THE WELFARE OF FREE-LIVING WILD ANIMALS IN EUROPE: HARM CAUSED BY HUMAN ACTIVITIES

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As part of a study into the effects of human activities on the welfare of free-living wildlife, the relative scale and severity of welfare problems in wild mammals and birds in Europe were investigated. Major cases were described and compared in terms of the nature and level of harm (pain, stress and fear) they cause, the duration of these effects and the number of individuals affected. The use of anticoagulant rodenticides, myxomatosis in rabbits, the poisoning of wildfowl by ingested lead shot, the contamination of seabirds with fuel oil, the effects of shooting, injuries due to collisions with road traffic and predation by domestic cats all severely compromise the welfare of large numbers of animals. Practical approaches to the alleviation and prevention of some of these welfare problems are discussed. We suggest that in assessing the environmental impact of new developments and technologies prior to their implementation, possible consequences to wildlife welfare should always be considered.

Keywords: *animal welfare, birds, control, free-living, hunting, mammals, myxomatosis, pain, poisoning, road deaths, shooting, stress, wildlife*

Introduction

Humans and free-living wild animals compete for space, food and other resources. Many human activities can compromise the welfare of wild animals and in some cases the effects are severe and involve very large numbers of animals. As far as we are aware, there have been no previous attempts to review the impact of human activities on the welfare of free-living wild animals in Europe or to assess and compare the scale and severity of particular cases. Most welfare interest has been focused on domesticated animals and the welfare implications of human interactions with wild animals have received little attention.

There has always been a difference between the degree of human protection or responsibility given to those animals under our direct care when compared with those with which we compete for resources. From the perspective of efficient and economic production it makes sense to invest money in the care of farm animals but to eliminate competitors (eg rodents and rabbits) by the cheapest means possible, although some legislation exists to protect the welfare of free-living pest species, for example the EC Plant Protection Products Directive (91/414). By contrast, legislation such as the UK Protection of Animals Act 1911 makes it an offence to cause unnecessary suffering to confined but not free-living animals. However, if it is accepted that high standards of welfare should be a guiding principle in the husbandry of production animals, then it is inconsistent not to apply this principle to man's interactions with wildlife.

Because the welfare implications to wildlife of new technologies and developments have received little attention, there is no consensus about where efforts and resources for improvements can be directed most effectively. There is thus a danger that, perhaps prompted by minority group pressures rather than informed opinion, resources may be channelled to cases of relatively minor importance.

We recently undertook a review of cases in Europe in which the welfare of wild mammals and birds has been compromised as a result of human activities (including human-induced changes to the environment) (Sainsbury *et al* 1993). Data were collected, by literature review and questionnaire survey, on interactions which had adversely affected the welfare of free-living mammals and birds during the ten year period to December 1992. A large number of welfare problems were reported (Sainsbury *et al* 1993). As part of the study we reviewed methodology for the assessment of wildlife welfare, and a full description of rationale for the technique we adopted has been published elsewhere (Kirkwood *et al* 1994).

Here we use this comparative approach (Kirkwood *et al* 1994) to describe in more detail some of the cases that appeared from our study (Sainsbury *et al* 1993) to be of major importance, in terms of the scale and severity of the harm they caused to animal welfare and the numbers of animals affected. Approaches to the amelioration and prevention of some of these welfare problems are discussed.

Assessment of harm to welfare

Our approaches to the assessment of harm to the welfare of wild mammals and birds and to the relative importance of various cases have been described in detail elsewhere (Kirkwood *et al* 1994). It is widely accepted that animals can experience and suffer pain, fear and stress but 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) (Bateson 1991; Moberg 1985; Rowan 1988). We have proposed that in the assessment and comparison of cases in which the welfare of wild mammals and birds is compromised by human activities, the following factors should be considered: the nature of the harm caused, its duration, the number of animals affected and their capacity to experience suffering. Without a firm basis for assessing the variation in the suffering capacity of mammals and birds that occur in the wild in Europe, we have suggested that this should be assumed to be equal among them.

Our approach to the assessment of welfare problems included the following steps:

1 description of the cause (eg ingestion of lead shot)
2 recording the species or range of species involved
3 description of the pathological effect or stress produced by the harm (eg enteritis, fracture of the humerus, or confinement), based on observations or inferred from knowledge of the process
4 judgement, based on 3, on the likely level of stress, fear and/or pain created
5 description of the magnitude of the case in terms of the numbers of animals affected and the duration of the harm

Obtaining reliable data on the numbers of animals affected and the duration of suffering can be very difficult but these factors present no great conceptual difficulties. We have attempted to estimate the ranges (eg 10–100, 100–1000 etc) within which the actual number affected is likely to occur. These estimates, although based on published and unpublished sources, are speculative and conservative, and in some cases may be underestimates. Estimates of the range of the duration of harm were made in a similar manner.

Judging the levels of stress and pain is less straightforward. In line with the recommendations of other workers (Sanford *et al* 1986), we graded stress into three categories according to severity: physiological stress, overstress and distress (see Kirkwood *et al* 1994). In physiological stress the animal puts little effort into the adaptive response and is unconscious of it. In overstress the response is still unconscious but involves significant effort with the diversion of significant resources; and in distress the animal puts substantial resources into the adaptive response, is aware of the effort and may suffer detrimental side-effects from the response. In the assessments we judged whether fear was likely to have been present or absent but made no attempt to categorize its intensity. Levels of pain were judged by extrapolation from the human experience of similar pathological effects, into pain and severe pain.

In this study we were not concerned with cases in which human activities result in instantaneous deaths since, although these may have ethical implications, they have no impact on welfare because the animal does not experience fear, distress or pain.

In the ensuing sections we describe cases in which human activities compromise the welfare of free-living wild mammals and birds, and discuss possible approaches to the amelioration and prevention of some of these problems. The cases are those which, using the methods described above, were important in our recent survey (Sainsbury *et al* 1993) in terms of the severity of the harm caused, its duration and the numbers of animals involved. We discuss the derivation of our estimates of these factors in each case. A summary of the major cases is provided in Table 1.

Cases in which prolonged severe pain and distress occur in many animals

Toxicities

Warfarin-like anticoagulant rodenticides

The second generation warfarin-like anticoagulant rodenticides, such as brodifacoum, difenacoum and bromadiolone, lead to death by producing multiple internal haemorrhages over several days or weeks (Meehan 1985). Clinical signs include depression, vomiting, anorexia, ataxia, diarrhoea, haemorrhage, melaena, weakness and dyspnoea (Dorman 1990). Haemorrhage may occur into body cavities and there may be epistaxis, haematemesis or haematuria. Meehan (1985) pointed out that internal bleeding in some sites, for example into joints, is known to be an extremely painful condition in humans with haemophilia. It seems likely that anticoagulant rodenticides induce severe pain and distress.

According to Richards, cited by McDonald (1988), warfarin takes up to five or six days of feeding to kill but the second generation substances take only two days. Gibson (1989) considered that death occurs 3–10 days after ingestion with signs apparent after 24 hours. However, continued feeding is required for the bait to be effective and so it is assumed that the period of pain and distress is shorter than the duration between first ingestion and death. It seems likely therefore that the duration of the pain and distress caused by these agents may be in the order of several hours to a few days.

Table 1 Severe and large-scale welfare problems in Europe related to human activity.

Cause of harm	Associated human activity	Example of species or groups of mammals or birds affected	Pathological effect	Severity of harm		Number affected annually (estimated range)
				Category of maximum stress, fear and/or pain	Duration of harm (estimated range)	
Ingestion of warfarin-like anticoagulant rodenticides	control of rodent pests	*Mus musculus*, house mouse *Rattus norvegicus*, brown rat *Sciurus carolinensis*, grey squirrel	internal haemorrhage, anaemia, circulatory shock	distress, severe pain	hours to days	10–100 million
Ingestion of lead shot	shooting for the purpose of hunting or control of populations	Anseriformes (swans, geese, ducks)	paralysis and impaction of digestive tract, anaemia, muscular atrophy	distress, severe pain	days to months	10,000–100,000
Collision with road vehicles	road transport	various mammals and birds	wounds, haemorrhage, fractures	distress, severe pain	minutes to days	100,000–1 million
The strike of, and piercing by, a bullet or shot	shooting for the purpose of hunting or control of populations	various mammals and birds	wounds, haemorrhage, fractures	distress, severe pain	minutes to days	200,000-2 million
Predation by domestic cats	the keeping of domesticated cats	various mammals and birds	wounds, haemorrhage, fractures	distress, fear, severe pain	minutes to days	1–10 million
Ingestion, inhalation or contamination with fuel oil	shipping, pipelines	auks, sea ducks	enteritis, liver and kidney degeneration, muscular atrophy	distress, severe pain	days to weeks	1000-10,000
Myxoma virus infection	introduction of myxomatosis to control the rabbit population	*Oryctolagus cuniculi*, European rabbit	subcutaneous oedema, visceral haemorrhage, lymphatic necrosis	distress, severe pain	days to months	1–10 million

Footnote to Table 1

The level of stress and pain is described as 'maximum' because there was uncertainty whether the cause would produce harm at the stated level throughout the listed duration. Refer to the text for a description of the derivation of the estimates of duration of harm and numbers of individuals affected.

The number of animals affected by these agents is very large. Warfarin-like anticoagulant rodenticides are the most commonly used agents of rodent control in the UK (Meehan 1985; see Richards 1989) and probably in Europe as a whole. M R Hadler (personal communication 1993) estimated the total number of rodents killed in the European Union (EU) by anticoagulants at 42 million per year. This calculation was based on the assumption that 20 per cent of the approximate mass of bait sold in the EU per year (12,500 tonnes) is eaten by rodents and that the lethal dose of bait is about 30g. Hadler estimated that because rodents continue to feed after the lethal dose has been absorbed due to the delayed action of anticoagulants, twice the lethal dose is eaten. Hadler pointed out that the amount of bait used may be greater or less by 25 per cent in any year due to climatic variations. It is clearly difficult to estimate the total number of rodents killed in this way with great precision, but it seems likely that the number is in the order of tens of millions annually.

There are more humane alternatives to the anticoagulant rodenticides but none as yet which are as effective. Alphachloralose and reserpine are probably the most humane rodenticides currently in use (Meehan 1985). Both of these agents act as sedatives. If death occurs during the period of sedation then they probably cause no stress or pain. However, neither are effective against rats, and mice develop tolerance to alphachloralose (Meehan 1985). Meehan (1985) reported that one chemosterilant, alphachlorohydrin was available for use in the UK but that it was unlikely to be used widely because in many situations the presence of any live rodents is unacceptable in view of public concerns.

Break-back and torsion traps have been considered as alternatives to anticoagulant rodenticides but can only be viewed as humane when they cause instantaneous death. H Niemeyer (personal communication 1994) found that between 10 and 14 per cent of voles (*Microtus agrestis* and *Clethrionomys glareolus*) and mice (*Apodemus sylvaticus* and *Apodemus flavicollis*) caught by wooden break-back traps had non-fatal injuries (total number of trapped animals = 443). In studies of the same species caught by torsion traps between 30 and 53 per cent received non-fatal injuries (total number of catches = 144) (H Niemeyer personal communication 1994). These figures suggest that traps cannot be recommended as more humane alternatives to anticoagulants. 'Sticky-boards', in which rodents are captured by glue, are not a good proposition on welfare grounds because stress may be prolonged.

