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From Aversion to Appreciation: The Effects of Outdoor Experiential Learning on Children's Negative Perceptions of Invertebrates

Bethan C. Stagg [1,2,*] and Harriet White [1]

[1] School of Education, University of Exeter, Exeter EX2 4TH, UK; h.white@exeter.ac.uk
[2] Society and Environment Research Group, Alice Holt Lodge, Forest Research, Farnham GU10 4LH, UK
* Correspondence: bethan.stagg@forestresearch.gov.uk

Abstract

Invertebrates are essential for ecosystem functioning but are declining worldwide at an unprecedented rate. A particularly maligned group are the invertebrates that live in or near soils, which play a crucial role in nutrient cycling and soil formation. Educational strategies that reduce aversion to invertebrates could improve public support for invertebrates and raise their profile in policy and conservation. We investigate the impacts of experiential learning with ground-dwelling invertebrates in the school grounds on children's (7–9 years) perceptions using a mixed methods approach, with before-after testing using questionnaires and interviews. We also explore the characteristics of children's previous experiences with invertebrates and nature interactions. Following piloting, 155 children from four schools participated, with 113 children completing questionnaires and 36 taking part in interviews. A range of invertebrate types were rated as significantly less frightening and disgusting after the intervention, which interviews suggested was because children felt more confident observing and looking for animals, or became more interested in the animals' structures or behaviours. The most popular ground-dwelling invertebrates were woodlice and ants, whilst the least popular were slugs and spiders. Children who regularly had contact with nature outside of school were less likely to express disgust or fear about invertebrates. Positive invertebrate experiences tended to take place in nature-rich areas, whilst negative experiences took place in the built environment and often involved attack or injury. The study highlights the value of experiential learning and nature-based encounters with ground-dwelling invertebrates for addressing negative perceptions. We discuss the challenges and opportunities for implementing this form of environmental education, using a post-humanist perspective.

Keywords: nature experience; experiential learning; human-nature interaction; insect education; invertebrate conservation; fear and disgust; hands-on; biophobia

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1. Introduction

Invertebrates are essential for ecosystem functioning but are declining worldwide at an unprecedented rate. They represent about 80% of all described species and provide critical ecosystem services ranging from primary productivity to pollination, as well as pest control [1,2]. The drivers of the rapid decline in invertebrates include urbanisation, habitat fragmentation and loss, and environmental pollution [3]. Public awareness about this ecological catastrophe is low, and it has also received limited attention in research, policy

and education [4]. Invertebrates are strongly underrepresented on the World Conservation Union's (IUCN) Red List of Threatened Species and receive less conservation funding than vertebrate taxa [5]. A particularly maligned group are the invertebrates that live in or near soils. These ground-dwelling animals play a crucial role in nutrient cycling and soil formation but are significantly neglected in many global biodiversity assessments and conservation policies [6,7].

Educational strategies that address these negative attitudes could improve public support for invertebrates and raise their profile in policy and conservation [5]. Sustainability education in schools is a valuable opportunity for reaching children from a range of sociocultural backgrounds and laying the foundation for pro-environmental behaviour development [8]. Whilst informal, out-of-school nature experiences are often considered the gateway for discovering local plants and animals, the steady decline in adults' own nature interactions means that children are less likely to be supported in accessing these [9]. Thus, schools and other educational settings are becoming increasingly important for providing children and young people with biodiversity experience.

1.1. Biophobia as a Constraint to Pro-Nature Behavioural Development

The aversion to certain wildlife is known as biophobia and impedes the development of pro-nature behaviours [10]. Biophobia is driven by negative interactions with wildlife or exposure to negative information, which are particularly impactful on people with limited knowledge or experience of nature. These exposures evoke fear and disgust reactions, followed by the desire to avoid nature or the organisms that the person fears. These behaviours lead to disconnection from nature and, as a result, weakening their motivation to protect or conserve nature. This negative feedback loop is described as "the vicious cycle of biophobia" [10].

The increase in urbanisation is a key factor in the loss of people–nature interactions and disconnection from nature. People that have limited access to natural areas, particularly biodiverse areas, interact less frequently with nature and lose their emotional affinity with nature as a result, along with their motivation to directly experience nature [11]. This process is described as "extinction of experience" and is particularly severe in children and young adults due to the loss of nature interactions as part of formative experiences [11].

Biophobia is particularly common for invertebrates and is characterised by these processes [12]. Adults' fear and disgust levels were positively associated with the level of urbanisation of both the adult and childhood residences, the frequency of nature experiences and invertebrate knowledge [13,14]. People in urban areas were also more likely to encounter invertebrates indoors relative to outdoor environments, demonstrating the lack of opportunity for positive encounters. Children's fear and disgust levels were affected by similar factors, with the biophobia of family members also contributing to these factors [13]. The worrying implications for invertebrate conservation are demonstrated by studies that found a negative association between levels of invertebrate biophobia and pro-environmental attitudes (perceptions of invertebrates as pests and support for pesticide-free farming) [15].

Ground-dwelling invertebrates tend to evoke the strongest fear and disgust reactions. Arachnid species were ranked as most frightening animals from a range of animal groups, despite the fact that only harmless arachnid species were used [16]. Adults and children exhibited negative attitudes towards ground-dwelling invertebrates, preferring colourful flying invertebrates such as butterflies [17,18]. Animals inhabiting dark places are shown to evoke fear, particularly if they have many legs, exhibit rapid movements or have apparent biting or stinging structures, the case for many crawling invertebrates [19]. The disgust reaction to ground-dwelling invertebrates is also believed to arise from the fact many people

associate soil and ground surfaces with dirt and infection [14,20]. Many invertebrates are brown (for camouflage) or covered in mucus (to prevent desiccation), factors that are also associated with disease [21].

