Outcomes from monitoring the fourth year of a five-year voluntary transition from hunting with lead to non-lead shotgun ammunition in Britain

Green, Rhys e.; Taggart, Mark a.; Pain, Deborah j.; Clark, Nigel a.; Clewley, Louise; Cromie, Ruth; Dodd, Stephen g.; Huntley, Brian; Huntley, Jacqui; Leslie, Roderick; Porter, Richard; Price, Mike; Robinson, James a.; Robinson, Robert a.; Sinclair, Michael; Smith, Ken w.; Smith, Linda; Spencer, Jonathan; Stroud, David

Published in:
Conservation Evidence Journal

Publication date:
2024

Outcomes from monitoring the fourth year of a five-year voluntary transition from hunting with lead to non-lead shotgun ammunition in Britain

Rhys E. Green[1,2*+], Mark A. Taggart[3+], Deborah J. Pain[1,4+], Nigel A. Clark[5], Louise Clewley[6], Ruth Cromie[6], Stephen G. Dodd[2], Brian Huntley[7], Jacqui Huntley[8], Roderick Leslie[9], Richard Porter[10], Mike Price[11], James A. Robinson[6], Robert A. Robinson[5], Michael Sinclair[3], Ken W. Smith[2], Linda Smith[2], Jonathan Spencer[12] & David Stroud[13]

[1] *Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK*
[2] *Centre for Conservation Science, RSPB, The Lodge, Sandy, Bedfordshire SG19 2DL, UK*
[3] *Environmental Research Institute, University of the Highlands and Islands, Castle Street, Thurso KW14 7AP, UK*
[4] *School of Biological Sciences, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, UK*
[5] *British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU, UK*
[6] *Wildfowl & Wetlands Trust, Slimbridge, Gloucestershire GL2 7BT, UK*
[7] *Department of Biosciences, Durham University, South Road, Durham DH1 3LE, UK*
[8] *Department of Archaeology, Durham University, South Road, Durham DH1 3LE, UK*
[9] *8 Somerset Street, Bristol BS2 8NB*
[10] *King's Head Cottage, Cley next the Sea, Norfolk NR25 7RX, UK*
[11] *15 Lawnfold, Hadfield, Derbyshire SK13 2EG*
[12] *Environmental Change Institute, Oxford University Centre for the Environment, South Parks Road, Oxford OX1 3QY, UK*
[13] *Spring Meadows, Taylors Green, Warmington, Peterborough PE8 6TG, UK*

*corresponding author email address: reg29@cam.ac.uk
+these authors were the principal investigators and contributed equally to the study

DOI: https://doi.org/10.52201/CEJ21/SSSV6262

SUMMARY

The 2023/2024 shooting season was the fourth since UK shooting and rural organisations announced their intention that hunters should make a full voluntary transition from the use of lead to non-lead shotgun ammunition by 2025. The SHOT-SWITCH research project has monitored the proportions of wild-shot common pheasants *Phasianus colchicus* available to consumers in Great Britain that were killed using lead and non-lead shot in each of the shooting seasons since the beginning of the transition. In the study's fourth season, 2023/2024, 93% of pheasants obtained during the usual sampling period had been killed using lead ammunition. Whilst this indicates a marginal decline in the proportion of pheasants shot using lead since the beginning of the transition, when it was over 99%, much remains to be done if the intended full voluntary transition to non-lead shotgun ammunition is to be achieved in its final season (2024/2025). Some food retailers intend to cease selling game meat products from animals killed using lead ammunition. Our study indicates that whilst all of a small sample of pheasant carcasses obtained from one of these retailers (Marks & Spencer) were from birds killed using non-lead shot, a larger sample obtained from another of the retailers (Waitrose) had mostly been killed using lead shot.

BACKGROUND

In February 2020, nine UK shooting and rural organisations called for a complete voluntary transition from the use of lead to non-lead shotgun ammunition for hunting within five years (BASC 2020). The UK food retailers Waitrose & Partners and Marks & Spencer stated in 2019 that they intended to soon cease selling game meat products derived from animals killed using lead ammunition (Barkham 2019; Marks & Spencer 2019). In this paper, we report results from the fourth and penultimate shooting season (2023/2024) of the SHOT-SWITCH project, which monitors the proportion of wild-shot common pheasants *Phasianus colchicus* available to consumers that were killed using lead and non-lead shot.

