MINIMALLY INVASIVE HEALTH MONITORING OF WILDLIFE

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Investigations of free-living wild animals often involve capture, restraint or other forms of manipulation. There is a need, on both scientific and welfare grounds, to develop and to use less invasive techniques, especially for the assessment of health. Already some such procedures exist, ranging from observation of clinical signs to the laboratory examination and analysis of faeces and other naturally voided samples.

Minimally invasive and non-invasive health monitoring of vertebrate animals is outlined and examples are given of samples from mammals, birds, reptiles, amphibians and fish that can provide useful information.

Keywords: *animal welfare, wildlife, health monitoring, vertebrates*

Introduction

In recent years there has been an upsurge of interest in the health of free-living wildlife (Cooper 1989; Franzmann 1993; Kirkwood 1993). This has been prompted by a number of factors, amongst them concern over i) the effect that infectious and non-infectious diseases may have on free-living animals, especially endangered species; ii) the spread of pathogens from wildlife to humans and domestic livestock; and iii) the paucity of information on infection and disease available to those involved in activities such as rehabilitation and translocation of wildlife and in the maintenance and breeding of animals in captivity. Biologists have become more involved in the health of wildlife for many reasons, including the possible genetic influence on host-parasite interactions - a hypothesis that has attracted much attention over the past 15 years (Loye & Zuk 1991; Crawley 1992).

Studies on free-living wild animals can necessitate catching, handling and manipulation (Fowler 1986). Biologists from many different disciplines use such 'intervention' techniques in order to examine, mark, track or perform experimental procedures on animals. Veterinarians handle and manipulate wildlife to perform clinical examinations, to take samples for laboratory investigation and, sometimes, to carry out medical or surgical treatment.

The monitoring of the health of wild animal populations can be an important part of management programmes. It often involves 'invasive' intervention techniques, as outlined above - for example, the taking of blood and other samples for laboratory investigation.

There are strong arguments for minimizing the extent to which wild animals are manipulated. Restraint, examination and the taking of samples can prove difficult and sometimes dangerous to the operator. Interventions can also cause stress, damage or death to individual animals and may have adverse effects on others in the group or vicinity (Burrows *et al* 1994; Cooper & Williams 1995; Morton *et al* 1995). Clinical and laboratory results obtained from animals that have been chased or captured may be erroneous. Last, but not least, there is increasingly both public and professional concern about welfare and the ethics of intervention in wildlife work (Threlfall 1989; Farnsworth & Rosovsky 1993). These various factors suggest that there is a need to reassess field techniques, including those aimed at health monitoring, and where possible to minimize their adverse effects.

This paper describes techniques which can prove useful in health monitoring of wildlife, but which can be considered 'minimally invasive' in so far as their impact on the animals is concerned. The term 'minimally invasive' is used in preference to 'non-invasive' since even observation or collection of naturally voided samples can have an adverse effect on the behaviour, and possibly even the survival, of a wild animal. 'Invasive' is described in the Oxford Dictionary as 'any intrusion or invasion of privacy' and is a reminder that in biological terms also it need not involve physical contact.

The aims of health monitoring

To monitor, from the Latin *monere* (to warn), can be defined as 'to warn, check, control or to keep a continuous record'.

Health monitoring is thus a form of preventive medicine, its most important function being to detect ill-health before distinct clinical signs of disease, or death, occur. In addition, the collection of biomedical data helps to provide baseline information on a species.

The primary aim of health monitoring of wildlife is to obtain sufficient data to ascertain whether a group or population shows clinical signs of disease or is subclinically affected by an infectious or non-infectious agent. Substantial scientific information can be obtained from a live wild animal if it is examined thoroughly and samples are taken. This, however, involves capture and restraint with the attendant disadvantages and dangers listed earlier. Post-mortem examination also yields valuable data – sometimes more than clinical investigation – but, unless the specimen is found dead, necessitates killing the animal. Generally, far less information can be gained if there is no clinical examination of the live animal, since this limits the choice of samples (for example, there is usually no access to blood). However, such 'minimally invasive' techniques have a significant role to play in health assessment and are likely to assume even more importance in future.

Methods

Three categories of investigation will be considered:

1. Analysis of records.
2. Observation.
3. Collection of samples.

Analysis of records

Increasingly, wild animal populations are 'managed' and a corollary to this is that demographic data are recorded, especially when the species in question is rare. Kirkwood (1994) pointed out the importance of population monitoring in conservation and, in particular, in helping to pinpoint the cause of a decline.