Invertebrate biophobia is also common in educational settings. Primary school students disliked invertebrates and had a low motivation to protect them compared to mammals and birds [22]. Primary and secondary school teachers' knowledge and awareness about invertebrates was considerably lower than for flowers, mammals and birds [23]. Trainee teachers exhibited more negative attitudes than positive attitudes towards invertebrates, reacting to them with disgust and fear c [24,25]. These negative emotions reduced educators' interest and self-efficacy towards teaching about invertebrates. Educational practitioners' antipathy and aversion to invertebrates can be expected to impede their ability to effectively deliver biodiversity education and inspire pupils, highlighting the need for novel strategies for engagement.

1.2. The Role of Direct Experience for Addressing Biophobia from a Post-Humanist Perspective

Educational activities that provide direct positive contact with nature are proposed as a solution to counteract the negative experiences and experience deficits that contribute to biophobia [10]. Direct experiences, which included close observation, drawing, touching and handling animals, reduced children's fear and disgust towards snails [26], woodlice [27], spiders and scorpions [28,29], earthworms and beetles [30]. However, since the experiences were classroom-based and often with farmed insects, these studies provided limited insights about the impact of nature-based direct encounters with ground-dwelling invertebrates on negative perceptions. An exception is Drissner et al.'s study [31], which found that more children that participated in fieldwork collecting and observing small invertebrates (mainly ground-dwelling ones) exhibited positive emotions towards the animals than the control group, which received classroom-based learning. Nature-based experience with wild pollinators was also effective for changing perceptions [32,33].

Post-humanist perspectives provide a valuable framework for explaining how direct nature experience might influence children's invertebrate perceptions. In a post-humanist perspective, we perceive child–animal relationships as intra-actions or entanglements, where the children and the "more than human" bodies exist in the same space, with forces and flows operating between them [34]. Agency does not sit solely with the child but is entangled in the reactions and exchanges that occur between the various actors [35]. Negative direct experiences with nature often arise from people's uninformed or inappropriate actions, for example, reacting to an animal in a way that provokes an attack or not having the necessary equipment [10,36]. By showing the child how to find and respectfully observe an invertebrate, they are more likely to witness its intriguing natural behaviours, such as foraging or nesting, rather than aggression or concealment. Situating these experiences in the animal's habitat rather than the classroom means that the animal has access to the resources and exchanges that produce these natural behaviours. We might also expect the other actors and entanglements in the direct nature experience to influence children's invertebrate perceptions, for example, the behaviours of peers, teachers and material phenomena like the weather or learning aids [37]. By shifting the focus from the human to the "more-than-human" encounters and "enmeshed relations", we aim to gain deeper insights about the qualities of the experience and pedagogic possibilities. This change in perspective is encapsulated by the "common world pedagogies" proposed by Taylor [38].

1.3. Outdoor Experiential Learning

Experiential learning theories also provide a valuable theoretical lens for understanding how learners benefit from nature-based direct experiences. Kolb's [39] Experiential Learning Theory highlighted the central role of concrete experience in learning, and how these experiences contribute to existing mental models. Concrete experiences are those where the learner actively engages in an activity rather than passively observing it, and which arouse emotions rather than being purely intellectual. Fieldwork and other nature-based learning provide concrete experiences of living organisms and systems [40]. These "hands-on" experiences are often rich in tactile and multisensory qualities and emotional arousal, both positive and negative. They often challenge existing beliefs and provide opportunities for reflection and assimilation of learning. Teachers considered outdoor experiential learning to be the most effective approach for learning about biodiversity [41].

Outdoor experiential learning provides opportunities for spontaneous interactions with wild organisms [42]. Experiencing wildlife in its natural habitat, as opposed to captivity or classroom environments, was an important precursor for developing young people's environmental stewardship beliefs [42]. Experiential outdoor education improved young adults' motivation and reduced levels of fear towards insects and other wild animals [43]. Experiential learning in the school grounds can be particularly valuable as it provides interactions with local organisms that children then encounter again in their neighbourhoods, thus promoting nature connectedness [44,45].

Experiential outdoor learning plays an important role in sustainability education more broadly [46]. Fieldwork was more effective for increasing adolescents' value-based environmental awareness than classroom learning, particularly for less nature-engaged learners [47]. Outdoor learning about biodiversity positively contributed to primary school pupils' depth of understanding and awareness about environmental citizenship and sustainability [48]. An outdoor ecological learning camp increased primary school students' climate-related awareness and intent to engage in pro-environmental behaviours [49].

1.4. Research Context and Objectives

For these reasons, this study focuses on outdoor experiential learning with invertebrates in the school grounds. The participants were children aged 7–9 years, a valuable target group because it is the age at which connection to nature is shown to start declining and thus could represent a critical intervention point [45,50]. The intervention was designed to encourage in-depth observation of the animals through drawing and studying their movement and behaviour. This study makes a number of contributions. First, it advances current understanding of the pedagogic potential of direct experiences in nature for addressing negative perceptions of a maligned invertebrate group. We also investigate children's previous experiences with invertebrates and interactions in nature, to deepen our understanding of the factors contributing to aversions. Second, the study makes methodological contributions, by adapting an existing research instrument (a semantic scale) to evaluate the effect of an intervention on children's perceptions or emotions towards different living organisms and developing a coding framework for assessing emotional responses to living organisms.

