The Impact of Environmental Educational Programs in Promoting Insects Conservation Awareness: A Scoping Review

Geanina-Magdalena Sitar •, Alina Simona Rusu••

Abstract

The decline of biodiversity and natural habitats, and the lack of progress in society's behaviour towards conservation, has prompted research into effective educational programs. Studies have shown that positive emotions towards nature, particularly in relation to the innate human predisposition towards the natural environment, can encourage environmentally friendly actions. As people's attitudes towards species are linked to familiarity and experiences, insects, and other invertebrates, despite their vital role in ecosystems, are often underappreciated and face inequalities in research and conservation. Negative attitudes towards insects are shaped by cultural and educational factors. Hence, education, particularly environmental education, can play a significant role in changing preconceptions and attitudes towards insects and fostering positive behaviour towards biodiversity conservation. This study presents a scoping review of environmental education programs focused on enhancing students' awareness of insects and their significance in the ecosystem (from 2000 to 2022). The aim was to analyse the effects of intervention programs and key characteristics that contributed to their efficiency. The review highlights the importance of program duration, outdoor experiences, and the use of inquiry-based and experiential learning methods in promoting positive attitudes and knowledge about insects. The findings have implications for the design and implementation of effective environmental education programs targeting insect awareness.

Keywords: insects' conservation; environmental educational programs; attitudes towards insects; pro-environmental behaviour.

1. Introduction

Over the last few decades, there has been a significant decline in biodiversity, as well as the fragmentation and loss of many natural habitats (Butchart et al., 2012; Ceballos et al.,

• PhD student, Doctoral School "Education, Reflection, Development", Faculty of Psychology and Sciences of Education, Babes-Bolyai University, Cluj-Napoca, Romania, giacob@yahoo.com

•• PhD, