

WILDLIFE INFECTIOUS DISEASE CONTROL IN EUROPE

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Abstract - During the last thirty years, common infectious diseases of humans or animals have changed their manner of attack... New epidemiological patterns have emerged as wild species have acted as victim, host or reservoir. This has been seen in rabies, bovine tuberculosis or, more recently, wild-boar classical swine fever. Attempts to control these diseases have not always been successful depending on the criteria of the proposed objective. Emerging diseases are of interest for veterinarians as well as public health officials. As far as wildlife is concerned, difficulties can arise in controlling the population dynamics either of the host or of the pathogen. Lessons learnt from previous experiences could help in the management of new emerging problems.

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1. Historical background

Not long time ago, at a conference, a student asked me " why was it so important to control rabies, since no human death due to rabies has been mourned in Western Europe for more than half a century..." This highlights the point that the need to control infectious diseases in wildlife, is based on what is considered important or not... Obviously, determining what is important is not solely a scientific task. Objective criteria are still lacking.

Currently international organisations, such as the World health organisation (WHO) or the Office international des épizooties, World animal health organisation, (OIE), have listed diseases which should be reported in human and in domestic species. Among them, several are known to occur in wildlife (table I). A special OIE working group, created in 1993, listed the diseases in wildlife which have the potential to cause problems. Nevertheless, new emerging diseases can occur anywhere, anytime.

Wildlife disease specialists (as far as they do exist) are well aware that "disease" is not a relevant concept (Artois, 1993). Usually the pathogenic effect (morbidity) of infection, however infectious or parasitic they might be, are not noticed. Some provokers used to say that in wildlife, "disease" simply does not exist (Moutou & Artois, 1984). Then apart from some uncommon cases, controlling wildlife disease means dealing with an impalpable reality. The last point to mention as an introduction, is a very unique characteristic of wildlife disease : wild mammals and birds arouse love and friendly attitudes from the general public. As symptoms of sickness are not obvious, and

since people are usually not aware that some infections can be passed on to man or domestic species, the rationale for control is difficult to be justified. Spectacular outbreaks of mass mortality (stranded whales, botulism) or infection (IKC, foot rot of sheep, ecthyma) in wildlife are immediately reported in the media, usually in a very emotional way, attracting public attention mainly because of the welfare concerns. Management then, is to be carried out under the scrutiny of TV, radio and newspapers. A situation which is not very comfortable, fortunately nowadays the mad-cow crisis has redirected some of the attention to another topic...

2. Surveillance

Management is based on the knowledge of an infectious problem in wildlife. For knowledge, surveillance is the most appropriate way to get structured data. According to a report from Leighton (1994, where relevant addresses could be found), few countries in Europe currently have their own wildlife diseases surveillance network. However a country scale reporting system, assessing an acceptable level of health in game species is recommended in a EU directive (92/45/CEE). It is no universal system for surveillance: some reporting systems are based on zoonotic or specific infection of economical importance, but mostly oriented toward domestic species, some are based on the interest in given animal groups: sea mammals, game animal, rehabilitation centres.

Specialised diagnosis departments for wildlife exist in Sweden (National veterinary institute, Uppsala), the area of Nordrhein-Westfalen,

Tab. 1 - Main parasites and infections in wildlife which are known to be (potentially) important for veterinary public health and economy in Europe.

