the five-year use of the insecticide fenitrothion on Canadian forests, which caused temporary changes in habitat use by the chestnut sided warbler, *Dendroica pensylvanica*.

Another example recorded by Douthwaite (9) was the effects of DDT on the fish eagle (*Haliaeetus vocifer*) population of Lake Kariba in Zimbabwe, which caused eggshell thinning and absence of chicks in more than half the nests. Douthwaite found that mercury levels were also high.

Capture invariably affects welfare.

When animals are trapped, the steel-jawed trap causes more pain and stress than the cage trap.

Snaring causes serious welfare problems for the animal.

Poisoning invariably causes poor welfare.

Behavioural responses to emotional challenges

Responses to fear such as the startle response, flight, or freezing and cessation of normal activity are easily observed and their intensity may indicate the degree of disturbance.

If food is in short supply the flight distance may be reduced and fights between animals occur, and there may be loss of bodily condition.

Behavioural responses to pain

The responses of an animal to moderate to severe pain in a limb or wing can be easily recognised, but if the pain is elsewhere in the body there may be no obvious symptoms.

Physiological responses in free-living animals

To stress and pain

The main response is increased heart rate and respiratory rate, and to a lesser extent body temperature. An increased respiratory rate can be observed without disturbing the animal. These increases are initiated by the adrenal medullary response secreting adrenalin and noradrenalin into the bloodstream, which occurs within a few seconds of the fear disturbance. These hormones are rapidly metabolised in one or two minutes, so sampling the blood immediately after killing will not produce useful information. Dopamine is also produced by alarming events and later may be found to be depleted in parts of the brain.

These responses are only determined by research techniques that involve capture of the animal and mainly involve changes in blood chemistry and effects on the immune system. Corticotropin releasing hormone is secreted by the action of interleukin (IB), which in turn causes the secretion of ACTH, which stimulates the release of glucocorticoids. The levels of glucocorticoids can be identified and give useful information about the welfare of an animal.

The major problem with measuring the adrenal cortex response is that the taking of a blood sample causes stress.

In primates and ungulates the predominant glucocorticoid produced is cortisol, whereas in rodents and chickens it is corticosterone. The level of prolactin also increases.

All short-term deleterious effects on welfare – crippling animals with gun shots, capture myopathy, vaccination,

and radio collaring or other marking methods – could have long-term consequences, such as effects on health. There is always danger with vaccination. The vaccine may not be exactly right for the species and there is stress of capture. Their potential long-term consequences should therefore be recognised and monitored. Two examples include the effect of vaccination on the black-footed ferret, *Mustela nigripes*, and on the African wild dog, *Lycaon pictus* due to problems always inherent with vaccines and the stress of capture and handling, which with some vaccines may have to be repeated.

Long-term effects include reduced reproductive rates, loss of weight, and impairment of the immune system leading to disease and shortened life expectancy.

Physiological responses to noise

The effects of noise on wildlife were discussed in a symposium organised by the Royal Society for the Prevention of Cruelty to Animals (RSPCA) that considered both the direct disturbance and the interference with wild animals acoustic signalling.

Many species, such as birds on airfields and rats in the London Underground, seem to be completely unaffected by very loud noise. However, species like elephants, crows and pigeons learn the significance of gun shots and depart, while other species may be attracted to some noises that humans make; elk for example are attracted to steam engines and mosquitoes attracted by engine noise.

The question arises of whether animals hear the early sounds of an imminent earthquake, because their behaviour changes before the earthquake strikes.

Probably the most significant effect of noise caused by humans is on marine vertebrates, though high-powered sound waves have been used to de-insecticise stored grain.

Physiological responses to capture

The capture and transport of wild animals inevitably impair welfare. The capture techniques include cage trapping, camp traps, drug immobilisation, mass capture by driving herds into a boma (an enclosure), net guns, manual capture using a lasso, foot-hold traps, and in the case of tortoises simply picking them up. These methods are all described in a book called *The capture and care manual* edited by A.A. McKenzie (22). The book also covers the precautions that must be taken to minimise effects on welfare and prevent injury to humans. There are also sections on transportation by road and air, which also impair welfare.

