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RESEARCH ARTICLE

Improving attitudes towards adders (*Vipera berus*) and nature connectedness in primary-age group children

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Abstract

1. Adder (*Vipera berus*) populations are experiencing declines in many countries, including the United Kingdom. Perceptions of adders and other venomous snakes are generally negative, making conservation of these species a challenge, and persecution remains within the top five perceived causes for adder declines in the United Kingdom. Improved understanding and attitudes are needed to support current conservation efforts. However, ensuring these positive attitudes continue into the future relies on addressing children's loss of connection to nature, and intervention at this early attitude-formation stage can be crucial for traditionally 'unpopular' species, such as snakes.
2. An adder-focussed public engagement project, *Adders are Amazing* !, was carried out in Pembrokeshire, United Kingdom, in 2018–19 to improve understanding and attitudes towards adders using a blended science-creative arts approach. The project included half-day primary school-based workshops to inform 111 pupils aged 8–11 about adder ecology, alongside creative art experiences. Questionnaires were used to measure the children's attitudes towards adders and their nature connectedness both before and after the workshops and these were compared with equivalent questionnaires carried out at a control school (57 pupils) where no workshops were conducted.
3. The project demonstrated that engagement that blends both art and science can significantly change attitudes towards adders without any direct contact with the animals themselves; specifically, participants' scores for 'Wonder', 'Learning Interest' and 'Conservation Concern' increased. The workshops also significantly increased measures of the children's general connectedness to nature (specifically, 'Enjoyment of Nature' and 'Responsibility for Nature').
4. We recommend conservation bodies focus on, and not shy away from, so-called 'unpopular' species, to promote understanding and acceptance of these species and support their conservation. Blended arts–science initiatives, which can be easily adapted to suit a wide range of species and the artistic practices of local communities, are an effective way to achieve this.

KEYWORDS
adder, art–science collaboration, attitude change, community engagement, nature connectedness, *Vipera berus*

1 | INTRODUCTION

Globally, snake populations are in widespread decline, which may have severe consequences for ecosystem functioning (Reading et al., 2010). Among the UK's herpetofauna, the status of the northern viper or adder (*Vipera berus*) has increasingly become a cause for concern (Julian & Hodges, 2019), with significant declines noted since the 1930s (Cooke & Arnold, 1982) and increasing localised risk of extinctions for this species in the United Kingdom (Gardner et al., 2019). Adders have recently been re-classified within Britain under IUCN Red List criteria, moving the species from the global and European assessment of 'Least Concern' to 'Vulnerable' in England and 'Near Threatened' in the United Kingdom as a whole (Foster et al., 2021). This further highlights the growing concern for the adder's future in the United Kingdom.

Adders in the UK (Gardner et al., 2019), and other viperine snakes worldwide (Crnobrnja Isailovic et al., 2009; Dirzo & Raven, 2003; Fischer & Lindenmayer, 2007; Gibbons et al., 2000), face many threats that are common to other species of conservation concern, including the loss, degradation and increased fragmentation of their habitat. However, on top of this, they also face persecution, which was identified by the Make the Adder Count scheme as one of the top five factors likely to be driving UK adder population declines (Gardner et al., 2019) and is one of the top three causes of adder declines cited in other studies (Baker et al., 2004; Cooke & Scorgie, 1984). Being a venomous snake, adders have been persecuted across Europe for centuries, due to perceived risks to human health and livestock (Bronckers, 2013; Langton, 1986). Dislike and misunderstanding of snakes are common throughout many cultures (Knight, 2008), fuelled by a strong international negative media bias towards snake bite-related events (e.g. bites and deaths) (Ballouard et al., 2013). In the United Kingdom, negative attitudes towards adders persist, encouraged by sensationalised media reporting (Adu, 2018; Burrows, 2020; Gysin, 2017; Pattinson, 2020) and this is likely to be hindering their conservation (Messenger, 2018).

A conservation strategy for the adder must therefore deconstruct these widely held and often negative attitudes towards adders and consider how to manage the conflicts that can arise when people live alongside a venomous snake. Such human–wildlife conflicts are common where communities live alongside feared or potentially dangerous species (Nyhus, 2016; Sponarski et al., 2016; Torres et al., 2018; Treves et al., 2006) and, since public support is key to conservation, it is essential to work with communities in such areas to generate positive attitudes, foster coexistence and minimise risk of conflicts. This means facilitating safe and positive human–adder interactions (or associations) within adder stronghold areas.

Key to this type of cultural change in perception is working with children, as it is during childhood that negative attitudes towards snakes and snake phobias typically develop (DeLoache & LoBue, 2009; LoBue et al., 2010). Today's children are more disconnected from nature than children were 50 years ago (Bragg et al., 2013), with increasing evidence that children are suffering from 'nature-deficit disorder' (Louv, 2010) and increasing 'biophobia' towards 'undesirable' species (Soga et al., 2020), which may in turn lead to a decrease in pro-environmental attitudes later in life (Mackay & Schmitt, 2019; Natural England, 2020; Nisbet et al., 2009; Richardson et al., 2020; Soga et al., 2020). Recent research has also demonstrated a clear link between nature connectedness and snake phobias, such that, those more connected to nature are less likely to demonstrate these fears (Zsido et al., 2022). If upcoming generations continue to become disconnected from their environment, coupled with the continual negative portrayal of adders within the media, there may be increased likelihood of future indifference towards adder conservation and of persecution even being considered acceptable. There is therefore a pressing need to reconnect children to their natural environment, the species around them, and to adders in particular, if conservation actions are to be successful long term.