Type	Name (in domestic species)	Host(s)/ Sentinel	Sp. Frequently mentioned	OIE	Mortality/ Carriage	Zoonose	of concern for domestic animals	of concern for wildlife conservation
tse	Bovine spongiform encephalopathy	bovine	Animals in zoological gardens	B115	?	?	y	n
v	African swine fever	porcine	Wild boar	A120		n	y	h
v	Aujeszky disease	porcine/carnivores	Wild boar, fox	B052	c	n	y	y
v	Avian influenza	birds	Birds (wild boar ?)		c	y	y	
v	Avian pox	poultry	Birds	B307		n	y	
v	Classical swine fever	porcine	Wild boar	A130	m/c	n	y	n
v	Foot and mouth disease	ruminant et porcine	Cervid, wild boar	A010	c	n	y	y
v	Hantavirus (Dobrova, Puumala, Seoul)	man	Field mice and voles		c	y	y	n
v	Myxomatosis	rabbit	Wild rabbit	B351	m	n	y	y
v	Newcastle disease	poultry	Birds	A160	m/c	n	y	
v	Rabbit viral haemorrhagic disease	rabbit	Wild rabbit	B353	m	n	y	
v	Rabies	mammals	Fox, bats	B058	m	y	y	y
r	Q fever	ruminant	Terrestrial vertebrate	B057	c	y	y	
b	Anthrax	mammals	Ungulate	B051	m	y	y	y
b	Avian botulism	ornamental birds	Waterfowl		m	y/n	n	y
b	Avian cholera	poultry	Birds	B306	m/c	n	y	
b	Avian tuberculosis	poultry	Birds	B303	c	y	y	
b	Bovine brucellosis	bovine	Ungulate	B103	m/c	y	y	n
b	Bovine tuberculosis	bovine, caprine, human	Cervid, wild boar, Carnivores	B105	c	y	y	n
b	Leptospirosis	mammals	Commensal rodents	B056	c	y	y	
b	Listeriosis	human	Mammals		c	y	y	
b	Lyme disease	human	Mammals		c	y	y	
b	Paratuberculosis	ruminant	Ungulate	B059	c	n	n	
b	Pasteurellosis	porcine	Mammals		m/c	y	y	
b	Salmonellosis	porcine	Vertebrate		c	y	y	
b	Sheep and goat brucellosis	ovine & caprine	Ungulate	B152	m/c	y	y	n
b	Swine brucellosis	porcine	Wild boar, hare	B253	c	y	y	
b	Tularaemia	hare	Mammals	B352	m	y	n	y
p	Leishmaniasis	human dog	?	B501		y		
p	Toxoplasmosis	human, Cat	Mammals		c	y	y	
c	Echinococcosis/hydatidosis	human, ovine	Fox, wolf, rodents	B053	c	y	y	
n	Trichinellosis	porcine	Wild boar, fox	B255	c	y	y	
ac	Mange	ruminant, equid	Mountain ungulates, fox	B213	m	n	y	n

Germany (Forsthaus Hardt, Bonn), the canton of Vaud (Institut Galli Valerio, Lausanne) in Switzerland and CNEVA Nancy in France. Several laboratories at research institutes (notably Pasteur Institutes; Institute of Animal Pathology, University of Bern, Bern - Switzerland ; Institute for Zoo Biology and Wildlife Research, Berlin, - Germany; Animal Diseases Research Association, Moredun Institute, Edinburgh - Scotland) and many veterinary universities (schools or colleges) are to some extent dealing with wildlife disease surveillance and diagnosis. Most of them carry out, on a limited scale of time and space, investigations concerning some noticeable infections. To the knowledge of the author, the SAGIR network in France is the only institutional network in Europe, officially recognised by a government for reporting mortality and diseases in wild species (Lamarque & Artois, 1997) as recommended by the EU.

On a broader scale expert members of the OIE work group on wildlife diseases, on an annual basis, have reported noticeable events occurring in this field in Europe (Artois *et al.*, 1997; Artois and Mörner, 1998). An informal network mainly based on the members of the European section of the Wildlife disease association (from the above mentioned institutions) provide data to the rapporteurs¹. EWDA have published an annual report to OIE on wildlife diseases in Europe since 1995, thanks to support from the CNEVA Nancy, France.

There is clearly a great deal of interest in wildlife disease surveillance in Europe, and a lot of information is circulating ; fortunately more and more is being published in international scientific journals, most notably in the Journal of wildlife diseases. But a significant proportion of results presented in different meetings do not appear in peer reviewed journals. Moreover, efforts to co-ordinate the activities in this field (European section of WDA have met every second year since 1995, a FAIR project should start on zoonoses in wild species) are just beginning to develop.