The International Air Transport Association has published guidelines on crating and documentation of wildlife, as has the Convention on International Trade in Endangered Species (CITES). These cover the size and construction of the crate and feeding and watering.

The welfare concerns of capture and transport are stress, injuries, shock, dehydration and adverse reactions to captive drugs. The author was in charge of the animal reception centre at Heathrow Airport for eight years, when almost a million living creatures passed through each year. Nearly a third were birds and mortality was high. For several years between 20,000 and 30,000 monkeys from India passed through. Welfare could only be described as poor. In recent years there have been improvements.

Physiological responses to marking

Animals are marked for identification by various methods such as microchips under the skin, rings on birds, clipping hair off, paint and stains on body, tags attached to flippers of seals and fins of fish, radio transmitters attached by various methods, clipping toes off small mammals and freeze branding. Most of these methods require capture and handling of the animals. The whale is one exception and is marked by the use of a harpoon tag inserted by hand or a gun.

Most of the methods do not seem to cause any welfare problems once achieved, except the method of removing a toe.

Captive animals

Captive animals include animals kept in zoos, safari parks, circuses, aquaria and by the public as companion animals, in laboratories for research, fish farming and captive breeding, and the civet cat which is kept in confinement for the perfume industry.

The main welfare problems are emotional and the stress resulting from these emotions. Animals should be properly fed and any pain they may suffer should be only accidental and promptly receive veterinary treatment. However, when non-expert owners keep companion animals, problems can arise that go unnoticed. In the course of work as a wildlife vet, the author has seen many cases of ill health such as rickets caused by the wrong diet, which only become noticeable to the owner when extreme. Not infrequently reptiles are kept in the wrong environment; for example a desert snake or lizard may be kept in a humid vivarium, or a snake that needs a moist environment kept in dry conditions. Sometimes terrapins that need a pool are kept like tortoises. Unfortunately, owners are often unable to assess welfare until the problem becomes so obvious that they need to call for a vet who is experienced in wildlife diseases.

The Federation of Zoological Gardens of Great Britain and Ireland produced a document on monitoring stress in zoo animals in 2004 by T. Smith (29). The monitoring, which was non-invasive, concentrated on the measurement of glucocorticoids in urine and faeces.

The document described stress as the biological response elicited when an individual perceives a threat to its homeostasis, and this includes long-term low-grade stress. It lists under physiological changes five components of stress response commonly used to assess stress levels, namely:

- parameters of immune function (e.g. decrease in T and B lymphocytes)
- cardiovascular output (e.g. heart rate, blood pressure)
- Darwinian fitness (e.g. reproductive output, longevity)
- endocrine parameters (e.g. concentrations of adrenalin or cortisol)
- behaviour (e.g. rates of scratching).

Smith advises that since the response varies both in individuals and situations, more than one index should be used. The two most commonly used are behaviour and quantification of glucocorticoids (typically cortisol) because one of the major changes is increased activity in the hypothalamic-pituitary-adrenal axis. The document points out that there are a range of variables that affect cortisol levels and lists species, population, genetics, individual temperament, social status, reproductive condition, developmental history, age, health condition, social environment, social support, season, weather conditions and time of day.

Because cortisol levels vary widely among individuals, the guidelines advise incorporating an extended control period that includes a range of events as described above, incorporating as many individuals as possible, taking a number of urine samples and doing this at the same time each day so as to minimise stress. It is suggested that samples be kept on ice after collection and frozen at minus 20°C within 2 h. The document gives a comprehensive list of references for further reading.

