THE WELFARE OF FREE-LIVING WILD ANIMALS: METHODS OF ASSESSMENT

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In assessing the relative merits of farm animal production systems or research procedures using live animals, the impact on the welfare of the animals involved is increasingly being taken into account. Many human activities and human-induced environmental changes can, similarly, adversely affect the welfare of free-living wild animals. As part of a study to investigate the ways in which, and the extent to which, this occurs, we considered methods for the assessment of wildlife welfare. Although it is widely accepted that animals can experience and suffer pain and stress, there are difficulties in measuring the intensities of these states (and continuing debate about the terminology and meaning of these and related concepts as applied to animals). In attempting to scale the degree of harm in the various cases examined, a number of factors need to be considered, including: the nature of the harm caused, its duration, the numbers of animals affected and their capacity for suffering. We explored ways of quantifying these. The study was undertaken to provide a basis for prioritizing actions to alleviate existing wildlife welfare problems and for assessing the possible wildlife welfare impact of future environmental changes or changes in industrial, agricultural and other practices.

Keywords: *animal welfare, birds, mammals, pain, stress, welfare assessment, wildlife*

Introduction

There has been a great deal of interest in the impact of human activities and human-induced changes to the environment on populations of wild animals. It has been estimated that the 5.3 billion human population consumes about 39 per cent of the total terrestrial primary production (the solar energy 'fixed' by plants) of the earth (IUCN/UNEP/WWF 1991) and the pursuit of human interests has often been detrimental to wildlife. In an overview of threats to vertebrate taxa Seal *et al* (1993) estimated that of 3,559 vertebrate taxa about which enough was known to permit assessments of population status, 1,390 (39%) were either critically endangered, endangered or vulnerable. Since the year 1600, 285 species of animals are known or believed to have become extinct (World Conservation Monitoring Centre [WCMC] 1992). Concerns for the conservation of species have led to many measures to protect and preserve both threatened habitats and also populations of specific rare and endangered species. In Europe recent legislation includes the Economic Community Directive 79/409/EEC on the Conservation of Wild Birds; the Ramsar Convention on Wetlands; the Bern Convention on the Conservation of European Wildlife and Natural Habitats, and the Bonn Convention on the Conservation of Migratory Species.

Table 1 **Some examples of ways in which human activities or changes to the environment have compromised or could compromise the welfare of free-living wild animals.**

1	By reducing food availability either by direct competition or indirectly by disturbance to the environment (Monaghan 1992).
2	As a result of consequences of artificially supporting high populations, for example: increased inter- or intra-species aggression, increased incidence of infectious diseases, and starvation when food supply cannot be sustained (eg Jessup 1988).
3	By accidental or deliberate introduction of infectious diseases (see Plowright 1988; Woodford & Rossiter 1993).
4	By releasing chemical pollutants into the environment leading to acute or chronic poisoning (Davis 1982; Camphuysen 1989; Ormerod *et al* 1991).
5	As a result of contaminating the environment with harmful debris (eg Balazs 1985; Camphuysen 1990).
6	By creating structures or using machines that may cause injury (eg Bevanger 1990; Haas 1993).
7	As a result of habitat destruction (Johnson 1991).
8	By introducing non-endemic animals (domestic or wild) into the environment which displace or harm wildlife (eg Furness 1988; May 1988).
9	By deliberate or accidental disturbance at, for example, nest or feeding sites (eg Yalden & Yalden 1990).
10	As a result of measures which do not result in instantaneous death to control wild animal populations, for example: shooting, poisoning, trapping or removing a food source (Britt 1985).
11	As a result of sub-optimal techniques in wildlife capture, release and translocation for sport, conservation, research or trade (eg RSPCA 1991; Woodford & Kock 1991).
12	As a result of sub-optimal techniques in the handling, husbandry, treatment and release of wildlife casualties (see Harris 1989; Lewis & Stocker 1993).
13	As a result of techniques which do not result in instantaneous death used in the capture and killing of wildlife for food or other resources.
14	As a result of disturbance or injury resulting from human recreational activities.

