Received: 11 December 2018 | Accepted: 17 April 2019

DOI: 10.1002/pan3.30

RESEARCH ARTICLE

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

Perspectives of ammunition users on the use of lead ammunition and its potential impacts on wildlife and humans

Julia L. Newth[1,2,3] | Alice Lawrence[1] | Ruth L. Cromie[1] | John A. Swift[4] | Eileen C. Rees[1] | Kevin A. Wood[1] | Emily A Strong[1] | Jonathan Reeves[1] | Robbie A. McDonald[3]

[1]Wildfowl & Wetlands Trust, Slimbridge, Gloucestershire, UK

[2]Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, Cornwall Campus, Penryn, Cornwall, UK

[3]Environment and Sustainability Institute, College of Life and Environmental Sciences, University of Exeter, Cornwall Campus, Penryn, Cornwall, UK

[4]John Swift Consultancy – Higher Wych, Malpas, Cheshire, UK

Correspondence
Julia L. Newth, Wildfowl & Wetlands Trust, Slimbridge, Gloucestershire, GL2 7BT, UK.
Email: Julia.Newth@wwt.org.uk

Handling editor: Steve Redpath

Abstract

1. Recent national and international policy initiatives have aimed to reduce the exposure of humans and wildlife to lead from ammunition. Despite restrictions, in the UK, lead ammunition remains the most widespread source of environmental lead contamination to which wildlife may be exposed.
2. The risks arising from the use of lead ammunition and the measures taken to mitigate these have prompted intense and sometimes acrimonious discussion between stakeholder groups, including those advancing the interests of shooting, wildlife conservation, public health and animal welfare.
3. However, relatively little is known of the perspectives of individual ammunition users, despite their role in adding lead to the environment and their pivotal place in any potential changes to practice. Using Q-methodology, we identified the perspectives of ammunition users in the UK on lead ammunition in an effort to bring forward evidence from these key stakeholders.
4. Views were characterised by two statistically and qualitatively distinct perspectives: (a) *Open to change*—comprised ammunition users that refuted the view that lead ammunition is not a major source of poisoning in wild birds, believed that solutions to reduce the risks of poisoning are needed, were happy to use non-lead alternatives and did not feel that the phasing out of lead shot would lead to the demise of shooting; and (b) *Status quo*—comprised ammunition users who did not regard lead poisoning as a major welfare problem for wild birds, were ambivalent about the need for solutions and felt that lead shot is better than steel at killing and not wounding an animal. They believed opposition to lead ammunition was driven more by a dislike of shooting than evidence of any harm.
5. Adherents to both perspectives agreed that lead is a toxic substance. There was consensus that involvement of stakeholders from all sides of the debate was desirable and that to be taken seriously by shooters, information about lead poisoning should come from the shooting community.

6. This articulation of views held by practitioners within the shooting community presents a foundation for renewing discussions, beyond current conflict among stakeholder and advocacy groups, towards forging new solutions and adaptation of practices.

KEYWORDS
ammunition, environmental contaminants, hunters, hunting, lead, Q methodology, shooting, waterfowl

1 | INTRODUCTION

There is international recognition of the risks presented by lead to the health of humans and wildlife (Arnemo et al., 2016; Green & Pain, 2015; Pain, Cromie, & Green, 2015; Stroud, 2015). Following regulation to remove lead in the environment from other sources such as paint and petrol (Stroud, 2015), recent policies have aimed to reduce the exposure of humans and wildlife to lead from ammunition (IUCN, 2016; Stroud, 2015; UNEP-CMS, 2014). Over the last 50 years, lead ammunition (primarily shot) has been subject to legislative and other forms of regulation in 33 countries world-wide (Kanstrup, 2019; Kanstrup, Swift, Stroud, & Lewis, 2018; Stroud, 2015). Currently, two countries have total bans on the use, trade and possession of lead shot: Denmark introduced legislation in 1996 (Kanstrup, 2006) and the Netherlands in 1993 (Avery & Watson, 2009). Partial and total restrictions on the use of lead ammunition for hunting have culminated in a range of experiences from different jurisdictions (Kanstrup, 2019). In Denmark, the proposed ban initially received a negative reception from hunters. Resistance was motivated by concerns about safety and the quality and expense of the alternatives to lead shot, compounded by tensions between stakeholders and a lack of organisational leadership (Kanstrup, 2015, 2019). Hunter attitudes became more positive with a widening appreciation of the environmental impacts of lead shot and the introduction of a new generation of shot types (Kanstrup, 2019). In the UK, partial restrictions on the use of lead ammunition, particularly over wetlands and foreshores, have been introduced to reduce morbidity and mortality of wildlife in England in 1999 (HMSO, 1999, 2002a, 2003), Wales in 2002 (HMSO, 2002b), Scotland in 2004 (HMSO, 2004) and Northern Ireland in 2009 (HMSO, 2009). Despite these restrictions, lead ammunition remains the most widespread and common source of environmental lead contamination to which wildlife might be exposed in the UK (Pain et al., 2015).

1.1 | The 'lead debate'

The risks arising from the use of lead ammunition and the measures taken to mitigate these have prompted intense discussion between stakeholder groups in the UK (Newth, Cromie, & Kanstrup, 2015). Shooting is a long-standing activity with established practices and traditions and is undertaken for a variety of purposes, including sport, pest management and hunting for food. Shooting, therefore, involves heterogeneous communities of participants (Kanstrup, 2019). Furthermore, stakeholder groups in discussions about lead extend beyond shooting, encompassing organisations advancing wildlife conservation, public health and animal welfare (Cromie et al., 2015). This discussion, as played out among membership organisations and vocal commentators in public arenas, is dominated by a 'lead debate' between those advocating retention of the *Status quo* (predominantly shooting and countryside management organisations) and those favouring stricter controls or phasing out of lead ammunition and replacement with non-toxic alternatives (predominantly wildlife conservation organisations). This 'lead debate' has become polarised in the UK and sits within a wider landscape of mistrust and tension between shooting and conservation organisations, despite their holding many conservation goals in common. There may also be a perception that moves to phase out the use of lead ammunition are 'anti hunting' and part of a wider attack on shooting and other legitimate field sports, leading to ratcheting up of regulation and restrictions (Cromie et al., 2015; Thomas, 2015).

As with other environmental conflicts, the 'lead debate' has been characterised by contested interpretations of the scientific evidence and can now be regarded as a sociopolitical issue (Arnemo et al., 2016). Evidence from the natural sciences alone is often insufficient to resolve conflicts (Haas, 2004; Hulme, 2009; Luks, 1999; Saltelli, Giampietro, Avan, Ambientals, & Autonoma, 2015) and this appears to be true in this case (Arnemo et al., 2016). Indeed, Byrd (2002) argues that without addressing the sociopolitical dynamics driving the public discourse behind such conflicts, interventions based solely on science are likely to polarise people and result in politically unviable management plans. The origins of many conflicts are related to values, changing attitudes and power relations (Raik, Wilson, & Decker, 2008) that have roots in social and cultural history (Redpath et al., 2013).

1.2 | The perspectives of ammunition users

Although the 'lead debate' could be characterised as an apparently 'intractable conservation conflict' (Redpath et al., 2013), played out by large organisations, relatively little is known of the perspectives

of individual ammunition users, despite their critical roles in (a) adding lead to the environment; and (b) adopting, or not adopting, any potential changes to practice. Efforts by statutory agencies and shooting and countryside management organisations to improve user compliance with regulations (e.g. through awareness-raising activities such as the 'Use Lead Legally' campaign) have been largely unsuccessful. Compliance with existing regulation remains generally poor in England (e.g. 77% of ducks were shot with lead shot in winter 2013–2014; Cromie et al., 2015), some 13 years after the introduction of regulations (HMSO, 1999), indicating that at least some shooting participants have not 'bought-in' to the legislation or guidance.

The success or otherwise of conservation interventions may depend on whether and how the opinions of relevant individual stakeholders are understood and catered for (Bennett et al., 2017; Madden & McQuinn, 2014; Redpath et al., 2013) and whether or not proposed solutions are perceived as appropriate (Zabala, Sandbrook, & Mukherjee, 2018). Understanding the viewpoints and values of individuals with respect to issues important for conservation has multiple benefits (Curry, Barry, & McClenaghan, 2013; Zabala et al., 2018), including identification of barriers or alignments (Frantzi, Carter, & Lovett, 2009), improved assessment of the effectiveness of policy and plans, improvement of public participation and stakeholder dialogue (Cuppen, Breukers, Hisschemöller, & Bergsma, 2010) and the facilitation of critical reflection (Zabala et al., 2018) as well as an opportunity to resolve contentious issues (Durning, 2005).