One UK company has recently marketed an electronic live-trap for mice designed for use in the food industry and similar factories (A P Meehan personal communication 1993). The trap alerts operators when a mouse is caught by emitting a signal and so during working hours the duration of stress due to capture could be reduced to a minimum. Meehan A P (personal communication 1993) believed these traps have the potential to replace anticoagulant rodenticides in many circumstances. However, R Johnson (personal communication 1993) did not consider that they were suitable for use on farms (which are the bulk of the UK market) due to the time-consuming nature of their use. Gibson (1989) recently reviewed alternative techniques such as the use of pheromones to disrupt mating or the use of ultrasonic cues to cause desertion of litters, but none are sufficiently developed to be a realistic option in the near future. It is important that research into humane methods of rodent control is pursued because some widely used rodenticides are likely to cause severe pain and distress.

Lead-poisoning due to the ingestion of gun-shot

Poisoning of wildfowl due to the ingestion of lead gun-shot is an extensive problem. Wildfowl ingest spent shotgun pellets while feeding or seeking grit. There have been several recent European studies investigating the extent of lead shot ingestion in wildfowl (Mudge 1983; Lumeij & Scholten 1989; Holt & Droslie 1989). However, there have been few attempts to estimate the number of birds affected. Mudge (1983) estimated that 8000 mallards died each year in Great Britain through lead pellet ingestion and his study showed that many other species of wildfowl were also affected. The use of lead shot was commonplace throughout Europe and so it seems likely that the total number of cases in wildfowl annually in Europe has been at least in the 10,000–100,000 range. Sanderson (1992) reviewed the mortality due to lead-poisoning in Europe and concluded that it was a serious problem.

In birds, lead-poisoning causes a prolonged illness of which the clinical signs include: lethargy, anorexia, paralysis of the upper digestive tract (crop, oesophagus, proventriculus and gizzard), vomiting, diarrhoea, ataxia, paralysis of the legs or wings, convulsions, anaemia and emaciation (Lumeij 1985). Pathological lesions include muscular atrophy, degeneration of the liver and kidney, extensive oedema and demyelinating lesions in the central nervous system (CNS) (Humphreys 1988). The lesions and signs are likely to cause severe pain and distress. On treatment, signs of recovery may be seen within 16 hours (Lumeij 1985) but in severe cases the clinical course can last several months before recovery (Sears *et al* 1989), and a prolonged course might be expected in wild birds because relatively few receive treatment.

Mudge (1992) considered approaches to the reduction of lead-poisoning due to the ingestion of lead shot. These included: introduction of codes of practice aimed at reducing the numbers of spent shot falling on waterfowl feeding areas; cultivation of wetland sediments to redistribute shot; manipulation of water levels to restrict the accessibility of shot lying on the beds of water bodies; provision of grit in areas where it is naturally scarce; treatment of sick birds; conversion to the use of non-toxic shot. He concluded that the only effective solution was the conversion to non-toxic shot. The other methods provide only temporary, unreliable or too labour intensive solutions. Conversion to steel shot was successfully completed in the USA during the 1980's despite concerns that crippling rates might be increased (Morehouse 1992; Bishop & Wagner 1992). The change to steel shot has also been made recently in Denmark (Rønholt 1992). The use of lead shot was banned in the Netherlands from early 1993 and efforts are being made to encourage a voluntary change in Finland, Norway and Sweden (Moser 1992). However, Shedden (1992) argued that a change to steel from lead shot should not be adopted in the UK because many guns are inappropriate for steel shot and because of the possibility of higher crippling rates. In spite of many studies in the USA, debate remains about whether lead or steel produce higher crippling losses (Morehouse 1992). There is some evidence that crippling losses decline as hunter experience and confidence with steel increases (Pain 1992). It is also important to note that crippling losses with steel must be balanced against lead-poisoning losses plus crippling losses with lead (Pain 1992). There is resistance to the use of steel shot in France and Ireland as well as the UK (Butler 1992; Havet 1992), and it has been suggested that there may be a lack of appreciation of the magnitude of the problem in some countries (Klotz 1992; Genghini 1992; Ramos 1992).

Trauma

Collisions with road vehicles

A large amount of data was obtained by Sainsbury *et al* (1993) on injuries and mortality in wild mammals and birds resulting from collisions with various modes of transport, of which collisions with road vehicles are most common. In a proportion of these cases the animals are not killed instantly but may receive severe injuries including, for example, fractures (Gaudron & Demeautis 1992), haemorrhage and damage to internal organs; which cause severe pain, distress and loss of function.

A number of authors have attempted to estimate the annual numbers of animals hit by road vehicles. For example Harris *et al* (1992) estimated that 50,000 badgers (*Meles meles*) are killed on roads in Britain each year; C J Mead (personal communication 1993) estimated from ringing recoveries that between one and ten million birds die on UK roads every year; an estimated 13,830 roe deer (*Capreolus capreolus*) were killed on French roads in 1984 (Desire & Recorbet 1985); B Clausen (personal communication 1993) reported estimates for hares and hedgehogs (*Erinaceus europaeus*) in Denmark as 55,000 and 73,000 per year respectively; Morris (1993) quoted a figure of 100,000 hedgehog road kills per year in Britain. These studies suggest that the total numbers of birds and mammals killed on roads in Europe could be in the 10 to 100 million range. The percentage of collisions which result in instantaneous death is unclear but even if we assume that only one per cent of these are not killed instantly, the total number of mammals and birds wounded is likely to be at least in the 0.1 to 1 million range. We surmise that the majority of those which are not killed instantaneously experience injuries severe enough to prevent normal behavioural repertoires such as foraging and therefore do not survive for longer than a few days.

