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VIRUS THREATS TO MONK SEALS

**An interview with Professor Ab Osterhaus,
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In 1997, a mysterious mass mortality event wiped out two thirds of the world's largest surviving colony of Mediterranean monk seals in Mauritania-western Sahara. Although the precise cause was never conclusively established, rival theories blamed both a toxic red tide event and a morbillivirus outbreak.

Now, in 2002, an ongoing virus epidemic in the North Sea has so far claimed the lives of some 20,000 common seals, threatening to overwhelm rescue centres. In the Dutch Wadden Sea alone, where the Seal Rehabilitation and Research Centre (SRRC) has registered more than 2,100 dead seals to date, it is suspected that half the population may have been eliminated.

But what of Europe's most endangered marine mammal? Already on the brink of extinction, how serious a threat are viruses to the survival of the Mediterranean monk seal, *Monachus monachus*? To learn more, we spoke to Professor Ab Osterhaus of Erasmus Medical Centre's Institute of Virology in Rotterdam, and Chair of the Scientific Advisory Board of the SRRC in Pieterburen.



Ab Osterhaus at Pieterburen

Q. When did you first become involved in monk seal conservation, and what inspired you to do so?

A. I've been working on seal viruses since 1984, and the first contact I had with monk seals was back in 1987, when two orphaned pups, Theo and Dimitri, were transferred from Greece to the SRRC in Pieterburen for rehabilitation. The Seal Centre was then at beginning of what was to become a long and fruitful collaboration with MOM, the leading monk seal NGO in the Aegean.

There were no suitable rehabilitation facilities in Greece at that time, and so the policy was still to bring monk seals to the Netherlands for treatment. That's basically against our rules today. The 1988 morbillivirus outbreak in the North Sea underlined the increased risks involved in moving animals in this way. As a result, it was decided that we should offer training and technical expertise, and also establish a mobile rehabilitation unit on Alonissos, in the Northern Sporades Marine Park, so that monk seals could be treated in situ.

Responding to the 1988 outbreak, we also created a multidisciplinary scientific advisory group, which I continue to chair on behalf of the SRRC. We established very stringent scientific and veterinary rules to guide the rescue and rehabilitation process.

Q. How great a threat is a virus epidemic to the survival of the Mediterranean monk seal as a species?

- A.** Well, I think there are two issues to consider here, dispersed as opposed to concentrated populations. The monk seal population in the Mediterranean is rather dispersed, which reduces the risk of a potential epidemic. A virus-infected animal, for example, might well die before having the opportunity to pass the infection on to other individuals. Even so, we always have to bear in mind that the animals do have contact with each other, have a wide interaction radius, and can travel quite considerable distances. With seals moving between colonies in the eastern Mediterranean, for example, there is also the possibility of cross-infection between monk seals in Greece and Turkey. As such, even in dispersed populations the threat of virus infections has to be taken seriously, especially that of morbillivirus infections.

Off the coast of Mauritania, on the other hand, there is a group of monk seals concentrated into a small geographical area where infectious disease could spell disaster. Potentially, disease could wipe out the entire population. Although outbreaks of this kind usually don't cause 100% mortality, with a species like the monk seal that is already on the brink of extinction, loss of 50% or more of the population – as happened in Mauritania in 1997 – could reduce genetic variability to a point where the colony can no longer sustain itself.

Q. What types of virus pose the greatest threat to monk seals?

- A.** Morbilliviruses, I think, constitute the major threat. Theoretically, this could be any morbillivirus: phocine distemper (PDV), canine distemper (CDV), rinderpest virus, even human measles virus – although this is unlikely to spread to seals because it is rarely seen in humans anymore in the industrialized world.

On another branch is the dolphin morbillivirus (DMV) and the porpoise morbillivirus (PMV). The interesting thing is that we originally thought that these two closely related viruses wouldn't spread to pinnipeds because they are essentially cetacean viruses, but we have seen at least two examples where cross-infection to monk seals did occur, in Mauritania and Greece respectively.

Of all these morbillivirus strains, however, I would say that the greatest threat to monk seals probably comes from CDV and its variant, PDV – the virus we're facing today that's killing many thousands of seals in the North Sea.



Victims of the 2002 PDV epidemic, 300 dead seals await necropsy in the Netherlands

Q. Could other viruses also pose dangers to monk seals?

- A.** No one has investigated it, but monk seals could also be susceptible to the herpes virus. We have identified a couple of seal herpes viruses which are mainly a threat to pups. Usually, what we see in harbour seals and grey seals is that although adults survive after suffering a respiratory infection, the pups can die.