1.3 | Q-methodology in conservation conflicts

Q-methodology uses a combination of quantitative and qualitative techniques to identify and explore subjective attitudes, viewpoints and perspectives on a given topic (Stephenson, 1953; Watts & Stenner, 2012). It combines the transparency of a structured quantitative technique with the richer understanding of a qualitative approach (Zabala et al., 2018). For contentious issues, Q-methodology may facilitate agreeable and compromise policy solutions in several ways. It may help decision-makers to: (a) clarify issues, through deeper understanding of the sometimes hidden interests and beliefs of stakeholders; (b) identify competing definitions of problems and solutions and reveal commonalities between them; and (c) as a consequence, forge new solutions (Durning, 2005). Within conservation conflict scenarios, Q-methodology has identified shared and opposing discourses relating to the management of large, terrestrial wildlife (e.g. Bredin, Lindhjem, Van Dijk, & Linnell, 2015; Price, Saunders, Hinchliffe, & McDonald, 2017; Zabala et al., 2018), with the aim of reaching acceptable solutions. Although some conservation conflicts might be well-suited to the application of Q-methodology, such use remains relatively uncommon and the method has rarely been used to explore diversity of viewpoints within potentially heterogeneous stakeholder groups. In this context, Q-methodology might help clarify the views of individual stakeholders within the shooting community, that is, ammunition users, who are instrumental to the success of guidance and legislation and help guide organisations and commentators participating in debate. Enhanced dialogue may prevent misunderstandings about perspectives and motivations of those with differing viewpoints and encourage discourse about the issue so that mutually agreeable compromises might be reached (Durning, 2005).

Here, using Q-methodology, we aim to identify the perspectives of ammunition users in the UK in relation to the substance of the 'lead debate' in an effort to bring forward evidence from these key stakeholders, who have influence over and are most affected by the issue.

2 | MATERIALS AND METHODS

A Q-study involves a relatively small number of purposively selected participants (usually 20–40 people) who are asked to rank, in order, a number of opinion statements about a specific topic (Cairns, 2012). The rankings, known as 'Q-sorts', are then analysed statistically using factor analysis to explore patterns or shared perspectives towards a topic. These 'factors', or social perspectives, are then interpreted with the aid of contextual information gained through post-sort interviews with all participants (Cairns, 2012).

2.1 | Constructing the narrative for the debate (the 'concourse')

A concourse which contains expressions of potentially varied perspectives of the topic (Webler, Danielson, & Tuler, 2009) was constructed using a 'semi-naturalistic approach' (Cairns, 2012; Robbins & Krueger, 2000), whereby opinion statements were drawn from a combination of semi-structured interviews with seven informed individuals (Webler et al., 2009) and through review of written materials (Stainton Rogers, 1995). The interviewees, all of whom were based in the UK, were purposively selected for their considerable professional knowledge of lead ammunition in relation to wildlife health, human health and shooting. They were not asked to rank statements for analysis. Written materials that included the broad subjects of lead ammunition, related impacts on wildlife and humans, associated politics and non-toxic/non-lead ammunition were selected for review. The scope was limited to information relevant to the UK only. Materials included published papers, perspectives and reports, articles in shooting and conservation magazines, content from shooting and conservation blogs, websites and forums, texts of international agreements and minutes of meetings and transcripts of parliamentary debates related to the issue of lead shot. This multisource approach was used to capture, as far as possible, the diversity of opinion and to provide a breadth of personal and organisational perspectives. A total of 243 statements written and released between January 2009 and June 2017 were selected and constituted the original concourse. The concourse was considered complete when the addition of new statements did not present any new opinions (Cairns, 2012).

2.2 | Constructing the Q-set

The concourse was refined to a manageable number of statements (termed the Q-set; Table 1) so that they could be sorted by the participants in the Q-sort stage. An unstructured strategic sampling approach was followed to ensure that the variability of the concourse was captured by the Q-set (Webler et al., 2009). Each statement was printed onto a card in a common format and read in detail several times by the members of the research team who were familiar with the topic (though none had participated in the interviews to construct the concourse). Group discussions explored possible meanings of each statement. The statements were assigned to clearly define themes and subthemes that emerged inductively from the concourse. The categories provided a means of grouping statements that had broad similarities (Webler et al., 2009). When no new themes emerged, it was surmised that major themes had been identified (Thomas, 2003). The statements were further reduced following Fisher's experimental design principles (Brown, 1980), whereby similar statements within each theme were eliminated to avoid repetition. The final Q-set constituted 56 statements and was created by selecting a number of statements from each theme and subtheme in order to encompass the spectrum of aspects discussed in the debate. A range of views within each theme was maintained (Cotton, 2015; Stainton Rogers, 1995). In order to minimise reflexivity (i.e. researcher interference) in the study design (Webler et al., 2009), verbatim statements were included where possible with minimal editing and paraphrasing of the statements employed only for the purposes of increasing clarity and brevity (Cotton, 2015; Stainton Rogers, 1995). The final Q-set was checked by eight informed individuals from both the shooting and conservation communities in the UK (Cotton, 2015; Stainton Rogers, 1995). Finally, pilot testing with five individuals helped refine the Q-sort process and ensured that instructions were clear and well understood.

2.3 | Participant selection

Participants from the UK's shooting community were selected through purposive sampling, instead of random sampling of a large number of participants. Q-method aims to identify the comprehensive diversity of perspectives that exist, rather than to determine how those perspectives are distributed across a population (Armatas, Venn, & Watson, 2017). Therefore, participants from the shooting community were selected for their familiarity with the issue (Webler et al., 2009). Based on previous studies (Cromie et al., 2010) and discussions with those from the community, views were deemed likely to vary according to how shooters predominantly accessed their shooting, their primary target quarry species and their familiarity with non-toxic shot (indicated by frequency of use), albeit acknowledging that there is likely some overlap between categories. These additional criteria were therefore used to identify participants within the shooting community (Table 2). Although some participants were known to each other, efforts were made to incorporate individuals from a breadth of distinct and separate friendship groups, whose members were unknown to each other. This was to reduce undue social influence within the sample, thus improving the likelihood that a diversity of views could be captured.

2.3.1 | Administering the Q-sort

Q-sorts were undertaken by each participant individually between August 2017 and February 2018. Participants were asked to rank the 56 Q-statements according to how strongly they agreed or disagreed with each (Brown, 1996). To facilitate this process, participants were given a deck of randomly numbered cards (with each card containing one statement from the Q-set), instructed to read all 56 statements and sort them first into three categories; Agree, Disagree and Neutral/Unsure/Not applicable (Cotton, 2015). The status of statements could be changed during subsequent sorting if desired. Statements were then sorted along a scale from 5 (agree most strongly) to −5 (disagree most strongly), where 0 is neutral (statements have zero salience), and with a fixed number of statements along the scale (Watts & Stenner, 2012). A pyramid-shaped grid, known as an array, is used as it requires respondents to rank the statements in a forced quasi-normal distribution (Curry et al., 2013; Figure S1). This encourages the participants to evaluate each statement carefully and helps them to reveal their preferences (Webler et al., 2009). Participants in the Q-sort were encouraged to interpret the statements in the context of others when sorting (Cairns, 2012; Webler et al., 2009). Once the statements had been ranked, each participant was asked to identify the areas in the grid that demarcated agree from disagree and neutral. Following the Q-sort, each participant was asked in an interview to elaborate on how they had interpreted the most salient statements (those placed at both extreme ends of the continuum on the array), their reasoning for ranking the statements in their unique way, and whether they felt that their perspective had been captured within the Q-set (Brown, 1980; Van Exel & de Graaff, 2005). The interviews provided information which, along with the factor analysis, helped give the Q-sorts meaning. The interviews were recorded by Dictaphone and transcribed. A number of verbatim statements were extracted to qualitatively illustrate the various perspectives within each identified factor. During the interview, participants engaged in a short discussion on whether they felt that solutions were required to reduce the risks of people and wildlife ingesting lead ammunition and, if so, to propose suggestions. Potential barriers to implementing change were also discussed. Those not believing that solutions were required were asked to explain their reasoning. Participants also provided additional socio-demographic information through the completion of a short questionnaire. Each participant gave their informed consent to participate before they were surveyed. The anonymity of participants was protected and the study and its methodology were approved by the College of Life and Environmental Sciences (Penryn) Ethics Committee at the University of Exeter (reference 2016/1498).