Although many deaths and injuries due to collisions with road vehicles are unavoidable, there are examples where specific problems have been overcome or ameliorated. Barragán Fernández and López Redondo (1993) reported on the use of tunnels, barriers and viaducts to reduce road mortality in Spain. Lafontaine (1993) reported that underpasses have been constructed under roads in order to reduce otter mortality in Brittany, France. Madsen (1990) found that mirrors placed next to roads were not successful at reducing otter mortality but that fences would be erected to guide otters away from roads. Methods to reduce road vehicle collisions may require detailed ecological and behavioural investigation, such as those undertaken for otters by Striese and Schreyer (1993), to ensure that they are used to greatest effect, especially where economic considerations preclude their use in all areas.

Bullet and shotgun wounds

In Europe wild mammals and birds are hunted for sport and for population control reasons. A number of different methods and weapons are used to shoot these animals in Europe. In some northern and eastern countries, archery and other out-dated methods are illegal, the use of shot on ungulates is usually forbidden (but see below), and minimum rifle calibre, cartridge length and bullet energy are stipulated. There are rules governing the minimum number of experienced hunting dogs that must be used during the hunt, and retrieving or at least searching for wounded game is generally compulsory (Bubeník 1989). Gill (1990) reported that German hunters are conscientious about tracking wounded deer.

Hunting practices vary widely between countries in Europe, for example in France, Italy, Spain and Sweden the use of shot to kill some species of deer is allowed (Bubeník 1989; Gill

1990). The use of dogs in deer hunting (often used to drive the deer towards the hunters) is allowed in Sweden, France, Spain and the UK. The proportion of shots causing instantaneous deaths in this form of hunting, is probably lower than when they are shot from high seats or by stalking (R Gill personal communication 1993).

The shooting of wildfowl in Europe is almost entirely carried out using shot, and may be carried out 'still' or from boats or other vehicles. Regulations vary from country to country. For example in Denmark shooting from motorboats is permitted only below a 5km h^{-1} speed limit and the use of electronically produced bird calls is disallowed (Bertelsen & Simonsen 1989). In a study by telemetry of crippled mallards (*Anas platyrhynchos*) with wing injuries, van Dyke (1981) found that 94 per cent died within two weeks (n = 35). Although the majority were predated, weight loss occurred prior to death and appeared to contribute to the likelihood of being taken by a predator. Some of the birds died of starvation. The survival time of animals severely injured by shooting is likely to vary greatly depending on the species, the habitat, the severity of the injuries and the extent to which these preclude normal behaviour. It may often be in the 1 to 10 day range. Van Dyke (1981) found that the most common injuries in ducks crippled in a shoot were wing fractures and he found that each bird was likely to have several wounds. Shooting injuries and the loss of function associated with them are likely to cause severe pain and distress.

There are very little data on the proportion of mammals or birds shot in Europe that are not killed instantly. Meltofte (1978) found that of 45 wildfowl and waders shot in Denmark 88.9 per cent were wounded. There are a number of reports on the hunting of wildfowl and deer in the United States which are of relevance to this issue. Studies on deer reported that the percentage of deer wounded rather than killed instantaneously after shooting was between 8 and 42 per cent (Gladfelter 1985; McCaffery 1984; Noble 1974). Crippling rates for ducks shot in the USA varied between 4.5 and 20 per cent (Anderson & Burnham 1976; Humburg 1982; Humburg & Sheriff 1980; Mikula 1977), and in geese between 35.8 and 40.9 per cent (Anderson & Sanderson 1979; Smith & Roster 1980). However, it is likely that wounding and crippling rates for deer and wildfowl may differ between Europe and the USA. In the USA there is little control over hunting, and training and proficiency testing are not generally required (R Gill personal communication 1993). Furthermore, it is not illegal to use shotguns for shooting deer. Some forms of American waterfowl hunting are practised at greater ranges than are traditional or encouraged in the UK (J Harradine personal communication 1993; Shedden 1992). In most of the northern and eastern European countries hunters must pass an examination to obtain an official accreditation to hunt, and training courses are available. In some countries hunters are tested at various intervals to ensure high shooting efficiency. As a result of the tighter controls it is perhaps likely that crippling rates are lower in northern and eastern Europe than those reported in the USA.

Examples of the information available on the numbers of mammals and birds shot annually in Europe are as follows: 400,000 brown hares (*Lepus europaeus*) in the UK (Potts 1990) and 900,000 in Spain (C Gortazar personal communication 1993); 1,677,550 roe deer shot in 1984 in 20 European countries (Gill 1990); 1,149,500 Galliformes in Switzerland, Germany, Austria and Czechoslovakia (Bubeník 1989); 7,221,500 pheasants (*Phasianus colchicus*) in France, Denmark, Luxembourg and Belgium in 1984 (Bertelson & Simonsen 1986); 3,582,200 Anseriformes in Switzerland, Germany and Austria (Bubeník 1989). Anseriformes and Galliformes probably represent the largest proportion of birds shot but other species (eg

Scolopacidae (sandpipers and snipe), Columbiformes (pigeons and doves) and Passeriformes are also shot in large numbers. Of the mammal species, in addition to deer and hares, large numbers of carnivores and rabbits (*Oryctolagus cuniculus*) are also shot.