The psychological problems encountered in captive animals are frustration and boredom due to their being prevented from fulfilling inherited biological needs, and continual mild fear or anxiety when they are unable to hide or have the necessary distance (flight distance) from humans. Some social species need the company of suitable companions and an individual will be stressed if kept solitary or with a group that is socially unstable.

Behavioural signs of stress

W.J. Jordan (13) has described behavioural responses to captivity in zoos. Especially among animals caught in the wild, these responses include stereotyped movements, pacing, ritual head turning, and repeated regurgitation and ingestion of food. Also hypertrophies develop or the lowering of thresholds, so that trivial stimuli may trigger abnormal behaviour. Some species – the extreme specialists such as the big cats and snakes, and the diet specialists like

the koala, *Phascolarctos cinerfeus*, and anteater, *Myrmecophaga tridactylia* – are more content than the opportunists – the neophilic – that never relax but are always exploring, even in the presence of an adequate food supply. The effects of captivity on this latter group are extreme. They deal with the situation in the following ways:

- a) they introduce novelty by inventing motor patterns
- b) they react to visitors in ways such as throwing things or begging
- c) they increase the quantity of reaction to normal stimuli
- d) they vary their reaction by, for example, playing with their food, and animals that prepare their food in the wild (such as agouties) will clean and peel food that has already been prepared; rodents will try to bury their food on concrete floors
- e) they perform normal responses to subnormal stimuli
- f) they perform rhythmic sequences, e.g. stereotypies such as pacing and circling
- g) some animals become coprophagic
- h) increased aggression and hypersexual behaviour can occur
- i) excessive grooming and cleaning leading to self-mutilation can occur, particularly in primates, carnivores and parrots
- j) animals may become apathetic.

In March 2000 the British government's Department of the Environment, Transport and the Regions published a document called 'Secretary of State's standards of modern zoo practice', which had a small section on welfare listing five principles (see www.defra.gov.uk/wildlife-countryside/gwd/zooprac/pdf/zooprac.pdf).

Provision of food and water

Both food and water are basic needs. The method of food presentation, the frequency of feeds and the nutritional balance must be taken into account. Food should be presented in a manner and frequency commensurate with the natural behaviour of the species, as well as the animals' nutritional requirements, which may vary according to season.

Provision of a suitable environment

An environment consistent with species requirements must be provided. This should include shade and shelter from rain, heat and cold, as appropriate. For example, animals that dig and root must be provided with suitable substrates, and climbers with appropriate three-dimensional environments. A balance must be struck between hygiene and the biological requirements of the species.

Provision of animal healthcare

Injury

An enclosure designed to minimise the risk of injury must be provided. The design should allow animals to get away from each other. In exhibits of mixed species, care should be taken that one species cannot injure another. Enclosures should be designed to minimise the risk of predators entering the exhibit.

Disease

Curative and preventive veterinary medicine should be provided. Every effort must be made to provide a correct diet and suitably hygienic environment from which pathogens are excluded or controlled.

Provision of an opportunity to express most normal behaviour

Animals should be allowed the opportunity to express most normal behaviour, taking into account current enrichment and husbandry guidelines.

Provision of protection from fear and distress

Particular areas to look at are: group composition, sex ratios, the numbers of animals in an enclosure, and space and furniture in both indoor and outdoor areas. Zoo animals are often confined for long periods in indoor area and the group composition should reflect this situation.

Enclosure design should allow for as much normal behaviour as possible, and provide areas of escape from other animals and the public.

Animals often benefit from mixed species environments. However, inter-species conflict can cause stress and this needs to be monitored, recorded and reviewed. Safety from potential predators must also be ensured.

Assessments of welfare can be made as described above and also by checking that the principles discussed above are followed.