The research questions are as follows:

RQ1. What are children's relative levels of fear and disgust for different groups of ground invertebrates and broader perceptions?
RQ2. What impact does a brief episode of outdoor experiential learning in the school grounds have on children's fear and disgust levels and broader perceptions of invertebrates?
RQ3. What impact did nature experiences and invertebrate encounters outside of school appear to have on children's perceptions about invertebrates?

2. Materials and Methods

We used a convergent mixed methods approach, and pre-post-evaluation of the intervention based on questionnaires and interviews to investigate the variables of interest. Ethics approval was provided by the University's Social Sciences and International Studies Ethics Committee in March 2023 (ID number 1312762). Schools and children were recruited using an opportunity sampling approach. Parents/adult carers were required to provide written consent prior to children's participation. Children were informed of the research prior to participation and were free to withdraw at any time.

2.1. Pilot Study

The intervention was piloted with 30 children and parents on 12 November 2022 in the university grounds. We discovered that deadwood habitats were more productive for sampling than soil and litter habitats. We realised that sessions were too complex for school delivery and omitted certain fieldwork methods and tools, specifically pitfall and bark traps and written instructions. The questionnaire was piloted with 22 children via parents recruited on the social media site X from 9 to 12 April 2023. Three statements were re-worded to provide greater clarity, based on feedback.

2.2. Participants and Session Format

We invited schools to participate via an email bulletin circulated to head teachers and science coordinators in primary schools in Devon, UK. In total, 155 children aged 7–9 years (Years 3 and 4) at four primary schools took part in the research, from 19 April to 13 June 2023. Three schools were in a town 10 miles from a city and one school was in the city centre. Sessions were delivered by the authors and a freelance practitioner, supported by class teachers and assistants. For the town-based schools, sessions were 2–3 h long and held in the school grounds or (for one) an adjacent public park. For the city school, there were two 90 min sessions on consecutive weeks, in the classroom and school grounds.

2.3. Intervention

In the first part of the session, children worked in groups, guided by instructors. Children that were reluctant to handle invertebrates or use the field equipment were placed in groups with children that felt comfortable with these activities. Instructors pointed out microhabitats (soil, deadwood, and leaf litter) and demonstrated how to collect animals, using hands, spoons, sorting trays, collecting pots, spoons and pooters, a suction device for collecting small invertebrates (Figure 1). Children were also shown how to get close to microhabitats and animals for an immersive experience and to avoid harming animals and habitats through careful handling and returning organic materials to their original place. Children were encouraged to use a picture-based field guide to identify what they found. Children placed an animal of their choice in a Petri dish, with fragments of leaf or wood to prevent distress to animals. Petri dishes were placed in the shade, and children were told not to shake them, to minimise the risk of distress and promote active movement.

The second part of the session focused on in-depth observation of the enclosed animals. Children completed an activity sheet with questions encouraging close observation, for example, "describe how does your animal moves", with a choice of words for children to circle. Children observed their animal using a magnifier and drew it as accurately as possible, based on observations alone. There was an optional extension activity, to partner up with a neighbour and compare their two animals, reflecting on their similarities and differences. For the urban school, children rotated in groups, due to the limited size of the outdoor area. In the classroom, groups observed and drew animals in Petri dishes using magnifiers and low-power microscopes.



Figure 1. Children participating in fieldwork, drawing and observation activities.

2.4. Questionnaire Design

The questionnaire contained a semantic differential scale, with two polar opposites, "disgusted" to "pleased" and "scared" to "relaxed", for seven photographs of ground-dwelling invertebrates (Supplementary File S1). This scale was informed by Leandre et al. [51], Rosenberg [52] and a similar scale developed by Drissner et al. [53]. We used specific species examples, species photographs and a validated suite of facial emojis as visual anchors, which are shown to elicit accurate emotional responses from children [54]. The questionnaire also included a Likert scale about broader perceptions of invertebrates, but the results are not reported due to poor correlation between variables and factors. The order of presentation of photographs was randomised to produce four separate versions of the questionnaire, to control for effects relating to order of presentation, such as response fatigue. There were also minimal demographic variables to minimise response fatigue.

Questionnaires and pencils were distributed to all children in the classroom before and after the session(s), which they were requested to complete without conferring. Children could choose whether to complete the questionnaire and it could only be completed by children who had a completed consent form from the parent or guardian. One researcher read the questions out loud to support children with literacy issues, whilst the other circulated around the room to answer children's questions as these arose. This approach also helped to ensure that children completed the questionnaires quietly without conferring. Children with additional needs were provided with 1:1 support by the teacher and teaching assistants.

2.5. Interview Design

The lead author conducted semi-structured interviews (15–30 min in length) to investigate children's perceptions and experiences in more depth from 13 to 18 July 2023. For interview questions, see Supplementary File S2. All participating schools were invited one week after the sessions, with three schools accepting the invitation and one declining. For the two schools where more than one class participated in sessions, teachers selected just one class for interviews, chosen as objectively as possible. Only children that had completed consent forms and were available during the lesson were interviewed. Children were interviewed in groups of three in an annex or corridor adjacent to the classroom. Interviews were recorded and children encouraged to take turns speaking, without interrupting or talking over each other. The interviewer gently encouraged less talkative participants to contribute and facilitated the discussion whenever it strayed off topic.