TABLE 1 Factor arrays for the two study factors. Factor 1 represents the 'Open to change' perspective while Factor 2 represents *Status quo*. A factor array (i.e. an estimate of the factor's viewpoint) was identified by combining a weighted average of all the individual Q-sorts that loaded significantly on a particular factor

		Factor	
	Statement	1	2
1	Stakeholder opinions from all sides of the lead poisoning debate should be included in any decision-making process.	2	3
2	Lead shot is better than steel at killing and not wounding an animal.	0	5
3	Supermarkets should clearly state that their wild game meat products might contain lead.	2	0
4	Lead ammunition harms the image of shooting.	1	−3
5	Steel shot is more likely to ricochet from hard surfaces than lead.	2	4
6	The phasing out of lead shot will lead to the demise of shooting.	−5	1
7	The financial impacts of any further restrictions on lead could be very damaging to shooting-related interests.	−3	0
8	Lead ammunition is not a major source of lead poisoning in wild birds.	−3	1
9	There is no evidence that lead poisoning causes bird populations to decline.	−3	1
10	Current game meat handling techniques are enough to address any risks to humans from lead shot.	−1	2
11	Shooters' pastimes and activities are being eroded.	−4	2
12	If shooters saw birds dying from lead poisoning, they would think twice about using lead ammunition.	4	0
13	The scientific evidence of the impacts of lead on waterbirds is robust.	1	−2
14	The shooting community probably does more for wildlife and habitats than any other group in the UK.	0	5
15	A large number of wildfowl die from lead poisoning each year.	0	−3
16	The risks to wild birds from lead ammunition have been exaggerated.	−3	3
17	Lead is a toxic substance.	5	3
18	Those with political power to influence the issue are biased in favour of keeping lead shot.	−1	−4
19	Lead poisoning is a major welfare problem for wild birds.	0	−4
20	Shooters and non-shooters have the same aim of having sustainable numbers of birds in the British countryside.	3	4
21	Steel shot damages shotgun barrels.	−1	1
22	There needs to be greater awareness within the shooting community about the harm lead poisoning does.	4	0
23	To be taken seriously, information about lead poisoning needs to come from within the shooting community.	1	1
24	There should be better enforcement of current regulations restricting the use of lead shot.	1	−2
25	Opposition to lead ammunition is driven more by a dislike of shooting than any evidence of harm.	−2	4
26	If use of non-toxic ammunition makes people more aware of good range judgement, then they will shoot better.	−1	−3
27	Steel and lead shot are comparably priced.	−1	−2
28	More research should be done on the performance of non-toxic ammunition.	0	3
29	Eating game killed by lead ammunition has adverse effects on human health.	−2	−5
30	The most effective solution to reduce the risks of lead would be to replace lead shot with non-toxic alternatives.	2	−1
31	There are no safe levels of lead exposure.	1	−2
32	More guidance on different ammunition types, and techniques for their use, would reduce concerns about non-toxic shot.	2	0
33	Those selling game meat for human consumption are not very aware of possible lead contamination in their meat.	−1	−4
34	There is clearly a need for solutions to reduce the risks of lead poisoning.	3	0
35	The risks to human health from lead ammunition have been exaggerated.	−2	3
36	There should be better observance of current regulations restricting the use of lead shot.	4	−2

(Continues)

TABLE 1 (Continued)

	Statement	Factor 1	Factor 2
37	Current restrictions on using lead shot in England and Wales are not sufficient to address lead poisoning in waterbirds.	1	0
38	If you have to shoot at shorter ranges it's not as sporting or fun.	−4	−1
39	Shooting at closer range with non-toxic shot damages the meat.	−2	−1
40	Using plastic wads with non-toxic shot can cause problems with livestock.	0	2
41	Non-toxic shot is widely available.	3	2
42	The shooting community and cartridge manufacturers need to work together and come up with a viable alternative to lead shot.	0	4
43	Ballistically, alternatives to lead shot that are fit for purpose already exist.	3	−1
44	Current human health advice is enough to reduce the risks of lead shot to humans.	−1	2
45	Sooner or later, lead shot will be banned.	0	−2
46	Using non-toxic shot would have a negative financial impact on me.	−2	1
47	Non-toxic shot is ineffective against clay targets.	−5	−3
48	Regulations are essential to reducing lead poisoning in waterbirds.	3	−3
49	Lead poisoning in birds is not a big enough problem to justify current regulations.	−4	1
50	Accumulated spent lead shot in intensively shot locations should be removed from the soil to reduce environmental contamination.	−2	−4
51	Shooting organisations are afraid they will look weak if they support a ban on lead shot.	1	−1
52	I am happy to use non-lead ammunition.	4	−1
53	A wider range of non-toxic cartridges would become available if there was a ban on lead.	2	−1
54	Some 'non-toxic' alternatives to lead have greater toxicity than lead.	−3	0
55	Robust scientific evidence should determine how we use lead shot.	5	2
56	If we stopped using lead shot we'd have more birds to shoot.	−4	−5

Note: Statement numbers from the Q-set are presented in brackets followed by their corresponding factor array score which relates to a scale of agreement (e.g. −5 = most disagree; 0 = neutral; +5 = most agree). For example, (17, +5) indicates that statement 17 is strongly agreed with.

2.4 | Statistical analysis

The 30 Q-sorts were analysed using centroid factor analysis and subjected to a Varimax rotation in PQMethod (Schmolck, 2014). An unrotated factor was considered significant when: (a) its Eigenvalue exceeded one (Kaiser–Guttman criteria: Guttman, 1954; Kaiser, 1960, 1970); (b) the cross product of its two highest loadings exceeded twice the standard error of the correlation matrix (i.e. >±0.27, Humphrey's Rule; Brown, 1980); and (c) there were two or more significant factor loadings following extraction (Brown, 1980; Table S1). Factor loadings (i.e. the extent to which an individual Q-sort exemplifies the pattern for a defined factor) were regarded as significant when ≥±0.34 at the $p < 0.01$ level (Brown, 1980) (Table S1), where:

$$\text{Significant factor loading} = 2.58 \times (1/\sqrt{\text{number of items in Q- set}})$$

TABLE 2 Summary of the characteristics of survey participants. Based on previous studies (Cromie et al., 2010) and discussions with those from the community, it was hypothesized that viewpoints were likely to vary according to how shooters predominantly accessed their shooting, their primary target quarry species and their familiarity with non-toxic shot (indicated by frequency of use), albeit acknowledging that there is likely some overlap between categories

Characteristics	Response (number of respondents)
Use of non-toxic shot	Very frequently/frequently (14), occasionally (11), rarely/very rarely (3), never (1), unknown (1)
Main quarry species	Wildfowl (10), terrestrial (13), mixed (5), deer (1), unknown (1)
Main access to shooting	Syndicate/club (11), local contacts (9), shoots alone (1), employment (2), mixed methods, including commercial (3), mixed methods, excluding commercial (2), unknown (2)
Age	25–34 (3), 35–44 (6), 45–55 (6), 55–64 (9), 65+ (5), Unknown (1)
Gender	Male (30), female (0)
Occupation	Business/industry/construction (9), farming/land management (4), conservationist/researcher (4), game management (4), cartridge supplier (1), rural commentator/journalist (2), retired (6)

Factors selected using these criteria (Table S1) were then rotated (Schmolck, 2014). Q-sorts that load significantly on the same factor (e.g. see Table 3) show a similar sorting pattern suggesting similar and/or shared viewpoints among participants (Watts & Stenner, 2012). A single, typical Q-sort (termed a factor array) was created for each rotated factor by combining a weighted mean of all the significantly loading Q-sorts (Brown, 1980; Watts & Stenner, 2012; Table 3; Figure S1). Interpretations of the factor arrays were made by holistically examining the way items were patterned within each and by drawing distinctions between them (Stenner, Cooper, & Skevington, 2003). In order to minimise researcher bias that may arise during the interpretation process, a protocol (known as a 'crib sheet') for analysing factor arrays developed by Watts and Stenner (2012) was systematically and rigorously followed for each array. This ensured that a methodical approach to factor interpretation was applied consistently in the context of each factor and helped to deliver genuinely holistic factor interpretations by forcing engagement with every statement in the factor arrays (Watts & Stenner, 2012). A 'reflexive' approach (Galdas, 2017) was also adopted which ensured critical self-reflection about preconceptions, relationship dynamics and the analytical focus, throughout the process. For this, the lead researcher made use of observation and reflection to repeatedly examine these aspects, processing through an ongoing internal dialogue and also in discussion with colleagues that were further removed from the subject (Attia & Edge, 2017).

TABLE 3 The rotated factor matrix. The loadings indicate the extent to which each Q-sort is associated with each of the study factors following rotation

Sort number	Factor 1	Factor 2
1	0.6684	−0.4248
2	0.2244	0.7025[a]
3	0.5362[a]	0.2377
4	0.0096	0.8426[a]
5	0.6077[a]	0.1417
6	0.4084[a]	−0.0330
7	0.5248[a]	−0.0383
8	0.4316[a]	0.2421
9	0.5574[a]	0.2656
10	0.6947[a]	0.2477
11	−0.1989	0.7495[a]
12	0.6766[a]	−0.0755
13	0.0146	0.6006[a]
14	0.6967[a]	0.1362
15	0.7434[a]	0.0074
16	0.0532	0.5185[a]
17	0.0065	0.6312[a]
18	0.3381[a]	0.1736
19	0.2259	0.7108[a]
20	0.6856[a]	−0.0933
21	0.3842[a]	0.3290
22	0.2094	0.5258[a]
23	−0.0807	0.7516[a]
24	0.2837	0.6375[a]
25	−0.1903	0.7204[a]
26	0.5973[a]	0.0711
27	0.6639[a]	−0.0979
28	0.6313[a]	−0.2830
29	0.5579[a]	0.1875
30	0.4762	0.4972
% explained variance	22.7	20.2
Eigenvalue	6.8	6.1

*Indicates which factor each Q-sort is significantly loaded on (i.e. ≥±0.34 at $p < 0.01$). For example, sorts 3 and 5 significantly load on to Factor 1 and contribute to the weighted average derived from the array which exemplifies Factor 1 (Table 1; Figure S1). Q-sorts 1 and 30 are confounded, that is, they significantly load on to both factors.