ACTIONS

Five-year voluntary transition to non-lead ammunition

Several UK shooting and rural organisations followed their announcement of the voluntary transition in 2020 with efforts to publicise it and to encourage their members and other hunters to switch from using lead to non-lead shotgun ammunition. The British Association for Shooting and Conservation (BASC) has enabled thousands of hunters to try shooting with non-lead ammunition at various UK events, such as game fairs, and has distributed many information leaflets. Both BASC and the Game and Wildlife Conservation Trust (GWCT) have provided detailed practical advice on making the transition, through guides on their websites (BASC 2022; GWCT 2022). Articles publicising and encouraging the transition were also placed in magazines read by hunters. In the 2023/2024 shooting season, GWCT made its demonstration shoot on a farm at Loddington in Leicestershire lead-free and is currently

ISSN 1758-2067

monitoring the changes in shooting practice there (R. Draycott, pers. comm.).

Voluntary transition by food retailers to sell non-lead shot game meat

Although Waitrose & Partners and Marks & Spencer both expressed intentions to stop selling game meat products from animals killed using lead ammunition (Barkham 2019; Waitrose 2020; Marks & Spencer 2019; 2022), SHOT-SWITCH surveys have found few, if any, oven-ready pheasants available for purchase in their stores from the 2021/2022 season onwards (Green et al. 2023a). However, sampling from these sources became possible during the 2023/2024 season and is reported in this paper.

CONSEQUENCES

Sampling of pheasants

From 1 October 2023 to 3 January 2024, we visited retailers of game meat and shoots widely distributed around Britain and obtained 340 whole or oven-ready prepared pheasant carcasses intended for human consumption. Sampling occurred during a similar period in all three previous seasons of the SHOT-SWITCH project. Information on how we obtained carcasses, collected information supplied by retailers, and coded the types of suppliers and their locations are provided in Green et al. (2021).

We visited 12 widely distributed Waitrose supermarkets as part of the sampling programme conducted during the usual period but did not find any oven-ready pheasant carcasses on sale there up to early January 2024, although labels for the product were in place on empty shelves in some stores. The oven-ready product 'No. 1 Pheasant topped with Bacon' was advertised and illustrated on the Waitrose website throughout the season, but it was marked as not being available (Waitrose 2024). However, on 15 January 2024, we noticed that the Waitrose website had changed the labelling of this product to indicate availability. We decided to conduct additional special sampling to obtain carcasses from Waitrose stores because they had not been available during the usual sampling period. We purchased 33 packed carcasses from nine stores in Chichester, Wymondham, Norwich, Lichfield, Uttoxeter, Sandbach, Northwich, Preston, and Edinburgh during 15-19 January 2024.

Extracting shotgun pellets

Pheasant carcasses were dissected and the soft tissues and broken bones were examined carefully to search for shotgun pellets. Methods used to locate and store pellets are described elsewhere (Green *et al.* 2021; 2022; 2023a; Environmental Research Institute 2023). From the carcasses obtained during the usual SHOT-SWITCH sampling period, we recovered between one and 11 shot and/or large shot fragments from 229 pheasants. No pellets were found in 111 of the carcasses dissected (33%).

From the carcasses obtained during the usual SHOT-SWITCH sampling period, carcasses from which at least one shotgun pellet was recovered came from 60 businesses located in Northern England (n = 49 carcasses), Central England (89), Southern England (58), Scotland (30) and Wales (3). These areas are as defined by the NUTS scheme (Office for National Statistics 2020). The types of businesses from which these carcasses were obtained were: butcher's shops (n = 139 carcasses), farm shops (21), game dealers (21), online retailers (32), supermarkets (6), and shoots (10). From the carcasses obtained during sampling in mid-January 2024 at Waitrose stores, at least one shotgun pellet was recovered from 22 carcasses and no pellets were recovered from 11 carcasses.