Paralleling the conservation movement, there has been growth in interest and concern for animal welfare. This has led to more rigorous and formal assessments of the welfare impact of management and research procedures on domestic and laboratory animals. Increasingly, the economic benefits of new or improved systems for farm animal production are weighed against any negative animal welfare impact (eg Sainsbury 1986; Moss 1992) and a similar process is applied, and more strictly formalized, in the assessment of whether the benefits of a research programme using live animals justify their use and any possible suffering caused to them (Smith & Boyd 1991). Furthermore, a considerable amount of legislation has been enacted recently to protect the welfare of, for example, animals in transit (EC Directive 91/628/EEC); animals used in research (*Animals* [*Scientific Procedures*] *Act 1986*); animals in zoos (*Zoo Licensing Act 1984* and the proposed EC Zoo Directive), and pet animals (the proposed European Convention for the Protection of Pet Animals).

In contrast to the interest in wildlife conservation and domestic animal welfare, the impact of human activities and human-induced environmental changes on the welfare of free-living wild animals has received relatively little attention. There is, however, no doubt that human activities have often had a severe effect on the welfare of wild animals (see Table 1; Swingland 1992; Wilkins 1992; Sainsbury *et al* 1993).

The traditional view in many societies and cultures is that humans are responsible for the welfare of animals under their care – domestic animals – but not for that of wild animals. However, because much of the earth's surface is now under human control, partial control or influence, and this inevitably often affects the fate of wild animals, it is now widely accepted that we have a degree of responsibility for their welfare. Attitudes to this subject differ and depend to some extent on such factors as the extent to which man is perceived to be the cause of incidents that harm the welfare of wildlife and the severity of the harm. However, many feel that we have an obligation to protect the welfare of wild animals as far as possible from harm caused by human activities, and some go a step further and advocate the veterinary care of free-living wild animals. There has been a dramatic increase in interest in some countries in interventions for wildlife welfare, for example in the rescue, treatment and rehabilitation of wildlife casualties (McKeever 1979; Cooper 1989; Kirkwood 1991,1993; Pierce 1991).

In the ethics of wildlife utilization or interactions there is a move towards assessment of the benefit of programmes, not just in relation to their possible impact on population viability, but also with respect to their welfare consequences. Concerns for welfare have led to tightening of controls on trade in wild animals and the harvest of wildlife for food or other products. For example, some countries have argued for a ban on whaling on the grounds that there is no humane method of slaughter.

It seems likely that welfare considerations will be taken into account increasingly in such interactions with wildlife in future and there is a need, therefore, to develop a methodology for wildlife welfare assessment. In the ethics of animal exploitation, it is often necessary to judge whether the benefit of a particular procedure outweighs the harm caused or whether one procedure is less harmful than another. Our aim in this paper is to outline and discuss ways in which the levels of harm caused to the welfare of individual free-living wild animals may be assessed for subsequent examination in relation to the benefits arising (for man or other

animals) from the human activities which cause them. It has become standard practice for environmental impact assessments to be undertaken prior to authorizing developments which may have a deleterious effect on habitats and their fauna and flora populations. In contrast, this paper is concerned with the welfare of individuals and we have chosen to focus on mammals and birds.

As far as we are aware, there have been few attempts to review the impact of human activities on the welfare of free-living wild animals or to assess and compare the scale and severity of particular cases. Although methods have been proposed for making such assessments for laboratory animals to assist in judging whether the benefits of research outweigh the harm caused by the procedures (eg Morton & Griffiths 1985; Smith & Boyd 1991; Porter 1992), there are no established methods for comparable assessments of harm caused to wild animals. Here we consider some methodological problems associated with this subject as it applies to wild mammals and birds.

Assessment of the scale and severity of harm to the welfare of free-living wild animals

Assessment of the scale and severity of harm to welfare requires consideration of several factors. We propose that at the simplest level these are:

1. The number of animals affected.
2. The cause and nature of the harm.
3. The duration of the harm.
4. The capacity of the animal to suffer.