2.6. Data Processing and Analysis

2.6.1. Questionnaire

A Friedman test was used to compare fear and disgust ratings for different species before the intervention, and eta-squared for effect sizes. A Wilcoxon Signed Rank test was used to compare fear and disgust ratings before and after the intervention and Matched-pairs Rank Biserial Correlation Coefficient for calculating effect sizes [55]. Non-parametric tests were used for questionnaire analysis because data did not fit the assumptions for t-tests. We used IBM SPSS Amos 28 for analyses unless stated otherwise.

2.6.2. Interviews

The authors immersed themselves in four interview transcripts (a different set for each author), analysing preliminary themes independently, based on the research questions. Authors met to compare results for the transcripts and to develop a coding scheme for the identified themes (Supplementary File S3). The two authors coded the same interview separately without conferring and met again to compare codes, to refine the process and resolve conflicts in coding. Inter-coder reliability was not used as it was not felt to be meaningful or justified with the small sample size [56]. The first author subsequently coded all interview transcripts using NVivo 14, conferring with the second author where there were ambiguous coding decisions.

3. Results

Of the children that participated in the activity, 113 completed the pre-activity questionnaire and 92 children completed the post-activity questionnaire. Forty-two children did not complete any questionnaires either because they did not have consent or chose not to complete the questionnaire on the day. Twenty-one children did not complete the post-activity questionnaire because it was administered at the end of the school day and some children were required to complete outstanding tasks or prepare bags instead. Thirty-six children from three schools participated in interviews.

3.1. Children's Fear and Disgust Levels for Different Groups of Invertebrates (RQ1)

3.1.1. Questionnaire Data

There was a significant difference between disgust ratings for the seven invertebrate groups prior to the intervention ($\chi^2 = 64.129$, $n = 84$, degrees of freedom = 6, and $p < 0.001$), with a moderate effect size (eta-squared = 0.300). The ratings were closest to "disgust" for the beetle larva and the slug, and closest to "pleased" lowest for the woodlouse (Figure 2). There was also a significant difference in fear ratings ($\chi^2 = 118.603$, $n = 87$, degrees of freedom = 6, and $p < 0.001$), with a moderate effect size (eta-squared = 0.622). The ratings were closest to "fear" highest for the beetle larva and millipede and closest to "relaxed" for the woodlouse and slug (Figure 3).

3.1.2. Interview Data

When asked what they thought about invertebrates, some children said that they liked all of them (Table 1). Many children specified negative and positive perceptions about different types, and some explained reasons for how they felt, once prompted.

Slugs were perceived as the most disgusting invertebrate group, with many children saying that they did not like their slimy texture. A few children did not like snails, earthworms or invertebrate larva (two cases) for the same reason. By contrast, many children liked snails, either because the children liked handling them or thought the patterns on the shells were attractive. Snails were the invertebrate group that children most frequently

expressed nurturing behaviour or empathy towards, perhaps because they were commonly encountered and easy to pick up.

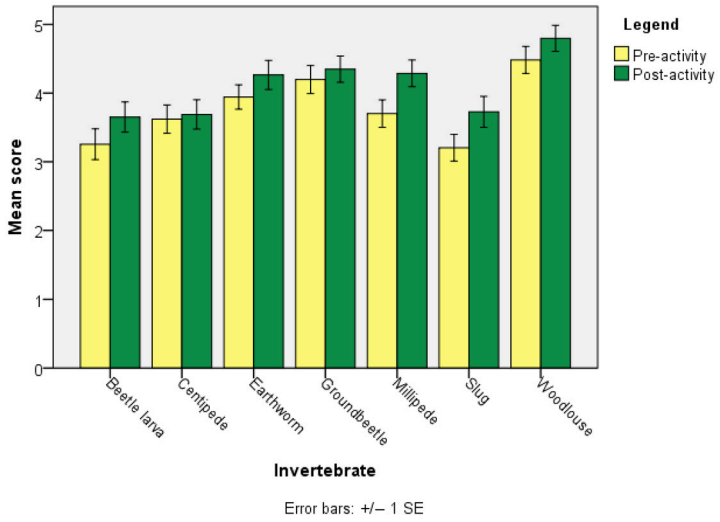


Figure 2. Comparison of disgust ratings before and after the intervention, based on a semantic differential scale, with two polar opposites, where 1 is "disgusted" and 6 is "pleased" (n = 92).

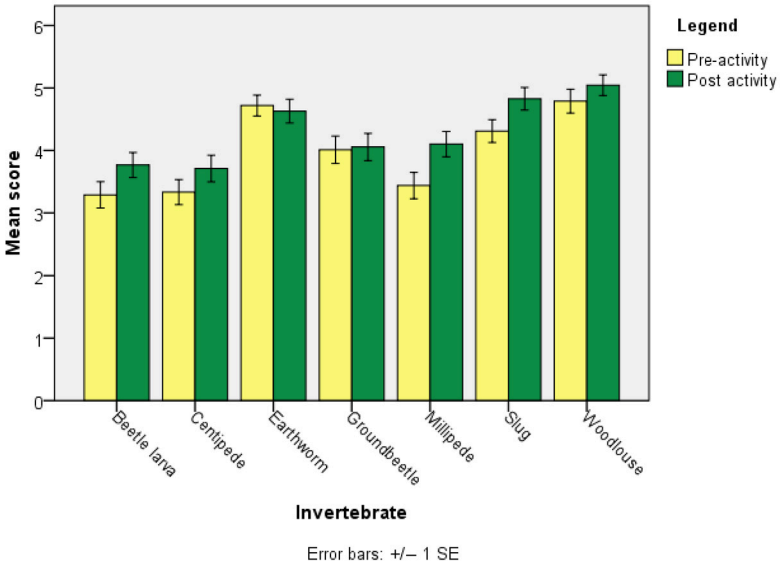


Figure 3. Comparison of fear ratings before and after the intervention, based on a semantic differential scale, with two polar opposites, where 1 is "scared" and 6 is "relaxed" (n = 92).