Chemical analysis of pellets

Tubes containing recovered shotgun pellets were sent to a laboratory at the Environmental Research Institute, University of the Highlands and Islands, Thurso, UK for qualitative examination and chemical analysis of the pellets, as described previously (Green *et al.* 2021; 2022; 2023a). In cases where more than one pellet was recovered from a carcass, we carried out qualitative tests to assess whether they were likely to be of the same or different metallic compositions. The tests included assessments of attraction to a magnet, susceptibility to melting with a soldering iron, malleability, and specific gravity. Multiple pellets from the same carcass were all found to be of the same type, except in one case where both magnetic and non-magnetic pellets were recovered from the same carcass. We selected a single pellet of each type from each carcass to determine its principal metal composition. We dissolved each pellet in acid and used an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES; Agilent 5900 with SPS4 autosampler) to estimate the proportion of the mass of each pellet comprised of each metallic element. The methods are described in detail by Green *et al*. (2021; 2022; 2023a). We considered a pellet to be principally composed of an element if that element comprised 50% or more of its initial mass.

Chemical composition of pellets

Carcasses obtained during the usual SHOT-SWITCH sampling period: The principal element in 214 of the 230 shotgun pellets analysed was lead (mean percentage lead by mass; 95%; minimum 50%). Nine pellets were composed principally of iron (average percentage iron by mass; 98%; minimum 96%). Three pellets were composed principally of bismuth (average percentage bismuth by mass; 98%; minimum 96%). Four pellets were composed principally of zinc (average percentage zinc by mass; 97%; minimum 94%). The ICP-OES assays also measure the proportions by mass in the pellets of copper and tungsten, but none of the pellets analysed was composed principally of those elements. Of the 229 carcasses with at least one pellet recovered, 214 had at least one pellet composed principally of lead. These

ISSN 1758-2067

carcasses were obtained from all regions and from 58 of the 60 businesses sampled. The percentage of carcasses with at least one lead shot recovered, as a proportion of carcasses with shot of any type recovered, was 93.4% (95% binomial confidence limits 89.4-96.3%; Clopper & Pearson 1934). Shot composed principally of non-lead metals were recovered from 15 carcasses obtained from eight businesses located in Northern England (n = 12 carcasses), Central England (1), Southern England (1) and Scotland (1).

Two of the pheasant carcasses obtained during the usual SHOT-SWITCH sampling period were obtained from a Marks & Spencer store in Glossop (Derbyshire). Shot recovered from one of these was principally composed of bismuth and that recovered from the other was principally composed of iron. Four pheasant carcasses obtained during the usual SHOT-SWITCH sampling period from which shot were recovered in the 2022/23 season were from a Marks & Spencer store in South Woodford (London) and were included, but not separately identified, in the results reported by Green *et al*. (2023a). The shot recovered from all four carcasses were principally composed of bismuth. Hence, we did not recover lead shot from any of the six carcasses obtained from Marks & Spencer stores in these two seasons: non-lead shot were recovered from all of them. Carcasses were not available from Marks & Spencer stores visited in the previous two seasons (2020/21 and 2021/22). Because of the small sample size, the confidence interval for the proportion of Marks & Spencer pheasants killed using lead shot is wide (estimate 0%; 95% confidence interval 0%-45.9%). However, the proportion of carcasses with lead shot was significantly lower for Marks & Spencer carcasses than those from other retailers sampled during the usual SHOT-SWITCH sampling period in both seasons (2022/23; Fisher exact test, two-tailed $p < 0.0001$; 2023/24; $p = 0.004$).

Waitrose supermarkets: We recovered 40 shotgun pellets (14/carcass) from 22 carcasses obtained from Waitrose stores. The principal element in 20/22 shotgun pellets recovered was lead (average percentage lead by mass; 94%; minimum 66%). Two pellets were composed principally of iron (average percentage iron by mass; 99%; minimum 99%). Of the 22 carcasses with at least one pellet recovered, 20 had at least one pellet composed principally of lead. The carcasses with lead shot were obtained from all of the eight stores where we obtained carcasses from which shot were recovered. The two carcasses from which we recovered iron shot were both from the same store in Preston, Lancashire. The percentage of carcasses with at least one lead shot recovered, as a proportion of carcasses with shot of any type recovered, was 90.9% (95% binomial confidence limits 70.8-98.9). This proportion is similar to the equivalent proportion from carcasses obtained during the usual sampling period in 2023/24 (93%) and did not differ significantly from it (Fisher exact test; two-tailed $p = 0.650$).