Analysis of population dynamics can prove useful, therefore, in health monitoring. For example, a reduction in numbers of animals in the population may indicate an increase in death rate, prompting a search for carcases for post-mortem examination or, alternatively, justifying capture and sampling of live animals. More specific indications that disease is involved may be, for example, the failure of young animals to survive or a change in the age structure of a group.

Data can be of value retrospectively. For example, following an outbreak of infectious disease in a free-living population, records of movement of animals from one group or locality to another may provide useful clues on how and when pathogens may have spread.

Valuable information may also be obtained from other records. Thus, for example, programmes in Central Africa directed at protecting the endangered mountain gorilla (*Gorilla gorilla beringei*), co-ordinate and control visits made by tourists to see habituated groups of these animals (Foster 1993). If an infectious disease of human origin occurs in the gorillas, careful analysis of the records of visitors may permit the source of the outbreak to be traced.

While records rarely, if ever, provide a specific diagnosis, they can play a useful part, especially in combination with other information, in compiling a picture of the health status of a population of animals. However, it is vital that records are reliable. There are clear advantages if those establishing demographic databases for wildlife collaborate closely with veterinarians in order to ensure that pertinent information (eg births, deaths), of value to people in both disciplines, is being recorded in a readily retrievable form.

Observation

Observation implies that animals are inspected from a distance, without being touched or manipulated in any way. Observation is a traditional part of diagnosis in veterinary medicine where it is usually followed by restraint of the animal and detailed examination. Observation alone can, however, provide many valuable data and may even yield some information that is not always available if a wild animal is handled. This is because some subtle clinical signs, such as muscle fasciculations or mild lameness, can disappear or become imperceptible once the animal is restrained and handled.

Observation is of two types, (i) with the animal unaware, or (ii) with the animal aware, of the observer's presence. Fossey (1983), working with mountain gorillas described these as 'obscured contacts' and 'open contacts' respectively. The information obtained can be different but is sometimes complementary.

The points listed in the following summary of the pros and cons of each observation method differ according to the species and its ecology. It is, for example, almost impossible to observe species that inhabit open areas, such as steppe, without their being aware. Even where there is cover, some species are shy and only very limited observation is possible. Another consideration is the extent to which the animals are accustomed, or have been habituated, to humans. Some species, eg the mountain gorilla, are virtually impossible to observe in the free-ranging state and even when seen, may show abnormal responses (eg diarrhoea) in response to fear of humans and the subsequent flight reaction.

Animal unaware	**Animal aware**
Normal behaviour	Behaviour possibly altered by presence of observer
Subtle signs of ill-health often apparent Certain signs may be missed (eg lameness) because the animal is not disturbed	Subtle signs of ill-health may be masked Signs such as lameness may be observed because the animal is disturbed
Close proximity to the animal, prolonged viewing and repeated visits may be possible	The animal may be disturbed by presence of observer and thus (unless habituated) not permit close proximity, prolonged viewing or repeated visits. On the other hand, it is possible to present a stimulus and then to assess the response.
Little, if any, impact on the animal – 'non-invasive'	Slight impact on the animal – 'minimally invasive'

How observation is carried out is also governed by a number of factors, including the species of animal, the terrain, and the training and experience of the observer. A systematic approach is essential and helpful advice on this and record-taking should be sought from an experienced ethologist or those who are working with the animals on a day-to-day basis. Observation from a distance, using binoculars/telescope, is usually best but may make detection of abnormality difficult. Particular points that are important in health monitoring are listed in Table 1.

Table 1 Important points in observation.

Observation	Comments
General behaviour, including interaction with the remainder of the group (where applicable) and variations in (for example) time spent sleeping/resting compared with that of conspecifics	Usually non-specific but abnormality (differences) may be a general indicator of ill-health. Depends upon a sound knowledge of the species
Gait	Check for lameness (NB some nesting birds feign injury)
Feeding, drinking Defecation Urination Other specific behaviour patterns, eg rumination, flight (birds)	Important indicators of health or disease but knowledge of what is normal is essential. May also yield samples (saliva, faeces, urine) for examination in the laboratory
Appearance: presence or absence of lesions, discharges, etc	Where appropriate compare the appearance of one organ (eg eye) with the other. Look for signs of asymmetry, eg one leg a different shape from the other, which may indicate an injury or lesion.
State of pelage (fur or feathers)	Some animals moult regularly and systematically: others may not

Equipment needed for observation will also depend upon the circumstances and the technique being used, but a checklist, pen, binoculars/telescope and watch are essential while a voice-activated tape recorder and camera can prove useful.

Collection of Samples

A range of samples can be collected and used in health monitoring. While most of these are voided or shed by the animal (eg faeces), a few are part of the animal's environment, for instance, a sample of the water in which fish or amphibians live.