The total number of wild mammals and birds shot in Europe each year is very unlikely to be below the 10–100 million range. Even if the wounding rate is only two per cent (and this is a very conservative estimate), the total number wounded will not be less than 200,000 and is probably considerably more. It is likely that tightening of controls over hunting could be beneficial in reducing the percentage of non-instantaneous deaths in some areas. Research into the comparison of the welfare impact of various methods of hunting would be valuable for some species.

Wounding by domestic cats

Domestic cats, the majority of which are kept as companion animals, often hunt small mammals and birds. They probably kill a large proportion of those they catch instantly but some are killed later or after a period of play, and others escape after wounding and can develop local or systemic secondary infections (eg with *Pasteurella multocida*) which may lead to death (Korbel *et al* 1992). The wounds caused by cats vary from minor scratches or bites to severe puncture wounds, lacerations and fractures which are likely to cause severe pain and distress. Unless killed swiftly, animals caught by cats are also likely to experience fear. Depending on the severity of the wounds and whether or not secondary infections occur, it is likely that animals wounded by cats may survive from a few minutes to several days. A proportion are likely to recover.

The number of small mammals and birds killed by domestic cats in Britain was estimated by May (1988) at 100 million per year. This estimate was based on the work of Churcher and Lawton (1987) who recorded the number of prey items brought home by cats in a village in Bedfordshire, UK. Their figures may underestimate the total number of kills made by the cats, as George (1974) found that cats in Illinois brought home only about half of the animals they killed. Churcher and Lawton (1987) found that although habitat influenced the species taken by the cats, it did not influence the number of animals killed per cat per year.

Based on the above, the total number of domestic cat kills across Europe is likely to be in the 100–1000 million range. We have no data on the number that are wounded, but even if this is only one per cent of the number killed, this would represent over a million cases per annum. Wounding by cats is a common presenting sign in animals treated at wildlife hospitals. No easy ways to reduce the scale of this problem are apparent. In response to the perceived destruction of endangered native fauna by cats, legislation in some areas of Australia decrees that cat owners must confine their pets in an escape-proof building during the night and that residents can keep the cats they possess but cannot acquire new ones (Anderson 1994). The results of this legislation are so far unclear.

The toxic and traumatic effects of oil contamination

Waterbirds, particularly those that feed by diving (eg auks and diving ducks), are at risk of oiling. Although major oil spills are widely publicized, the more frequent minor incidents probably affect larger numbers of birds (Clark 1984). Oil can harm birds in two ways: external contamination damages plumage function and ingestion or inhalation cause toxic effects. Depending on the proportion of the birds plumage affected and the amount and type of oil, the effects of external contamination may include severe impairment of thermoregulation, locomotion and thus feeding. The pathological lesions associated with oiling include muscular atrophy, enteritis, adrenal hypertrophy, interstitial emphysema and liver and kidney degeneration (Gullett 1987; Wood *et al* 1993). Oiling is likely therefore to be associated with severe pain and distress.

Unless oiling is very minor, affected birds are unlikely to recover (unless treated) and death is likely to occur within days. The duration of the period of suffering of severely oiled birds in the wild is probably within the 1 to 10 day range, although chronic effects could lead to death over a longer time-scale. Records of the survival of treated oiled birds in rehabilitation centres are available from several sources. For example Rehfisch *et al* (1992) reported that of 26 birds (of the Orders Anseriformes, Charadriiformes, Podicipediformes) treated after an oil spill in the River Severn, UK, seven died between one and 25 days after admission (χ = 5.6 days; SD = 8.5) and 19 were released between three and 25 days after admission (χ = 8.1 days; SD = 7.0) . At the Norfolk Wildlife Hospital, UK in 1992 and 1993, 125 oiled birds of the Orders Gaviiformes, Procellariiformes, Pelecaniformes, Anseriformes and Charadriiformes were released between 1 and 123 days after admission (χ = 26.0 days; SD = 19.7) and another 70 birds of the same Orders died in care between 1 and 172 days after admission (χ = 9.9 days; SD = 23.4) (I Robinson personal communication 1993).

Beached bird surveys, in which dead birds are collected from specific stretches of beach and recorded, are well organized on some European coasts and have provided much of the data on the incidence of oiling in birds (eg Camphuysen 1989; Heubeck 1987). These surveys have limitations because the number washed up will depend on wind direction and many other factors. Secondly, birds which have died from other causes may become oiled before they are washed up. However, Stowe (1982) deduced that these surveys provide a guide to the number of birds involved. On the Netherlands coast approximately 30,000 birds were washed ashore every winter between 1969–1985 of which approaching 70 per cent were oiled (Camphuysen 1989). Baillie and Mead (1982) estimated that 70,000 birds were killed by oil in the eastern North Sea in the winter of 1980–1981. Over 16,000 guillemots (*Uria aalge*) were found on Shetland and Orkney beaches between 1976 and 1991 of which 12 per cent were oiled (Heubeck *et al* 1992). Underwood and Stowe (1984) found that of 34,000 seabirds wrecked in February 1983, less than 15 per cent were oiled. It seems that the incidence of oiling of seabirds may have declined somewhat as a result of improvements in protocols for oil transport and accident prevention and control. However, Furness (1993) considered that oil was the major cause of death for seabirds in the south-east and north-east North Sea and the English Channel, and that it was the main cause of death of beached seabirds on the coasts of Denmark, Germany, the Netherlands and Belgium. It is hard to estimate the present annual totals for European waters but from the data presented above it seems unlikely that it is below the 1000–10,000 range and may well be above it.