3 | RESULTS

A total of 36 people were approached; 30 (83.3%) actually participated (two individuals declined, two initially agreed to participate but later withdrew and two did not respond to the invitation). Detail of the composition of the participants is provided in Table 2. Two factors were extracted (Table 3) and according to the following selection criteria, represented the most plausible summary of the Q-sorts (Watts & Stenner, 2012) (Table S1): Eigenvalues exceeded 1.0 (Kaiser–Guttman criteria: Guttman, 1954; Kaiser, 1960, 1970), the cross product of each factor's two highest loadings exceeded twice the standard error of the correlation matrix (i.e. >±0.27, Humphrey's Rule; Brown, 1980), and there were two or more significant factor loadings (i.e. ≥±0.34) following extraction (Brown, 1980). Together both factors accounted for 43% of the rotated explained variance (Table 3) which falls at the lower end of the range of explained variance that would ordinarily be considered acceptable (35%–40% or above; Kline, 1994; Watts & Stenner, 2012). In total, 28 of the 30 Q-sorts significantly loaded onto one of the two factors and two sorts were confounded as they loaded significantly onto both factors. Here, we aim to understand and explain the perspective exemplified by each factor and shared by participants whose sorts have significantly aligned with them. Statement numbers from the Q-set are presented in brackets followed by their corresponding factor array score. For example, (17, +5) indicates strong agreement with statement 17 (see Table 1 for array scores associated with each statement and factor). Pertinent comments made by participants during the post-sort interviews are also used to support interpretation.

3.1 | Factor 1: Open to change

Résumé: *This group of ammunition users believed that lead is toxic; refuted the view that lead ammunition is not a major source of poisoning*

in wild birds; believed that solutions are needed, and the phasing out of lead shot will not lead to the demise of shooting. They are content to use non-lead ammunition.

Factor 1 has an Eigenvalue of 6.8 and explains 22.7% of the study variance. A total of 17 participants significantly loaded on this factor.

3.1.1 | Evidence and impacts

> I think we're all aware that lead is a toxic substance. It's been taken out of petrol, it's been taken out of pencils. And now, in certain circumstances, it's been taken out of shotgun ammunition (Participant 5)

This perspective was characterised by a strong belief that lead is toxic (17, +5) and some agreement that there are no safe levels of lead exposure (31, +1). It refutes the views that lead ammunition is not a major source of poisoning in wild birds (8, −3) and that it has no impact on bird populations (9, −3). Scientific evidence of the impacts of lead on waterbirds was perceived to be robust (13, +1). This position did not believe that the risks to wild birds from lead ammunition have been exaggerated (16, −3) nor that opposition to lead ammunition is driven more by a dislike of shooting than any evidence of harm (25, −2). Eating game killed by lead ammunition was not thought to have adverse effects on human health (29, −2). However, the risks to human health from lead ammunition were not perceived to have been exaggerated (35, −2).

3.1.2 | Solutions

> I am very happy to use non-lead ammunition. It's not an opinion; I use it, it works, and therefore I'm in complete agreement with it (Participant 12)

This viewpoint recognised the need for solutions to reduce the risks of lead poisoning (34, +3). It strongly agreed that if shooters saw birds dying from lead poisoning, they would think twice about using lead ammunition (12, +4), and that there was a need for greater awareness within the shooting community about the harm lead poisoning does (22, +4). There was also strong support for better observance of current regulations restricting the use of lead shot (36, +4) and the need for robust scientific evidence to determine how lead shot is used (55, +5). This view strongly disagreed that lead poisoning in birds is not a big enough problem to justify current regulations (49, −4).

Regulations were seen as essential for reducing lead poisoning in waterbirds (48, +3). This position supported the replacement of lead shot with non-toxic alternatives as the most effective solution for reducing the risks of lead (30, +2). There was strong agreement with the statement 'I am happy to use non-lead ammunition' (52, +4) and agreement that guidance on different ammunition types, and techniques for their use, would reduce concerns about non-toxic shot (32, +2). According to this view, alternatives to lead shot that are fit for purpose (in ballistic terms) already exist (43, +3). Therefore, there was ambivalence about whether the shooting community and cartridge manufacturers need to work together to develop a viable alternative to lead shot (42, 0). Using non-toxic shot was not believed to have a negative financial impact on the individual (46, −2). There was neither agreement nor disagreement with the notion that lead shot is better than steel at killing and not wounding an animal (2, 0). There was some disagreement that current human health advice is sufficient to reduce the risks of lead shot to humans (44, −1) and that current game meat handling techniques are enough to address any risks to humans from lead shot (10, −1).

3.1.3 | Cultural and sporting aspects

> I don't see any reason why the phasing out of lead shot will lead to the demise of shooting… Indeed, in some senses, if we lost lead shot, or gave up lead shot, we might be in a stronger position to promote what we do, because it is such a controversial issue (Participant 14)

This position strongly disagreed with the view that shooters' pastimes and activities are being eroded (11, −4). There was strong disagreement that shooting at shorter ranges is not as sporting or fun (38, −4). The financial impact of any further restrictions on lead was not perceived to be very damaging to shooting-related interests (7, −3). This perspective adhered to the view that shooting organisations are afraid they will look weak if they support a ban (51, +1). There was strong disagreement that the phasing out of lead shot would lead to the demise of shooting (6, −5), and there was uncertainty that lead shot will be banned in the future (45, 0).

3.2 | Factor 2: *Status quo*

Résumé: *This group of ammunition users believed that lead is toxic but did not regard lead poisoning a major welfare problem for wild birds; opposition to lead ammunition is driven more by a dislike of shooting than evidence of any real harm; there is ambivalence about the need for solutions and they are unhappy with the non-toxic alternatives.*

Factor 2 has an Eigenvalue of 6.1 and explains 20.2% of the study variance. In total, 11 participants significantly loaded on this factor.

3.2.1 | Evidence and impacts

> If it was right what they're saying, why are there not people picking up birds all across the countryside?
>
> In the shooting world we're up against so much opposition. A lot of people just don't like what we do, they don't like shooting… (Participant 25)

This perspective agreed that lead is a toxic substance (17, +3) but disagreed that there are no safe levels of lead exposure (31, −2).

Lead ammunition was not perceived to be a major source of lead poisoning in wild birds (8, +1) and lead poisoning was not regarded as a major welfare problem for wild birds (19, −4). The scientific evidence of the impacts of lead on waterbirds was not believed to be robust (13, −2) and the risks to wild birds from lead ammunition were thought to have been exaggerated (16, +3). It was strongly agreed that opposition to lead ammunition is driven more by a dislike of shooting than any evidence of harm (25, +4). There was strong disagreement that eating game killed by lead ammunition has adverse effects on human health (29, −5). Furthermore, the risks to human health from lead ammunition were perceived to have been exaggerated (35, +3).

3.2.2 | Solutions

> It's been overlooked, the fact that lead is the cleanest killing ammunition out there (Participant 25)

There was ambivalence about the need for solutions to reduce the risks of lead poisoning (34, 0) although agreement that robust scientific evidence should determine how lead shot is used (55, +2). This view did not agree that there should be better observance of the current regulations restricting the use of lead shot (36, −2). There was some agreement that lead poisoning in birds is not a big enough problem to justify current regulations (49, +1). Regulations were not deemed essential for reducing lead poisoning in waterbirds (48, −3). This position disagreed with the suggestion that the most effective solution to reduce the risks from lead would be to replace lead shot with non-toxic alternatives (30, −1). There was some disagreement with the statement 'I am happy to use non-lead ammunition' (52, −1) suitable alternatives to lead shot already exist (43, −1). It was strongly agreed that lead shot is better than steel at killing and not wounding an animal (2, +5) and that steel is more likely to ricochet from hard surfaces than lead (5, +4). There was strong support for the shooting community and cartridge manufacturers working together to develop a viable alternative to lead shot (42, +4). This view strongly disagreed that accumulated spent lead shot in intensively shot locations should be removed from the soil (50, −4). There was strong disagreement that those selling game meat for human consumption are not very aware of possible lead contamination in their meat (33, −4) and there was satisfaction that current human health advice is sufficient to reduce risks of lead shot to humans (44, +2). Current game handling techniques were deemed to be sufficient to address any risks to humans from lead shot (10, +2).

3.2.3 | Cultural and sporting aspects

> So they [the gamekeepers] are managing the habitats so they are not only beneficial to the pheasants but also all the other wildlife that's there as well (Participant 4)

This position strongly adhered to the view that the shooting community probably does more for wildlife and habitats than any other group (14, +5). There was agreement with the notion that shooters' pastimes and activities are being eroded (11, +2) and that the phasing out of lead shot will lead to the demise of shooting (6, +1). There was uncertainty about whether the financial impacts of any further restrictions on lead could be very damaging to shooting-related interests (7, 0). There was strong disagreement that those with political power are biased in favour of keeping lead shot (18, −4). This view did not believe that lead shot will be banned in the future (45, −2).

3.3 | Consensus among perspectives

> Well, if you've got to have a discussion, you need to have the people who are against it and the people who are for it, so you can have a balanced debate (Participant 25)

There were five statements of statistically significant consensus across both factors (Table 4). Both parties indicated that lead poisoning was a shared problem; the involvement of stakeholders from all sides of the debate was desirable and there was consensus that to be taken

TABLE 4 Statements with statistically significant consensus across both factors. These are items whose rankings do not distinguish between factors, that is, the study factors have ranked these statements in the same or similar ways (where $p > 0.05$). Both the Q-sort value and normalised factor scores (the *z* scores) are shown. It should be noted that the authors noticed some difficulty with participants' interpretation of statement 56. It was clear in the follow-up interviews that some took this statement to refer to lead's impacts on wild bird populations while others linked it with reared game bird populations. There is therefore likely some ambiguity with the interpretation of this statement in this analysis

	Statement	Factor 1 Rank (*z* score)	Factor 2 Rank (*z* score)	Differential *z* score
1	Stakeholder opinions from all sides of the lead poisoning debate should be included in any decision-making process	2 (0.820)	3 (0.968)	−0.148
21	Steel shot damages shotgun barrels	−1 (0.022)	+1 (0.156)	−0.134
23	To be taken seriously, information about lead poisoning needs to come from within the shooting community	+1 (0.423)	+1 (0.212)	0.211
41	Non-toxic shot is widely available	+3 (0.830)	+2 (0.573)	0.257
56	If we stopped using lead shot we'd have more birds to shoot	−4 (−1.828)	−5 (−2.084)	0.256

seriously by shooters information about lead poisoning should come from the shooting community. It was agreed that some challenges associated with the non-toxic alternatives (steel shot damages shotgun barrels) remain, though the alternatives were believed to be widely available. Key statement positions that define the two factors and consensus statements are illustrated in Figure 1.

4 | DISCUSSION

The risks of lead ammunition use to human and wildlife health and the measures taken to mitigate these have long been debated in the UK, culminating in a current conflict primarily enacted between groups representing shooting and conservation interests (Cromie et al., 2015; Newth et al., 2015). While this conflict between groups is well known, we have explored the diversity of perspectives among ammunition users, the critical group for their role in releasing lead into the environment and adopting any related changes to shooting practice. Durning (2005) proposed that Q-methodology can be deployed to help resolve conflicts and forge solutions for contentious policy issues in three main ways: (a) Clarifying perspectives; (b) Identifying competing problem definitions and solutions; and (c) Forging new solutions. Here, we discuss the contribution of this study to each of these, summarising and exploring the links between each perspective's definition of the problem and preferred solutions (Derry, 1984; Weiss, 1989).

4.1 | Clarifying perspectives

The views of individual ammunition users in the UK about the 'lead debate' were characterised by two statistically and qualitatively distinct perspectives: (a) 'Open to change'—those that refuted the view that lead ammunition is not a major source of poisoning in wild birds, believed that solutions to reduce the risks of poisoning are needed, were happy to use non-lead alternatives and did not feel that the phasing out of lead shot would lead to the demise of shooting; and (b) *Status quo*—those who did not regard lead poisoning as a major welfare problem for wild birds, were ambivalent about the need for solutions and felt that lead shot is better than steel at killing and not wounding an animal. Opposition to lead

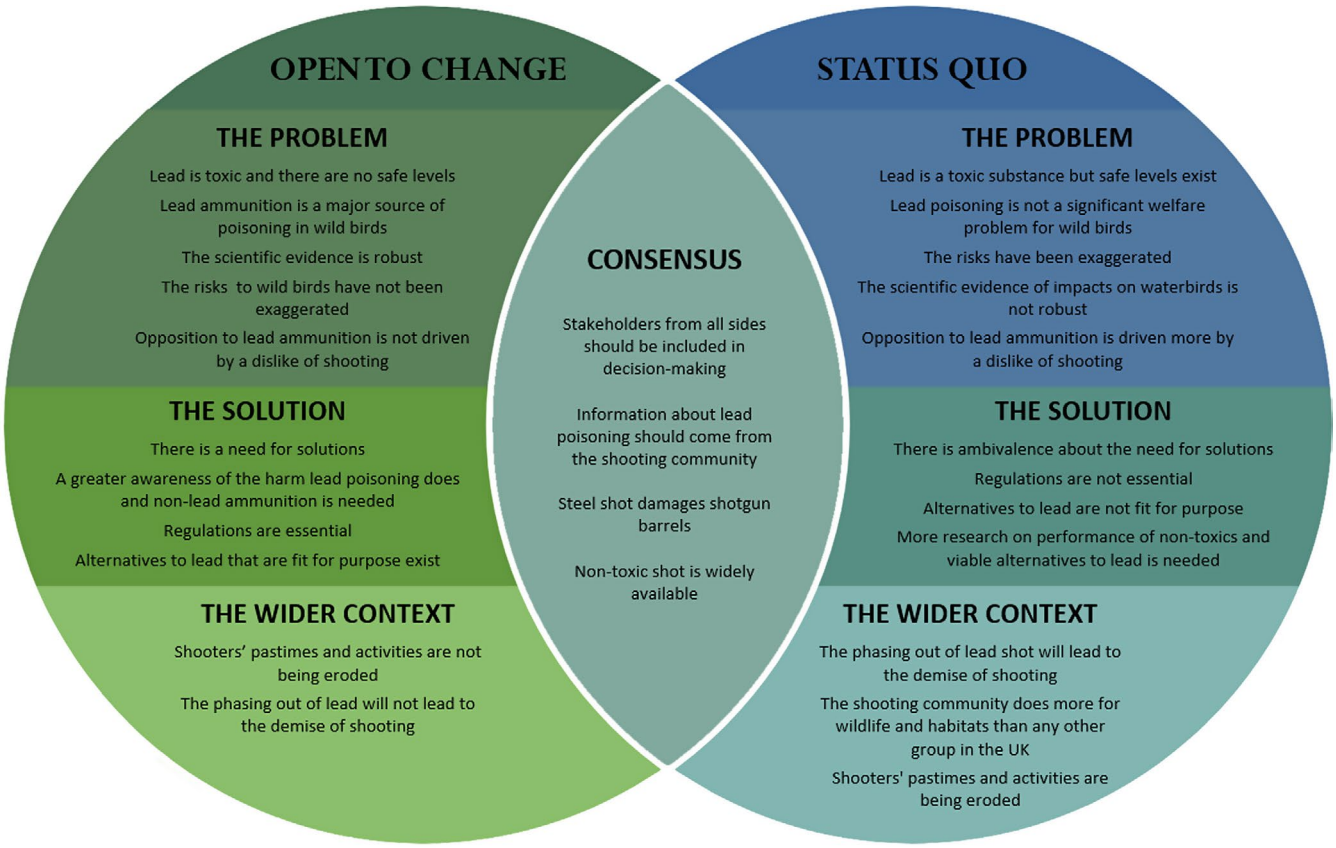

FIGURE 1 A Venn diagram depicting views on some key statements that define two subject positions derived from a Q-method study of ammunition users. Topics of consensus between the two positions are highlighted in the centre. For each perspective, statements were allocated to three themes that emerged inductively from the Q-set: the problem, the solution and the wider context. Taking a holistic approach advocated by Q-method (Watts & Stenner, 2012), statements that reflected a breadth of factor scores, from −5 to +5, within each factor array were extracted, and statements related to topics regarded by the authors as most prevalent within the 'lead debate' were prioritised for inclusion. Statements with statistically significant consensus across both factors (see Table 4) were included in the 'Consensus' section. For brevity and illustrative purposes, these statements were summarised and included in this Venn diagram. This figure therefore represents a 'snap-shot' of each perspective rather than a comprehensive view

ammunition was driven more by a dislike of shooting than evidence of any harm. To understand fully the complexity and nature of perspectives, they should be placed within their wider socio-economic and cultural contexts. Both therefore are discussed within the context of views about the future of shooting in the British landscape.

The two perspectives had contrasting views about the future of shooting. The *Status quo* perspective was framed by fears that the phasing out of lead shot would lead to the demise of shooting and that shooters' pastimes and activities were being eroded. These fears were compounded by the feeling that opposition to lead shot is driven by a dislike of shooting. This perspective reflects a prevailing message in the printed shooting media in recent years, which has suggested that a ban on lead shot represents 'the thin end of the wedge' with a call for all attacks on shooting to be resisted (Cromie et al., 2015). Such concerns were also reflected in comments made during the interviews and suggest that some may perceive their shooting heritage as a whole to be under threat, for example:

> People with political influence are using banning of lead shot in the hope therefore that people will give up shooting. So it's the sprat to catch the mackerel. The thin end of the wedge (Participant 13)

Moreover, this shooting heritage was believed to make an important contribution to the conservation of British wildlife. This sense of pride in the 'shooting life' was a strong theme in the post-sort interviews:

> The shooting community wants the wildlife to succeed…My grandfather was a tenant farmer, he told me that you're only here for a short period and you're only the steward of the land in your lifetime, and you have an obligation to leave it looking better than you found it (Participant 13)

Conversely, 'Open to change' disagreed that shooters' pastimes and activities were being eroded and that the phasing out of lead shot would lead to the demise of shooting:

> I don't agree that the phasing out of lead shot would lead to the complete demise of shooting. I think the phasing out of lead shot will have short-term impacts on shooting (Participant 12)

4.2 | Identifying competing definitions of the lead problem

Problem definition provides the foundations for the construction of policy and its implementation, as well as influencing which stakeholders take part in the decision-making process (Weiss, 1989). We found contrasting definitions of the problem among ammunition users. Although both perspectives agreed that lead is toxic, the extent of its toxicity was disputed: 'Open to change' believed that lead is a genuine problem and there are no safe levels of lead, whereas *Status quo* believed that the lead problem is exaggerated and safe levels exist. Such contrasting definitions of the 'lead problem' was manifested in differing views on its impacts and the need for (and preferred) solutions.