The number of animals affected and the duration of the harm to each individual (points 1 and 3) give an unambiguous and rational description of the scale of the problem in terms of animal days. The nature of the harm and the capacity of the animal to experience and suffer pain and stress (points 2 and 4) pertain to the intensity of the harm to the animal. Although there may be practical difficulties in measuring or estimating the number of animals affected or the duration of the harm, these parameters present no great conceptual difficulties. Assessment of the severity of harm and the capacity of animals to suffer is, however, less straightforward because it is not possible to experience the feelings of other animals (including humans). This problem has been discussed by many authors (eg Crook 1983; Duncan & Dawkins 1983; Bateson 1991; Walvoort 1991; Sandøe & Simonsen 1992; Mason & Mendl 1993). Our approaches to assessing and where possible quantifying each of these factors (1 to 4) in free-living wildlife are discussed below.

1. The number of individuals affected

It may be relatively simple to estimate the number of animals affected in discrete incidents (eg localized oil-spills) at which reliable counts of affected animals have been made. On the other hand, estimating the total number of animals affected per year by a challenge that occurs repeatedly or continuously over a wide area (eg use of anticoagulant rodenticides), may be difficult. Where precise data are difficult to obtain, it may be possible, at least, to make cautious estimates of the upper and lower levels of the numbers involved in some regions.

2. The nature of the harm

The assessment of harm to wildlife welfare depends, in each case, upon knowledge of the challenge or cause of the harm (eg ingestion of lead shot, entanglement in fishing line); observation or knowledge of its effects (eg local tissue damage, prolonged attempts to escape), and on inference of the welfare consequences (eg severe pain, fear, distress). It is important to define and categorize both the cause and the nature of the harm as precisely as possible so that the rationale for the welfare inferences (see below) is clear. Some examples taken from the survey by Sainsbury *et al* (1993) are listed in Table 2.

Table 2 **Example of classification of causes and types of harm to the welfare of free-living wild mammals and birds resulting from human activities or human-induced changes to the environment.**

Group affected	Cause	Human activity	Effects	Welfare consequences
Waterfowl	Ingestion of lead	Dispersal of lead shot and lead fishing line weights	Include: Anaemia Enteritis Weight loss Central nervous system disturbance	Severe distress Pain
Seabirds, waterfowl	Oiling	Spillage of fuel oils	Contamination of plumage Hypothermia Cold stress Toxic effects – local tissue damage	Severe distress Pain
Birds	Entrapment	Mist netting for ringing	Fear Incapacitation	Overstress
Marine mammals	Entrapment (by catch)	Use of some types of fishing gear	Superficial wounds Drowning	Pain Severe distress
Rodents	Ingestion of anticoagulant agents	Control of rodent pests	Haemorrhages	Severe distress Pain

(*cases from Sainsbury* et al *1993*)

Humans recognize a variety of states which cause unpleasant sensations. These include pain, fear, anxiety, boredom, frustration, exhaustion, stress and disease. Although it cannot be proven, it is quite logical to suspect that unpleasant states, that to some extent correspond to these, can be experienced by some animals. Assessment of these states is, however,

difficult as has been discussed by many authors (eg Kitchell & Johnson 1985; Moberg 1985a; Morton & Griffiths 1985; Sanford *et al* 1986; Wallace *et al* 1990; Bateson 1991; Smith & Boyd 1991; Porter 1992; Sandøe & Simonsen 1992; Wall 1992; Mason & Mendl 1993). There are, fundamentally, two problems. The first is the technical difficulty of measuring indices of, for example, pain, fear or stress. The second is the difficulty of knowing to what extent the animal is conscious of, or suffers, these states (see Crook 1983).

In this section we discuss and review the concepts of stress, fear, frustration, pain and some other states, and we also discuss the welfare relevance of disease. The second issue, that of the capacity of animals to suffer these states, is considered later.