Species which evoke negative emotions such as fear, hatred and disgust (e.g. snakes, spiders) are commonly described as 'unpopular' (Castillo-Huitrón et al., 2020). While education alone can improve attitudes towards, and increase willingness to protect, 'unpopular' species (Barthel et al., 2018; Monge-Nájera, 2017; Schönfelder & Bogner, 2017), including venomous snakes (Ballouard et al., 2012; Burghardt et al., 2009), some argue that direct, hands-on experience with unpopular animals is essential to improve attitudes (Ballouard et al., 2012, 2013; Prokop et al., 2009; Randler et al., 2012) and information-focussed interventions on their own may not be as effective (Ballouard et al., 2013; Morgan & Gramann, 1989; Prokop et al., 2009). However, the stress caused to wild snakes through capture and handling has been well documented (Moore et al., 2000; Schuett et al., 2004), raising welfare concerns against handling in environmental education, and health and safety concerns clearly preclude taking venomous snakes into schools. In the case of the adder, an alternative and more imaginative strategy is therefore required to obtain the same improvements in attitudes, without direct contact with live adders.

The 'non-contact' intervention developed for this study combined learning through scientific classroom-based activities with learning through the creative arts. Art–science collaborations are increasingly considered to be an effective strategy within conservation for increasing awareness and changing public attitudes (Brennan, 2018; Ellison et al., 2018; Harrower et al., 2018). The increased emphasis on STEAM programmes, where hard scientific messages are moulded with artistic elements to improve science education, is now widely evident (Colucci-Gray & Burnard, 2020). Such collaborations can help scientists communicate with more diverse audiences

more effectively than factual science-based education alone (Ellison et al., 2018) due to increased emotional resonance (Ballengée, 2015; Curtis et al., 2014; Harrower et al., 2018), leading to both cognitive and affective results (Sanders, 2022). Holistic approaches, which engage not only the 'head' but also the 'hand' and 'heart', may therefore positively change attitudes and behaviours towards conservation and local biodiversity through improving both ecological awareness and nature connectedness (Evans, 2014; Renowden et al., 2022). It has been argued that a deeper, even spiritual, appreciation of 'unpopular' species such as snakes cannot be reached solely through scientific facts and rational discourse (Burghardt et al., 2009), but can be achieved by incorporating creative and artistic methods (Harrower et al., 2018).

The aim of this study was therefore to determine whether combined scientific and creative art workshops using a non-handling approach could significantly improve attitudes towards adders and connectedness to nature in primary-school-age children (aged 8–11). This research was part of a community-based art–science project led by Amphibian and Reptile Groups of the UK (ARG UK) entitled 'Adders are Amazing!', working with communities on the St David's Peninsula in south-west Wales, United Kingdom. The three objectives of the study were to:

1. Measure the effect of the *Adders are Amazing*! workshops on attitudes towards adders in young children (aged 8–11).
2. Determine whether this species-focussed environmental education intervention can also improve general connectedness to nature in young children.
3. Ascertain whether there is a link between general connectedness to nature and attitudes towards adders in young children.

We demonstrate that blended science-art engagement is an effective means to improve public perceptions of a venomous species. The transferability of these methods highlights their potential, not only to improve adder conservation in the United Kingdom and other countries, but also the long-term conservation prospects of a wide range of other venomous and 'unpopular' species.

2 | METHODS

2.1 | Study location

The project took place on the St David's Peninsula, Pembrokeshire, in south-west Wales, United Kingdom. The area is considered a stronghold for the adder and is a largely rural county with an abundance of suitable habitat for adders within protected conservation areas, such as the Pembrokeshire Coast National Park and other designated sites. There are several factors which are believed to contribute to the stability of adder populations in the county, including relatively well-connected coastal heathland, presence of lowland heath and commons both of which are important habitats for the adder, and traditional Pembrokeshire 'hedge banks' that provide sheltered structures for over-wintering. However, even within this largely beneficial environment, much of the county has been intensively grazed by livestock farming, mainly sheep and cattle, which has degraded the habitat for reptiles such as the adder. In addition, historically, adders were perceived as a threat to livestock and therefore routinely persecuted, often for a bounty (local farmers and land managers, personal communication). This combination of positive and negative conditions made it an ideal case study area for the project, which aimed to improve public understanding of adders in a location where both the public and the animals may benefit.

2.2 | Study schools

Following ethical approval from the University of Chichester (UoC 2122_42), one hundred and sixty-eight 8- to 11-year-old children were recruited from three semi-rural primary schools in Pembrokeshire, Wales. Consent to participate was obtained from parents prior to commencement of the study. An opt-out letter was sent to parents by the participating schools. One parent requested that their child to not be included in the data collection. Two of the schools received the non-contact intervention (111 pupils), and the third acted as a control group (57 pupils).

The intervention schools were chosen based on their close proximity to known adder populations. Project resources and the in-depth nature of the interventions dictated the number of participants engaged. The control school also had adders nearby and was chosen for having a similar size and semi-rural location to the intervention schools. There was a sufficient distance (approximately 32 miles) to minimise any risk of community transmission of project knowledge/effects to its pupils from the intervention schools.

2.3 | Interventions

A summary of the interventions is presented in Table 1.

The intervention consisted of two half-day workshops with all classes containing 8- to 11-year-olds (62 children in intervention school 1, and 49 in intervention school 2). This was conducted during the autumn term of 2018. The first workshop comprised a single classroom-based, scientific teaching session lasting approximately 2 h per class. The second comprised a classroom-based art activity, lasting a further 2–3 h per class whose creative outputs were incorporated into two creative public engagement events. The interventions engaged the 'head', 'heart' and 'hand', a framework used within art–science collaborative work to help embody learning and deepen engagement (Renowden et al., 2022; Sipos et al., 2008). Methods engaged participants cognitively through the 'head' (knowledge acquisition and dispelling of 'adder myths' during science workshop), then deepened the learning and emotional experience through methods engaging the 'hands' (psychomotor; introduction to materials related to the animals themselves, creation of art and clay works, hands-on

TABLE 1 Summary of interventions.

