OXFORD LEAD SYMPOSIUM: CLOSING REMARKS

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So much first-class information has been presented during the symposium that I cannot attempt to summarise it all, but what I would like to do is pick out what I think are the main issues to emerge:

Lead must now be one of the most thoroughly and extensively studied of anthropogenic toxins. At this symposium, we have heard only parts of the evidence available on its biological impacts, mostly relating to the UK; when added to findings from the rest of the world, we have a huge body of scientific evidence, which is consistent and overwhelming in its messages. In what I have to say now, I will rely mainly (but not entirely) on this current symposium.

Effects on people

Toxic effects of lead on people have been recognised for centuries (Stroud 2015). It is a non-essential component of the diet which, at very low levels, affects multiple physiological systems, including nervous, renal, cardiovascular, immune and reproductive systems. It also affects the behaviour of animals, and has been implicated in the criminal behaviour of some people. Influential medical publications have listed lead as 'probably carcinogenic'.

Owing to this knowledge, most important sources of lead in the environment of the UK have already been significantly reduced or eliminated (paints, gasoline, lead-pipes *etc.*), while other remaining uses (as in batteries or lead-sheeting) are well controlled. This leaves lead-based ammunition as the remaining greatest source of emissions of lead to the environment that remains largely unregulated. An estimated 5,000 tonnes of lead ammunition are deposited on the UK every year, raising existing environmental levels, especially in areas of concentrated shooting activity (Pain *et al.* 2015).

Since additives to petrol were regulated, the main source of lead contamination of people has been *via* the diet, that derived from lead ammunition is the most readily controllable source. Lead obtained from wild meat, whether in the form of shot pellets or bullet fragments, has been linked with elevated blood levels in people, such blood levels tending to increase linearly with the amounts of game meat consumed. Links between the use of lead ammunition and lead in the human body, and between lead in the body and human health and well-being are now firmly established by several independent studies (*e.g.* see Green and Pain 2015, Knutson *et al.* 2015).

In recent years, lead has been shown to affect adults and children at far lower concentrations in body tissues than formerly thought, and at lower concentrations than current regulations acknowledge (although acceptable levels have been reduced over the years (Green and Pain 2015)). There is no level of lead exposure in children or adults known to be without deleterious effects. In other words, there is no toxicity threshold: the concept of a 'safe level' is redundant. Exposure in childhood to even slightly elevated levels of lead produces measurable and lasting neurological deficits in intelligence and behaviour. Neonates and children with growing brains are especially susceptible.

Relatively new findings concern the behaviour of bullets and shot: the way that lead-based ammunition leaves behind tiny fragments on passage through an animal. These can be distributed widely within carcasses, including places distant from the wound tract. This makes it almost impossible for people to avoid ingesting lead along with meat. The bits of lead are so small and scattered that no normal butchery can remove them. So the consumption of lead-killed meat almost inevitably results in the consumption of undetected lead. While this fact may have been known to some for years, new studies have re-emphasised it in a most dramatic way, for example from X-ray images of shot animals (Green and Pain 2015, Gremse and Reiger 2015).

Average levels of lead in game meat, measured in recent years, have been many times higher than the suggested maximum permissible concentration in domestic meat. Some individual meals prepared from gamebirds killed with lead shot have over one hundred times the *maximum permissible* level for domestic meat (Green and Pain 2015).

Since the impacts of lead are largely hidden, usually undetectable without medical study, we can reasonably assume that we have much bigger human health problems caused by lead ammunition than previously recognised. Lead poisoning could potentially affect people anywhere in the UK, if they eat wild waterfowl or game, but particularly those for whom wild game forms a significant part of the diet (such as some of the shooters themselves and their families and associates). Diabetes, mental and renal problems are some familiar illnesses that are known to be exacerbated by lead. Recent surveys have shown that, among the hunting community alone, up to 12,500 children in the UK are now exposed to dietary ammunition-derived lead from game meat in sufficiently large amounts to be at risk from some health consequences (as defined by the European Food Safety Authority).