Stress

The concept of stress has proved to be difficult to define (Moberg 1987). It is commonly used to infer difficulty in coping but, strictly, the term describes a state of threatened homeostasis (Johnson *et al* 1992). Stress responses are combinations of anatomical, physiological, biochemical, immunological and behavioural adaptations to changes or challenges in an animal's environment (Sanford *et al* 1986). The three broad classes suggested by Sanford and others (1986) are useful. Paraphrased and altered slightly, these follow:

Physiological stress – in which the animal puts little effort (resources) into the response and is unconscious of this effort, and in which adaptation is within the normal range.

Overstress – in which the animal diverts significant, but still unconscious, effort (resources) into the adaptive response which may lead to the detriment of other biological processes (growth, maintenance of immune function etc).

Distress – in which the animal puts substantial effort (resources) into the adaptive response and is probably aware of the effort and may be considered to be suffering, and in which the diversion of effort is to the detriment of other biological processes and in which the response may have detrimental side-effects (see below).

Stressors can be physical or psychological. Physical stressors include disturbances of the internal environment (eg hypoxia, hypoglycaemia); external environmental challenges (eg extreme heat and cold), and multifaceted stressors (eg noxious stimuli and physical strain such as exercise or injury). Psychological stressors include those that result in fear, anxiety or frustration (Johnson *et al* 1992). In many cases physical and psychological stressors act in combination.

If a challenge is mild or of short duration, the stress response may rapidly bring about changes which negate the effect of the stressor and return the animal to a state of homeostasis. However, if the stressor is present for a longer duration, a complex series of neuro-endocrine changes may occur and there is a delicate balance between the adaptive effects of these responses and their potential for harmful effects. Examples of pathological effects brought about through side-effects of a stress response (distress) to a severe or chronic challenge include: arteriosclerosis (Radcliffe *et al* 1969); stomach ulceration (Brodie & Hanson 1960); acceleration of ageing (Johnson *et al* 1992); reduction in resistance to infection (Cohn 1991); depression or abnormal behaviour; weight loss or reduction in weight gain (Smith & Boyd 1991), and suppression of reproductive function (Moberg 1985b).

The relationship between levels of stress and welfare has been addressed by various authors (eg Broom 1985; Moberg 1985a; Wiepkema & Koolhaas 1993). As implicit in Sanford and others' (1986) classification into physiological stress, overstress and distress, it is generally accepted that the levels of stress that result in harmful effects, namely the diversion of efforts to such an extent that normal functions (immuno-competence, growth, reproduction etc) are compromised or that pathological changes occur, compromise welfare. It is also widely accepted that levels of stress that would, if not alleviated, lead to pathological states are unacceptable for the welfare of captive animals. Moberg (1985a, 1987) describes the concept of a pre-pathological state in this context. High stress levels (overstress or distress) may be caused by a number of types of challenge including disease (and other causes of pain) and occur when animals experience a substantial reduction in predictability and/or control of events (Wiepkema & Koolhaas 1993). As an example of severe stress associated with extremely low predictability and control of events, Wiepkema & Koolhaas (1993) suggest the state experienced by an inexperienced but alert rat restrained for an hour on a laboratory table.

There are considerable difficulties in measuring stress levels. Various authors (eg Moberg 1985a) have considered the use of a suite of behavioural, autonomic and neuroendocrine responses as possible indices of well-being. However, since biological responses of an animal vary depending on the nature of the stressor and responses to the same stressor can vary between individuals, interpretation of results is complicated. No single response (eg change in corticosteroid level, heart rate or behaviour) can indicate if a particular situation is stressful and it is therefore recommended, in the assessment of welfare of farm or laboratory animals, that a number of physiological and behavioural variables are monitored simultaneously. The measurement of stress levels in free-living wild animals therefore presents considerable challenges.