Intervention	Themes	Activities	Duration
Science workshop	• Adder biology and identification. • Adder ecology and habitats. • Role in wider ecosystem. • Human–adder interactions.	• Exploring preconceptions. • Group discussions with visual aids and supportive materials. • Creating clay adders. • Creating adder amulets. • Outdoor food chain game.	2 h per class
Art workshop	• Adder ecosystem themed artworks.	• Mono-printing. • Making bookmarks. • Creating handmade paper adder scales. • Mosaics. • Window scenes.	2–3 h per class
Art exhibition	• Positive aspects of snake mythology.	• Presentation of children's artwork in local gallery	2-weeks
Lantern workshop	• Interconnectedness with other vulnerable species.	• Creating adder lanterns. • Creating animal head dresses. • Creative writing and dramatisations.	2-h (older year group)
Outdoor community performance	• Adder as a benevolent mother figure. • Interconnectedness with other vulnerable species.	• Narrated lantern procession and storytelling involving children from the schools, their families and the local community.	1 h performance

interactions with models of the animals during both science and art workshops) and 'heart' (affective experiences; creative writing, storytelling during workshops and public engagement event).

2.3.1 | Science workshops

All scientific workshops were delivered by the ARG UK project officer, an experienced adder ecologist with expertise in providing interactive, child-focussed activities within educational settings. Content was tailored to fit with the schools' science curriculum and adjusted to be age appropriate for each class.

The science workshops addressed: adder biology and identification, adder ecology and habitat and the adder's role in the ecosystem. The children created clay adders and adder amulets during these sessions to help them focus on identification features of the animal. The workshops involved indoor and outdoor work and highly interactive elements, including food chain games and learning about other living things within the adder's environment (plants, animals) and how everything is connected, including to humans, within their environment.

No live snakes were brought into the workshops; however, a set of custom-made, realistic leather adder models was used as a 'nearest alternative', along with an adder skeleton, adder sloughs and a dead slow worm, which the children could interact with.

There was a focus on dispelling misconceptions surrounding adders. Children were asked about their preconceptions surrounding adders, such as whether they are slimy, large, aggressive or dangerous animals, and any incorrect information was gently corrected in each session.

The adder ecologist also told stories of personal encounters with adders in the wild, providing authenticity of experience for the children and allowing them to build up trust in the workshop leader and the credibility of the information provided. This included information on how to behave upon encountering an adder in the wild (using a 'SSS—Stop, Step Back and Smile' approach).

The science workshop therefore provided indirect experiences of the animals, as well as passing on a positive vicarious (i.e. imagined) experience of adders through the adder ecologist sharing their stories.

2.3.2 | Art workshops

In the art workshop, class groups engaged with local artist Emily Laurens to create adder-themed artworks using different age-appropriate techniques, including mono-printing, making bookmarks, creating handmade paper adder scales, mosaics and using tissue paper to create window scenes of adders (Figure 1). Many of the artworks also showed the wider ecosystem and the importance of the natural habitats on the peninsula for all local wildlife and people. These themes were facilitated by the artist who had an understanding of adder ecology.

Two of the older year groups in each school (53 children in total) worked on an additional task to create an 8-m-long adder lantern named 'Gwiber' ('adder' in Welsh), and animal headdresses representing other threatened animals within the adder's local environment (chough, dormice, glow worms) (Figure 2).

These creative activities were then incorporated into two public events: an adder-themed art exhibition, where the children's artworks were displayed in a local gallery for 2 weeks, and an outdoor community performance within the adder's local habitat, involving the school children and members of the local community (300+ participants). These events took place as part of the wider *Adders are Amazing*! project to raise awareness in the local community of the ecological issues surrounding the adder, and other native species. The theme for

FIGURE 1 Examples of artworks created by the school children (large mosaic, left; ink monoprint, right).

FIGURE 2 'Gwiber', the giant adder lantern, on a community engagement event involving the school children at St Davids Airfield.

both events drew on positive aspects of snake mythology, portraying Gwiber as a 'benevolent mother figure and protector of the countryside', intended to provide fun, memorable and positive experiences for the participants within their local outdoor environment.

2.3.3 | Total contact hours

Although contact hours with the ecologist and artist varied slightly according to school timetables, a similar effort was given to the two intervention schools, with an average of 24 h of input time per school including all workshops (three workshops each of 2 h duration for three classes per school) and public events (two optional public events; a performance lasting 1 h and the art exhibition).

2.4 | Measuring impact in intervention schools

The impact of the interventions was assessed using a questionnaire (Appendix S1) developed by the authors. This was implemented 1 month before the intervention began, and again 6 months following the interventions (11 months apart, in total). Previous work has shown that significant improvements in environmental attitudes can be achieved immediately following environmental education programmes (Bogner, 1998) but may not be sustained over time (Nolan et al., 2022; Redman & Redman, 2016). The 6-month gap between questionnaires was a compromise between the desire to measure longer-term effects and the need to complete data collection within the same school year to minimise participant loss before follow-up, which can be an issue with long-term assessments of impacts after such programmes (Nolan et al., 2022). Questionnaires were administered to the 111 children across the two schools receiving the interventions.

The questionnaire comprised four sections (structure and scoring shown in Table 2).

The first section of the questionnaire collected demographic information.

The second section of the questionnaire measured the participant's Connectedness to Nature Index. This scale was developed by Cheng and Monroe (2012) and consists of 16 questions categorised into four themes: (1) Enjoyment of Nature, (2) Empathy for Nature, (3) sense of Oneness with Nature and (4) sense of Responsibility for Nature. The average for each sub-scale was then calculated giving a range of possible scores from one to five. Higher scores indicate greater connectedness to nature. The index has previously been used to assess connectedness to nature in young children and received confirmatory factor analysis by Sobko et al. (2018), who concluded the index captured the four main themes with good internal consistency; Cronbach's alpha scores, a measure of validity and the extent to which the items measure the same characteristic, ranged from 0.75 to 0.87. Any score above 0.7 is considered good (Bland & Altman, 1997).