J. Webster (31) points out that the main welfare problems in well-kept zoos are likely to be psychological, namely boredom, frustration and anxiety. To this the author would add fear for some of the more timid species. Webster goes on to say that predators are not permitted to hunt, nor can animals be allowed to hide from the public who have paid to see them. Species such as monkeys may experience frustration of their motivation to gather food. In what Webster (31) calls higher animals, there is anxiety about being confined in small barren enclosures in constant sight of humans, which can lead to ulcerative colitis. He also points out that there is a loss of responsiveness to stimuli in animals that have been denied for long periods the opportunity to perform constructive behaviours that give

pleasure or avoid pain. This was described by Professor Meyer-Holzappel (23) who wrote 'the indifference of the animal to all goings-on is comparable to states of mourning and depression in man' and therefore a sign of poor welfare.

In a report by Lindley (19) on conditions in zoos in Ontario, Canada, the author points out that measuring blood cortisol or other parameters is not adequate to prove that an animal is 'stressed' at a given time; it must be clear how that parameter relates to a particular kind of stress (e.g. exhaustion, fear or overheating). Behaviour can, however, be described accurately, as in the case of the various types of stereotypic behaviour that are repetitive, apparently functionless and do not occur in the wild. Displacement behaviour occurs when an animal is frustrated in its aims.

In order to care properly for any animal in captive conditions it is imperative to recognise that the composite creature is more than just flesh, blood and bone – animals also have natural desires and feelings (14).

Wemelsfelder (32) has suggested that: 'each animal has basic, genetically inherited, behavioural needs which clearly matter to it, because when it is prevented from performing these behaviours it resorts to abnormal behaviour or becomes apathetic. An animal can be said to be bored when it has to adapt to its environment in an abnormal way, indicative of under-stimulation, in order to maintain its sense of selfhood. Boredom can be regarded as a form of distress, indicating that an animal is stressed, not due to over-stimulation, but due to under-stimulation.'

Lord (20) asks if an animal pacing its cage is as disturbed as a human with schizophrenia pacing a room, and points out that psychiatrists have long known that abnormal repetitive behaviours in humans are a symptom of something more worrying. Such behaviours occur in over 36 mental disorders.

Elephants are among the most social animals, and according to Stevenson (30) elephants must be maintained in as appropriate a social group as possible so that welfare needs can be fully realised. Failure to do so will result in poor welfare.

Assessing the welfare of laboratory animals has been more than adequately dealt with in a 207-page report by Caroline Manser (21). It covers behaviour, glucocorticoids, anterior pituitary hormones, posterior pituitary hormones, catecholamines, cardiovascular physiology, neurochemistry, opioid peptides, the immune system, pathological lesions related to stress, miscellaneous parameters, body weight and assessment of pain.

Manser points out that stressors can be emotional or physical, although there is some overlap. Stressors that affect laboratory animals, such as the fear of mice and rats in open spaces and bright lights, may not always be apparent to the handlers. Stresses of captivity and laboratory procedures are particularly intense in primates.

Sales *et al.* (25) have pointed out that ultrasound generated by running taps and cage washers is adversary to rodents. Manser lists elements that affect behaviour patterns as:

- a) fear related
- b) anxiety related
- c) frustration in the group
- d) position in the social order of the group
- e) separation from the group
- f) apathy or depressed behaviour.

Manser cautions that assessment should be done without disturbing the animals to get a reliable result.

Dr Kalin (16) is a neuroscientist who has studied the neurobiology of fear. A lot of his work in recent years has been done with rhesus monkeys (*Macaca mulatta*). He has shown that levels of stress hormones influence how appropriately animals and people behave in the face of fear. For example, monkeys that started off with a relatively low level of cortisol in the blood froze for shorter periods in the face of a frightening situation than did their counterparts with higher cortisol levels. Dr Kagan (15) and his colleagues found a similar situation in the reactions of children to frightening situations. They measured cortisol concentrations in the saliva of children at home where they were most relaxed and then observed the children confronting an unfamiliar situation in the laboratory. High basal cortisol levels were associated with greater inhibition in the strange setting. These similarities between humans and monkeys again imply that monkeys are reasonable models of human emotional reactivity.

