

## **Risk to human health from exposure to lead from lead bullets and shot used to shoot wild game animals**

### **Background**

When EFSA published their opinion on lead in food, they identified high consumers of game meat as a sub group with higher exposure to lead. It was not possible to carry out a definitive risk assessment as data on game consumption were insufficient (limited number of consumers in the National Diet and Nutrition Survey - NDNS). Subsequently the Agency (FSA in Scotland) commissioned a research project on the *'Habits and behaviours of high-level consumers of lead-shot wild-game meat in Scotland'* to identify high-level consumers of lead-shot wild-game meat in Scotland and to investigate their habits and behaviours associated with its consumption. Following this, it was planned that a risk assessment would be carried out and if the exposure to lead from this source was a concern, risk management measures would be put in place.

### **Safety Assessments on lead in food**

The Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) advised that efforts should continue to reduce exposure to lead from all sources since it is not possible to identify a threshold for the toxic effects of lead. Similar conclusions were reached by the EFSA and JECFA. In 2010, EFSA calculated that an average dietary lead intake of **0.5 µg/kg bw/day** in children would be associated with a 1 point decrease in IQ. JECFA has separately calculated that a dietary intake of **0.3 µg/kg bw/day** is associated with an IQ deficit of 0.5 point. For adults, EFSA identified effects on the cardiovascular system and kidneys as critical effects and calculated that dietary lead intake values of **1.50 µg/kg bw/day** could result in a 1% increase in systolic blood pressure and **0.63 µg/kg bw/day** could result in a 10% increase in the prevalence of chronic kidney disease.

### **Main findings of the consumption survey that are relevant to risk assessment**

- High consumers of game meat were defined as those who ate it at least once a week during the shooting season and approximately the same frequency out of season. 200 respondents were identified and were interviewed; these high-level consumers are likely to represent worst case scenarios.
- Interviews with experts in the field of wild-game meat preparation and lead shot removal (consultant chef, game dealer, gun expert/ stalker/ shooting party organiser and veterinary surgeon) and in-depth preparation/consumption interviews with domestic and commercial respondents involved in wild-game preparation (i.e. butchers, game dealers, shooters and game-keepers) were carried out. Therefore groups at highest risk have been covered.

- Qualitative information on portion sizes has been obtained. 66% of respondents felt that portion sizes should be consistent with meats such as chicken, pork or beef while 25% believed that wild-game meat portions would be slightly smaller than those of pork or beef.
- Information on the frequency of consumption is also needed for exposure assessment since the effects of lead are due to chronic exposure. During the shooting season, 51% of the interviewees eat wild game at least once a week (21% out of season) and 14% eat it 3 or 4 times a week, 6% maintain this consumption level even outside the main shooting season.
- People of all ages within the family eat the wild game, including children and elderly members. However there was a small drop in consumption levels for children under 5 years old and adults between 65 and 74 (77% and 82% respectively).
- There is no specific information on consumption by pregnant women. Consumption prior to pregnancy would also be important due to skeletal accumulation and mobilisation during pregnancy.
- Many of the people interviewed shoot the game themselves or are given it by people they know who shoot, which is relevant to its preparation.
- A vast majority of the consumers prepare the game themselves.
- Wine is the main ingredient used in preparation (88%). This is very relevant - at acidic pH (2 - 4) of the wine as well as vinegar (38%) and tomato sauce (33%) - tiny fragments of lead would dissolve and be more available.
- It was considered normal to freeze game - therefore it is available for consumption throughout the year.
- Most interviewees remove obvious pellets before cooking and discard severely damaged meat, but not all.
- Even though most consumers would expect the presence of lead shot, finding it in game meat is not common place. It is found less than occasionally by 79% and even less (85%) when eating out. Most interviewees (80%) remove obvious pellets before cooking and discard severely damaged meat, but not all.

### **Data on lead levels in game**

**FSA Survey:** A limited number of game meat samples (both wild and farmed) were included in an Agency survey (2007) of metals present in various foods. Any visible shots were removed before analysis. It was found that lead was present in some

samples of pheasant and venison with a maximum concentration of 1.63 mg/kg in one sample of pheasant. The mean concentration was 0.41 mg/kg for samples of pheasant and 0.05 mg/kg for venison. A majority of the samples of venison (10 out of 13) had lead concentrations below the limit of detection.

**The National Surveillance Scheme (NSS):** Game samples are included in this surveillance carried out by the Veterinary Medicines Directorate (VMD) and samples of both wild and farmed deer as well as pheasant and partridge are included. Results are published at <http://www.vmd.defra.gov.uk/vrc/reports/annual.html> data from 2004 - 2011 have been looked at.