In view of the large potential impact of oil toxicity on wildlife welfare, continued close monitoring of oil spill incidents is required and protocols for preventing and dealing with accidents should be updated regularly. Little is known about possible long-term effects of oil ingestion at sublethal doses (but see Lipscomb *et al* 1991).

Infectious diseases

Myxomatosis

Myxomatosis was deliberately introduced into the wild rabbit population in France in 1952. It spread to the UK in 1953 and into other parts of Europe at a similar time and had a dramatic impact on the numbers of rabbits. It was estimated that 99 per cent of rabbits were killed in the UK (Ross *et al* 1989). Since then the rabbit population has steadily increased due to changes in the virulence of the virus and the development of resistance in the rabbit (Trout *et al* 1992).

The disease can produce a prolonged illness in rabbits. In the acute stage the signs include lethargy, conjunctival inflammation, swelling of the eyelids, fever and a watery ocular discharge. If the rabbit survives this stage, then the swelling extends to the lips, face, ears, and anogenital areas. Many die at this stage but others develop cutaneous haemorrhages (Harkness & Wagner 1989). Pathological lesions include subcutaneous oedema, visceral haemorrhage, epithelial proliferation and hyperkeratinization, and necrosis of lymphatic tissue (Harkness & Wagner 1989). It is likely that the disease causes severe pain and distress. In those animals that survive the infection the lesions regress over one to three months, (Harkness & Wagner 1989) but animals surviving the acute stage may die up to five weeks later of secondary pneumonia (Brooks 1986). The duration of the period of harm caused by myxomatosis may therefore be several weeks.

Several methods have been used to estimate the number of cases of myxomatosis that occur annually in the UK. Rees *et al (1985) estimated the population of rabbits in the UK* in 1985 at 20 million. Tittensor (1981) estimated that the density of rabbits varied between 1–15 per hectare in winter and 1–40 per hectare in summer. The UK covers an area of 24,160,000 hectares (ha) and the rabbit is considered widespread throughout, up to the tree line (Cowan 1991). In view of this, 20 million would appear to be a reasonable estimate of the minimum population.

Cowan (1991) noted that outbreaks of myxomatosis still occur annually in most populations. Ross and Tittensor (1986) estimated that outbreaks of myxomatosis kill between 5 and 38 per cent of a rabbit population, and in a population of rabbits investigated by Cowan (1987) approximately 5–10 per cent of rabbits in any year had myxomatosis. Assuming the estimate of population size derived by Rees *et al* (1985) is correct, this would represent between one and 7.6 million cases per year. Ross and Tittensor (1986) found that only 47–69 per cent of rabbits showing signs of myxomatosis die, and so the total number affected may be greater than 7.6 million. The number of cases of myxomatosis in the UK is therefore very likely to be in the 1 to 10 million range. Rabbits are also widespread in France, Germany, Spain, Austria and eastern Europe (Cowan 1991), and the European total may therefore be an order of magnitude greater.

No practical methods are available for preventing myxomatosis in free-living rabbit populations at present. The history of myxomatosis illustrates the very serious consequences that can follow the introduction of an infectious disease into susceptible populations. It serves also to emphasize the need for careful risk assessments and disease screening when animals are translocated or released into the wild (Woodford 1993; Beck *et al* 1993; Ballou & Lyles 1993), and also the need to consider welfare aspects when considering the use of infectious diseases in biological control programmes.

Less severe cases involving many animals

The following cases can be distinguished from those above by a shorter duration of harm or the likely absence of pain (stress and fear occur alone).

Poisoning by strychnine

Strychnine has been used for killing moles for many years and the practice continues in the UK. Atkinson *et al* (1994) estimated that approximately 530,000 moles were poisoned with strychnine in the UK in 1991 but its use has been decreasing due to increased regulation. Strychnine use is banned in Germany and France but its use elsewhere in Europe is unclear.

Strychnine causes greatly increased reflex excitability and tetanic convulsions, and death occurs due to respiratory paralysis (Blood *et al* 1983). Stychnine poisoning therefore causes severe pain, fear and distress (Neville 1985). Neville (1985) considered that the time between ingestion of strychnine and death in moles was between 15 minutes and 2 hours but once signs commenced death followed 15–30 minutes later.

Atkinson *et al* (1994) considered the alternatives to the use of strychnine to control moles. Alphachloralose and aldicarb are more humane but not as effective. Traps, from the evidence available, did not appear to be more humane. Atkinson and Macdonald (1994) investigated the use of a repellants which may be a realistic proposition for small-scale use. However, in at least one case when the mole was evicted from its territory it died. Atkinson *et al* (1994) investigated the costs of mole control in relation to the scale of the problems that moles produce on farms. They found that on the majority of farms where mole control was carried out there was insufficient reason to continue, or that other methods such as the treatment of silage were more economic.

Entanglement in fishing gear

A number of marine mammals and diving birds are drowned each year in European waters as a result of accidental capture and entanglement in fishing nets (Clausen & Anderson 1988; Kuiken *et al* 1994b; Northridge 1988; Robins 1991). Data collected on bycatch has been limited but the following examples give an indication of the scale: in the south-eastern Kattegat (Sweden) from 1982 to 1986, between 3300 and 6500 seabirds were found drowned annually (Oldén *et al* 1986); Strann *et al* (1990) estimated that between 10,000 and 100,000 auks were bycaught annually in north Norway between 1984 and 1989; the estimated annual bycatch of cetaceans by fishing boats from a single harbour in Denmark was 750 animals (Kinze 1990); Goujon (1993) estimated that 1900 cetaceans were bycaught in French waters during 1992. These findings suggest that the number of marine mammals and seabirds killed in this way in European waters is at least in the 10,000 to 100,000 range.