Circus animals present a different problem because the animals are trained and/or tamed, so behavioural responses may be impossible to interpret. There is the added stress of travelling, close confinement and the denial of social grouping for those species for which such grouping is necessary.

The author examined the welfare of two circus elephants in Spain. One was crippled, with a hind leg that had healed at an abnormal angle after a fracture. Both animals were kept in a steel container truck where the temperature reached 50°C in the summer days. Animal welfare was very poor but there were no obvious behavioural signs.

Schmid (27) examined the effects of keeping 29 circus elephants temporarily in paddocks. He found that stereotype movements were virtually absent in such conditions, although they were very frequent when the shackled keeping method was used.

Moinde *et al.* (24) collected scientific data to assist in the development of guidelines for humane relocation of threatened and endangered arboreal non-human primates by studying a troupe of 31 lowland Sykes monkeys (*Cercopithecus albotoxatus*). For animal welfare, they concluded that data about the normal behaviour of the monkeys should first be collected, that many traps should be used simultaneously to avoid caging the monkeys too long, and that the relocation site should be carefully considered.

Poor welfare can cause varying degrees of immunosuppression. For example, glucocorticoids inhibit immune function by inhibiting interleukin 1 synthesis. Stress increases susceptibility to mammary tumour in rats.

Rabbits and mice kept in overcrowded cages develop thickened artery walls and microscopic heart muscle lesions.

Fish in farms can become infected with disease and parasites, which will have an impact on welfare.

Endangered species that are bred in captivity can suffer the same welfare problems as animals in zoos.

Species bred in captivity for other purposes, such as birds and mammals reared for release for sport hunting, may suffer the added welfare problems of transport. Farming of turtles subjects the animals to close confinement in tanks.

The civet cat in Ethiopia is kept in a cage unable to turn around, causing severe welfare problems.



Évaluation scientifique du bien-être des animaux sauvages et en captivité

B. Jordan

Résumé

Ces dix dernières années, l'intérêt accru et la recherche sur la conscience, les émotions, le stress et la douleur, ont servi l'évaluation scientifique du bien-être des animaux sauvages, vivant en liberté ou en captivité. Comme il est impossible de réaliser une étude physiologique détaillée chez les animaux vivant en liberté, il faut recourir au comportement et à la valeur adaptative darwinienne, qui sont en corrélation avec le bien-être. Seuls les animaux en captivité se prêtent à la réalisation d'études physiologiques plus complètes, non sans difficultés.

En résumé, il est démontré que le bien-être d'un animal est amoindri si celui-ci présente un comportement similaire à celui des animaux dont les réponses physiologiques indiquent un mal-être et si sa valeur adaptative darwinienne est affectée comme chez ces animaux.

Mots-clés

Comportement – Conscience – Douleur – Émotion – Maladie – Physiologie – Stress.



Evaluación por métodos científicos del bienestar de los animales salvajes y cautivos

B. Jordan

Resumen

En los últimos diez años, la evaluación por métodos científicos del bienestar de la fauna salvaje y cautiva se ha beneficiado del creciente interés que despiertan temas como la conciencia, las emociones, la tensión o el dolor y del volumen cada vez mayor de investigaciones al respecto. Dada la imposibilidad de efectuar un estudio fisiológico detallado en animales en libertad, es preciso basarse en el comportamiento y la "aptitud" darwiniana, que según se ha comprobado guardan correlación con el bienestar. Sólo en los animales cautivos es posible, y no sin dificultades, realizar estudios fisiológicos más completos. Dicho en pocas palabras: cabrá pensar que el bienestar de un animal corre peligro cuando muestre un comportamiento semejante al de animales cuyas respuestas fisiológicas denoten, pruebas mediante, un escaso nivel de bienestar, y cuando su aptitud darwiniana se vea comprometida de forma análoga a la de esos animales.

Palabras clave

Comportamiento – Conciencia – Dolor – Emoción – Enfermedad – Fisiología – Tensión.

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