For 'Open to change', the scientific evidence on the impacts of lead on waterbirds was believed to be sound and the evidence was trusted (i.e. not considered exaggerated nor influenced by a wider dislike of shooting sports). Conversely, those aligned to *Status quo*' were less inclined to believe the evidence, which was not regarded as robust and was perceived to have been exaggerated. This distrust of the evidence is again likely compounded by the strong sense that opposition to lead ammunition is driven more by a dislike of shooting than evidence of harm. Mistrust of scientists often stems from a questioning of their motives rather than their expertise or integrity (Wissenschaft im Dialog, 2017). Multiple factors may contribute to distrust of science, including religious beliefs, level of education, political affiliation and socio-economic status (Kabat, 2017; Kahan, 2002). Distrust is a key barrier to collaboration (Ansell & Gash, 2007) and to the resolution of conservation conflicts (Young et al., 2016), and therefore may have serious implications for conservation, the success of which often relies on effective collaboration.

In the post-sort interviews, several ammunition users linked their disbelief about the impacts of lead with their own personal experiences, notably that they had never knowingly encountered a lead poisoned bird nor had been aware of any impacts on their own health following a lifetime of eating game:

> But here I am, I've been eating game for, I don't know, 72 years, and I'm still here. So it's ineffective on me (Participant 19)

Neither perspective believed that lead shot was harmful to human health. Mortality of wild birds from lead poisoning often goes undetected (Cromie et al., 2010; Newth et al., 2013). Unlike wildlife diseases such as botulism, large-scale die-offs of wild birds from lead poisoning are rare events (Pain, 1991). Furthermore, sublethal impacts of lead on the physiological systems of birds (Franson & Pain, 2011; Newth et al., 2016) and humans (Arnemo et al., 2016; EFSA, 2010) may not be obvious (Cromie et al., 2015).

It should also be considered that when conservation issues are politicised, individuals may selectively understand the science in accordance with their own value-based demands (Chamberlain, Rutherford, & Gibeau, 2012; Kahan, Jenkins-Smith, & Braman, 2011; Sarewitz, 2004) and this may partly explain the polarity in viewpoints in this study.

4.3 | Preferred solutions

Status quo was ambivalent about the need for a solution to reduce the risks of lead shot, perhaps unsurprisingly given the view within this group that lead poisoning is not a significant problem. A previous

survey of British shooters found that a key reason for non-compliance with the current lead shot restrictions was that 'lead poisoning is not a sufficient problem to warrant restrictions' (Cromie et al., 2010). There was also support for this sentiment within *Status quo*, associated with little enthusiasm for suggested solutions such as awareness raising, better observance or enforcement of the current regulations and further regulations to replace lead shot with non-toxic alternatives. In contrast, as well as agreeing that lead was a significant problem, 'Open to change' recognised the need for solutions to reduce the risks of lead poisoning. Regulations were seen as essential and there was some support for the replacement of lead shot with non-toxic alternatives. This view strongly agreed that shooters would think twice about using lead ammunition if they saw birds dying from poisoning and that greater awareness of the issue would help:

> I just can't imagine that anybody, whether they were shooters or not, would think that it's acceptable to see birds being poisoned or dying. If they saw it, I think it would upset them (Participant 10)

In recent years, the 'lead debate' has been punctuated by numerous national laws (HMSO, 1999, 2002a, 2002b, 2003, 2004, 2009) and international agreements (IUCN, 2016; Kanstrup et al., 2018; UNEA, 2017; UNEP-CMS, 2014, 2017) which have called, to varying degrees, for the replacement of lead ammunition with non-toxic alternatives. Views on non-lead alternatives notably differed between the two perspectives. Those in 'Open to change' were more likely to be happy to use non-lead options, felt that they were fit for purpose and therefore saw little need for further research to develop a viable alternative. They believed that the availability of further information on non-lead ammunition would reduce concerns. A previous survey found that 41% of British shooters felt that more guidance about the non-lead options would help improve compliance with current restrictions (Cromie et al., 2010). However, those in *Status quo* were generally not happy to use non-lead ammunition, did not feel that the alternatives were fit for purpose and strongly believed that lead shot was better than steel at killing and not wounding an animal. A dislike of the alternatives was also a key reason that British shooters gave for not complying with the current regulations in England (Cromie et al., 2010) and concerns about the effectiveness of non-lead shot relative to lead have been reported in shooting communities elsewhere (Kanstrup, 2006, 2015, 2019). There was a strong belief among those in *Status quo* that more research should be done to develop a viable alternative. It seems logical that those who were more content with the non-lead alternatives, reflecting the perspective of 'Open to change,' are more likely to support the replacement of lead shot with these alternatives while those who were not, are less likely to support this suggested solution. There was some support from those within 'Open to change' for the notion that shooting organisations are afraid they will look weak if they support a ban on lead shot. This may reflect the pressure that membership-oriented shooting organisations are under to provide both leadership and to reflect their memberships' views and supporting a ban may feed into a narrative of giving in to the opposition.

4.3.1 | Commonalities

Although the two perspectives differed on many issues, there was consensus that to be taken seriously information about lead poisoning should come from within the shooting community:

> Yes. If you want to hear bad news, you want to hear it in the pub, from your mates, rather than in the media, at a press conference directed at you. You want to be in the room, and you want to be in ownership of leading the way out of what the issue might be (Participant 22)

This indicates that such sources would have greater credibility among shooters. In Denmark, critical advocates within the hunting community persuaded other hunters of the benefits of non-toxic ammunition using evidence from hunter-led research (Kanstrup, 2019; Newth et al., 2015). In principle, both perspectives supported using robust scientific evidence to guide lead shot policy and management and agreed that opinions from all sides of the 'lead debate' should be included in the decision-making process. Effective participation may improve relationships by increasing trust and sharing perspectives and ultimately reduce conflicts (Ansell & Gash, 2007; Redpath et al., 2013). Both perspectives believed that shooters and non-shooters have the same aim of having sustainable numbers of birds in the British countryside:

> I feel as though my view would be the same as a non-shooter. We want to see the same thing, we don't want to see the decline in wildlife at all. We'd rather see the uprising of it (Participant 17)

4.3.2 | Forging solutions

Conflicts are often oversimplified as they become entrenched and polarised, losing the nuanced perspectives that may exist among the parties. Furthermore, individuals within a polarised stakeholder group do not necessarily hold uniform opinions on wildlife management (Chamberlain et al., 2012; Rust, 2017). Here, use of Q-method has allowed access to a complex issue, enabling the perspectives of ammunition users, as the key group of actors, to be clarified, competing definitions of the problem and preferred solutions to be identified and commonalities to be revealed. Critically, these perspectives arise solely from within the shooting community of ammunition users. In a conflict commonly depicted as between those in favour of shooting versus those opposed, we reveal that a diversity of views on lead ammunition are held within the shooting community itself. Further studies are required to assess the prevalence of the views identified. The variables influencing the views outlined within this paper merit further examination using interdisciplinary methods from the social sciences and psychology. A deeper understanding

of factors predicting the use of lead and non-lead ammunition would be beneficial for addressing non-compliance with the current regulations and acceptability of any future changes to practice. Given that the lead debate is dynamic and influenced by various socio-economic and political factors (Cromie et al., 2015), this study may form a useful foundation for a longitudinal study whereby changes in perspectives on the issue across time can be explored.

The views of women shooting participants were not captured within this study as women were not specifically targeted during participant recruitment. Studies have shown that women exhibit relatively stronger environmental concern and behaviour than men (Vincente-Molina, Fernández-Sáinz, & Izagirre-Olaizola, 2018), and therefore targeted work to assess the perspectives of women in relation to the lead shot issue merits further examination. Overall, the clarification of views held by ammunition users presents an opportunity for the shooting community to take forward discussions and potentially forge new solutions.

ACKNOWLEDGEMENTS

We are extremely grateful to all participants and advisors from the shooting community for their trust, time and contribution to this study.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

J.L.N. conceived the idea, J.L.N., R.A.M., A.L., R.L.C. and J.A.S. designed the methodology; J.L.N. collected the data; J.L.N. and E.S. prepared the data for analysis; J.L.N. analysed the data; J.L.N. led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

All data supporting the results in this paper are available from Zenodo (digital repository): https ://doi.org/10.5281/zenodo.2653514 (Newth et al., 2019).