Examples of samples and signs that can prove useful in health monitoring of vertebrates are given in Table 2. Some of the samples listed can be obtained relatively easily (eg the faeces of large mammals and the moulted feathers of birds) but others (eg shed skins of reptiles) may be difficult to locate or (eg faeces of fish) rapidly deteriorate. It is always important to remember that linking a sample with an individual is difficult, if not impossible. Health monitoring is usually on a group basis. Signs, such as nests, burrows and tracks, often need particular skill in interpretation.

Most of the samples listed need to be examined both macroscopically and microscopically. Established techniques, eg diet analysis of faeces (Carss & Parkinson 1996) can often be adapted to provide information on health. A variety of laboratory tests may also be necessary but will not be discussed in detail here. Techniques being developed in domesticated animals - for example, to assay steroid hormone concentrations in faeces (Larter *et al* 1994; Graham *et al* 1995) - have considerable potential in work with wildlife. Radionuclide concentrations have been assessed in the faeces of red deer (*Cervus elaphus*) and can be correlated with values in internal organs (McGee *et al* 1995). The examination of saliva for antibodies is beginning to be used for the detection of intestinal nematode infections in humans (Needham *et al* 1996) and has potential in wild animals.

Feathers and eggs of birds have proved particularly amenable to analysis and examination (Peakall 1987) and provide a good example of often-untapped information about the health of wild animals. Whenever possible, changes or abnormalities in samples should be quantified: for example, faecal consistency of gorillas can be graded from 1-5 (Cooper and Nizeyi, in preparation).

The importance of collecting, handling and processing samples proficiently cannot be over-emphasized and the following rules are suggested:

1. Take any sample that is available, even if at the time it appears inadequate or of poor quality. It may not be easy or even possible to obtain another later.
2. Collect samples hygienically and use the optimum container, swab, transport medium or fixative. Seal containers, especially bags, securely to prevent escape of parasites. Follow a standard technique that minimizes error at each stage of collection.
3. If there is likely to be a substantial delay before processing the specimen, consider carrying out some investigations (eg examination of wet preparations of faeces for fragile parasites) in the field. Special equipment, eg a battery-operated microscope, may be needed for this.
4. If there is insufficient material to carry out a range of tests, choose those that are most relevant. Draw up protocols to facilitate this choice.

Table 2 Samples and signs for health monitoring.

Species	Samples/Signs	Comments
Mammals	Faeces Urine Hair	Can provide much useful information on gross and microscopical examination and laboratory analysis
	Saliva	Has potential in detecting parasite burdens (see text) and possibly in providing other information
	Nests or burrows	May yield hairs and/or ectoparasites
	Food remains	If fresh, may provide information on feeding behaviour and dentition and permit collection of saliva (see above)
	Tracks (footprints)	May reveal pedal injury, lameness, haemorrhage
	Scent marks	Areas marked by scent may show discharge, blood
Birds	Faeces/urates	Can provide much useful information on gross and microscopical examination and analysis
	Feathers	Dropped feathers, especially during the moult, can yield information on health status and heavy metal concentrations as well as ectoparasites
	Nests	May contain feathers, faeces/urates, and ectoparasites
	Food remains	If fresh, may provide information on feeding behaviour and permit collection of saliva
	Pellets (castings)	A rich source of information about the bird's diet and digestion and may yield parasites
	Tracks	As for mammals
	Unhatched eggs or eggshells	Can provide useful data on infectious disease, pesticides, nutrition
Reptiles	Faeces/urates	As for birds
	Shed (sloughed) skin or scales	Much information - microscopy, culture
	Food remains	As for birds and/or mammals
	Tracks	As for mammals
	Unhatched eggs or egg-shells	As for birds
	Water (aquatic species)	See below
Amphibians	Faeces Urine	As for mammals
	Shed skin	As for reptiles
	Unhatched spawn	As for unhatched eggs or egg-shells
	Water (immature specimens and aquatic adults)	See below
Fish	Faeces	As for mammals
	Water	Often the only non-invasive way of health monitoring fish. A carefully collected water sample can provide valuable information on the aquatic environment which in turn often reflects the health of the fish

5. Where appropriate, seek help from colleagues with specialist knowledge or facilities. Remember that submission to another country of 'recognizable derivatives' from certain protected species may necessitate CITES permits (Cooper 1987).
6. Keep careful records including, where possible, photographs of important findings.
7. Retain surplus material so that it can be used for further tests or retrospective studies at a later date.
8. Publish results.