The levels for 161 samples of wild deer ranged from less than limit of detection (LOD) to 180 mg/kg. 83% (134/161) of the samples were below 0.1 mg/kg (EU legal limit for beef, lamb, pork and chicken) and 94% (152/161) were below 1 mg/kg. Three samples (<2%) had levels above 10 mg/kg (15.84, 33.5 and 180 mg/kg) and the average lead concentration of 161 samples of wild deer is **1.62 mg/kg** (median is 0.01 mg/kg). If the three high levels are excluded, the average lead concentration for wild deer is **0.195 mg/kg**.

During the analysis, no attempt is made to remove visible shot. Representatives of the National Game Dealer's association (who provide samples of game for the NSS) have informed the FSA that the bruised part of the carcass or the meat close to the wound channel is often given to the VMD because of the lower value of this meat. These two reasons might explain the three high values observed.

The levels of lead in pheasants and partridges were higher than those in larger game. Data for pheasant (58 samples) ranged from less than LOD to 4.84 mg/kg with one high value at 77.6 mg/kg. 54% of the samples were within the legal limit of 0.1 mg/kg for beef, lamb, pork and chicken. The average concentration is **1.87 mg/kg** (median level of 0.078 mg/kg); including the high value. If the single high value is excluded, the mean value reduces to 0.54 mg/kg. Data for partridge (53 samples) from the NSS was similar - ranging from less than LOD to 4.58 mg/kg and two high values at 14.51 mg/kg and 16.0 mg/kg. In the case of partridges, 42% of the samples were below 0.1 mg/kg. The average concentration is **1.33 mg/kg** (0.79 mg/kg without including the two high values) and the median is 0.169 mg/kg. The high levels are presumably from fragments of lead shot in the samples - it is most likely that consumers would remove them before preparation or consumption.

Lead levels in farmed game are also measured in the NSS. However, risk of increased lead exposure from *farmed game* is not an issue because

- Farmed game animals are normally shot in the head. Since heads are largely discarded and not used for human consumption there would be no public health implications.

- In some cases farmed wild boar and farmed deer are transported to the abattoir and slaughtered there by bleeding after stunning either with captive bolt or with electrical stunning.
- This assumption is supported by data showing that the average concentration of lead in farmed game is less than 0.010 mg/kg.

**EFSA data:** EFSA collected data submitted by Member States on lead in various foods. In 2,521 samples of game meat, lead levels ranged from <LOD to 867 mg/kg. The mean, median and P95 levels were 3.15 mg/kg, 0.02 mg/kg and 1.525 mg/kg respectively. The fact that the P95 value is lower than the mean indicates that there are a small number of occurrence values that are extremely high. Even though the EFSA values can be used to compare with other occurrence values, they cannot be used to carry out risk assessments for the following reasons: the EFSA report does not give details on the game species analysed; it is assumed to be a mixture of large game animals and game birds. Also, the report does not provide any further details on sample preparation (other than that one sample taken around the entry wound which had a lead level of 3,090 mg/kg was excluded).

**Data from scientific literature:** Some data from the literature on wild game are given in the table below.

	Average lead concentration mg/kg	details	Reference
Red grouse	1.17	any apparently whole gunshot or large fragments removed after cooking	Pain (2010)
Mallard	0.34	any apparently whole gunshot or large fragments removed after cooking	Pain (2010)
Partridge	1.12	any apparently whole gunshot or large fragments removed after cooking	Pain (2010)
Partridge (NSS data quoted)	8.05	Shot not removed	Pain (2010)
Pheasant	0.98	any apparently whole gunshot or large fragments removed after cooking	Pain (2010)
Pheasant (NSS data quoted)	1.61	Shot not removed	Pain (2010)
Woodpigeon	0.43	any apparently whole gunshot or large fragments removed after cooking	Pain (2010)
Woodcock	3.41	any apparently whole gunshot or large fragments removed after cooking	Pain (2010)
Deer (NSS data quoted)	0.38	lead bullet particles not removed	Pain (2010)