Influenza viruses from birds should also be taken into serious consideration. There were massive outbreaks of influenza virus disease in seals in the 1980s, killing substantial portions of the population, and those were transmitted by birds. Again, these have not as yet been detected in monk seals but they do present a threat. These animals inhabit areas where migratory birds basically fly over their heads, and these birds do carry a plethora of different influenza viruses, some of which are undoubtedly dangerous for monk seals.

Q. How many of these potentially-lethal viruses have been detected in monk seals?

- A. The only viruses that has been detected in monk seals so far are the morbilliviruses. In January 1996, a sick adult monk seal was discovered on the Aegean island of Psara. The animal, which subsequently died, was found to be infected with PMV, the porpoise morbillivirus. Then, during the 1997 mass mortality in Mauritania, we isolated DVM, the dolphin morbillivirus.



January 1996: an adult monk seal on Psara was found to be infected with PMV, the porpoise morbillivirus

- Q. How difficult is a virus to detect and confirm as cause of death, even in a mass mortality situation? During the 1997 mass mortality in Mauritania, for example, there was controversy and uncertainty over whether the cause could be attributed to a virus or a toxic red tide phenomenon.

- A. That controversy is still there, although we are in the camp that maintains that the virus infection was the most probable cause. But we couldn't prove it. In the 1988 North Sea outbreak we could prove that the PDV was responsible for the epidemic by doing an infection experiment. I developed a vaccine in 1989, took a group of naïve seals, vaccinated four, sham vaccinated two, and then challenged them with the virus. The two sham vaccinated animals contracted the disease and died. And that's how I proved the virus was responsible. I was heavily criticized as a result.

During the 1997 mass mortality in Mauritania, I also isolated the virus. We demonstrated the presence of DMV and showed that a majority of animals had developed antibodies against it, and so there was definitely a spillover of the dolphin morbillivirus to the monk seals. You can always argue that that wasn't the primary cause, but that virus would definitely have debilitated the immune system of the animals. Whether or not it was the final cause of death, we will never know. However, we had one pup that was brought in for rehabilitation that died about 10 days later with a virus infection – that animal could not have died as a result of the algae bloom.

We also had blood and tissue samples analysed here in the Netherlands by the WHO reference lab and they couldn't find any evidence of an algae bloom – the toxins were just not there. The Spanish team then produced a report with contradictory findings, and so opinion remains divided.



1997: A mass mortality event strikes the monk seal colony in Mauritania / western Sahara, wiping out two thirds of the surviving population. Divided opinion blames both a morbillivirus epidemic and a toxic algae bloom or 'red tide'.

- Q. What kinds of symptoms do morbilliviruses produce in monk seals? Do symptoms vary between adults, juveniles and pups?

- A. Where morbilliviruses are concerned, if there is a naïve population – we can assume the monk seal population in the Mediterranean is naïve to morbilliviruses since we have not detected antibodies during periodic checks – then you would see all three categories, adults, juveniles and pups, being affected. If however, the virus has already been in the population, it is the pups that are most vulnerable because adults that have survived the infection are probably immune for life.

In contrast to the Mediterranean, a substantial proportion of the monk seal population in Mauritania carries antibodies to the dolphin morbillivirus. DMV specific immunity in the animals that survived the 1997 epidemic will most probably protect against other morbilliviruses as well.

In the acute phase, the virus mainly causes respiratory symptoms, including severe pneumonia from which the animals may die. If they survive the first acute infection, many other symptoms may appear, including neurological symptoms – which are usually fatal – gastrointestinal symptoms and skin problems. The point is, this virus severely debilitates the immune system, which means the animals become vulnerable to a host of other viruses and agents. During the 1988 North Sea outbreak, for example, we were isolating herpes viruses, influenza viruses, pox viruses, bacteria, parasites – you name it. This so complicated the diagnosis that we didn't know what the primary cause was, initially.

- Q. Given their differences in habitat and behaviour, how are such viruses practically transmitted between species – for example, between dolphins and monk seals?**

- A. It's true that these species don't normally interact. However, seals are quite curious, so if you have a lot of dead dolphins floating in the water that still harbour viruses, then there is a possibility of contagion. The potential infectiousness of the virus also depends on environmental conditions. In the Arctic, for example, a carcass could remain infectious for weeks or longer. If it's in the Mediterranean, in summertime, then it's only a matter of days.

- Q. What kind of time frame is involved in the development of a virus infection?**

- A. The incubation period is 1-2 weeks. After about a week the animal will start excreting the virus. This is the period when the animal is highly infectious – and so in theory it could come into contact with a number of other animals.

The monk seal we found on Psara was severely debilitated – it didn't swim and soon died – but you could quite easily imagine a real life situation whereby canine distemper virus is spread from domestic dogs to monk seals in the Mediterranean. If that were to happen, it is possible that a CDV epidemic could develop of the kind previously seen in the Antarctic among crab-eating seals, in the Caspian Sea and Lake Baikal, that killed tens of thousands of animals.

- Q. What is the potential risk of monk seals contracting CDV and other viruses through contact with other wild and domesticated species, such as beech martins, bats, goats?**

- A. In Greece, there are outbreaks of CDV amongst dogs from time to time, but it also affects other terrestrial carnivores, like martins and foxes.

Goats have another virus, *peste des petites ruminants* (PPRV), and also rinderpest which has appeared in Turkey in the past and is closely related to DMV. These could be a potential problem for monk seals – we just don't know. As yet, we've not found a morbillivirus in bats, but they do harbour other viruses and also share cave habitat with monk seals. So far, I've tried to confine my comments to known threats, but I could give you a list of 50 other viruses out there which could be a potential threat, and it's important to keep that in the back of your mind. Everyone, for example, now takes the threat of morbilliviruses seriously. But when we first identified the phocine morbillivirus we had a hard time convincing the scientific world. So one has to guard against preconceived ideas, to be vigilant, and keep an open mind.

- Q. Must viruses be considered a new threat to monk seals, or is there historical evidence to suggest that marine mammal populations have always had to contend with such periodic outbreaks?**

- A.** I think these viral epidemics are not really new – only the frequency and intensity has changed. The earliest mass mortality that we know of was in 1955 amongst crab-eating seals in Antarctica, when the Americans mounted an expedition to the South Pole using non-vaccinated dogs. The dogs were dying of CDV and they probably dumped them in the water, causing an enormous mortality among the seals.

Q. To what extent can susceptibility to viruses among marine mammals be linked to deteriorating environmental conditions, such as pollution and malnourishment due to overfishing pressures?

- A.** First of all, the chance of animals becoming infected is higher because of increased contacts, both with domesticated animals and free-ranging or migrating species. There is an increased incidence, for example, of species moving into non-native habitats due to overfishing, climate change and other anthropogenic factors.

That, in fact, was the case that was made for the 1988 North Sea outbreak – that European fishermen were depleting fish stocks around Greenland, driving harp seals towards Scandinavian waters in search of food, and bringing the virus with them.

As a small concentrated population, the monk seal colony in Madeira must also be considered at risk from this phenomenon. In the last two years, for example, many hooded seals have been found well outside their customary geographic limits, and have been sighted in the Caribbean, Spain, even the Mediterranean.

If any of these animals were to carry a morbilli- or other virus, and come into contact with the Madeiran monk seal population, the risk could be significant. There may, in fact, even be a case for vaccinating this population.

Pollution is another factor. We know from seals in northwestern Europe that their immune system has been impaired – before the outbreaks – due to a build up of chemical pollutants like PCBs and dioxins. There are also new substances like halogenated compounds used in antifouling agents on ships and in flame retardants – substances whose effects have not been fully studied as yet but that are building up in the environment.

Q. Vaccination is now routinely administered to monk seals undergoing rehabilitation. But under what circumstances is vaccination feasible for wild populations?

- A.** It is only administered routinely where we are concerned. We do not provide the vaccine to others at this stage, or only on a very limited basis. That's just a practical problem.

There is also the question of which vaccine to use. I am currently in discussions with our Ministries of Environment and Agriculture on precisely this issue, given the severity of the outbreak in the North Sea. There is a vaccine that's used in the United States which is a GMO, a genetically modified organism. It's actually based on canary poxvirus and that's a virus that does not replicate in mammals. The virus has been modified in such a way that it expresses the glycoproteins of CDV and that protects mink and ferrets against the virus. We think it will also protect against phocine distemper and other morbillivirus infections in seals. I've been trying to use that vaccine in the Netherlands but, since it's a GMO, I can't get the required permission. As a result, some people have started vaccinating seals with live attenuated vaccine. These should never be used in wild animal populations because of the risk involved. There is the notorious case of the black-footed ferret which was almost wiped out by vaccination with an insufficiently attenuated vaccine. What we are using is an inactivated vaccine, which may not be as effective as the GMO vaccine. Unfortunately, in Europe there is a knee-jerk reaction against anything associated with GMOs and, while I share many of those misgivings, this should be an exception.