Discussion

The monitoring of the health of wild animals is likely to become increasingly relevant as populations come under pressure due to habitat degradation and other adverse factors. At the same time, concern is growing over the extent to which wild animals are manipulated in order to obtain scientific information (Young *et al* 1996). One result of this has been the production of guidelines or codes of practice for those who work with wildlife (Dein 1991). Examples cover wildlife rehabilitation (British Wildlife Rehabilitation Council 1989; Cooper 1990), the use of wild birds in research (American Ornithologists' Union 1988), studies on amphibians and reptiles (American Society of Ichthyologists and Herpetologists *et al* 1987), and work on free-living species in general (Canadian Council on Animal Care 1984).

The capture, restraint and sampling of wild animals in order to investigate their health status is likely to continue. So also is the killing of species to obtain diagnostic specimens – although sampling methods that can be used on live animals are increasingly being encouraged (Henry & Meeker 1981; Larsson & Lindegren 1987). In this context it is worth noting that, as long ago as 1959, J B S Haldane made a plea for the 'non-violent study of birds' (Haldane 1959). What seems certain, is that there will be greater public and peer pressure to reduce to a minimum methods that necessitate physical restraint, anaesthesia or other invasive activities (Burrows *et al* 1994). This means that those concerned with the health of wildlife must be familiar with non-invasive or minimally invasive methods that can be used, at least in the initial stages, to obtain data.

If less invasive techniques are to be encouraged, there is a need to improve their efficacy and value in terms of the information yielded and how this can best be interpreted and used. There are two main challenges in this respect: first, how to obtain a larger and better selection of specimens for investigation; and second, how to make greater use of the material that is obtained.

The person working in the field can make the greatest contributions to the first of these since he or she is in a position to observe wild animals and in so doing determine better ways of obtaining material – hair, feathers, body secretions, etc – that might yield information. Closer collaboration between biologists and veterinarians is essential. The latter challenge largely involves laboratory-based personnel who can, for example, work on improved microtechnological approaches to obtaining more data from tiny samples. Quality control is important.

Animal welfare implications

The animal welfare implications of minimally invasive health monitoring are substantial. The techniques discussed in this paper do not require an animal to be captured or even touched. When disturbance is involved, this is usually limited to close proximity to humans and the attendant disquiet or fear that this may elicit. Disruption of feeding or other routines can also occur. These arguments may, of course, be countered by those who argue that methodologies for minimally invasive health monitoring are in their infancy and, as a result, an animal may suffer while a diagnosis is awaited. Yet immobilization (for example) may permit detailed and comprehensive investigations to be performed, often permitting immediate therapy of infectious disease or physical injury. This is an area in which debate will continue. Probably there is a need to assess each case on its merits and, in so far as minimally invasive health monitoring is concerned, to do a cost-benefit analysis.

Minimally invasive techniques demand a fresh approach by those involved in monitoring the health of wildlife. Ability to capture and restrain animals must be balanced with a willingness to observe, to record and to collect and examine samples. A book published in the United Kingdom nearly 30 years ago was entitled, *Be a Nature Detective* (Knight 1968). Its author taught young naturalists how to learn much about the biology and behaviour of native wild animals by observation and, in particular, by examination of their signs, eg footprints, partly gnawed food items, dropped feathers and regurgitated pellets. A similar approach, combining a scientific mind with a sensitivity to, and empathy with, living creatures, is needed if methods of minimally invasive health monitoring are to be improved and refined. The great scientist Paracelsus stated that, 'The physician must know the invisible as well as the visible.' This might also be considered to be the aim of those involved in the health assessment of wildlife.

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References

American Ornithologists' Union 1988 Report of committee on use of wild birds in research. *Auk:* 1A-41A

American Society of Ichthyologists and Herpetologists, the Herpetologists League and the Society for the Study of Amphibians and Reptiles 1987 Guidelines for the use of live amphibians and reptiles in field research. *Journal of Herpetology 4:* 1-14

British Wildlife Rehabilitation Council 1989 *Ethics and Legal Aspects of Treatment and Rehabilitation of Wild Animal Casualties.* BWRC: Horsham, UK

Burrows R, Hofer H, and East M L 1994 Demography, extinction and intervention in a small population: the case of the Serengeti wild dogs. *Proceedings of the Royal Society of London, B256:* 281-292

Canadian Council on Animal Care 1984 Wild vertebrates in the field and in the laboratory. *Guide to the Care and Use of Experimental Animals,* Volume 2, pp191-200. CCAC: Ottawa, Canada

Carss D N and Parkinson S G 1996 Errors associated with otter *(Lutra lutra)* faecal analysis. I. Assessing general diet from spraints. *Journal of Zoology 238:* 301-317