Red deer	0.22 (0.010–1.5)	lead bullet particles not removed	Falandysz (2005)
red deer killed with lead bullets		samples were collected from around the entry and exit wounds, from around the bullet pathway at different sites along its length	Dobrowolska and Melosik (2008)
	8.5	15 cm from the bullet path	
	1.16	a radius of 25 cm from the bullet pathway	
	0.16	muscle far distant from the bullet pathway	
white-tailed deer; ground meat	18.9	lead fragment mass per package (0.91 kg) averaged 17.2 mg (0.2 - 168±39.8 mg); ground up with fragments; radio-dense fragments analysed.	Hunt (2009)
retail big game meat samples n = 64	Mean 5.9±19 Median 0.2 (0.01–122)	Swiss food control authorities	References in Haldimann (2002)
red deer from Baranja, Croatia	0.148±0.061 (median - 0.027)	Tissues damaged by the shot not used	Lazarus (2007)
eiders (seabird) killed with lead shot (Greenland)	mean 6.1	Data obtained from the abstract	Johansen (2004)
thick-billed murre (seabird) killed with lead shot (Greenland)	Soup - 0.0063 mg/l  Breast meat 0.22	Skinned and viscera, head, wings and legs removed, after which the carcass was cooked. The soup and breast meat were then analyzed.	Johansen (2001)
Game meat	Mean 3.15 Median 0.020 P95 1.525 (<LOD - 867)	Data submitted by Member states; no further details	EFSA opinion on lead in food

### Occurrence values used in risk assessment for large wild game

There are reports in the literature that lead bullets used to shoot game can shatter on impact and tiny fragments of lead can be found distributed in the flesh of the animal, particularly around the wound channel (for example Dobrowolska and Melosik (2008) in table above, Grund 2010). However, the meat around the wound channel is usually discarded; 80% of the interviewees in the current survey indicated that the bruised meat around the wound channel is discarded and that they would remove all/most visible shot. Also, when large wild game is processed at Game Handling Establishments, the affected parts of the carcass would be removed and discarded due to the damage caused by the bullet (bruising). Therefore the majority if not all of any lead would not reach the consumer. Some tiny lead fragments can be found in

muscle that is away from the wound channel as shown by studies carried out by the Minnesota Department of Natural Resources<sup>1</sup>.

It is evident that while a substantial proportion of the large game samples have lower lead levels, fairly high lead levels can be measured if any lead fragments from the bullet are present in the meat. As seen in the venison samples of the NSS, 3/161 samples had high lead concentrations. Since it is evident that the three high levels must have been samples taken close to the wound channel, these are treated as outliers and excluded from the analysis. The average lead concentration for wild deer was **0.195 mg/kg**. This value has been used to carry out the risk assessments, which is appropriate since the majority of the interviewees (80%) in the survey indicated that meat damaged by the bullet (wound channel) would be discarded. If a consumer repeatedly ate meat that has lead residue from the lead ammunition (wound channel), their exposure to lead would be higher.

### **Occurrence values used in risk assessment for game birds**

The main game birds that are consumed are pheasant and partridge<sup>2</sup>. Again these can be either farmed or wild. Pheasants and partridges are reared in captivity before being released for shooting and can be legally shot with lead bullets. Data from the Game and Wildlife Conservation Trust show that in 2004, about 35 million pheasants<sup>3</sup> and 6.5 million red-legged partridges<sup>4</sup> were released annually. About 15 million pheasants and 2.6 million red-legged partridges were shot that year<sup>5</sup>.

Regarding sale of small game, colleagues from the FSA Operations Group have indicated that the lead pellets are very small and it would be impractical to ensure they are removed during the dressing procedure: trying to remove them would be very time consuming (would eat into the processor's profit margins) and would cause damage to the birds which would likely make them unsalable. There is also a public acceptance that wild game will contain shot pellets: this is normally taken as proof that the animal was hunted and the industry claims it confers authenticity. As a result if wild game meat goes through a metal detector at the processing plant the chances are that the sensitivity for metal will be set so that only very large amounts are detected. Pellets will therefore reach the consumer, both for product marketed as fresh meat and for product served cooked in pubs and restaurants. Some supermarkets may penalise financially the processing plant if carcasses do have lead pellets but the amount of wild game meat sold through supermarkets in the UK is very small.