Spiders were perceived as the most frightening, which some children attributed to venom or sudden movements, but others were unable to explain why they felt this way. A similar number of children shared positive perceptions about spiders, generally perceiving them to be interesting or impressive due to their size or behaviours. Children also expressed fear about ants, bees and wasps (two cases for wasps), which in all cases was either because they had been bitten or stung by the animal or witnessed this happening to someone else.

Many children were positive about woodlice, either liked their appearance or found their behaviours interesting, and there were no children with negative opinions of woodlice. Many children also favoured ladybirds, either because of their colourful appearance or because they enjoyed watching them flying around. A few children were positive about bees or dragonflies for similar reasons. Children also expressed positive opinions about grasshoppers and crickets, generally because they enjoyed catching them. Some children described ants as interesting or impressive, due to their strength, teamwork or other

behaviours. Opinions about centipedes and millipedes were mixed, with some children perceiving them as frightening or irritating (two cases for millipede), and others expressing awe about their large number of legs or movements.

Table 1. Comparison of perceptions about different invertebrate groups. Negative perceptions are presented in italics. Only individual perceptions where $n > 3$ are included; however, where $n > 3$ for a mixture of perceptions with the same valence (positive or negative), these are totalled and also included. For definitions of perceptions see Supplementary File S3.

Invertebrate Group	Perception	Number of Interviewees	Example Quotations
All invertebrates	Like	5	I just love mini beasts.
Ant	Interest/awe	6	I liked the ants. Because it's so cool that they can grow wings.
	Fear	*3*	*I've been bitten by several guard fire ants. . . It really hurts.*
Bee	Mixed positive	4	I see bees and I just like to watch them get the pollen from the flowers.
	Fear	*3*	*Once I got stung by a bee. . .. it stung me here.*
Beetle	Mixed positive	3	The long black beetle I found looks cool and I liked it.
Centipede	Interest/awe	5	I found a red one. . .. And it had three tail things.
	Mixed negative	3	They're really crawly. They're really annoying.
Cricket	Mixed positive	3	We just hold them and look at them.
Dragonfly	Mixed positive	3	They've got literally lots of great colours.
Earthworm	Interest/awe	4	I bang at my feet on the ground. . . and then that makes the worms think it's rainy and they can come up then.
	Mixed negative	*4*	*Worms, maybe [dislike], because. . . I don't really like slimy things.*
Grasshopper	Mixed positive	5	I catch grasshoppers a lot.
Ladybird	Interest/awe	3	I like to watch ladybirds wherever they go.
	Other positive	7	I really love ladybirds, I think they might be one of my favourite minibeasts.
Slug	Mixed positive	4	Slugs are really beautiful.
	Disgust	*10*	*I find slugs disgusting.*
	Other negative	*4*	*I hate slugs.*
Snail	Empathy	5	I help snails. If they're on the pavement, I help them.
	Other positive	7	They're actually quite a nice feeling. . . on my hand.
	Disgust	*3*	*I find snails gross.*
Spider	Interest/awe	3	I like catching spiders. . . Once in our shed we found a massive one, that big.
	Other positive	4	I love them [spiders], but after I found the red and green one, I felt really, really happy.
	Fear	*8*	*Spiders are scary for me.*
	Dislike	*5*	*I don't like spiders.*
Woodlouse	Interest/awe	9	I love woodlice because they curl up into a ball.
	Other positive	5	I've always liked woodlouse.

3.2. The Impact of the Intervention on Fear and Disgust Ratings and Broader Perceptions (RQ2)

3.2.1. Questionnaire Data

There was a shift in rating from "disgusted" in the direction of "pleased" following the activity, which was significant at the 5% level for all invertebrates apart from the centipede and ground beetle, with variable effect sizes (Figure 2; Table 2). Effect sizes under 0.2 are considered to represent a small effect, between 0.2 and 0.5 are considered medium, and above 0.5 are considered large [57]. There was a significant shift in rating from "scared" in the direction of "relaxed" for all invertebrates apart from the earthworm, centipede and ground beetle, with variable effect sizes (Figure 3; Table 3).

Table 2. Comparison of disgust ratings for invertebrate groups before and after the study intervention, based on a semantic differential scale, with two polar opposites, where 1 is "disgusted" and 6 is "pleased". An effect size close to zero denotes a weak relationship; an effect size close to +1 or −1 denotes a strong relationship.

Animal	Number of Respondents	z-Statistic	*p*-Value (Two Sided)	Effect Size
Beetle larva	86	−2.317	0.021	−0.2
Centipede	87	−0.305	0.760	−0.05
Earthworm	71	−3.610	<0.001	−0.65
Ground beetle	86	−0.783	0.434	−0.13
Millipede	87	−3.648	<0.001	−0.57
Slug	88	−2.674	0.007	−0.42
Woodlouse	89	−2.168	0.030	−0.40

Table 3. Comparison of fear ratings for invertebrate taxa before and after the study intervention, based on a semantic differential scale, with two polar opposites, where 1 is "scared" and 6 is "relaxed". An effect size close to zero denotes a weak relationship; an effect size close to +1 or −1 denotes a strong relationship.