Changes across shooting seasons

We compared our results for the usual sampling period with those from earlier SHOT-SWITCH monitoring (Green *et al.* 2021; 2022; 2023a) and an earlier study of pheasant carcasses collected in the 2008/2009 season reported by Pain *et al*. (2010) (Table 1, Figure 1). In 2023/2024, 93% of pheasants with any shot recovered contained lead shot. This proportion was lower than in the first three SHOT-SWITCH seasons, when it was > 99% in 2020/2021 and 2021/2022 and 94% in the 2022/2023 season. We fitted a logistic regression model to the data in Table 1, including data from 2008/2009, which is well before the beginning of the transition period. We treated the number of years elapsed since the 2008/2009 season as the independent variable in the regression. We detected a significant downward trend ($\text{logit}(P_{Pb}) = 14.92 - 0.8303 * \text{YEAR}$, $t_3 = 3.81$, two-tailed $p = 0.031$). However, the modelled

Table 1. Numbers of pheasant carcasses examined and numbers with lead, iron, bismuth, zinc and shot of all kinds recovered in the usual sampling period in each of the four seasons of the SHOT-SWITCH project (2020/21 to 2023/24) and from an earlier study in 2008/09 (Pain et al. 2010). (95% Clopper-Pearson confidence limits of percentages). *One carcass contained lead and iron pellets. ⁺One carcass contained zinc and iron pellets.

	Shooting season				
Number of carcasses examined	2008/09	2020/21	2021/22	2022/23	2023/24
shot recovered	12	180	215	235	229
no shot recovered	10	96	121	121	111
lead shot recovered	12	179*	214	221	214
iron shot recovered	0	2*	1	10	9⁺
bismuth shot recovered	0	0	0	4	3
zinc shot recovered	0	0	0	0	4⁺
total	**22**	**276**	**336**	**356**	**340**
Percentage with lead of those with any shot	100.0 (73.5-100.0)	99.4 (96.9-100.0)	99.5 (97.4-100.0)	94.0 (90.2-96.7)	93.4 (89.4-96.3)
Percentage with lead of all carcasses	54.5 (32.2-75.6)	64.9 (58.9-70.4)	63.7 (58.3-68.8)	62.1 (56.8-67.1)	62.9 (57.6-68.1)

ISSN 1758-2067

decline was small and insufficient to meet the target reduction: the expected value from the regression for the 2024/2025 season, the last of the transition period, is 84% of carcasses with lead shot.

Ellis & Miller (2023) suggested an alternative measure of the proportion of pheasants killed using lead shotgun ammunition in which the number of carcasses from which lead pellets were recovered is divided by the total number of carcasses dissected. This might be more appropriate than our measure if the proportion of pheasants shot using non-lead ammunition from which at least one pellet was recovered was much lower than the equivalent proportion for birds killed using lead shot. To check this proposal, we calculated the average number of lead and non-lead shot/carcass for carcasses from which at least one shot was recovered. If the method proposed by Ellis & Miller (2023) is valid, we would expect that the average number of shotgun pellets recovered for carcasses found to contain at least one non-lead pellet would be considerably lower than the equivalent mean for carcasses with lead shot. We pooled data on the numbers of recovered shot/carcass across all four SHOT-SWITCH seasons because of the small sample size for non-lead shot in any individual season. We calculated confidence intervals for the means by generating 10,000 bootstrap samples by taking n observations at random, with replacement, from the n records of shot number per carcass available. We calculated the average number of shot recovered/carcass from each bootstrap sample, ranked these averages and took the bounds of the central 9,500 values to be the 95% confidence interval. We did this separately for carcasses with lead and non-lead shot recovered. The means for lead and non-lead shot were very similar (average for lead = 1.98 pellets/carcass; 95% confidence limits 1.87-2.10; n = 828 carcasses: average for non-lead = 1.97; 95% confidence limits 1.42-2.65; n = 31). The average for non-lead, expressed as a percentage of the average for lead, was 99%. The 95% bootstrap confidence interval for this percentage (71% to 135%) indicates that it is unlikely that there is a difference in the proportions of birds from which shot were recovered between those killed using lead and non-lead shot large enough to bias our estimates substantially in either direction. We therefore do not consider that the measure proposed by Ellis & Miller (2023) is an accurate alternative to the one we have used. However, we note that, even if it is adopted, analysis of the results shown in Table 1 indicates no evidence for a downward trend over time in the proportion of pheasants killed using lead shotgun ammunition in response to the voluntary transition. The fitted logistic regression model of the trend in the alternative Ellis-Miller measure is logit(P_{Pb}) = 0.3894 + 0.01121*YEAR; t_3 = 0.41, two-tailed p = 0.711).