Wiepkema and Koolhaas (1993) presented a list of critical signs to assist in evaluating an animal's stress status. These are helpful to the assessment of the stress status in free-living wild animals and are worth mentioning here (with some changes). Those associated with a pre-pathological state are: chronically enhanced plasma cortisol levels; abnormal reactivity of neuro-endocrine systems (eg heart rate changes); reduced immune capacity, and reduced reproductive capacity. Signs of a pathological state of stress are: most of the above; severe disease; severe external wounds or organ damage; behaviour associated with being ill or wounded; expressions of fear, and injurious behaviour (Wiepkema & Koolhaas 1993). The concepts of pre-pathological and pathological states correspond quite closely with those described by Sanford and others (1986) as overstress and distress.

Sainsbury and others (1993) decided not to attempt to grade stress but simply to decide, from knowledge of the cause of the challenge in each case examined and its effects (see Table 2), if it was likely that the animals involved were stressed or not. It was assumed that all conditions that were likely to be associated with pain, incapacity (confinement or loss of function due to, for example, healed injuries) or fear would also cause stress. However, where sufficient information about the causes and effects of particular wildlife welfare challenges is available, it would not be unreasonable, using the criteria offered by Sanford and others (1986) and Wiepkema and Koolhaas (1993), to attempt cautiously to discriminate between

overstress and the more severe condition of distress. An animal that injures itself in attempts to escape or which has severe disease can be described as being in a state of distress, whilst one which is likely to be diverting significant resources away from normal functions but which is probably unconscious of the effort and, as yet, in reasonable health, can be described as being in a state of overstress. We suggest that the term severe distress may be appropriate to describe cases in which the harm leads to the death of the animal.

Anxiety and fear

Although there has been a tendency to deny that animals can experience anxiety but an acceptance that they do experience fear (Rowan 1988), attempts to distinguish between anxiety and fear have not been entirely satisfactory (Smith & Boyd 1991). The term anxiety has been used to encompass several states, such as fear and apprehension, that are difficult to define and measure. Erickson (1950) commented that (in humans) 'fears are states of apprehension which focus on isolated and recognizable dangers...anxieties are diffuse states of tension...which magnify and even cause the illusion of an outer danger, without pointing to appropriate avenues of defence or mastery.' Anxiety can arise as a correlate of stress and pain but, at least in humans, may also arise independently of these (Smith & Boyd 1991).

We suggest that attempts to subcategorize fear or to distinguish between fear and anxiety in free-living wild animals are inappropriate at present. It seems reasonable to consider fear in assessments of wildlife welfare because, particularly if severe or prolonged, it is likely to be experienced as an unpleasant state and one which, through diversion of resources (time and energy) away from normal functions, may cause overstress or distress. Signs that can be attributed to fear (eg vigorous attempts to escape when captured or confined) are often clearly shown by wild animals.

Boredom and frustration

If a state like that of boredom in humans occurs in animals, it is more likely to arise in captive animals confined in relatively stable and uniform environments than in free-living animals. However, it is possible that free-living animals that are persistently prevented from carrying out an activity they are motivated to perform suffer from some frustration. This could occur, for example, as a result of repeated disturbance at feeding or breeding grounds and, here again, could lead (as a result of diversion of time and energy resources from normal biological functions) to pre-pathological or pathological states. However, in view of the difficulties of defining or measuring frustration, we consider that it would not be appropriate to include it as distinct from stress in consideration of the welfare of free-living wildlife. Incapacity due to entanglement in nets or capture in traps might cause frustration, but in most cases, resulting stress probably can be attributed to fear or physical harm (eg injury or oxygen or food starvation) rather than to frustration.

Pain, discomfort and suffering

Pain is a perception that has no definitive physical dimensions and which is modified by circumstances (Kitchell & Johnson 1985). It is not surprising therefore that its detection and assessment presents a number of difficulties in both mammals (eg Kitchell & Johnson 1985; Morton & Griffiths 1985; Bateson 1991; Wall 1992) and birds (Gentle 1992). Zimmerman (1986) defined pain as 'an aversive sensory experience that elicits protective motor actions,

results in learned avoidance and may modify species-specific traits of behaviour'. It is normally elicited by stimuli which are actually or potentially noxious (Kitchell 1987). In humans, the term is often used to describe emotional states as well as physical sensations, but in the animals with which we are concerned, it is probably appropriate to restrict the definition to include the latter only.