Bycaught marine mammals are often injured in their attempts to escape from fishing gear (eg Kuiken *et al* 1994b) and die due to immersion. Diving mammals can, in some cases, survive underwater for more than an hour (Castellini 1991; Wartzok 1991) and so severe pain and distress may be experienced for up to one hour. Diving birds caught in fishing gear probably lose consciousness in minutes. A number of reports have investigated the impact of bycatch in Europe (Northridge 1988; Northridge *et al* 1991; Robins 1991; Thomas 1992) but there is a great need for further study into how fishing practices can be changed to alleviate the problem.

Live-trapping

Wild birds and mammals are live-trapped in various ways and for many different purposes. For example, mist netting is used to catch birds for control purposes or to enable metal or other rings to be attached for studies of survival, migration and aspects of ecology (Calvo & Furness 1992). Sainsbury *et al* (1993) estimated that millions of birds were caught in this way every year in Europe. When caught for ringing, the procedure is brief and rarely causes any physical damage. It is likely to cause brief distress and fear but no pain.

Sainsbury *et al* 1993 also estimated that hundreds of thousands of mammals and birds were caught every year in Europe using cage traps for either control or research purposes. Where cage traps are used responsibly, it is customary for them to be checked at least every 24 hours by the gamekeeper or other attendant (The Game Conservancy 1991). Although some trapped animals may injure themselves in attempts to escape, as long as traps are checked regularly, they are unlikely to cause more than brief distress. However, N Dunstone (personal communication 1993) considered that a high proportion of cage trapped mink (*Mustela vison*) die from starvation because the traps are not visited frequently enough, while many river keepers kill the mink by submerging the trap if they find the animal alive.

A number of other trapping and netting techniques are used to capture birds in Europe. A minimum of 600,000 larks (Alaudidae) were estimated to be caught each year in France using a type of net called 'les pantes à alouettes', which functions using either ropes or a spring (A Duncan personal communication 1993). Finches (Fringillidae) and buntings (Emberizidae) are captured in Belgium and France using a type of cage trap. Between 1983 and 1992 the Ministere de l'Agriculture (1992) in Belgium reported that 353,482 birds were caught in this manner and Bertelson and Simonsen (1989) quoted a figure of 250,000 in France for 1978 but suspected the yearly total was much higher. In north-east France (the Ardennes) over 78,000 thrushes (Turdinae) were caught between 1988 and 1992 using 'laces', a type of snare, and over 187,000 thrushes were caught by liming in south-eastern France in the same period (Ministere de L'Environnement 1989, 1990, 1991, 1992, 1993). 'Liming' involves the capture of birds by placing glue on branches, to which the birds stick when they alight. All the above trapping/netting methods probably cause distress and fear but are potentially without pain. However, in some cases poor techniques or accidents may result in pain or prolonged distress. A Duncan (personal communication 1993) noted that the wings and legs of birds caught by liming may be ripped off as the bird is removed from the liming stick.

Cases in which the welfare consequences are difficult to evaluate

This section discusses three cases in which data were sparse but which have the potential to be large-scale. It seems likely that a variety of changes to the environment compromise the welfare of wild animals, for example if their food, or feeding, breeding or resting sites become unavailable or damaged. It has been suggested that commercial fishing could reduce fish stocks and thus lead to starvation in seabirds. However, at least in the North Sea, there is at present no categorical evidence to link a decline in the number of seabirds through starvation with a reduction in fish stocks due to over-fishing (Monaghan 1992).

Disturbance

Outdoor human recreation has increased dramatically over recent decades (Götmark 1989) and there is a greater potential for disturbance of wild animals. Sainsbury *et al* (1993) found that the quantitative information on the duration of harm, due to disturbance caused by human recreational activity, was from specific studies on small populations and therefore the results did not fully represent the problem. Repeated disturbance can harm welfare by, for example, reducing feeding time or by stimulating abnormal territorial aggression due to flights into neighbouring territories (Yalden & Yalden 1990; Yalden 1992). Götmark (1989) reviewed 70 papers worldwide on the effects of disturbance on birds, and found that decreased reproductive success or increased predation were reported in 73 per cent of these. In 75 per cent of papers a lower nesting density in disturbed areas was reported and in others an increased predation of eggs. Although studies have been undertaken on the effects of human disturbance on the welfare of park deer (Langbein & Putman 1992), we are not aware of any comparable studies on truly free-living mammals or birds.

Diseases caused by environmental pollution

It has often been suggested that environmental pollution could damage the health of wild animals and in some cases this has been demonstrated. For example, environmental pollution with persistent organochlorine pesticides caused serious population declines in some species of birds of prey in Europe from the 1950s onwards (Newton *et al* 1992). More recently, it has been reported that poor reproduction in forest passerines appears to be related to declines in snail populations (and thus available dietary calcium) due to acidification of soils (Graveland *et al* 1994). It has been suggested that polychlorinated biphenyls (PCBs) may cause chronic toxic effects in some species. Some PCB congeners are known to cause immunosuppression in laboratory animals resulting in a higher than normal incidence of infectious diseases, but there is little evidence of this in wild animals at present (eg Kuiken *et al* 1994a; Swart *et al* 1994). It is often very difficult to prove or disprove possible links between chronic exposure to low levels of environmental contaminants and effects on health. The intensity of monitoring of wildlife health is generally low and the possibility that environmental contamination may affect the welfare of some wild animals cannot be ruled out.