DISCUSSION

Our results from SHOT-SWITCH monitoring during the usual sampling period indicate that efforts made by shooting and rural organisations during the four years since their announcement of a voluntary transition from hunting with lead to non-lead shotgun ammunition have so far had a marginal effect on the types of ammunition used by hunters to shoot pheasants intended for the retail trade. Of the birds killed in 2023/2024 from which shot were recovered, 93% contained lead shot, compared with 100% in 2008/2009, well before the transition began. Assessments of the trend in the proportion of pheasants killed using lead shot indicate only a small, though statistically significant, downward trend over time. The best estimate of the percentage of pheasants expected to be killed using lead shot in the last season of the transition period (2024/2025), as projected from the fitted regression model, is that it will be about 84%.

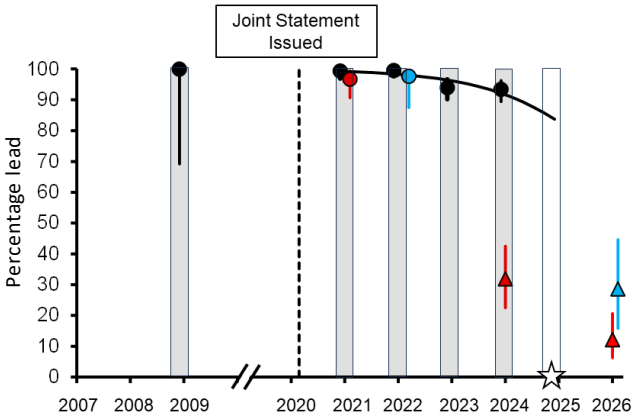

Figure 1. Comparison of the estimated percentages of carcasses of wild-shot common pheasants killed in Great Britain using lead shotgun ammunition (black circles) between a study conducted in the 2008/2009 shooting season (Pain *et al.* 2010) and four recent SHOT-SWITCH studies which sampled carcasses between late October and early January (Green *et al.* 2021; 2022; 2023, and the present study). The vertical lines associated with the black circles are 95% confidence intervals. The curve is from a logistic regression model fitted to the data from the five surveys. Grey bars represent the timing of the October-January shooting seasons for which there are data on shotgun ammunition types used. The white outlined bar denotes the single future season (2024/2025) remaining within the proposed voluntary transition. The white star represents the intended endpoint of the voluntary complete transition to the use of non-lead shotgun ammunition advocated by nine shooting and rural organisations in February 2020. Red and blue circles represent reported proportions of large gamebird shoots continuing to use lead shot, with their 95% confidence intervals shown by vertical lines, based upon questionnaire surveys by Savills (2021: red) and Savills (2023: blue). Red and blue triangles are proportions of shoots stating their intention at the future time shown to still be using lead shot, as reported at the time of the two Savills surveys.

ISSN 1758-2067

It has been argued that, because we do not find shot in all pheasant carcasses dissected, the SHOT-SWITCH measure of the proportion of carcasses in which any shot is found that contain lead might overestimate the proportion of pheasants killed with lead pellets (Green *et al*. 2023b; Ellis & Miller 2023). This would be true if non-lead shot were more likely than lead to pass through the bird's body without embedding in it. However, several pieces of evidence indicate that there is no such difference. Firstly, the proportion of X-rayed wild-shot pheasant carcasses with no embedded shot present was higher in the UK in 2008/2009, when virtually all birds were killed using lead shot, than it was in Denmark in 2016/2017, when almost all birds were killed using non-lead shot (Pain *et al*. 2010; Kanstrup & Balsby 2019). Secondly, experiments commissioned by BASC showed no consistent difference in penetration of a ballistic gel simulation of a gamebird carcass by steel and lead shot (Champion 2021). Thirdly, in a double-blind study in which US hunters shot mourning doves *Zenaida macroura* with lead and iron shot without knowing which type they were using, necropsy analyses detected no differences in the proportion of carcasses with through-body pellet strikes or average embedded pellet depth (Pierce et al. 2015). Finally, we found no indication of a difference in the average number of shot recovered/carcass between carcasses with lead and non-lead shot recovered. Hence, the conclusions we have drawn here about the proportion of birds killed using lead shotgun ammunition, based upon the proportion of carcasses from which shot were recovered that contained lead shot, are likely to be accurate.