The third section of the questionnaire gathered information on Attitudes towards adders. These questions were based on the work of Prokop et al. (2009) and comprised a 25-item questionnaire based on a Likert scale response from 1 to 5 (Carifio & Perla, 2008) covering five dimensions of attitude (where we substitute here more intuitive labels for the dimensions used by Prokop et al., 2009): (1) '*Wonder*' recorded children's wonder at adders and included statements such as, 'Seeing an adder in the wild

TABLE 2 Summary of questionnaire structure.

Questionnaire section	Content	Components	Score
1	Demographics	Age, gender	
2	Connectedness to Nature Index	Enjoyment of Nature Empathy for Nature Oneness with Nature Responsibility for Nature	1–5
3	Attitudes towards adders scale	Wonder Dislike/fear Learning interest Interaction willingness Conservation Concern	1–5
4	Species ranking	10 species from different classes and family groups (hazel dormouse, adder, sand lizard, curlew, water vole, noctule bat, pearl-bordered fritillary, great crested newt, lesser silver diving beetle	Top 3 species chosen and ranked in order of preference for conservation desirability (first to third)

would be very special'; (2) '*Dislike/fear*' recorded dislike and fear of adders and included statements such as, 'adders are creepy', and 'adders are frightening' (we contend that scores for Wonder and Dislike/fear are not mutually exclusive, insofar as you could be frightened of an adder, but also consider seeing an adder as a special moment); (3) the '*Learning Interest*' dimension assessed children's interest in gathering information about adders and included statements such as 'Learning more about adders is a good thing'; (4) the '*Interaction Willingness*' dimension investigated the children's willingness to interact with adder habitat and exploration of nature, and included statements such as 'I would go into the countryside even if there were adders in it'; and finally, (5) the '*Conservation Concern*' dimension assessed the children's concern for the conservation of adders and included statements such as 'Adders are worth saving' and 'Adders need our protection'. The average score for each dimension was calculated giving a possible range from one to five, with high scores indicating more positive attitudes towards adders (excepting for the Dislike/fear dimension, where a high score indicated strongly negative responses). Each dimension was considered an independent scale, and therefore no aggregate score was generated. Cronbach's alpha scores for the positive dimensions ranged from 0.77 to 0.93.

The final section of the questionnaire presented nine animals from a range of taxonomic groups (mammals, reptiles, birds and insects) all of which are of conservation concern in the United Kingdom. Before and after the interventions, the children were asked to choose three animals that they would like to help if they could.

2.5 | Control school measurements

Children at the control school (57 children aged between 8 and 11) acted as a 'wait-list' control group and followed their usual school curriculum. Identical questionnaires were administered to the control schools at approximately the same time as the baseline and follow-up questionnaires administered to the intervention schools, such that the timing of and interval between questionnaires was comparable. The control school received the intervention after completion of data collection. This ensured equal educational opportunities were provided, and incentivised involvement.

2.6 | Analysis

Questionnaire responses were recorded on paper, and then manually entered into Excel, where a random selection was then checked for accuracy of input. The data from this point were anonymised and transferred into SPSS 20 for statistical analysis. Throughout, data are presented as means ± standard deviations.

Two-way mixed-model ANOVAs were used to test for statistically significant (Carifio & Perla, 2008) differences between scores (attitudes towards adders or nature connectedness) from schools (control vs. intervention), and over time (pre- and post-intervention). A Mann–Whitney *U*-test revealed groups were not significantly different for age ($U=3501.0$, $p=0.242$) or gender ($U=3174.0$, $p=0.969$). Post hoc *t*-tests were used to identify score differences between groups and Cohen's *D* was calculated for effect size. Statistical significance was accepted as $p<0.05$.

Pearson correlations were used to investigate the relationship between attitudes towards adders and connectedness to nature, pooling the baseline data from all three schools. Statistical significance was accepted as $p<0.05$.

The species choice data (which animal the children would like to help if they could) were analysed by summing the number of times each animal was chosen across the sample and then ranking the animals in ascending order from most often chosen to least often chosen.

3 | RESULTS

3.1 | Study participant demographics

The full participant sample included 77 boys (46%) and 91 girls (54%). There were thirty-five 8-year-olds (20.9%), fifty-three 9-year-olds (31.6%), thirty-three 10-year-olds (19.6%) and forty-seven 11-year-olds (27.9%). Figure 3 shows the demographics for the control and intervention schools separately.

3.2 | Changes in attitudes towards adders

The intervention schools showed a significant increase in Wonder and Learning Interest scores towards adders after the intervention (Figure 4). The Wonder dimension showed a significant main effect for time ($F_{(1.166)}=7.521$, $p=0.007$), and a significant interaction between group (i.e. intervention or control) and time ($F_{(1,166)}=5.282$, $p=0.023$), and post hoc *t*-tests confirmed a significant increase of 11% (ES −0.371, small to medium effect) in the intervention schools only. Likewise, Learning Interest showed a significant interaction between group and time ($F_{(1,166)}=80.32$, $p=0.005$) and post hoc *t*-tests confirmed an increase of 5% (ES −0.258, small effect) for the intervention schools only.

The intervention schools' scores also showed a significant increase in the Conservation Concern dimension. There was a significant main effect for time, ($F_{(1,166)}=13.933$, $p<0.0005$), a significant interaction with group ($F_{(1.166)}=4.952$, $p=0.027$) and the post hoc *t*-tests demonstrated a significant increase of 12.5% (ES −0.447, medium effect) for the intervention schools.

There was no significant change in the children's Dislike/fear dimension, or their scores in the Interaction Willingness dimension in the intervention schools (Figure 4).

There was no significant change in any attitudes towards adders during the course of the study in the control school (Figure 4). Interestingly, at baseline, the control school showed significantly higher scores than the intervention schools in the Wonder, Learning Interest and Conservation Concern dimensions. However, the intervention schools had almost achieved or slightly exceeded the control school's scores in Wonder and Conservation Concern after the interventions (Figure 4).