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<sup>1</sup> [http://files.dnr.state.mn.us/fish\\_wildlife/lead/bulletstudy/resources/publicsummary.pdf](http://files.dnr.state.mn.us/fish_wildlife/lead/bulletstudy/resources/publicsummary.pdf)

<sup>2</sup> <http://www.shootingfacts.co.uk/pdf/pacecmainreport.pdf> page 22

<sup>3</sup> [http://www.gwct.org.uk/research\\_surveys/wildlife\\_surveys\\_and\\_ngc/national\\_gamebag\\_census\\_ngc/birds\\_summary\\_trends/229.asp](http://www.gwct.org.uk/research_surveys/wildlife_surveys_and_ngc/national_gamebag_census_ngc/birds_summary_trends/229.asp)

<sup>4</sup> [http://www.gwct.org.uk/research\\_surveys/wildlife\\_surveys\\_and\\_ngc/national\\_gamebag\\_census\\_ngc/birds\\_summary\\_trends/228.asp](http://www.gwct.org.uk/research_surveys/wildlife_surveys_and_ngc/national_gamebag_census_ngc/birds_summary_trends/228.asp)

<sup>5</sup> <http://www.shootingfacts.co.uk/pdf/pacecmainreport.pdf>

Lead shot (smaller pellets) are used in shooting **game birds** and there is a greater probability of finding a lead shot in a game meal. Therefore the average concentration of 1.87 mg/kg lead in pheasant (as measured in the NSS) has been used and the outlier was not excluded. Average levels measured in other game birds are lower (except woodcock where an average level of 3.41 mg/kg has been reported based on 16 samples, Pain et al 2010). However woodcock is less frequently consumed. The use of the mean occurrence value for pheasant from the NSS in the risk assessment is also appropriate because the FSA survey and other surveys<sup>2</sup> indicate that in the UK, pheasant is the most popular wild game for respondents who shoot personally. Therefore, the average concentration of lead in pheasant will be used for risk assessments.

In general, mean and median occurrence values for game birds (for pheasant - 1.87 mg/kg and 0.078 mg/kg respectively) are higher when compared to wild deer (0.195 mg/kg and 0.01 mg/kg respectively).

### **Risk assessments**

The following points have been considered while estimating the exposures to lead:

1. The risk assessment is only for high-level consumers of game; these are consumers who have indicated that they would regularly consume game meat - one or two times every week, throughout the year. This would be a conservative estimate as even among high-level consumers, it is not considered an everyday meal and is generally eaten no more than once or twice a week (page 42 of report).
2. A portion size approach has been used; an average serving of venison has been assumed to be 120g as indicated in the FSA portion size book<sup>6</sup>. An average serving of game bird is assumed to be 100g, similar to a medium average portion of chicken or turkey. Estimates of exposure for one and two portions of game meat in a week have been carried out; this is in accordance with the results of the FSA survey (page 39 of report).
3. Most of the visible shot will be removed before/while eating and therefore the assessments below are worst-case scenarios.
4. Toddlers are the most vulnerable population group, because of the effect of lead on the developing brain together with their proportionally higher food consumption on a body weight basis. The FSA survey indicated that among those interviewed, 23% of children under 5 did not eat game meat.

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<sup>6</sup> Food Standards Agency (2002) *Food portion sizes*, 2<sup>nd</sup> edition. London: TSO.

5. Other than a general observation on portion sizes, there is no specific information on the quantity of game meat consumed by a toddler. National Diet and Nutrition Survey (NDNS) data indicate that the consumption of meat and poultry by a toddler is approximately one third of an adult's consumption. Therefore portion sizes of 40 grams (large game) and 30 grams (game birds) have been used for a toddler.

The table below shows the exposure to lead calculated for one or two portions of venison and game birds. Background (upper-bound) exposures from the rest of the diet (including meat and poultry) as well as exposures from beef, pork, lamb and poultry as calculated from the 2006 TDS are given for comparison. It can be seen that the occurrence levels for lead in beef, lamb, pork and poultry (< 0.003 mg/kg) are much lower than the average levels measured in game meat.

Food	Consumption	Conc of lead (mg/kg)	Exposure to lead (µg/kg bw)		
			Adults	Toddlers 1.5 - 4.5 years	Young Persons 4 - 18 years
Mean upper-bound exposure from the rest of the diet (high-level exposure)	NDNS data	TDS data	<b>0.10 (0.18)</b>	<b>0.25 (0.42)</b>	<b>0.15 (0.30)</b>
Mean exposure from meat (beef, lamb & pork) - TDS data (high-level exposure)	NDNS data	0.003	0.002 (0.006)	0.004 (0.012)	0.003 (0.008)
Venison	One 120 g portion a week (40 g for toddlers)	0.195	0.044	0.077	0.080
Venison	Two 120 g portions a week (40 g for toddlers)	0.195	0.088	0.154	0.161
Mean exposure from poultry - TDS data (high-level exposure)	NDNS data	0.003	0.002 (0.005)	0.003 (0.009)	0.002 (0.006)
Pheasant	One 100g portion a week (30 g for toddlers)	1.87	0.352	0.553	0.644
Pheasant	Two 100g portions a week (30 g for toddlers)	1.87	0.704	1.105	1.289



**Exposure to lead from venison:** An adult regularly eating wild venison shot with lead ammunition (two 120 gram portions a week) could nearly double (1.9 times) the dietary exposure to lead when compared to the average exposure from the rest of the diet. Similarly in the case of toddlers (consumption of two 40 gram portions a week), the exposure to lead could nearly double (1.6 times) the average dietary exposure to lead. The exposures will be higher if meat close to the wound channel or meat that is damaged by the bullet is regularly consumed.