Four pheasants in our sample were shot with zinc shotgun pellets (three only with zinc and one with zinc and iron shot). No pheasants shot using zinc pellets were recorded in the three previous seasons of SHOT-SWITCH monitoring (Green et al. 2021; 2022, 2023a), but three other carcasses of pheasants killed using zinc shot were recorded in samples obtained for research purposes in 2022 from a UK wholesale supplier of wild-shot game (Green *et al.* 2024). This apparent recent increase in the use of zinc shot for hunting is of concern because zinc shot are toxic when ingested by waterbirds (Levengood *et al.* 1999) and probably also by other bird species. This type of shotgun ammunition has therefore not been approved as a non-toxic shot type for use in the USA and Canada, which are the only jurisdictions in which the chemical composition of non-lead shotgun ammunition used for hunting is regulated (Thomas 2019). We recommend that consideration be given to restrictions on the use of zinc shotgun ammunition for hunting.

Up to the 2021/2022 shooting season, the findings from the SHOT-SWITCH surveys have been reasonably consistent with those from questionnaire surveys of the actual practice of a sample of large gamebird shooting estates (Savills 2021; 2023). These surveys indicated that > 95% of the estates were continuing to permit the use of lead shotgun ammunition in the 2020/2021 and 2021/2022 shooting seasons, but that most intended to have phased out lead shot by the 2024/2025 season (Savills 2021; 2023; Figure 1). However, the proportion of pheasants killed using lead in the 2023/2024 season was much greater than the proportion of estates that had earlier expected that they would still be allowing the use of lead shot in 2023/2024, with no overlap between the confidence limits of the two proportions for this season (Figure 1). We have been informed by managers of shooting estates that their requests to hunters to use only non-lead shot on their land are often not respected. Much of the hunting of pheasants is by private individuals who visit the shoot as paying participants and bring their own guns and ammunition. It is difficult for shoot managers to apply rigorous enforcement measures under these circumstances.

The types of shotgun pellets recovered from pheasant carcasses obtained from retail outlets which indicated that they intended to sell only game killed using non-lead ammunition were reported in previous papers on the SHOT-SWITCH project (Green et al. 2022; 2023a). Members of the National Game Dealers Association (NGDA) undertook not to sell any game killed with lead ammunition, beginning in the 2022/2023 season (BGA 2021), but monitoring of several NGDA members during that season showed that all of those sampled were still selling pheasants killed using lead shot (Green *et al*. 2023a). The NGDA undertaking is no longer operative (Wild Justice 2022; Green *et al*. 2023a). The food retailer Waitrose announced its intention to sell only game meat products from animals killed using non-lead ammunition in 2019 (Barkham 2019), but implementation for pheasants and other gamebirds was delayed (Waitrose 2020) because of lack of availability of carcasses of birds sufficiently assured to have been killed using non-lead shot (Green *et al*. 2023a). We were unable to obtain any oven-ready pheasants from Waitrose stores in the 2021/2022 and 2022/2023 seasons and up until early January of the 2023/2024 season. Over 90% of pheasant carcasses obtained from all the Waitrose stores sampled in mid-January 2024 from which shot were recovered contained lead shot. Marks & Spencer also stated its intention to sell only game meat products from animals killed using non-lead ammunition in 2019. As for Waitrose, we have found it difficult to source adequate samples of oven-ready pheasant products from Marks & Spencer stores, but none of a small sample of carcasses obtained in 2022/2023 and 2023/2024 from which shot were recovered contained lead shot.

We conclude that progress with implementing the intended voluntary transition from the use of lead to non-lead shotgun ammunition for hunting pheasants sold for human consumption has been slow. The transition will only be completed successfully in the next, final season of the transition if there is a very substantial increase in the proportion of hunters

ISSN 1758-2067

switching to non-lead ammunition. Similarly, the voluntary change by food retailers to selling only gamebird meat products from birds killed using non-lead ammunition has made limited progress so far.