ORCID

Julia L. Newth https://orcid.org/0000-0003-3744-1443
Eileen C. Rees https://orcid.org/0000-0002-2247-3269
Kevin A. Wood https://orcid.org/0000-0001-9170-6129
Robbie A. McDonald https://orcid.org/0000-0002-6922-3195

REFERENCES

Ansell, C., & Gash, A. (2007). Collaborative Governance in theory and practice. *Journal of Public Administration Research and Theory*, *18*, 543–571. https://doi.org/10.1093/jopart/mum032

Armatas, C., Venn, T., & Watson, A. (2017). Understanding social-ecological vulnerability with Q-methodology: A case study of water-based ecosystem services in Wyoming, USA. *Sustainability Science*, *12*, 105–121. https://doi.org/10.1007/s11625-016-0369-1

Arnemo, J. M., Andersen, O., Stokke, S., Thomas, V. G., Krone, O., Pain, D. J., & Mateo, R. (2016). Health and environmental risks from lead-based ammunition: Science versus socio-politics. *EcoHealth*, *13*, 618–622. https://doi.org/10.1007/s10393-016-1177-x

Attia, M., & Edge, J. (2017). Be(com)ing a reflexive researcher: A developmental approach to research methodology. *Open Review of Educational Research*, *4*(1), 33–45. https://doi.org/10.1080/23265507.2017.1300068

Avery, D., & Watson, R. T. (2009). Regulation of lead-based ammunition around the world. In R. T. Watson, M. Fuller, M. Pokras & W. G. Hunt (Eds.), *Ingestion of lead from spent ammunition: Implications for wildlife and humans* (pp. 161–168). Boise, Idaho: The Peregrine Fund.

Bennett, N. J., Roth, R., Klain, S. C., Chan, K., Christie, P., Clark, D. A., … Wyborn, C. (2017). Conservation social science: Understanding and integrating human dimensions to improve conservation. *Biological Conservation*, *205*, 93–108. https://doi.org/10.1016/j.biocon.2016.10.006

Bredin, Y. K., Lindhjem, H., Van Dijk, J., & Linnell, J. D. C. (2015). Methodological and ideological options mapping value plurality towards ecosystem services in the case of Norwegian wildlife management: A Q analysis. *Ecological Economics*, *118*, 198–206. https://doi.org/10.1016/j.ecolecon.2015.07.005

Brown, S. R. (1980). *Political subjectivity*. New Haven, CT: Yale University Press.

Brown, S. R. (1996). Q methodology and qualitative research. *Qualitative Health Research*, *6*, 561–567. https://doi.org/10.1177/104973239600600408

Byrd, K. (2002). Mirrors and metaphors: Contemporary narratives of the wolf in Minnesota. *Ethics, Place & Environment*, *5*, 50–65. https://doi.org/10.1080/13668790220146456

Cairns, R. C. (2012). Understanding science in conservation: A Q method approach on the Galapagos Islands. *Conservation and Society*, *10*, 217–231. https://doi.org/10.4103/0972-4923.101835

Chamberlain, E. C., Rutherford, M. B., & Gibeau, M. L. (2012). Human perspectives and conservation of grizzly bears in Banff National Park, Canada. *Conservation Biology*, *26*, 420–431. https://doi.org/10.1111/j.1523-1739.2012.01856.x

Cotton, M. D. (2015). Stakeholder perspectives on shale gas fracking: A Q-method study on environmental discourses. *Environment and Planning*, *47*(9), 1944–1962. https://doi.org/10.1177/0308518X15597134

Cromie, R. L., Loram, A., Hurst, L., O'Brien, M., Newth, J., Brown, M. J., & Harradine, J. P. (2010). Compliance with the environmental protection (restrictions on use of lead shot)(England) Regulations 1999. Report to Defra. Bristol.

Cromie, R., Newth, J., Reeves, J., Beckmann, K., O'Brien, M., & Brown, M. (2015). The sociological and political aspects of reducing lead poisoning from ammunition in the UK: Why the transition to non-toxic ammunition is so difficult. In R. J. Delahay & C. J. Spray (Eds.), *Proceedings of the Oxford lead symposium* (pp. 104–124). Oxford, UK: Edward Grey Institute, University of Oxford.

Cuppen, E., Breukers, S., Hisschemöller, M., & Bergsma, E. (2010). Q methodology to select participants for a stakeholder dialogue on energy options from biomass in the Netherlands. *Ecological Economics*, *6*, 579–591. https://doi.org/10.1016/j.ecolecon.2009.09.005

Curry, R., Barry, J., & McClenaghan, A. (2013). Northern Visions? Applying Q methodology to understand stakeholder views on the environmental and resource dimensions of sustainability. *Journal of Environmental Planning and Management*, *56*, 624–649. https://doi.org/10.1080/09640568.2012.693453

Derry, D. (1984). *Problem definition in policy analysis*. Lawrence, KS: University of Kansas Press.

Durning, D. (2005). Using Q-methodology to resolve conflicts and find solutions to contentious policy issues. Network of Asia-Pacific Schools and Institutes of Public Administration and Governance(NAPSIPAG) Annual Conference 5–7 December 2005, Beijing, China.

EFSA. (2010). Scientific opinion on lead in food. *EFSA Journal*, *8*, 1570. https://doi.org/10.2903/j.efsa.2010.1570

Franson, J. C., & Pain, D. J. (2011). Lead in birds. In W. N. Beyer & J. P. Meador (Eds.), *Environmental contaminants in biota. Interpreting tissue concentrations* (pp. 563–593). Boca Raton, FL: Taylor & Francis.

Frantzi, S., Carter, N. T., & Lovett, J. C. (2009). Exploring discourses on international environmental regime effectiveness with Q methodology: A case study of the Mediterranean Action Plan. *Journal of Environmental Management*, *90*, 177–186. https://doi.org/10.1016/j.jenvman.2007.08.013

Galdas, P. (2017). Revisiting bias in qualitative research: Reflections on its relationship with funding and impact. *International Journal of Qualitative Methods*, *16*, 1–12. https://doi.org/10.1177/1609406917748992

Green, R. E., & Pain, D. J. (2015). Risk of health effects to humans in the UK from ammunition-derived lead. In R. J. Delahay & C. J. Spray (Eds.), *Proceedings of the Oxford lead symposium* (pp. 27–43). Oxford, UK: Edward Grey Institute, University of Oxford.

Guttman, L. (1954). Some necessary conditions for common-factor analysis. *Psychometrika*, *19*, 149–161. https://doi.org/10.1007/BF02289162

Haas, P. (2004). When does power listen to truth? A constructivist approach to the policy process. *Journal of European Public Policy*, *11*, 569–592. https://doi.org/10.1080/1350176042000248034

HMSO (Her Majesty's Stationary Office). (1999). The environmental protection (restriction on use of lead shot) (England) Regulations 1999. Retrieved from https://www.legislation.gov.uk/uksi/1999/2170/contents/made

HMSO (Her Majesty's Stationary Office). (2002a). The environmental protection (restriction on use of lead shot) (England) (Amendment) Regulations 2002. Retrieved from https://www.legislation.gov.uk/uksi/2002/2102/contents/made

HMSO (Her Majesty's Stationary Office). (2002b). The environmental protection (restriction on use of lead shot) (Wales) Regulations 2002. Retrieved from https://www.legislation.gov.uk/wsi/2002/1730/contents/made

HMSO (Her Majesty's Stationary Office). (2003). The environmental protection (restriction on use of lead shot) (England) (Amendment) Regulations 2003. Retrieved from https://www.legislation.gov.uk/uksi/2003/2512/contents/made

HMSO (Her Majesty's Stationary Office). (2004). The environmental protection (restriction on use of lead shot) (Scotland) (No. 2) Regulations 2004. Retrieved from https://www.legislation.gov.uk/ssi/2004/358/contents/made

HMSO (Her Majesty's Stationary Office). (2009). The environmental protection (restriction on use of lead shot) Regulations (Northern Ireland) 2009. Retrieved from https://www.legislation.gov.uk/nisr/2009/168/contents/made

Hulme, M. (2009). *Why we disagree about climate change: Understanding controversy, inaction*. Cambridge, UK: Cambridge University Press.

IUCN. (2016). WCC Resolution 082: A path forward to address concerns over the use of lead ammunition in hunting. Retrieved from: https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_RES_082_EN.pdf

Kabat, G. C. (2017). Taking distrust of science seriously. *EMBO Reports*, *18*, 1052–1055. https://doi.org/10.15252/embr.201744294

Kahan, D. M. (2002). The logic of reciprocity: Trust, collection action and law. John M. Olin Center for Studies in Law, Economics, and Public Policy Working Papers. Paper 281.

Kahan, D. M., Jenkins-Smith, H., & Braman, D. (2011). Cultural cognition of scientific consensus. *Journal of Risk Research*, *14*, 147–174. https://doi.org/10.1080/13669877.2010.511246

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, *20*, 141–151. https://doi.org/10.1177/001316446002000116

Kaiser, H. F. (1970). A second generation little jiffy. *Psychometrika*, *35*, 401–415. https://doi.org/10.1007/BF02291817

Kanstrup, N. (2006). Non-toxic shot-Danish experiences. In G. Boere, C. A. Galbraith & D. A. Stroud (Eds.), *Waterbirds around the world* (p. 861). Edinburgh, Scotland: The Stationery Office.

Kanstrup, N. (2015). Practical and social barriers to switching from lead to non-toxic gunshot-a perspective from the EU. In R. J. Delahay & C. J. Spray (Eds.), *Proceedings of the Oxford lead symposium* (pp. 98–103). Oxford, UK: Edward Grey Institute, University of Oxford.