Effects on wildlife

Lead is similarly toxic to a range of other vertebrates, especially mammals and birds. Some species, such as waterfowl, game birds and pigeons, ingest spent gunshot incidentally along with the grit needed in food breakdown, while meat-eating scavengers ingest lead fragments from the carcasses and discarded gut piles of shot animals on which they feed. A deer shot through the thorax with a lead bullet may have large numbers of lead fragments in the pile of viscera discarded in the field by the hunter. Worldwide, more than 130 wild bird species are known to be affected in this way. In some species thousands or tens of thousands of individuals die from lead poisoning every year in North America alone. There is no reason to think that the situation is much different in Europe. These incidental casualties include quarry species which the hunters themselves would otherwise seek to preserve. Recent estimates imply that some 50,000-100,000 waterfowl may die of ingested lead poisoning in the UK each year (Pain *et al.* 2015). This lead poisoning does not normally produce obvious mass mortalities of the type that can result from disease, because birds die slowly through the year, a few at a time, their carcasses swiftly removed by scavengers. Lead-caused mortality is therefore largely hidden, invisible to the average hunter or country-dweller.

While this incidental mortality of waterfowl, game birds and scavengers may be substantial, we have few assessments of its effects on population levels. For lead-poisoning to reduce a population, or cause it to be smaller than it would be in the absence of lead, it has to be additive to other deaths, and not compensated by reduction in other mortality. However, quantitative circumstantial evidence indicating population-level effects is available for some waterfowl (Mateo 2009), and for some scavenging birds of prey, such as eagles and vultures (various in: Watson *et al.* 2009). Such evidence is available for the white-tailed eagle *Haliaeetus albicilla* in central Europe and the Steller's sea eagle *Haliaeetus pelagicus* in Japan (the latter problem having been reduced recently by a legal ban on lead bullets). The evidence on population effects is particularly striking in the California condor *Gymnogyps californianus* in North America, which can no longer maintain a self-sustaining population in its historic range: the mortality from ingested lead-based ammunition well exceeds its natural reproductive rate. Wherever lead-based bullets of current design are used as now in game hunting, it is recognised that the condor is unlikely to survive without intensive remedial intervention anywhere in North America. It is being kept from extinction in the wild only by a programme of conservation management involving annual releases of captive-bred birds, coupled with veterinary care, involving frequent capture of wild individuals and treatment to reduce their blood-lead levels (Green *et al.* 2008).

Of course, we are not concerned with Condors in Europe, but southern and central Europe has vultures that are certainly affected by lead, though population-level effects have not been documented. And northern Europe has scavenging raptors that are exposed to ammunition-derived lead, but again no research to examine population-level effects has been done.

If lead ammunition was banned, given all the lead already in the environment, how can we be sure that such a ban would reduce the mortality of affected species, and that their populations (if reduced by lead) would recover? Well, first of all, the uptake of lead by waterfowl and others is much greater in the shooting season than during the rest of the year, which implies that birds are ingesting recently-applied lead, not older stuff much of which presumably eventually sinks into the substrate, putting it beyond reach. A seasonal cycle in lead uptake is also apparent in raptors and other scavengers that feed on the carcasses of quarry species (Pain *et al.* 2015). Most strikingly, however, we have the example of the sedentary mute swan *Cygnus olor* in Britain (Perrins 2015).

These birds got their lead mainly from fishing-weights rather than gunshot, and following a ban in lead fishing weights in 1987, lead-caused mortality declined from 25% per year in the 1970s to 2% in more recent years, and populations switched from decline to increase. On the most affected river systems, swan numbers doubled within a decade (Perrins *et al.* 2003). This showed convincingly that, if effective restrictions were imposed, this highly vulnerable species could and did respond by recovery.

Alternatives to lead

Non-toxic alternatives to lead ammunition have been developed, are widely available, and apparently perform well, once the right ammunition has been identified for a particular purpose and gun, and hunters have got used to it (Gremse and Reiger 2015, Kanstrup 2015, Thomas 2015). The argument that lead is best, and that alternatives are less good, is no longer tenable. Steel shot is of similar price to lead shot, but some other alternatives are currently more expensive. Nevertheless, the cost of new ammunition is still trivial compared with the other costs of hunting (Thomas 2015). Lead gunshot was banned totally in Denmark nearly two decades ago and in some other countries more recently, apparently without any detrimental effect on the sport (Kanstrup 2015). The same numbers of people are still hunting, and at similar level. Lead is clearly dispensable as a form of ammunition. In Germany, research on the new non-toxic bullets has been undertaken to improve their performance, and to smooth the transition from lead (Gremse and Reiger 2015).

More research

One standard way to avoid making controversial decisions is to call for more research, from which we can usually benefit. But over the years, evidence on the problems caused by lead ammunition has continued to accumulate, and specific gaps in knowledge have been identified and filled, continually updating our information base. Recent information has served mainly to confirm what we already know, and that the problems persist, but it has added further worrying facts. The essential messages have not changed. Surely we already have sufficient scientifically-robust information to take action against the use of lead-based ammunition for sport hunting. It would be irresponsible not to do so.