Some authors have distinguished between pain and discomfort, eg Spinelli and Markowitz (1987) offered hangovers and motion sickness as examples of states that were associated with discomfort rather than pain in humans. However, the concept of discomfort is close to that of tolerable pain and the distinction between them is blurred and immeasurable, at least in animals, so it seems appropriate to include all forms of unpleasant physical sensations as varieties of pain and to be cautious in making qualitative distinctions regarding their nature.

Pain can be classified, according to its severity, as tolerable or intolerable. Tolerable pain in animals is that at a level at which the animal exhibits no signs and which cannot therefore be detected by an observer. It is assumed to occur by extrapolation from human experience. Intolerable pain is that at an intensity which causes detectable behavioural or other changes or signs (Spinelli & Markowitz 1987). Tolerable pain cannot, by definition, be detected by behavioural signs but intolerable pain can be assessed by observing signs that would be consistent with it in humans and other animals. However, the use of human perception of an animal's behaviour as a yardstick of the severity of pain has some obvious and some less obvious difficulties (see discussions by Bateson 1991 and Wall 1992). Animals may not react to pain in the same way as humans and the ability to tolerate pain is likely to vary widely from one individual to another and with time (as in man). Reliable interpretation of signs of pain is likely to depend on thorough knowledge and familiarity of the normal behaviour of the species and its responses to various challenges. Signs that are indicative of pain in a variety of species have been clearly set out by Sanford and others (1986).

In the context of welfare assessments of free-living wild animals, it is reasonable to assume that pathological lesions detected by clinical or post-mortem examination can provide a basis from which to judge the likelihood of the presence of pain (see Walvoort 1991) and estimation of its severity. This requires extrapolation from human experiences and familiarity with the responses of other animals to similar lesions. In our survey of wildlife welfare (Sainsbury *et al* 1993), we made our judgement on the likelihood of pain in each case from knowledge of the cause and the type of pathological lesions resulting (see Table 2). We suggest that it is not unreasonable, from knowledge of severity and type of lesions, to attempt to distinguish severe pain from lesser levels of intolerable pain. For example, we would classify a compound fracture of the femur as a cause of severe pain in contrast to the level associated with an injury which resulted in only a slight limp.

Spinelli and Markowitz (1987) defined suffering as 'a severe emotional state that is extremely unpleasant, that results from physical pain and/or discomfort at a level not tolerated by the individual'. Rowan (1988) quoted the broader definition of Kitchen *et al* (1987) that suffering is 'the unpleasant emotional response to more than minimal pain and distress'. We support this broader definition that encompasses both pain and stress. States comparable to pain and stress may occur in all animals but the degree to which they are consciously experienced or suffered will depend on the capacity of the animal to experience suffering.

Disease

In assessment of welfare, the disease status of an animal has to be considered. We use the term disease in its broadest sense to include infectious and non-infectious conditions. The latter category encompasses trauma, poisoning, and states such as exhaustion (which the Brambell Report [Command Paper 2836, 1965] listed as an example of a state of suffering), starvation, and dehydration. Many diseases cause pain and stress and, as mentioned above, disease may arise as a consequence of stress.

We suggest that generally, and possibly in all cases, the impact of a disease on the welfare of free-living wild animals can be assessed in terms of the levels of pain and stress it causes (see Table 2). However, Broom (1992) pointed out, using the example of an anaesthetized injured animal, that there can be sub-optimal welfare in spite of an absence of suffering. Thus there may be cases in which a disease may be considered to affect welfare although causing no stress or pain. Conditions such as benign tumours (eg lipomas) or some congenital abnormalities (eg polydactyly) might come into this category.