Kanstrup, N. (2019). Lessons learned from 33 years of lead shot regulation in Denmark. In N. Kanstrup, V. G. Thomas & A. D. Fox (Eds.), *Lead in Hunting Ammunition: Persistent Problems and Solutions* (Ambio Vol.*48*). Stockholm, Sweden: Springer. https://doi.org/10.1007/s13280-018-1125-9

Kanstrup, N., Swift, J., Stroud, D. A., & Lewis, M. (2018). Hunting with lead ammunition is not sustainable: European perspectives. *Ambio*, *47*(8), 846–857. https://doi.org/10.1007/s13280-018-1042-y

Kline, P. (1994). *An easy guide to factor analysis*. London, UK: Routledge.

Luks, F. (1999). Post-normal science and the rhetoric of inquiry: Deconstructing normal science? *Futures*, *31*, 705–719. https://doi.org/10.1016/S0016-3287(99)00028-2

Madden, F., & McQuinn, B. (2014). Conservation's blind spot: The case for conflict transformation in wildlife conservation. *Biological Conservation*, *178*, 97–106. https://doi.org/10.1016/j.biocon.2014.07.015

Newth, J. L., Cromie, R. L., Brown, M. J., Delahay, R. J., Meharg, A. A., Deacon, C., … Pain, D. J. (2013). Poisoning from lead gunshot: Still a threat to wild waterbirds in Britain. *European Journal of Wildlife Research*, *59*, 195–204. https://doi.org/10.1007/s10344-012-0666-7

Newth, J. L., Cromie, R. L., & Kanstrup, N. (2015). Lead shot in Europe: Conflict between hunters and conservationists. In S. M. Redpath, R. J. Gutierrez, K. A. Wood & J. C. Young (Eds.), *Conflicts in conservation: Navigating towards solutions* (pp. 177–179). Cambridge, UK: Cambridge University Press.

Newth, J. L., Lawrence, A., Cromie, R. L., Swift, J. A., Rees, E. C., Wood, K. A., … McDonald, R. A. (2019). Perspectives of ammunition users on the use of lead ammunition and its potential impacts on wildlife and humans [Dataset]. *Zenodo*, https://doi.org/10.5281/zenodo.2653514

Newth, J. L., Rees, E. C., Cromie, R. L., McDonald, R. A., Bearhop, S., Pain, D. J., … Hilton, G. M. (2016). Widespread exposure to lead affects the body condition of free-living whooper swans *Cygnus cygnus* wintering in Britain. *Environmental Pollution*, *209*, 60–67. https://doi.org/10.1016/j.envpol.2015.11.007

Pain, D. J. (1991). Why are lead-poisoned waterfowl rarely seen? The disappearance of waterfowl carcasses in the Camargue, France. *Wildfowl*, *42*, 118–122.

Pain, D. J., Cromie, R., & Green, R. E. (2015). Poisoning of birds and other wildlife from ammunition-derived lead in the UK. In R. J. Delahay & C. J. Spray (Eds.), *Proceedings of the Oxford lead symposium* (pp. 58–84). Oxford, UK: Edward Grey Institute, University of Oxford.

Price, S., Saunders, C., Hinchliffe, S., & McDonald, R. A. (2017). From contradiction to contrast in a countryside conflict: Using Q Methodology to reveal a diplomatic space for doing TB differently. *Environment and*

Planning A, *49*, 2578–2594. https://doi.org/10.1177/0308518X17726782

Raik, D., Wilson, A., & Decker, D. (2008). Power in Natural Resources Management: An Application of Theory. *Society & Natural Resources*, *21*, 729–739. https://doi.org/10.1080/08941920801905195

Redpath, S. M., Young, J., Evely, A., Adams, W. M., Sutherland, W. J., Whitehouse, A., … Gutiérrez, R. J. (2013). Understanding and managing conservation conflicts. *Trends in Ecology & Evolution*, *28*, 100–109. https://doi.org/10.1016/j.tree.2012.08.021

Robbins, P., & Krueger, R. (2000). Beyond bias? The promise and limits of Q method in human geography. *The Professional Geographer*, *52*, 636–648. https://doi.org/10.1111/0033-0124.00252

Rust, N. A. (2017). Can stakeholders agree on how to reduce human-carnivore conflict on Namibian livestock farms? A novel Q-methodology and Delphi exercise. *Oryx*, *51*, 339–346. https://doi.org/10.1017/S0030605315001179

Saltelli, A., Giampietro, M., Avan, E., Ambientals, T., & Autonoma, U. (2015). The fallacy of evidence based policy Science for policy. *Predicaments and Doubts*. *Futures*, 1–30.

Sarewitz, D. (2004). How science makes environmental controversies worse. *Environmental Science & Policy*, *7*, 385–403. https://doi.org/10.1016/j.envsci.2004.06.001

Schmolck, P. (2014). PQMethod (version 2.35). Retrieved from: http://schmolck.org/qmethod/

Stainton Rogers, R. (1995). Q methodology. In J. A. Smith, R. Harre & I. Van Longenhove (Eds.), *Rethinking methods in psychology* (pp. 178–193). London, UK: Sage.

Stenner, P. H. D., Cooper, D., & Skevington, S. M. (2003). Putting the Q into quality of life; the identification of subjective constructions of health-related quality of life using Q methodology. *Social Science and Medicine*, *57*, 2161–2172. https://doi.org/10.1016/S0277-9536(03)00070-4

Stephenson, W. (1953). *The study of behaviour: Q technique and its methodology*. Chicago, IL: University of Chicago Press.

Stroud, D. A. (2015). Regulation of some sources of lead poisoning: A brief review. In R. J. Delahay & C. J. Spray (Eds.), *Proceedings of the Oxford lead symposium* (pp. 8–26). Oxford, UK: Edward Grey Institute, University of Oxford.

Thomas, D. R. (2003). A general inductive approach for qualitative data analysis. Auckland, New Zealand: School of Population Health, University of Auckland. Retrieved from https://www.frankumstein-.com/PDF/Psychology/Inductive%20Content%20Analysis.pdf

Thomas, V. (2015). Availability and use of lead-free shotgun and rifle cartridges in the UK, with reference to regulations in other jurisdictions. In R. J. Delahay & C. J. Spray (Eds.), *Proceedings of the Oxford lead symposium* (pp. 85–97). Oxford, UK: Edward Grey Institute, University of Oxford.

UNEA. (2017). United Nations Environment Assembly 3 UNEP/EA.3/Res.4 Environment and Health. Retrieved from: https://papersmart.unon.org/resolution/uploads/k1800154.english.pdf

UNEP-CMS. (2014). Resolution 11.15. Preventing poisoning of migratory birds. Adopted by the Conference of the Parties at its 11th meeting, 4–9November 2014, Quito, Ecuador. Retrieved from: https://www.cms.int/en/document/preventing-poisoning-migratory-birds

UNEP-CMS COP12. (2017). Leaders' breakfast: Moving towards a pollution-free planet. 12th Meeting of the Conference of the Parties. October 2017, Manila, The Philippines. Retrieved from: https://papersmart.unon.org/resolution/uploads/outcome_of_leaders_breakfast_cms_cop12_22_october.pdf

Van Exel, N. J. A., & de Graaf, G. (2005). Q methodology: A sneak preview. Retrieved from: https://qmethodblog.files.wordpress.com/2016/01/qmethodologyasneakpreviewreferenceupdate.pdf

Vincente-Molina, M. A., Fernández-Sáinz, A., & Izagirre-Olaizola, J. (2018). Does gender make a difference in pro-environmental behaviour? The case of the Basque Country University students. *Journal of Cleaner Production*, *176*, 89–98. https://doi.org/10.1016/j.jclepro.2017.12.079

Watts, S., & Stenner, P. (2012). *Doing Q methodological research: Theory, method and interpretation*. London, UK: Sage.

Webler, T., Danielson, S., & Tuler, S. (2009). *Using Q method to reveal social perspectives in environmental research*. Greenfield, MA: Social and Environmental Research Institute.

Weiss, J. A. (1989). The powers of problem definition: The case of government paperwork. *Policy Sciences*, *22*, 97–121. https://doi.org/10.1007/BF00141381

Wissenschaft im Dialog. (2017). Science barometer 2017. Retrieved from: https://www.wissenschaft-im-dialog.de/fileadmin/user_upload/Projekte/Wissenschaftsbarometer/Dokumente_17/Einzelgrafiken/Sciencebarometer2017_brochure_web.pdf

Young, J. C., Searle, K., Butler, A., Simmons, P., Watt, A. D., & Jordan, A. (2016). The role of trust in the resolution of conservation conflicts. *Biological Conservation*, *195*, 196–202. https://doi.org/10.1016/j.biocon.2015.12.030

Zabala, A., Sandbrook, C., & Mukherjee, N. (2018). When and how to use Q methodology to understand perspectives in conservation research. *Conservation Biology*, https://doi.org/10.1111/cobi.13123

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Newth JL, Lawrence A, Cromie RL, et al. Perspectives of ammunition users on the use of lead ammunition and its potential impacts on wildlife and humans. *People Nat*. 2019;1:347–361. https://doi.org/10.1002/pan3.30