Cooper J E 1989 (ed) *Disease and Threatened Birds.* Technical Publication No 10. International Council for Bird Preservation (Birdlife International): Cambridge, UK

Cooper J E 1990 A tenderness towards all creatures: paradoxes and portents in wildlife rehabilitation. *Proceedings of the International Wildlife Rehabilitation Council Conference: Beyond the bird in the hand,* pp 4-10. International Wildlife Rehabilitation Council: Suisan, California, USA

Cooper J E and Williams D L 1995 Veterinary perspectives and techniques in husbandry and research. In: Warwick C, Frye F L and Murphy J B (eds) *Health and Welfare of Captive Reptiles*, pp98-112. Chapman and Hall: London, UK

Cooper M E 1987 *An Introduction to Animal Law*. Academic Press: London, UK

Crawley M J 1992 (ed) *Natural enemies. The Population Biology of Predators, Parasites and Diseases.* Blackwell Scientific Publications: London, UK

Dein F J 1991 Standards for free-ranging wildlife. *Proceedings American Association of Zoo Veterinarians* 1991. American Association of Zoo Veterinarians: Philadelphia, USA

Farnsworth E J and Rosovsky J 1993 The ethics of ecological field experimentation. *Conservation Biology 7:* 463-472

Fossey D 1983 *Gorillas in the Mist.* Houghton Mifflin: Mass, USA

Foster J W 1993 Health plan for the mountain gorillas of Rwanda. In: Fowler M E (ed) *Zoo and Wild Animal Medicine*, pp331-334. W B Saunders: Philadelphia, USA

Fowler M E 1986 (ed) *Zoo and Wild Animal Medicine.* W B Saunders: Philadelphia, USA

Franzmann A W 1993 Veterinary contributions to international wildlife management. In: Fowler M E (ed) *Zoo and Wild Animal Medicine*, pp42-44. W B Saunders: Philadelphia, USA

Graham L H, Goodrowe K L, Raeside J I and Liptrap R M 1995 Non-invasive monitoring of ovarian function in several felid species by measurement of fecal estradiol-17B and progestins. *Zoo Biology 14:* 223-237

Haldane J B S 1959 The non-violent scientific study of birds. In: Daniel J S (ed) *A Century of Natural History,* pp417-425. Bombay Natural History Society/Oxford University Press (1983): Oxford, UK

Henry C J and Meeker D L 1981 An evaluation of blood plasma for monitoring DDE in birds of prey. *Environmental Pollution (Series A) 25:* 291-304

Kirkwood J K 1993 Interventions for wildlife health, conservation and welfare. *Veterinary Record 132:* 235-238

Kirkwood J K 1994 Veterinary education for wildlife conservation, health and welfare. *Veterinary Record 135:* 148-151

Knight M 1968 *Be a Nature Detective*. Warne: London, UK

Larsson P and Lindegren A 1987 Animals need not be killed to reveal their body-burdens of chlorinated hydrocarbons. *Environmental Pollution 45:* 73-78

Larter N C, Rajamahendran R and Sivakumaran K 1994 Immunoreactive faecal progestins as indicators of reproductive status. *Veterinary Record 134:* 474-475

Loye J E and Zuk M 1991 (eds) *Bird – Parasite Interactions. Ecology, Evolution and Behaviour.* Oxford University Press: Oxford, UK

McGee E J, Symott H J, O'Keefe C and Colgan P A 1995 Radionuclide uptake by red deer (*Cervus elaphus*) on mountain grazing. *British Veterinary Journal 151:* 671

Morton D J, Anderson E, Foggin C M, Kock M D and Tiran E P 1995 Plasma cortisol as an indicator of stress due to capture and translocation in wildlife species. *Veterinary Record 136:* 60-63

Needham C S, Lillywhite J E, Beasley N M R, Didier J M, Kihamia C M and Bundy D A P 1996 Potential for diagnosis of intestinal infections through antibody detection in saliva. *Transactions of the Royal Society of Tropical Medicine and Hygiene 90:* 526-530

Peakall D B 1987 Toxicology. In: Pendleton B A G, Millsap B A, Cline K W and Bird D M (eds) *Raptor Management Techniques*, pp321-329. National Wildlife Federation: Washington DC, USA

Threlfall W 1989 Use and abuse of wildlife in research. *Bio-Ethics '89 Report of the Proceedings of an International Symposium on the Control of the Use of Animals in Scientific Research,* pp155-167. Animal Welfare Foundation: Canada

Young S, Macdonald D and Linzey A 1996 Study and be damned? *BBC Wildlife 14(1):* 64-67