3.2.1 | Species rankings

At baseline, the dormouse was ranked as the species the children would most like to help in both the control and intervention schools (Table 3), being almost universally selected by children as one of their three chosen species. In contrast, the lesser silver diving beetle was ranked lowest in all of the schools (and this did not change over the course of the study).

In the intervention schools, the adder was ranked 6th at baseline and it advanced to third place after the interventions, showing the greatest upward movement in ranking of any species (Table 3) and indicating a positive shift towards wishing to prioritise conservation efforts towards adders. Meanwhile, the water vole decreased from second to eight place in the schools receiving the intervention.

The adder was ranked very highly in the control school—second place at baseline, and joint first with the dormouse at follow-up—potentially reflecting the control school's significantly higher scores for Wonder, Learning Interest and Conservation Concern at the start of the study.

We note that the species 'selection process' was something that the children initially showed reluctance to apply as they wanted to 'help all of the animals'.

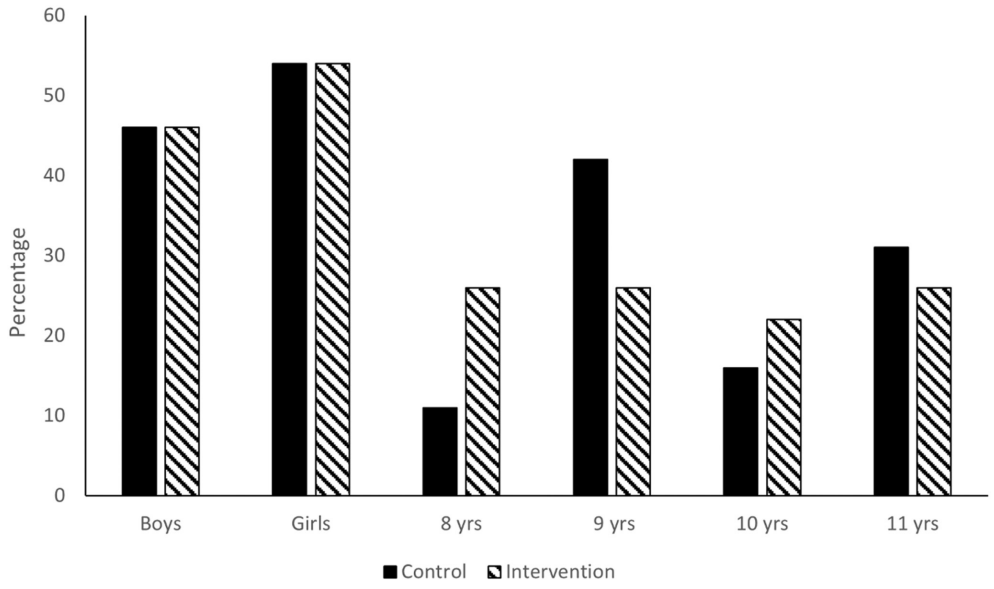

FIGURE 3 Study participant demographics for control and intervention schools.

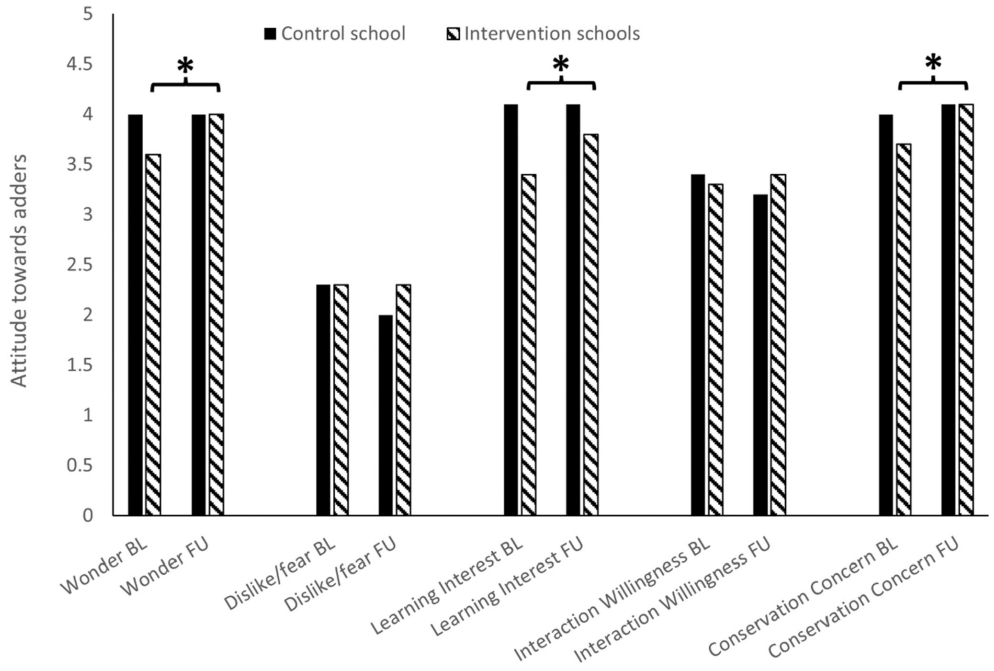

FIGURE 4 Changes in attitudes towards adders between baseline (BL) and follow-up (FU). * denotes statistical significance between baseline and follow-up scores in intervention schools (two-way ANOVA and post hoc *t*-tests; $p < 0.05$). Solid bars indicate control school, hatched bars intervention schools.

TABLE 3 Species ranking. Ranked from 1 (most often chosen as a species the children 'choose to help') to 9 (least often chosen).

	Control school rankings			Intervention schools' rankings		
Animal	**Baseline**	**Follow-up**	**Change**	**Baseline**	**Follow-up**	**Change**
Dormouse	1	1	0	1	1	0
Adder	2	1	+1	6	3	+3
Sand lizard	3	3	0	3	4	−1
Curlew	3	5	−2	4	2	+2
Water vole	5	4	+1	2	8	−6
Noctule bat	6	6	0	5	5	0
P.B. fritillary	7	7	0	8	6	+2
Great crested newt	8	8	0	7	7	0
L.S diving beetle	9	9	0	9	9	0

Abbreviations: LS, lesser silver diving beetle; PB, pearl-bordered fritillary.