ACKNOWLEDGEMENTS

We thank Leo Batten, Margaret Breaks, Jacquie Clark, Sophie Green, Shireen Green, Jonathan More O'Ferrall, Rachel Taylor and Matthew Webster for assistance with obtaining and processing the pheasant carcasses and Jade Roberts, Maider Guiu and Thomas Thompson for their help with shot composition analysis. Roger Draycott (GWCT) kindly provided information on recent efforts by GWCT to promote the transition to non-lead ammunition. Roger Draycott (GWCT) and Nicola Buckingham (Savills) helped us to access the Savills Game and Conservation Benchmarking Surveys. We thank Ann Thornton, Bill Sutherland and anonymous reviewers for useful comments. The Royal Society for the Protection of Birds, the Scottish Alliance for Geoscience, Environment and Society and Waitrose & Partners contributed to the costs of materials and reagents for the study. The contribution of results for 14 pheasant carcasses provided by M.P. was supported by Wild Justice.

This paper is the fourth publication of results from the SHOT-SWITCH project. More information on the objectives and methods of the project is available on the website of the Environmental Research Institute, University of the Highlands and Islands, Thurso, UK (Environmental Research Institute 2023).

REFERENCES

Barkham, P. (2019) *Waitrose stops sale of birds shot with lead as experts call for UK ban*. The Guardian online. https://www.theguardian.com/business/2019/jul/29/experts-call-for-ban-on-lead-shot-as-waitrose-overhauls-sale-of-game

BASC (2020) *A joint statement on the future of shotgun ammunition for live quarry shooting*. https://basc.org.uk/a-joint-statement-on-the-future-of-shotgun-ammunition-for-live-quarry-shooting

BASC (2022) *Guide to Using Non-lead Shot.* https://basc.org.uk/lead/guide-to-using-non-lead-shot/

BGA (2021) *NGDA: Statement on Lead free Ammunition* https://www.britishgameassurance.co.uk/ngda-statement-on-lead-free-ammunition/

Champion, S. M. (2021) *Steel vs lead shot lethality. Analysis of the relative lethality of 12 gauge lead shot vs its steel alternative.* Report number CU/CDE/SMC/2231/21. Cranfield University, UK.

Clopper, C. & Pearson, E.S. (1934). The use of confidence or fiducial limits illustrated in the case of the binomial. *Biometrika*, 26, 404–413.

Ellis, M.B. & Miller, C.A. (2023) Efforts to ban lead ammunition: a comparison between Europe and the United States. *Wildlife Society Bulletin* e1449. https://doi.org/10.1002/wsb.1449

Environmental Research Institute (2023) *How to find, store and record gunshot pellets from the carcass of an oven-ready pheasant.* https://eri.ac.uk/wp-content/uploads/2021/02/SHOT-SWITCH-HOW-TO-FIND-SHOT.pdf

Green, R.E., Taggart, M.A., Pain, D.J., Clark, N.A., Clewley, L., Cromie, R., Elliot, B., Green, R.M.W., Huntley, B., Huntley, J., Leslie, R., Porter, R., Robinson, J.A., Smith, K.W., Smith, L., Spencer, J. & Stroud, D. (2021) Effect of a joint policy statement by nine UK shooting and rural organisations on the use of lead shotgun ammunition for hunting common pheasants *Phasianus colchicus* in Britain. *Conservation Evidence Journal,* **18,** 1-9. https://doi.org/10.52201/CEJ18ROTZ8607

Green, R.E., Taggart, M.A., Pain, D.J., Clark, N.A., Clewley, L., Cromie, R., Dodd, S.G., Elliot, B., Green, R.M.W., Huntley, B., Huntley, J., Pap, S., Porter, R., Robinson, J.A., Sheldon, R., Smith, K.W., Smith, L., Spencer, J. & Stroud, D. (2022) Effectiveness of actions intended to achieve a voluntary transition from the use of lead to non-lead shotgun ammunition for hunting in Britain. *Conservation Evidence Journal* **19**, 8-14. https://doi.org/10.52201/CEJ19/SAFD8835