Previous restrictions on the use of lead ammunition

Previous legislation in England in 1999, concerning the use of lead over wetlands and for wildfowl shooting, has been lamentably ineffective, because of lack of compliance and enforcement. People evidently feel that they will not be caught, and the statistics on prosecutions confirm this. There has been no decline in lead poisoning in waterfowl examined in Britain from before and after this ban (Newth *et al.* 2012). Among ducks intended for human consumption purchased in Britain in 2008-10, at least 70% had been shot with lead ammunition (Cromie *et al.* 2015). A laudable campaign, led by hunting organisations to encourage compliance, did not change this.

Future restrictions on the use of lead ammunition

There are two approaches towards getting hunters to switch from lead to less toxic alternatives. One is by persuasion; informing them of the facts and hoping they will make the switch themselves. This approach has clearly not worked: witness the continued use of lead shot over wetlands for more than a decade after the 1999 ban; witness the continuing opposition by some hunters and their organisations to restrictions in the use of lead. This leaves us with the only other approach which is mandatory. All other major uses of lead have long been banned or strictly regulated by law, yet this particular use, which provides a direct and important route for lead into the human blood stream, remains unrestricted. Legislation proved necessary in Denmark to cut the use of lead; as in Britain, the dissemination of scientifically-collected findings and appeals to the better nature of hunters had not worked. Danish hunters now accept it, and (as confirmed by surveys) would not go back.

Awareness problems

The questions that remain in my mind are not so much to do with the effects of lead, on which the scientific evidence is overwhelming, widespread and unequivocal. Rather they concern the attitudes of many hunters and their representatives. What a pity we had so few representatives of hunting organisations attending the symposium, while the majority of those invited declined to attend. Given all the information we now have on the

impacts of lead on human health and well-being, on its effects on wild bird populations, and given that satisfactory alternatives to lead are now available, why is it that a large sector of the hunting community in Britain and elsewhere remains opposed to the replacement of toxic lead by non-toxic alternatives? Do they just not know about the evidence, do they not understand the problems, do they not believe the results of robust science replicated in region after region, or have they been continually fed with misleading information? Do they think the problems are not big enough to worry about (the invisible problem syndrome), do they just object to any further regulation or change of any kind, or do they see the banning of lead as a step on the way to banning hunting? How can those organisations that represent hunters and yet continue to oppose restrictions on lead justify to their own members the stance they have taken, given the knowledge we now have? Why do these organisations not take a lead in educating their members, and supporting a legal ban in the use of all lead ammunition? Given this intransigence, is it time to put these issues more forcefully before the general public?

Whatever the answers to these questions, all raised during our discussions at the symposium, there is clearly a communication problem. No-one has suggested that decisions on such important issues as lead poisoning should be left to hunters alone. If it were just hunters who wanted to put only themselves at risk, without affecting other people, domestic livestock or wildlife, it is their choice. But their behaviour *does* affect other people (including their families and associates), domestic animals and wildlife. There are issues of health, well-being and mortality, and also of animal welfare. In the UK, hundreds of thousands of wild bird and mammal carcasses end up each year in the human food chain for consumption by people not involved in hunting, being sold by butchers, supermarkets, hotels, restaurants, pubs or online shopping outlets. Yet all this meat is distributed to the unsuspecting public without any accompanying health warnings. Campaigns to promote the sale of game meat as healthy food omit to mention the lead within. In the presence of the information now readily available, and which has been available for several decades, how can this be allowed to continue? How will the shooting bodies who oppose restrictions on lead justify to their members and the general public the stance they have taken for more than three decades after all other major uses of lead, from paints to petrel to pipes, have been banned or seriously restricted? Europe is moving in the right direction, but far too slowly.

We wish the Lead Ammunition Group well in their deliberations, and look forward to their report. The recent Convention on Migratory Species resolution on poisoning (UNEP-CMS 2014) is also important because it puts our government under an obligation to do something. My own view is that a legislative ban is needed on the use of lead in all ammunition used for hunting. At one stroke this would alleviate the problems created for people (especially the hunters themselves), for wildlife and for domestic livestock by this unnecessary but highly toxic material. Of course, a date for the ban would need to be set ahead, to give hunters and manufacturers time (ideally no more than two years) to shift to other materials. After our day of excellent science, practical experience and discussion, these are the thoughts I would like to leave you with.

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Embedded lead gunshot in the flesh of small ducks exposes predators such as this marsh harrier *Circus aeruginosus* to lead poisoning.

Photo Credit: B. Townsend