A useful surveillance programme is based on accurate data. It is not the purpose of this paper to review problems linked with the identifying of a pathogen accurately at the individual and population level. This question has been examined by Wobeser (1994). Problems stem from making the diagnosis itself (sensitivity and specificity of tests available for domestic species are different in wild species), the way in which to collect samples (bias of recruitment) and

finally with the assessment of the presence/absence of the infection (Bacon & Macdonald, 1980) and variation of prevalence rate in space and time.

3. Control

3.1. Aim

Hone (1994) pointed out that a clear distinction should be made between wildlife control and pathogen or disease control. Actually, the purpose of controlling an infectious disease in wildlife is not precisely defined: is eradication of the pathogen the target, or is it to prevent the contamination of the domestic stock or humans? Rationale for the need of a control is often imposed by threat to human health or for economical reasons. But an analysis of different strategies targeting either the reservoir, the pathogen or the transmission are rarely properly addressed. For example, two books published at the turn of the 80's/90's, explicitly dealing with rabies control (Thraenhart *et al.* 1989, Bögel *et al.*, 1992) did not include any chapter about why rabies should be controlled, neither analysing the chances of success or risk of failure of different strategies. Wobeser (1994) considers that four questions should be asked before beginning any control program:

"Why? How? How far and finally, How will success be measured?"

Krebs *et al.* (1998) reviewing the badger TB problem in the UK, stated how different the opinions are, concerning the need of limiting bovine TB incidence in cattle. According to the point of view on the perception of the seriousness of the threat or on the acceptance of the role of badgers as a reservoir, the necessity and the efficacy of badger culling remains a matter of debate. A lack of clarity in the aim of the badger TB control programme and the general absence of a way to assess efficacy of measures carried out, led these authors to conclude that any demonstration of success or failure was still lacking. In practice, programmes are frequently designed to fit with the perception of what is feasible on the short term, in order to decrease the level of complaints linked with the disease.

The question of a real need a management should not be avoided. In most instances, abstinence is a reasonable position. Gilmour & Munro (1991) argued that nature should be allowed to take its course and achieve a balance. Experts should carefully compare the expected evolution of the infection in the presence or absence of a control, rabies has been an

example that not enough vaccination can slow the natural spread of the infection, extending the period of time of its consequences at a given point (Smith & Harris, 1991, Tischendorf *et al.*, 1998).

3.2. Programme

Most of the problems we deal with in this paper are considered important at the country scale. One can wonder by whom and how the decision to control a wildlife infection, is taken. To address this point, one only can refer to non-scientific literature. For rabies and CSF, regular meetings (supported by EU, WHO, OIE and private foundations) have been organised for central veterinary officers to allow a consultation with experts of different countries. For badger TB, the British MAAF has essentially been responsible for the decision, reviewed by several and successive reports (Zuckermann, 1980; Dunnet, 1986; Krebs *et al.*, 1997).

As a consequence of the vagueness of clear objectives, establishment of action plans are usually empirical, resulting from a trial and error process. Action plans are then progressively improved by experience gained in the field. The standard format is a series of regulations enumerating a list of actions to be done by select people, based on opinions expressed by experts. If the disease is epidemic and spreading on a large area, cross border co-operation is necessary, as seen in fox rabies control programmes.

Transmission, after replication of the pathogen within the host, is a key point in the control of contagious diseases. In wildlife, this task is complicated by insufficient knowledge of the dynamics of most host populations. Experimental approaches are notably difficult since the host is usually very elusive which stimulated an extensive array of literature based on the theoretical aspects of the population biology of pathogens in natural hosts populations (Bailey, 1975, Anderson & May, 1979, May & Anderson, 1979, only to mention the most prominent authors). Conditions for the persistence of both the host and the pathogen, and control strategies were the most important areas addressed by these papers, and the voluminous literature which has followed since (see Grenfell & Dobson, 1995; Barlow, 1996; Tompkins & Wilson, 1998 for recent reviews). Few of the proposed models have been actually employed in order to draw up control strategies; in Ontario a spatial simulation model on fox rabies was used to define the plans for distribution of vaccine baits (Voigt *et al.*, 1985). In

addition Anderson *et al.*, 1981; David *et al.*, 1982; for rabies (see Pech & Hone, 1992 for a literature review of a dozen rabies models), Hone *et al.* (1992) or Guberti *et al.* (1997) for CSF, Anderson & Trehwella (1985) or Smith *et al.* (1995) for bovine TB, published hypothesis on the limitations or prospects of different strategies of control. But to what extent this information has really been used by managers, remains non-documented.