Animal	Number of Respondents	z-Statistic	*p*-Value (Two Sided)	Effect Size
Beetle larva	75	−3.028	0.002	−0.534
Centipede	90	−1.887	0.059	−0.29
Earthworm	78	−1.287	0.198	0.25
Ground beetle	71	−1.138	0.255	−0.24
Millipede	89	−3.763	0.001	−0.60
Slug	87	−3.394	0.001	−0.54
Woodlouse	84	−2.748	0.006	−0.57

3.2.2. Interview Data

Many children felt that participation in the activity had changed the way they felt about invertebrates (Table 4). Approximately half explained that they felt more confident as a result of spending time in close proximity to invertebrates, observing them or handling them, and the others. The others felt more interested in invertebrates due to learning more about them or seeing and encountering new and different types. One child said that she had started drawing invertebrates since the event and another that it had made her feel like she could now look around and find them. Four children felt more positive about a specific invertebrate group (spiders or centipedes) because of participation. By contrast, a similar number said that the intervention had not changed how they felt. Two children explained their feelings had not changed because they already liked invertebrates. Others did not provide reasons for the lack of change in perceptions.

Table 4. Interviewees' perceptions about the intervention activity. Only perceptions where $n > 3$ are included. For definitions of perceptions see Supplementary File S3.

Perception	Number of Interviewees	Example Quotations
Feel more confident about invertebrates due to the activity	5	I sort of felt more confident about them because before, I felt a little bit like, well, I didn't really want to go near them. . . But then when we did the minibeast hunting, I felt like, okay, they're not scary or anything, they're just fun. I think just maybe looking at them and maybe touching them a little bit. . .
Feel more interested in invertebrates due to the activity	7	I've always quite liked minibeasts, but after that lesson I thought I liked them more because I had more interest in them, of knowing what they were because I had heard more.
Feel more positive about a specific invertebrate group due to the activity	4	I didn't really know very much about centipedes, so it [the activity] helped me with the centipedes, but not with anything else.
The activity did not change the way they felt about invertebrates	8	I felt the same. I always liked them.
Described one or more positive experiences related to the activity	10	It was so much fun when we were collecting bugs and putting them in little pots.
		We got lots of different mini beasts. And it was exciting to get them because you said what type of stuff they are.
		We got a lot of woodlice from that giant log. . . they were hiding in tiny little cracks.
		I found it was really fun. And then I also found a lot more things I didn't think I'd find on that.
Described the experience of using the pooter (suction devices for collecting small invertebrates)	11	We had these tubes. . . one of them, we had to suck it up at and then the other we had to aim for the minibeast we found. . . I got a spider and a little fly what I was trying to catch.
		There were these weird machines. I didn't want to do it.
Expressed frustration about the elusive nature of the animals, their size or tendency to escape	4	I had a baby snail, but I don't know where it went. The container was closed but then when I looked everywhere for it, it just had disappeared.
Mentioned an aspect of the group working	4	I was in [Child]'s group, and she found a huge minibeast.
		I feel like, if we choose our groups, then we work better together.
Mentioned the magnifying pots used during the activity	4	Putting woodlice inside this tiny pot.
		We could decorate the inside of the pots, so they have somewhere to hide.

Many children recalled positive experiences from the activity, with others listing the invertebrate groups they had found. Only one child had a negative experience, recounting how the area where the activity took place was where they were normally allowed to play, making him feel sad because they were not allowed to play on that occasion. Another child mentioned that she was not happy with the group she had been placed in and felt that the children should be able to choose their own groups. Many children mentioned the sampling equipment, particularly the pooters (suction devices for collecting small invertebrates), with some enjoying the experience, whilst others found them difficult to use, or chose not to use them because they aroused disgust. A few children expressed frustration with the elusive nature of the animals, their size or tendency to escape, whilst a few children shared their excitement about finding invertebrates that they did not normally see.

3.3. The Impact of Experiences Outside School on Invertebrate Perceptions (RQ3)

Most children stated that they regularly spend time outdoors, with only three children visiting nature sometimes or rarely (Table 5). Approximately half the children went on to say they liked spending time in nature, or described nature-based activities, whilst the rest mentioned sports.

Table 5. Interviewees' perceptions about experiences with nature and invertebrates outside of school. Only perceptions where $n > 3$ are included. For definitions of perceptions see Supplementary File S3.

Experience or Perception	Number of Interviewees	Example Quotations
Regularly spends time outdoors	33	I like playing football with my dad.
Regularly spends time specifically in nature or doing nature-based activities	14	I collect feathers and I've got 10 blackbird feathers. Once I went to [names local park] and I got two cool feathers. One was massive and it looked like a pheasant feather. . .
		I like picking up leaves and stuff. In the autumn, conkers and sometimes acorns.
Describes finding invertebrates inside the house	15	There was a giant spider in the lounge, and it was dangling and my dad was on the sofa and didn't realise it was on top of him.
		In my old house, we lived in a bungalow and there was loads of slugs.
		We used to keep finding shield bugs on the window.
Describes looking for or observing invertebrates in the garden	10	Once when I saw a woodlouse, I had chalk and I drew a circle around it and it thought the circle was walls so it couldn't get out. So I was testing it in my garden.
Describes creating habitats or providing food to garden invertebrates	5	We have made a pond. . . we've got water skiers. We've got lots of dragonflies coming.
		We saved a pregnant woodlouse. . . we put it in a tub and made a really nice home.
Describes someone being attacked by an invertebrate in the garden	3	She was cartwheeling in our garden and a bee just came up and stung her on the finger.
Describes invertebrates consuming or attacking garden plants	3	We have loads of snails in our garden trying to eat the flowers.
Describes seeing invertebrates on the way to school	4	We were walking to school and she [mother] saw a caterpillar what was striped black and orange