Monk seal blood test. Serum samples from stranded, sick or dead monk seals should be collected and analysed as a matter of routine.

Q. Should vaccination be considered as a prophylactic measure in the eastern North Atlantic monk seal population?

A. I think vaccination should be considered for concentrated populations of monk seals, for instance in Mauritania and Madeira. You just have to weigh the benefits against the drawbacks and the practical problems involved. If you start to vaccinate you probably have to administer the vaccine several times.

Q. That obviously poses a high risk of disturbance.

A. You always have to weigh the pros and cons. But I think the opportunity should be taken to vaccinate the animals during other hands-on research procedures, such as the collection of blood or tissue samples. I agree that we should take whatever measures are possible to guard against unnecessary disturbance, but experience has shown that once an outbreak is already raging the logistics become far more difficult, particularly when there are no properly agreed protocols and scientific lightweights are taking decisions. I think all rehabilitated animals should in principle be vaccinated, but this has not been followed elsewhere.

Q. Are sufficient safeguards currently in place to guard against a possible epidemic among monk seals? And are there any specific steps that governments and NGOs should be taking to reduce risks?

A. The most important step is to develop a coherent action plan to deal with such emergency situations, composed of multidisciplinary teams. While a start has been made and working groups formed, I don't think they're functioning to the standard required yet. In fact, I'm almost certain that if there were to be another outbreak, then we'd see the same problems that occurred in 1997 in Mauritania.

Of course, there are always tensions between rival groups or individuals, but these problems can only be dealt with effectively with the right leadership and the right coordinating skills.

So far, I don't think we have the right experts around the table. The inevitable result is that – at least where infectious diseases are concerned – certain individuals are expressing opinions that they're really not qualified to talk about, even if they are experts in other fields, like population biology.

A rejuvenation of the expert teams – bringing talented young scientists into the equation – would, I think, be another step in the right direction.

Q. What special measures should monk seal conservation organisations be taking to monitor and guard against possible outbreaks? If it is not the case already, should blood samples be routinely obtained from stranded animals for analysis?

A. We have been getting serum samples from Greece, but not regularly from Turkey or Madeira. But this should be done on a routine basis. We are, in fact, currently trying to set up a coordination system for necropsies in the Greek – Turkish area, in Madeira and Mauritania. Once all the necessary contacts have been established, we will offer to analyse the samples free of charge, as we are currently already doing.

Q. How complex a procedure is it to test for the presence of viral infection? How quickly can results be obtained from analysis of blood and tissue samples?

A. Usually transport takes more time than the analysis. Although the procedure is complex, we have streamlined it in such a way that within 48 hours we have the result.

Q. What special measures should be in place to prevent disease transmission between monk seals undergoing rehabilitation and the wild population?

A. This is a point I've raised repeatedly. We have to be very careful, but with the safeguards we have at Pieterburen it is virtually impossible for rehabilitated animals to pose a greater risk than wild animals. If you rehabilitate professionally, there is no increased risk. I'm convinced of that. But 'professionally' – that's the key word. If rehabilitation is being undertaken where there are other species, particularly exotic species, in the same location, or if dogs and cats are allowed to roam around the facility, or if there are migratory birds in the immediate area, then there are serious risks of disease transmission.

Q. In what ways do you imagine that advances in virology will eventually pay practical dividends in safeguarding threatened and endangered species from viral mass mortality events?

A. I think there are three main areas. First in diagnostics. Although we are already quite advanced in this field, we could improve matters by making diagnostic capabilities more widely available. The second area is vaccination: we need to develop vaccines that can be used safely, and perhaps without touching the animals, thereby reducing or even eliminating disturbance. The third area where I see progress being possible is in anti-viral therapy. A diseased animal, for example, in the early stages of infection, could be treated with a specific anti-viral to combat the full onset of the disease. This is still a long way off, but in humans anti-viral therapy is already being used routinely for several virus infections.

Further reading

An Osterhaus et al. bibliography of papers and reports relating to seal virus research has been added to the [Monachus Library](#): **Osterhaus, ADME.** 2002. Bibliography of publications concerning seal virus research, 1985-2002.

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