3.3. Technique

Among the possibilities of control reviewed by Wobeser (1994), management through population reduction has been used in an attempt to control badger bovine TB, CSF in wild boars and fox rabies (other examples of population control are listed by this author). Different methods were employed to kill badgers, wild boars and foxes, either at the den (burrow gassing) or by shooting or trapping (or even poisoning). A trial to reduce an animal population will be sooner or later balanced by reproduction or immigration. It would be desirable to slow these parameters. Contraception has been considered, at least in epidemiological (Wobeser, 1994) or for experimental design (Artois and Bradley, 1995), but is still unpractical under field conditions. Very few of such plans are aimed to evaluate the desired level of population decrease. In addition, only a subjective appraisal of the efficacy is expected.

Most of the drugs or vaccines available for the treatment of domestic species can be used to treat or prevent similar infections, at the individual level, in wild species. But problems for delivering them to free ranging individuals are extremely difficult to solve. In practice, spreading baits for an oral administration is the most well advanced technique (Linhart *et al.*, 1997), but viral vectored transmission is considered as well (Robinson *et al.*, 1997). Examples of treatment, mostly with wormicides, are presented by Wobeser (1994). Before the actual use of orally delivered vaccines for European foxes, (see below), limited trials were carried out for protecting rare valuable species against anthrax (De Vos *et al.*, 1973) or to test feasibility (Rosatte *et al.*, 1981), by parenteral injection (other examples from North America are mentioned by Wobeser, 1994). The limitation of these methods are the capability to immunise (or treat) a sufficient proportion of the population during a significant period of time. Cost, practicality and efficiency are the main limitations of a final success.

4. Results

4.1. Effect of lethal control

Since the recognition of badgers as a potential vector of TB for cattle in 1980 (Zuckerman, 1980), various strategies have been implemented to cull them. According to the review of Krebs *et al.* (1998) several reasons have prevented to compare the efficiency of different strategies in decreasing the number of reactive cattle. However, it has been noticed that severe removal of badgers at a local scale reduced the incidence of TB in cattle. But persistence of the *Mycobacteria* within the environment and social behaviour of badgers has allowed the infection to persist despite control efforts.

Control of CSF by wild boar shooting have been attempted in Europe, but were poorly documented in peer reviewed scientific journals (Aubert *et al.*, 1994). Appropriate methods to assess the culled fraction of the population have never been used in any country. According to French (Coustel & Fouquet, 1994, Burger *et al.*, 1997) and Italian (Guberti *et al.*, 1997) experiences, the level needed for control does really surpass the usual hunting cull and should essentially target the young boars. In the known recorded outbreak CSF in these countries, the natural turn-over of the boar population allowed boars to recover in the space of a few years. After culling, long persistence of the infection within the infected population is a common rule, with a very slow decrease in the registered virus carriers and seropositives. Apparent eradication was claimed when no more infected were recorded, but persistence of antibodies in young at this time should lead to a more prudent diagnosis. To my knowledge, no appropriate statistical method has been applied anywhere in Europe to assess the probability of detection of the CSF infection in wild boars at a low level (see Wobeser, 1994 for description of available standard methods).

For years, the only way to control rabies was by fox culling. Organisation and efficacy were reviewed and discussed by Macdonald *et al.*, 1981. In several instances, bounties were paid to non-professionals in order to encourage fox destruction. Origin of the samples (tails) turned in for payment of a bounty was difficult to assess (when samples were actually checked); payment of bounties was in some circumstances unduly considered as a regular support for outdoor entertainment, consequently a decrease of the resource fox population was not desired. These factors, associated with social

changes in rural areas and the capacity of the fox population to overcome destruction, did not allow control to be efficient on the long term, neither against the progression of the geographic expansion (Artois, 1983) nor against subsequent re-occurrences of the infection (Aubert, 1994). Blancou *et al.* (1991) cautiously concluded, that fox culling has never been proven as efficient for the control of rabies on the European continent.

4.2 Oral vaccination

To this point, rabies has been the only example where the pathogen causing an infection in wildlife has been targeted for control on a significantly large scale. The project was in mind of several scientists, but Baer *et al.* (1971) were the first to demonstrate that immunisation against rabies was possible in fox by the oromucosal route of administration. Years were spent in research in the lab, animal facilities and finally in the field before Swiss researchers first released the SAD strain on a limited scale field trial in 1978 (Steck *et al.*, 1982). European co-operation, under the auspices of WHO allowed a prudent and progressive expansion of fox oral vaccination against rabies in several countries (Stöhr & Meslin, 1996). Much work has been devoted to the assessment of efficacy and safety of the method, including a project in a BAP EEC programme on GMO: Flamand *et al.*, 1991. Oral immunisation of foxes techniques have been reviewed in Wandeler (1991). Currently, where sufficiently well co-ordinated efforts have been concentrated in an area, using good vaccines and an appropriate method of bait distribution, a dramatic decrease of rabies has been observed (Aubert, 1995). By comparison, untreated areas have suffered a persistence of the infection (Aubert, 1992).

To be complete, trials to treat foxes against echinococcosis with baits loaded with Praziquantel (Schelling *et al.*, 1997), or to vaccinate wild boars against CSF are currently carried out on a limited scale in Germany (EU meeting, Perouse, 1998). Only preliminary data have been published in peer reviewed journals.

5. Discussion

The management of wildlife infectious diseases in Europe is still exceptional, apart from the three above mentioned examples, few other diseases are known to be worth considering (echinococcosis, Lyme disease...). Recent crisis have attracted attention concerning emerging

diseases ; as pointed out in several reviews (Morse, 1993; Brown, 1997; Chomel, 1998), several factors are involved. Among them, the followings are notably worrying (only to mention European examples) :

- Introduction of an exotic (potential or actual) reservoir (e.g. racoon dog rabies in Finland and Poland, human tularaemia acquired from imported hares in Italy and Spain),
- changes in demographic balances of natural wild reservoir and/ or vectors amplify a pathogen otherwise not noticeable (e.g. Aujeszky virus infection in wild boars in central Europe, fox mange in Scandinavia, fox rabies (bat rabies ?), wild boar trichinellosis, multilocular echinococcosis, Looping ill amplified by hare population on the increase in Scotland, Lyme disease amplified by increase of deer which could have increased tick populations),
- wild free ranging populations can be infected by domestic species and then act as reservoir (Chamois Brucellosis in the Alps, Badger Tuberculosis),
- both combined (CSF in wild boar),
- change in breeding practices of domestic species increases the chances of cross infections (e.g. Swine brucellosis at *Brucella suis* biovar 2 transmitted by wild boars to pigs in open air settlements)?
- Environmental (global ?) changes increase the potential for microparasites to become pathogenic (increase of avian botulism records).

Actually, separation of the origin of the cited problems is partly artificial, since in most cases, they are combined. In addition, some emerging problems are still not explained such as Hantaviruses, or Tick borne encephalitis ; others are just suspected to be able to occur sooner or later : epizootic of Newcastle disease in migrating waterfowl, highly pathogenic human influenza emerging from European wild reservoir by natural recombination between wild boar and waterfowl virus... Natural recombination of genes can as well create new pathogenic strains (Cholera, anthrax, *E. coli* H7 O157...), this could occur at any time in wild species and spread to humans and domestic species by some unexpected routes (how could *Brucella* infection have evolved in marine mammals?).