There may be difficulties in determining the extent to which human activities or human-induced changes to the environment may cause or exacerbate infectious diseases in free-living wild animals. It is often suspected, when unusual wildlife mortality incidents occur, that human changes to the environment may have played a role. For example, it was suggested that environmental pollution may have been a factor in the epidemic associated with high mortality in common seals *Phoca vitulina* in the North Sea in 1987 (later found to have been primarily due to the phocine distemper virus – Osterhaus & Vedder 1988). Determining links between human-induced environmental changes, for example increments in pollutant levels, and the incidence or severity of infectious or non-infectious diseases in free-living wildlife can be very difficult (see Peterle 1991) and, unless there is compelling evidence for a link, caution should be exercised in interpreting disease outbreaks in this way.

3. The duration of exposure to harm

In some cases it is possible to measure or estimate the duration of the period of harm to animals fairly accurately. For example, measurements have been made of the time between injury and death in harpooned whales (Øen 1992) and of the duration of restraint procedures for slaughter of cattle (Ewbank *et al* 1992). In other cases, for example toxicity resulting from gradual accumulation of an environmental contaminant, estimating the duration of the harmful effects may be difficult but will depend upon observations of signs of harm or extrapolation from other cases.

It has previously been suggested (Porter 1992) that the duration of the period of harm should be considered in relation to lifespan. There is a case for this when comparing between species because if, for example, stress lasted three months, this would represent a much greater proportion of the life of a mouse than that of an elephant. It is also possible, since the durations of many physiological and biological events increase between species roughly in proportion with the 0.25 power of body mass (Calder 1984), that a given time period is perceived as longer by small animals than by large ones – that a painful stimulus for a duration that would feel brief and transient to an elephant may feel more than brief and transient to a mouse. For these reasons, in some cases (particularly for interspecies

comparisons) it may be appropriate to present the duration of harm both as an absolute value (in days or whatever units are appropriate) and also as a proportion of maximum lifespan (maximum lifespan tends to scale with close to the 0.25 power of body mass).

4. The capacity of the animal to suffer

The capacity to suffer stress and pain is unlikely to be equal among animals and interspecies variation may be influenced by three related factors. These are: brain development, cognitive ability and awareness of self (see Smith & Boyd 1991). However, these are difficult to measure and may not anyway represent accurate indices of the capacity to experience suffering. Although, broadly, species with the highest degrees of encephalization (brain mass/body mass $^{0.75}$, Martin 1981) are often those in which there is greatest evidence of cognitive ability and awareness of self, the relationship is not consistent. (For discussion of relative brain size and intelligence see Macphail 1982; Pearce 1987.) Likewise, too little is known about variation in cognitive ability and awareness of self between species for distinctions to be made with confidence among higher vertebrates (Smith & Boyd 1991) except perhaps between the apes (or some of the Anthropoidea), and other species.

Porter (1992) proposed that, in assessing the benefit of research on live animals against the cost to the individuals used, animals could be categorized according to the criteria listed below:

1) low sensibility/consciousness;
2) some sensibility;
3) sentient but possibly limited consciousness;
4) sentient and highly conscious;
5) sentient, highly intelligent and pre-cognitive.

However, he did not, beyond suggesting that a mollusc should be in category 1 and a chimpanzee in category 5, propose how this should be applied to various taxa.

In the absence of a sound objective technique for assessing the capacity to experience pain and stress by taxa, we take the view that the safest position is to consider that all mammals and birds have the capacity to suffer the unpleasant sensations of pain or stress but that there is insufficient information for attempts to grade this among birds and mammals (with the possible exception of primates). The assumption that these animals experience suffering is made on the basis of the basic similarities of their neuroanatomy to that of humans and the similarities in their behavioural responses to stimuli that would be painful or stressful to humans (Smith & Boyd 1991).

Development of a welfare score?

In the preceding sections we have explained the rationale for the selection of the parameters (number of animals involved, type of harm, duration and capacity to experience suffering) relevant to the assessment of the scale and severity of incidents causing harm to the welfare of wild mammals and birds. Here we describe the ways in which these parameters may be used to generate a description of the scale and severity of harm to welfare that facilitates comparisons between cases.