**Exposure to lead from game birds:** The concentrations of lead in game birds are higher than in large game. An adult regularly eating pheasant shot with lead ammunition (two 100 gram portions a week) could increase their dietary exposure to lead by up to 8 times the background exposure from the rest of the diet. In toddlers the dietary exposure could be up to 5 times the background exposure (two 30 gram portions a week). These are conservative estimates, assuming visible lead shot is not removed. More than 60% of respondents stated that they only 'occasionally' or 'rarely' found a piece of lead shot (page 31 of report).

In a **toddler**, the average exposure estimated from one venison meal a week (40 grams) is **0.077 µg/kg bw** and one game bird meal a week (30 grams) is **0.553 µg/kg bw**. The exposure for game bird consumption is in the region of dietary lead levels associated with a 1 point decrease in IQ as calculated by EFSA (**0.5 µg/kg bw/day**). When lead exposure from the rest of the diet is included, this level will be exceeded. This indicates that the effect of lead on the neurodevelopment of toddlers regularly consuming game birds would not be negligible even if there were no other sources of exposure to lead. This estimation could be slightly conservative as the FSA consumption survey indicates that the consumption levels are slightly lower for toddlers (77% of children under 5 ate game meat). This is also supported by the Mintel report on game meat (Mintel, 2007) that women and children are less interested in game meat.

In the case of adults, EFSA estimated that dietary lead intake values of **1.50 µg/kg bw/day** could result in a 1% increase in systolic blood pressure and **0.63 µg/kg bw/day** could result in a 10% increase in the prevalence of chronic kidney disease. The estimated increased exposure to lead from one venison meal a week (120 grams) is **0.044 µg/kg bw** and **0.352 µg/kg bw** from one game bird meal a week (100 grams). Consumption of one or two large game meals a week will result in exposure that is considerably lower than the risk levels identified by EFSA and is unlikely to increase the risk of cardiovascular and kidney effects. However, regular consumption of one or two game bird meals per week (up to 0.704 µg/kg bw) could be associated with an increased risk of chronic kidney disease or cardiovascular effects.

*Woodcock*: Data from a limited number of samples indicate that the average level of lead in woodcock might be higher (3.41 mg/kg, 16 samples) than in other game birds. Consumption of woodcock has the potential to further increase exposure, but it is unlikely that woodcock will be consumed frequently throughout the year. For instance in 2004, less than 250,000 woodcock were shot (compared to 15 million pheasants and 2.6 million partridges).<sup>7</sup>

## **Conclusions:**

- The levels of lead in game meat shot with lead ammunition are higher than the average levels found in beef, lamb, pork and poultry. In general, lead levels were higher in smaller game (birds) than larger game (venison).
- A majority of the consumers use acidic media in the cooking and the lead would be more bioavailable.
- Regular consumption of game meat could increase exposure to lead; if two portions of venison (large game) are consumed every week throughout the year, it could nearly double the dietary exposure. The levels of lead could be higher in the meat close to the wound channel and if a person regularly ate this meat, their exposure to lead would be much higher.
- Consumption of two game bird meals every week throughout the year would increase the dietary exposure to lead by up to 8 times for an adult and up to 5 times for a toddler. These are conservative estimates, assuming visible lead shot is not removed. More than 60% of respondents stated that they only 'occasionally' or 'rarely' found a piece of lead shot (page 31 of report).
- This increased exposure would be a concern in the case of toddlers, young children and pregnant women, because of the neurotoxicity of lead to the developing brain.
- From estimates of dietary exposure to lead for adults, consumption of one or two large game meals a week is unlikely to be a health concern, whereas there is potential increased risk of cardiovascular or kidney effects with regular consumption of one or two game bird meals.
- The risks are lower for people who eat game occasionally.
- Farmed game would not pose concern with regards to lead exposure.

## **References for occurrence levels**

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<sup>7</sup> <http://www.shootingfacts.co.uk/pdf/pacecmainreport.pdf> page 22

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