When asked about their parents' perceptions of invertebrates, a similar number had negative and positive views (Table 6). Like children, many parents were scared of spiders or disgusted by slugs. However, there was little overlap between the parents and children, for these fear and disgust factors, with only two children in both categories for each. Approximately one third of parents regularly spent time in nature, often as part of family visits to nature. There was little apparent relationship between whether a child spent time in nature and the parent did, with only three children appearing in both categories. However, for the 14 children that described spending time in nature, only two said they felt disgust for gastropods or earthworms and four that they feared spiders. For the nine children that said a parent liked spending time in nature, none of those children said the parent found slugs or snails disgusting or that the parent feared spiders.

Table 6. Self-reported family members' perceptions and experiences with invertebrates. Only perceptions where $n > 3$ are included. For definitions of perceptions see Supplementary File S3.

Experience or Perception	Number of Interviewees	Example Quotations
Parent dislikes invertebrates	12	My dad doesn't really like them.
Parent likes invertebrates	14	My dad, he likes all the creatures.
Parent perceived spiders as frightening	6	My mum is absolutely afraid [of them].
Parent perceived slugs as disgusting	7	My mum thinks slugs are yucky.
Parent regularly spends time in nature	9	My mum's a forest schoolteacher.
		My mum really likes them [invertebrates] because she loves gardening.

When asked whether they ever saw invertebrates on a day-to-day basis, children described a range of invertebrate encounters (Table 5). A similar number of invertebrate encounters occurred inside the house compared to in the garden. Encounters inside the home were generally described in neutral or amused tones by the child (only two involved fear or disgust), often concluding with the child or parent putting the animal outside. Encounters in the garden were mostly characterised by the child actively looking for or caring for invertebrates (sometimes with other family members), although there were also a few instances of someone being stung or bitten in the garden.

4. Discussion

4.1. Children's Perceptions of Different Types of Invertebrates (RQ1)

In summary, many children perceived slugs and other mucus-producing animals as disgusting, spiders and biting insects as frightening, whilst other invertebrates were favoured if they had a colourful appearance, impressive features or intriguing behaviours. These findings correspond with other studies, e.g., [15], who found that spiders evoked the most fear, whilst slugs and snails evoked the most disgust, due to shape and mucus production. We did not find any evidence that reasons for mucus disgust related to association with disease but did not specifically investigate this issue. In one study, young adults' disgust for rats did not impact on interest levels, and the author [58] suggested that disgust might in fact be a curiosity-evoking emotion.

The most popular invertebrates were woodlice and ladybirds (and no child disliked these), because they were considered attractive or had interesting behaviours, which are similar findings to other studies [15,25,59]. Randler et al. [60] found that the levels of disgust for earthworms, snails and woodlice were strongly associated with levels of interest.

Like Sammet et al. [61], children described ants as interesting or impressive due to their strength and behaviours. Snails were more popular than slugs, a similar result to Corbacho-Cuello et al. [18].

These convergent findings demonstrate how consistent children's reactions to invertebrates are in different countries (mainly highly urbanised European ones). Authors proposed that both the innate differences between animals (for example, how colourful it is) and external factors, for example, the portrayal of different types of animals in children's books and other media contributed to these perceptions. None of the types of invertebrates were described as dull or boring, which contrasts with comparable studies about plants [23,58].

4.2. The Impact of the Intervention on Children's Perceptions (RQ2)

The direct encounters with ground-dwelling invertebrates and experiential learning were effective for addressing negative perceptions. Most of the invertebrates encountered were perceived as less frightening and less disgusting after the activity. Many children either felt that the experience had positively influenced their perceptions about invertebrates or recalled positive memories about the experience.

A key feature of the pedagogic design of the intervention was that it promoted close inspection of animals through drawing and a guided observation activity and allowed plenty of time for incidental encounters with animals. Ruck and Mannion [62] and Gannon [37] found that this "lived curriculum" of emotionally charged unplanned encounters with wild organisms was more important for affective change and pro-environmental attitudinal development than the planned curriculum. Immersive encounters between humans and other lifeforms in natural environments are also recommended for developing empathy and caring behaviours, particularly when accompanied by sensory interactions with the lifeform [63].

Another important aspect of the educational experience was that it generated positive emotions, which are more conducive to productive learning and produce higher levels of motivation to reengage with those natural phenomena in the future [45]. In a systematic review of environmental education evaluations, positive emotional connections were demonstrated to be one of the primary drivers of the measured positive outcomes [64]. Furthermore, interactions with animals were one of the most common sources of emotional connections in the reviewed literature.

The post-human perspective, where the child–animal relationship is viewed in the context of the reactions and exchanges that occur between the various actors, can support our understanding of how the intervention fostered or impeded positive experiences with invertebrates. A common frustration in the intervention activity was the propensity of the animal to escape: the agency of the invertebrate compromised the child's enjoyment of the nature experience. The adult educators, on the other hand, supported the experience, by locating suitable sampling locations and helping children to catch animals in collecting pots. Some children mentioned the social aspects of the experience, in terms of the other children that were in their group, with one child bemoaning that the rowdy behaviour of her peers had compromised the fieldwork experience. Furthermore, there were the relationships between "more than human" actors, for example, at one school the children witnessed a spider eating a dragonfly, which fascinated some and disgusted others.