Porter (1992) proposed a scoring system to assist in the evaluation of the merits of research using live animals, in relation to the cost in terms of impact on the welfare of the animals used. In this he advocated scoring a number of variables (including duration and number of individuals involved, eg 1-10 scores 1; 10-100 scores 2; 100 to 1000 scores 3 etc) and then *adding* the scores for each variable (number, duration, severity etc) to derive a figure which gave some reflection of welfare impact. However, we suggest that the absolute values for the duration and number of individuals should be used in such assessments and that, if any mathematical manipulations are to be attempted, these parameters should be multiplied rather than added in order to clearly indicate the real magnitude of the number of animal days involved. For the reasons indicated in the section on duration, it may be appropriate to consider scaling duration for variation in lifespan when comparing between species.

Thus the magnitude M of a case (in animal days) can be calculated:

$M = n \times t$ where n = number of animals involved
t = mean duration of harm to each individual (days)

or, in order to scale for variation in maximum lifespan:

$M = n \times t/l$ where l = maximum lifespan (days).

It has been suggested that it can be useful, in making ethical decisions about animal use, to allocate a score to the severity of harm to welfare and that this score can be added to other parameters to derive a figure that represents the scale and severity of the case (eg Porter 1992). However, as we have discussed above, it is very difficult to devise a robust way of scoring the degree of harm. Unless the scores allocated have some meaning (eg a score of 5 is five times more severe than a score of 1), they can be misleading and there is no logical basis for using them in any numerical manipulations. Since there are great difficulties in grading severity of pain or stress in a numerically meaningful way, we consider that this approach should be used with great caution. At present, attempts to generate a simple score that realistically reflects both scale and severity have been unsuccessful. We suggest therefore that the most useful and succinct summary of each case should include the following components:

1) a description of the cause (eg ingestion of lead shot);
2) a description of the effect, based on observations or inferred from knowledge about the effects of the cause (eg anaemia, enteritis);
3) judgement of the levels of stress and/or pain caused (eg intolerable pain, distress);
4) a description of the magnitude of the problem (eg the value M or separate data for numbers affected and duration).

Discussion and welfare implications

Concern for the welfare of animals used for human benefit in laboratories and farms has prompted the improvement of methods for its assessment; the development of protocols to assist in judging the balance of animal welfare cost against human benefit, and improved standards of animal husbandry. In comparison, there has been relatively little interest in the welfare impact of human interactions with free-living wild animals although there are many

cases in which human activities seriously compromise the welfare of large numbers. There are probably several reasons for this dichotomy, including: lack of awareness and information of human impact on wildlife welfare; perceived differences in the degree to which free-living and captive animals are under human stewardship, and tradition. However, there is no logical basis for making a distinction between free-living and captive (or domestic) animals in attempts to minimize unnecessary suffering.

Although a difficult question, it is reasonable to ask 'What are the greatest causes of unnecessary suffering in animals?' because these are the cases or areas at which efforts for improvement should be targeted. Answering the question involves consideration of the scale and nature of the harm caused to animals in various cases, and value judgements about the degree of suffering likely to be caused. Although value judgements are involved in this process, as pointed out by Smith and Boyd (1991) these need not be subjective or arbitrary. These authors suggest that between objective and subjective judgements there may be a category they refer to as inter-subjective and that these inter-subjective judgements are morally persuasive because they reflect consensus not on the judgement *per se* but on the procedures used to arrive at it.

Conclusions

In this paper we have considered the factors that should be taken into account in assessing the scale and severity of human-induced challenges to the welfare of free-living wild animals. We have also considered how these can be used to provide a basis from which to compare the magnitude of scale and severity between cases. Assessments undertaken in this way also provide a summary of information for use in weighing the costs and benefits of particular human interactions or exploitations of wildlife, and from which attempts may be made to answer the question posed above about identifying the greatest causes or areas of unnecessary animal suffering.

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