3.3 | Changes in connectedness to nature

The intervention school scores showed a significant increase within the Enjoyment for Nature theme of the Connectedness to Nature Index (Figure 5). The ANOVA for Enjoyment of Nature showed a significant main effect for time ($F_{(1,166)} = 6.438$, $p = 0.012$) and a significant interaction with group ($F_{(1,166)} = 5.778$, $p = 0.017$), and the post hoc *t*-tests indicated a significant increase of 8% (ES −0.382, small to medium effect) for the intervention schools only.

Both the intervention and control schools showed significant increases in the Responsibility for Nature theme of the Connectedness to Nature Index during the study (Figure 5). The ANOVA indicated a significant main effect for time ($F_{(1,166)} = 5.893$, $p = 0.034$) and post hoc *t*-tests showed a significant increase of 3% (ES −0.282, small effect) and 4% (ES −0.339, small effect) for the intervention and control schools respectively.

The control school had significantly higher baseline scores in three of the four themes within the Connectedness to Nature Index (Enjoyment, Empathy, and Oneness; *t*-test, $p < 0.05$).

3.4 | Correlations between connectedness to nature and attitudes towards adders

All themes within the Connectedness to Nature Index were significantly positively correlated with the Wonder, Learning Interest, Interaction Willingness and Conservation Concern dimensions of the Attitudes Towards Adders section of the questionnaire, when the

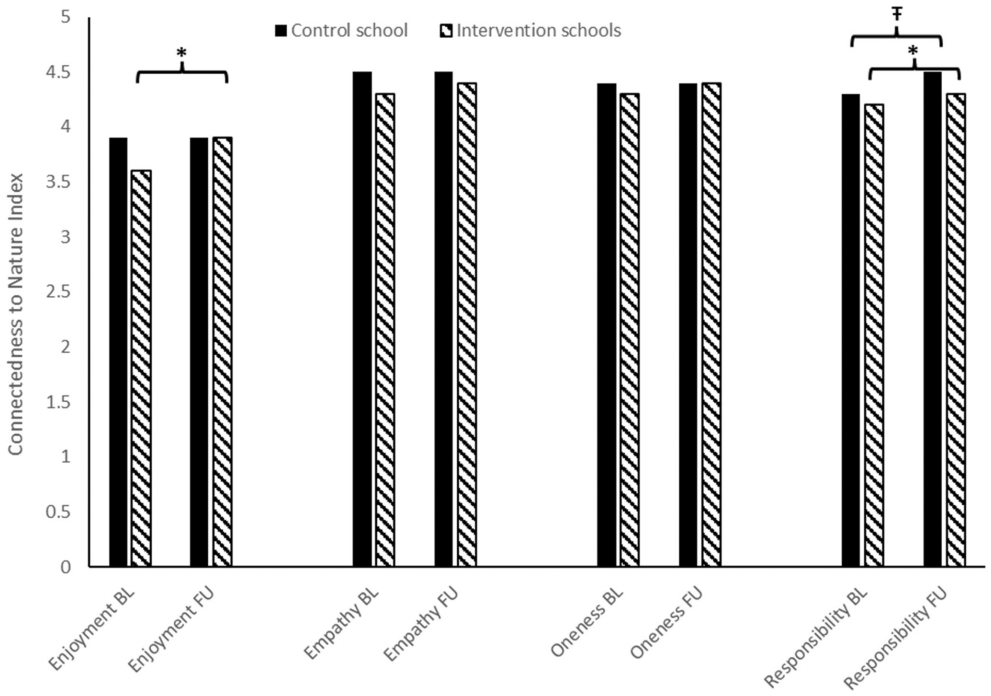

FIGURE 5 Changes in Connectedness to Nature between baseline (BL) and follow-up (FU). * denotes statistical significance between baseline and follow-up scores for the intervention schools (two-way ANOVA and post hoc *t*-tests; $p < 0.05$). Ŧ indicates significant change in the control school. Solid bars = control school, hatched bars = intervention schools.

TABLE 4 Pearson correlation coefficients between the themes within the Connectedness to Nature Index and the dimensions used to measure attitudes towards adders obtained by comparing the pooled baseline data from both intervention and control schools ($N = 168$. Bold text indicates significant correlations $p < 0.05$).

	Wonder	Dislike/fear	Learning interest	Interaction willingness	Conservation concern
Enjoyment	**0.413**	−0.076	**0.343**	**0.209**	**0.355**
Empathy	**0.329**	−0.063	**0.305**	**0.225**	**0.354**
Oneness	**0.293**	−0.085	**0.273**	**0.196**	**0.306**
Responsibility	**0.300**	−0.011	**0.314**	**0.218**	**0.373**

pooled baseline data from all schools were analysed (Table 4). Dislike/fear towards adders showed no significant correlation with any themes within the Connectedness to Nature Index.

4 | DISCUSSION

Our study has demonstrated that blended science-art engagement can significantly improve attitudes towards adders in young children—specifically by increasing Wonder, Learning Interest and Conservation Concern for this species' conservation needs—without the need for direct contact with this venomous species. The study participant questionnaires demonstrate how such a species-focussed science-art intervention can also improve general connectedness to nature in young children by significantly increasing their Enjoyment of Nature (as measured via the Connectedness to Nature Index), and our data indicate a significant correlation between general connectedness to nature and attitudes towards adders in young children. Finally, the study highlights the importance of collecting control and baseline measurements when assessing the effectiveness of such interventions and for potentially targeting where such interventions might most usefully be deployed.