Green, R.E., Taggart, M.A., Pain, D.J., Clark, N.A., Clewley, L., Cromie, R., Green, R.M.W., Guiu, M., Huntley, B., Huntley, J., Leslie, R., Porter, R., Roberts, J., Robinson, J.A., Robinson, R.A., Sheldon, R., Smith, K.W., Smith, L., Spencer, J. & Stroud, D. (2023a) Voluntary transition by hunters and game meat suppliers from lead to non-lead shotgun ammunition: changes in practice after three years. *Conservation Evidence Journal* **20**, 1-7. https://doi.org/10.52201/CEJ19/SAFD8835

Green, R.E., Pain, D.J. & Taggart, M.A. (2023b) *An updated response to concerns raised by Mr Ian Bell, Chief Executive Officer of the British Association for Shooting and Conservation, about the accuracy of conclusions drawn by the SHOT-SWITCH monitoring programme.* https://eri.ac.uk/wp-content/uploads/2023/06/Response_to_BASC_updated-20062023.pdf

Green, R.E., Taggart, M.A., Guiu, M., Waller, H., Pap, S., Sheldon, R., Pain, D.J. (2024) Difference in concentration of lead (Pb) in meat from pheasants killed using lead and iron (Fe) shotgun ammunition. *Science of the Total Environment,* 916 https://doi.org/10.1016/j.scitotenv.2024.170356

GWCT (2022) *Moving away from lead shot: a practical guide* https://www.gwct.org.uk/advisory/lead-ammunition/moving-away-from-lead-shot/

ISSN 1758-2067

Kanstrup, N. & Balsby, J.S. (2019) Danish pheasant and mallard hunters comply with the lead shotban. *Ambio*, **48**, 1009-1014. https://doi.org/10.1007/s13280-019-01152-7

Levengood, J.M., Sanderson, G.C., Anderson, W.L., Foley, G.L., Skowron, L.M., Brown, P.W., Seets, J.W., 1999. *Acute toxicity of ingested zinc shot to game-farm mallards.* Illinois Natural History Survey Bulletin **36**, 1-36.

Marks & Spencer (2019) Email from the Chief Executive's Office to David A. Stroud. 15 August 2019.

Marks & Spencer (2022) *Animal Welfare.* https://corporate.marksandspencer.com/sites/marksandspencer/files/marks-spencer/agriculture-and-supporting/Animal_Welfare_Report_2022_V2.pdf

Office for National Statistics (2020) *Eurostat: An overview of the 3 NUTS and 2 LAU layers in the UK.* https://www.ons.gov.uk/methodology/geography/ukgeographies/eurostat

Pain, D.J., Cromie, R.L., Newth, J., Brown, M.J., Crutcher, E., Hardman, P., Hurst, L., Mateo, R., Meharg, A.A., Moran, A.C., Raab, A., Taggart, M.A. & Green, R.E. (2010) Potential hazard to human health from exposure to fragments of lead bullets and shot in the tissues of game animals. *PLoS ONE*, **5**, e10315. https://doi.org/10.1371/journal.pone.0010315

Pierce, B.L., Roster, T.A., Frisbie, M.C., Mason, C.D., & Roberson, J.A. (2015) A Comparison of Lead and Steel Shot Loads for Harvesting Mourning Doves. *Wildlife Society Bulletin* **39**, 103–115. https://doi.org/10.1002/wsb.504

Savills (2021) *Game and Conservation Benchmarking Survey. Rural Research Briefing Note*. Savills, London.

Savills (2023) *Game and Conservation Benchmarking Survey. Rural Research Briefing Note*. Savills, London.

Thomas, V.G., 2019. Chemical compositional standards for non-lead hunting ammunition and fishing weights. *Ambio* **48**, 1076-1078. https://doi.org/10.1007/s13280-018-1124-x

Waitrose (2020) 'Lead Shot Pledge' on Waitrose online 'Animal Welfare page' https://www.waitrose.com/home/inspiration/about_waitrose/the_waitrose_way/waitrose_animal_welfarecommitments.html

Waitrose (2024) No. 1 Pheasant topped with Bacon. https://www.waitrose.com/ecom/products/no1-pheasant-topped-with-bacon/078233-39825-39826 Downloaded 5 January 2024.

Wild Justice (2022) *NGDA members selling game meat with high lead levels.* https://wildjustice.org.uk/lead-ammunition/ngda-members-selling-game-meat-with-high-lead-levels/

ISSN 1758-2067