Problems arising from the treatment and rehabilitation of sick or injured wild animals and release of those bred in captivity

Captive wild animals are released into the wild under a variety of circumstances. Some captive-bred animals are released for conservation purposes or by those who breed them for a personal hobby. Wild animals may be released after translocation for conservation or hunting purposes, and wildlife casualties are released from rehabilitation centres after treatment. Unless careful consideration is given to the release technique, the fitness of the animal for release and the suitability of the environment into which it is released, the welfare of the animals released (and of other animals in the area) may be compromised.

Several authors have drawn attention to potential welfare and disease hazards associated with release following rehabilitation (eg Harris 1989; Morris *et al* 1990; Stocker & Lewis 1993). Standards of practice of treatment, rehabilitation and release vary considerably in European countries and are subject to few controls. There is the capacity for causing unnecessary fear, pain and distress in these interventions with wild animals.

Releases for hunting and welfare (rehabilitation) purposes occur on a large scale, and interest in rehabilitation is growing. Bertelson and Simonsen (1989) found that an estimated

10 million pheasants (*Phasianus colchicus*) are released annually for hunting in Belgium, Denmark, UK, Ireland and the Netherlands. Peeters (1991) estimated that wildlife hospitals in the Netherlands receive over 30,000 birds per year for treatment and a high proportion of these may be released. For example, he reported that of 4650 birds rehabilitated after an oil disaster in the Netherlands in 1988, 26 per cent were released. In a recent survey in the UK, the number of birds and mammals released during one three-month period in 1993 was found to be 1946 (BWRC 1993). This figure is certainly an underestimate of the national total since records were not received from all rehabilitation establishments. There are few data on post-release survival, but in some cases this has been quite low (Cayford & Percival 1992; Morris *et al* 1990).

This is an area in which there is certainly potential for improvement through education, the establishment of codes of practice and research into release techniques.

Discussion

We have described several ways in which direct and indirect human interactions with wild animals have been or are harmful to the latter's welfare. The cases described here include those that we consider the most important in that it is likely that they cause prolonged severe pain and distress to large numbers of animals. We have also, more briefly, described other cases which cause less harm and also some whose scale and severity are hard to assess because of the lack of data.

In the survey on which this report is based (Sainsbury *et al* 1993) we tried to solicit and collect information from a wide range of sources. However, it is possible that there are other large-scale problems of which we are unaware. Although information was available on the accidental or illegal poisoning of mammals and birds with pesticides (Bijlsma 1992; Environmental Panel of the Advisory Committee on Pesticides 1992) the annual recorded numbers were low, possibly due to the difficulties of investigating these cases. We were unable to collect much information on the trapping of animals for control or for trade purposes and there were also obvious difficulties with obtaining data on illegal killing methods (for example the persecution of badgers by digging with dogs, but see Griffiths 1992).

In all cases described, the harm was a result of human actions or human changes to the environment. However, there are differences between these cases in the immediacy of the human responsibility for them, associated with differences in the degree to which they result from deliberate actions, the degree to which they could be avoided and the degree to which they result from present or past actions. In some cases (eg population control procedures) the harm results, or has resulted from deliberate action aimed at killing the animals, in others (eg road collisions or oil contamination) it is caused accidentally. In both situations steps to ameliorate and prevent further incidents should be encouraged. There is also perhaps a difference in the degree of human responsibility in cases in which the harm is an accidental side-effect of one of the more essential human industries (eg food production) compared with cases in which the harm is a side-effect of a less essential one (eg pet cat keeping).

Natural challenges such as starvation due to food shortages, stress due to extreme weather conditions, infectious disease and predation also cause severe harm to wild mammals and birds. We face a dilemma if we attempt to alleviate the harm due to human activities. For example shooting may not change the overall annual mortality rate of a population because a percentage of animals which are shot would otherwise die through starvation or predation. The relative severity of the harm produced by these challenges is then called to question.

Some interesting general points emerge from this review. First, it is clear that the welfare of large numbers of individuals of a wide range of species of wild animals is seriously compromised each year as a result of past or present human actions. Second, those cases which, using our methods of assessment, seem the most important in terms of the severity of the harm and the numbers of animals involved are not those which have received the greatest public attention. This may be because of the importance of the causal activity to certain components of human society, the public perception of some pest species and the absence of ready solutions to prevent suffering. Although in some cases there are relatively simple and inexpensive ways in which the problems could be ameliorated or prevented, in other cases this is not so. We have, tentatively, pointed to some approaches. There may be a case for tighter control of shooting in some areas to minimize crippling rates. There is a need for continued close monitoring of oil spills and enforcement of anti-pollution legislation. An alternative to lead shot would reduce the incidence of lead-poisoning. There is a need for further information and for dissemination of information on techniques and standards of rehabilitation of wildlife casualties and of release to the wild. Support should be given to the development of more humane rodenticides or rodent control systems. The majority of methods used to control pest species result in some degree of harm. We consider that those methods which kill a high percentage of individuals instantaneously are preferable.

There has been a movement towards undertaking rigorous environmental impact assessments prior to the implementation of new technologies and developments, to try to foresee and prevent any deleterious effects. Similarly, there has been encouragement for prior assessment of possible animal welfare implications when introducing new animal production methods. We suggest that consideration of the possible effects on wildlife welfare should be included in such assessments.

Animal welfare implications

Human activities increasingly affect the lives of free-living wild animals. Where possible, measures should be taken to avoid or alleviate problems that compromise their welfare. Resources for this are finite and it is necessary to identify and to direct efforts at the most important problems. In this study we have assessed the relative importance of welfare problems affecting free-living mammals and birds in Europe and suggested methods for the alleviation and prevention of some of the problems.

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