Finally, it should be mentioned that emerging diseases can affect the conservation of natural species in the same way : infectious kerato conjunctivitis in Chamois and Ibex was recently shown to be due to *Mycoplasma conjunctivae* (Giacometti *et al.*, 1998). This allows the speculation that sheep are responsible for the cont-

amination of wild ungulates, as it could be with Q fever, mange and probably other diseases. Small isolated populations of rare and endangered wild animals, not only overseas, are threatened with extinction if pathogenic parasites invade them from outside domestic reservoirs. Large populations have been affected by more extensive outbreaks : Phocine distemper and fox mange in Scandinavia has attracted attention, because of its origin and the ecological consequences of such mass mortality involving a transmissible infectious agent.

This present paper has addressed the questions of whether it was desirable to eradicate an infection in wild species and if desirable how to make the decision to control it : detection, alert function, aim and target, feasibility, environmental safety and ecological efficacy, are all key points to consider in making a good decision. It is of a special importance to consider ethical, sociological and political factors with a great deal of tact as the communication with the public concerned is of greater importance than the actual management done in the field (doing something just to show the public that something is being done could have dramatic consequences ; becoming an object of ridicule, being, at the least humiliating).

When it is decided to manage an infectious wildlife disease, much more planning, preparation in risk analysis should be done than is presently practised. One can wonder if increasingly culling a species would be sustainable, only for ecological reasons? As well, since most of the species (i.e. rodents, medium Carnivores and ungulates, among mammals) involved in infectious diseases in Europe are wide spread and populous, it would be well worth to spend more effort in understanding why they are doing so well. Alternative strategies to culling should be developed. Since sanitary hazards are frequently part of what makes an animal a "problem species", infections should be dealt with together with other problems in a pluri disciplinary approach.

Therefore, for human and veterinary public health officials, the challenge of developing a new field of expertise is posed. It is not uncommon to hear wildlife veterinarians arguing that field biologists, especially those involved in conservation, should be more involved in veterinary medicine (Hutchins *et al.*, 1991). This is true, but it is far too infrequent to see veterinarians taking lessons from scientists working in population biology, behavioural ecology, modelling or even bio statistics! Experience

from previous attempts to manage infections in wild free ranging species have shown that agencies dealing with human and animal health are not well enough informed. The common belief that a classical training in medicine and veterinary practice are sufficient to deal with this should be corrected (Peterson, 1991). On an other hand population biologists are notably disappointed by an absence of involvement in field research by microbiologists (Wake, 1998).

At least a minimum number of references should be available in offices, that would include the following: Combes, 1995; Caughley & Sinclair, 1994; Hone, 1994; Scott & Smith, 1994; Wobeser, 1994. The ideas and concepts included in these books (and surely several others) are well accepted by biologists and most, if not all, wildlife veterinarians, but they still should be popularised among veterinary officers, and government workers.

The lack of basic knowledge on these topics is not only a result of an inappropriate training, it is also a consequence of the fact that too many results obtained in this field are only published (when they are published) at non-scientific meetings, in internal reports, or solely in professional newspapers but rarely in peer reviewed international journals. A huge amount of crucial information is stored therefore in "grey literature" or simply in the memory of the actors of local events. Lessons and expertise deduced from previous experience are beneficial for the community on a whole since at the stage where we are, good descriptions and clear portrayal of facts are needed. We can certainly speculate and try to build hypotheses, models and theory about emerging infections and parasites, but factual information (properly sampled) is what is really desired.

On the European scale, greater co-ordination between agencies should be stressed. A special training in zoology of hosts and vectors (namely entomology and acarology), ecological epidemiology, population biology of parasites and infection, wildlife management, should be included in veterinary and medical schools (Kirkwood, 1994). Equally the study of diseases, infection and zoonoses should be a part of field biologists training. Money spent in this way would be better used that wasted in calamitous wildlife disease control programmes, the worst having not been mentioned in this paper. My final message is that the passion displayed by wildlife disease specialists does not mean they are not good professionals. Ecology

is as important as epidemiology, or even animal health ; wildlife management and conservation can be regarded just as can stock and cattle breeding ; in any case knowledge, expertise and experience do exist, it's just necessary to knock at the right door.

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