4.1 | Changing attitudes towards adders

There were significant improvements in three of the five dimensions of attitudes towards adders across the intervention schools, while measures of these dimensions in the control school showed no significant change. This points towards the success of blended art–science interventions for simultaneously improving ecological awareness and species-specific attitudes, and the three-place rise of adders in the intervention schools' species rankings underlines their ability to improve the status of traditionally 'unpopular' species. The dormouse remained in the 'top spot' in rankings, but this was not a surprise, given that small mammals are often categorised as 'cute and safe' and more popular due to their aesthetics than snakes (Knight, 2008). However, given the popularity of the adder in the control school at baseline raises the question as to whether snakes are as culturally 'unpopular' as is widely portrayed, especially considering how quickly the adder's popularity

changed in intervention schools, even when many of these children remained fearful of them.

This was one of the most interesting findings, as despite attitudes towards adders improving overall, Dislike/fear towards adders (identifying with statements such as 'adders are creepy' or 'adders are frightening') did not show any significant change despite the interventions. This may indicate the difficulty of changing deep-rooted attitudes over a relatively short intervention timescale and may suggest some children potentially remained fearful or phobic of adders. Our questionnaire did not differentiate between phobic fears and fears based on misunderstanding and the intervention was not designed to target phobic participants. However, significant increases in ecological awareness and an increased desire to conserve these animals was still achieved, as well as them becoming more 'popular', despite the persistence of negative attitudes. It could be argued that maintaining the children's awareness of adders as venomous and therefore potentially dangerous if people initiate inappropriate interactions, alongside their improved awareness of adder ecology and conservation, may actually be an optimal outcome, because this means they may be more likely to interact with adders in a more respectful, cautious and safety-conscious manner if they do encounter them in the wild.

Our observations of the study participants suggested the inclusion of art activities was key to facilitating attitudinal improvements in the presence of these pre-existing dislikes or fears. Children (and teachers) who disliked snakes were reluctant to engage or even look at pictures of adders during the initial classroom science sessions, risking reducing the efficacy of the fact-based side of the intervention. However, they appeared to be calmer and more engaged when encouraged to make models, pictures and adder amulets. This provides support for the use of psychomotor elements ('hand-' based experiences) in such programmes to engage an affective, 'heart-' based response not reachable through cognitive intervention in such participants (Renowden et al., 2022) who may be operating in 'fight or flight' mode. We believe this 'calming effect' was made possible through the inclusion of art activities and that it could represent a key mechanism within the Theory of Change (Krasny, 2020) for any engagement project where participants need to overcome a fear response. However, we emphasise that art activities can only provide this calming effect if, as in this study, they are deliberately non-pressured, supporting personal expression and creativity with positive reinforcement from the workshop leader. Furthermore, the use of clay to create 'snake-shaped' models and amulets provided a safe and tactile way to explore the physical aspects of a snake. Such creative involvement is known to add potency to conservation messages by enabling a connection to the target species on an emotional level (Ballengée, 2015; Curtis et al., 2014; Harrower et al., 2018) and these activities improved familiarity and offered 'positive snake experiences', which can potentially help to lessen concerns about the animals. Based on our observations, we strongly suspect that, if snake handling had been introduced with these subjects, fear of the animal may have remained too strong to allow such positive engagement, making the artistic approach more appropriate for this particular community. Further comparative studies, however, would be needed to confirm this empirically.

The lack of any significant change in the Interaction Willingness dimension potentially suggests that, although it is possible to significantly improve attitudes towards an individual species without any direct contact, we speculate that first-hand exposure may play a bigger role than indirect or vicarious methods in terms of increasing children's confidence to explore and interact with the wider natural environment (Duerden & Witt, 2010). Future research could address whether this is the case by comparing the effectiveness of a blended art–science approach (as used here) with and without field trips.

4.2 | Changing connectedness to nature

Children showed significant increases in their Enjoyment of Nature and Responsibility for Nature after the interventions (two of the four themes within the Connectedness to Nature Index) and, although not statistically significant, there were also small increases for the remaining two themes.

A statistically significant increase in Responsibility for Nature was also observed in the control school, demonstrating the importance of collecting control data (Nolan et al., 2022). However, this may also be attributed to other teaching around this topic within the control school's curriculum at that time and it is also possible that both control and intervention school children were potentially exposed to another source of information, for example, on television or other national media, which influenced this measure in both schools despite their geographic separation. In this respect the effect of the intervention itself on this measure cannot be conclusively determined.

Nevertheless, the lack of any change in the level of Enjoyment of Nature in the control school suggests the species-focussed interventions were responsible for improving this aspect of connectedness to nature in the intervention schools.

4.3 | Links between connectedness to nature and attitudes towards adders

Baseline analyses indicated that children who were more connected to nature before the intervention already had higher Wonder scores, which suggests a link between general connectedness to nature and attitudes towards individual species, regardless of whether the species is 'unpopular'. This could suggest that improving connectedness to nature could improve attitudes towards all wild animals, including 'unpopular' ones, which is supported by research by Zsido et al. (2022). However, we found Dislike/fear towards adders was not associated with connectedness to nature, which may reflect snake-specific phobia or fear-based traits that are unrelated to whether the subjects were connected to nature

or not. This implies caution should be exercised around switching to a generic connectedness to nature approach and some species-focussed element may still need to be included to support conservation of species that have strong traditionally negative associations for communities.

4.4 | Control schools, baseline data and targeting intervention effort

The control school had significantly higher baseline scores for attitudes towards adders and connectedness to nature which were close to the upper ceiling for all the scales. Although there was some small scope for the control school scores to increase (plus plenty of opportunity for them to decrease), this may represent a limitation on their effectiveness as a control. It later transpired that this school had a large focus on outdoor learning within its curriculum, to a much greater extent than the intervention schools, which could explain both its high baseline scores and the reason it responded to our request to participate in the study. This highlights the importance of collecting baseline data from as many schools as possible before selecting control and intervention schools that are well-matched. In practice, however, this can be extremely difficult to achieve in studies such as ours, which are ultimately only able to work with those schools who choose to respond and are able to gain consent from the participants.