This "animal and human entanglement" also featured material phenomena [37], for example, the sampling equipment or abiotic features of the habitat. Children's opinions about the pooters, suction devices for collecting small invertebrates, varied according to whether the children felt comfortable being that close to the animal and whether they used them correctly, as they do not work for larger insects. Logs could prove too heavy for children to move, or, in one school, a log stump disintegrated, revealing new types of invertebrates in the crevices. The "insect hotels" found in two of the school grounds were generally not the most productive sampling areas, as these were poorly designed, poorly sited and difficult to manipulate. Instead, the log stumps frequently used for seating in forest school areas hosted a variety of centipede and millipede species, whilst log piles and even discarded debris (traffic cones in one school, stacks of broken plant pots in another) were also productive sampling areas. A variety of invertebrates were found in all the sessions despite the variations in weather and school grounds, highlighting how reliable ground invertebrates are for urban fieldwork.

4.3. Children's Experiences in Nature and Invertebrate Encounters Outside of School (RQ3)

Children and parents that spent regular time in nature exhibited less fear and disgust for invertebrates, which could be due to multiple reasons. Perhaps individuals are more likely to spend time in nature if invertebrate encounters do not arouse negative emotions, or the same types of people that enjoy being in nature are also attracted to invertebrates, or spending time in nature reduces negative perceptions of wildlife. These findings correspond with other studies, who found that children and adults' levels of dislike, disgust, and fear were negatively associated with frequency of nature experiences [13,15]. Regular engagement with a particular place over time is particularly valuable for promoting children's environmental stewardship behaviours [62].

Like Fukano and Soga [14], encounters with invertebrates inside the home were common for these predominantly urban children. By contrast with Fukano and Soga, these encounters did not appear to increase children's disgust towards invertebrates but potentially this is because children are less concerned about the risk of infestation. Whereas encounters in the home were unplanned, invertebrate encounters in the garden generally resulted from children's own agency. The findings partially converge with Lam et al.'s study [44], where children exhibited relationally orientated interactions (e.g., observing and protecting organisms) in nature-rich environments. However, it is evident that other factors were influencing children's attitudes and behaviours in our study. Psychological wellbeing is an important prerequisite for moral behaviours and children are less likely to exhibit empathy and caring behaviours if their own wellbeing is compromised [65]. This could explain why children felt more inclined to protect and appreciate invertebrates (relational interactions) during agreeable experiences that they had elected to engage in.

4.4. Implications for Policy and Practice

There is accumulating evidence about people's negative perceptions of invertebrates, particularly those perceived as harmful or carrying disease [10]. Negative perceptions lead to avoidance behaviours that reinforce the antipathy towards such organisms and foster destructive behaviours and a lack of support for insect conservation. Our study contributes to the growing evidence that first-hand encounters promote positive perceptions for invertebrates and can be easily implemented as part of in-school environmental education. Our study also highlights the specific values of focusing on ground-dwelling invertebrates for providing access to what Lam et al. [44] described as "local, everyday nature" in urban areas. Ground-dwelling invertebrates are shown to provide an ideal group for student-led fieldwork enquiry [66]. We were able to find a range of species in even the most built-up school grounds and the least promising seasons and weathers, with minimal equipment and skills required. Our study identified species that could be used as potential flagship species for promoting engagement and features and behaviours that could increase general interest in biodiversity.

Positive invertebrate experiences were characterised by a sense of "kinship", of respect, empathy and interest in the invertebrate and a desire to coexist in the same space, or to nurture and protect the animal. These types of experiences produce the strong sense of wellbeing that encourages children to reengage with nature and dismantle the human-nature dualism that can impede the development of pro-nature values [62].

4.5. Study Limitations

Due to the opportunity sampling approach, schools were self-selecting, both for initial participation and for interviews. Some children did not complete both questionnaires due to other commitments. These experimental flaws mean that we cannot know if the sample of children was representative of the broader population of children for this age group and

selection bias may have occurred. Children also skipped questions in the questionnaires, in some instances. In any questionnaire, self-reported measures are subjected to various bias, for example, where children respond in the way they think the researcher wants them to, and there can be a risk of these desirability bias in interviews also. Interviews were conducted in groups which may have introduced peer influences.

We were unable to use delayed post-test questionnaires in this study, meaning that we could not measure whether the positive impacts of the intervention on children's perceptions were durable over time. A key limitation of the study was the brevity of the intervention, and we recommend that future studies should be longer in duration, to take advantage of the benefits that regular experience with invertebrates could provide to children.

5. Conclusions

Previous research has shown that negative perceptions of invertebrates prevent people from spending time in nature and pose a barrier to the development of pro-environmental behaviours. Our study demonstrated that these psychological barriers can be addressed relatively easily in middle childhood, at least in the short-term. Children of all backgrounds enjoyed experiential learning with invertebrates, even those that were squeamish around certain species. The study deepens our understanding of human perceptions about invertebrates that arouse fear and disgust. The study also contributes to the growing evidence that children and adults who regularly experience nature exhibit positive emotions towards less charismatic biodiversity. Our recommendation is that direct experience with ground-dwelling invertebrates is promoted as part of environmental education in schools and other outdoor learning settings, to encourage pro-nature behaviours towards an important but underappreciated animal group.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su182110761/s1, Supplementary File S1 Questionnaire; Supplementary File S2 Interview questions; Supplementary File S3 Coding Scheme for Interview Analysis.

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