4.5 | Wider implications for conservation and other species

With growing pressures on land and financial resources, efforts to conserve habitats and species are likely to require increasingly creative and divergent methodologies, especially when working with 'unpopular' species, such as venomous snakes, where negative public attitudes can be a significant barrier to conservation (Barthel et al., 2018; Monge-Nájera, 2017; Schönfelder & Bogner, 2017). Positive sentiment and knowledge help conserve species (Loyau & Schmeller, 2017), and with an urgent global call to conserve our rapidly disappearing viperine species (Maritz et al., 2016), increased public knowledge, understanding and appreciation of these species in particular is needed now more than ever. This research has demonstrated the effectiveness of a relatively low-cost conservation engagement programme on improving attitudes towards a species considered 'difficult' to conserve in the United Kingdom due to poor public image, despite participants not handling or having direct experience of the snakes to achieve this. The blended art–science approach can be easily transferred to other species and the creative methods adapted to incorporate the artistic traditions of local communities. As such, it offers a powerful tool to improve conservation prospects, not just for adders, but also for other 'unpopular' species around the globe.

Previous research has confirmed that increased nature connectedness is linked to pro-environmental behaviours in adulthood (Davis et al., 2009; Richardson et al., 2020; Zelinski et al., 2015) and to lower incidences of snake phobias (Zsido et al., 2022). This suggests a possible long-term benefit of childhood interventions (such as those tested here), and that positive childhood experiences of snakes in particular, may be important, due to snake phobias often emerging at this development stage (DeLoache & LoBue, 2009; LoBue et al., 2010). However, parental/primary-carer and family values towards nature also influence children's interest in pro-environmental behaviours (Cheng & Monroe, 2012; Soga et al., 2020), so unless a consistently positive message about the need for conservation is also experienced at home, the impact of such school-based interventions may be undermined or diluted over time. Conversely, child-focussed environmental education programmes have been demonstrated to influence adult knowledge and pro-environmental behaviours in the home environment (Damerell et al., 2013). Consequently, we recommend those employing child-focussed interventions for conservation purposes should also consider measuring familial attitudes, as this could help gauge the potential long-term effectiveness of their interventions and whether they may need to be supported by complimentary adult-focussed interventions in the wider community (the wider *Adders are Amazing*! project included both).

The adder's increase in the species rankings in our intervention schools demonstrates how easily conservation foci and perceptions can be changed. This is positive news for those trying to conserve 'unpopular' species, but conservation organisations should also bear in mind campaigns focussing on a single high-profile species might shift attention away from other species that may also need conservation efforts, disadvantaging them as a result (Veríssimo et al., 2017). The single-species campaign route can be a powerful motivator, but unless it is also a habitat maintaining or 'keystone species', the needs of other species could be compromised. Conservation focus ought to be based on ecological need and not purely aimed at charismatic species that are more palatable to the wider public for fundraising (Colléony et al., 2017). Our work demonstrates conservation bodies should not shy away from ecologically important yet 'unpopular' species, such as snakes, and that embracing the opportunity to champion them can genuinely change attitudes, with the potential to improve their conservation prospects. Our research also raises the question as to whether snakes are truly universally 'unpopular', or at least within UK children of this age range, so conservation should not shy away from including them in conservation drives. It has been argued that 'charismatic species' can be used to stand in for less popular species and their habitats, and conservation outcomes may be the same or better (McGowan et al., 2020). We propose that, by championing species traditionally considered 'unpopular' in their own right, we can improve societal acceptance and understanding of these species, in turn highlighting the need for unbiased and inclusive conservation efforts that encompass a wider range of species.

5 | CONCLUSION

We demonstrated that significant improvements in the perception of the adder (the UK's only venomous snake) among 8- to 11-year-old children was achievable through a species-focussed art–science programme. These interventions also improved measures of the children's general connectedness to nature, as measured via a questionnaire, and provide further support for approaches which blend such techniques in conservation and educational programmes (Renowden et al., 2022; Sanders, 2022). Given the links between nature connectedness as a child and pro-environmental behaviours later in life (Mackay & Schmitt, 2019; Natural England, 2020; Nisbet et al., 2009), local community-scale projects which focus on local keystone species and their habitats are an important conservation tool. Moreover, they are potentially vital, for 'unpopular' species such as vipers, around which phobias typically form during childhood and for working where human–wildlife conflicts occur (Nyhus, 2016; Sponarski et al., 2016; Torres et al., 2018; Treves et al., 2006). The relatively inexpensive blended art–science approach we employed, can be readily adapted to other species and to the local artistic practices of other communities, making it highly adaptable and transferable. We would urge conservation organisations to explore such methods to help improve children's connectedness to nature, to improve the conservation prospects of other traditionally unpopular species and to increase understanding and reduce persecution of species such as vipers for whom hands-on approaches are not appropriate.

AUTHOR CONTRIBUTIONS

Sam J. Kelly conceptualised the project, delivered the scientific workshops, co-designed the questionnaires and helped administer them within classrooms at baseline, entered data and wrote the original draft and follow-up drafts of the paper. Angela Julian supervised the project, helped review and edit the different drafts. John S. Kelly managed the project's ethical approval, designed the experimental design and conducted data analyses, as well as writing the methods and results sections. John Baker and Chris Monk co-supervised the project and provided review and editing for various drafts. Emma Gardner aided with interpretation, synthesis and concluding of the results, along with reviewing and editing.

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CONFLICT OF INTEREST STATEMENT

No conflict of interest has been identified.

DATA AVAILABILITY STATEMENT

The authors have archived the data collected during this research in the online, publicly available database Dryad Digital Repository https://doi.org/10.5061/dryad.8931zcrx1. Data can also be accessed upon request via the corresponding author.

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SUPPORTING INFORMATION

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

Appendix S1. Questionnaire used in the study.

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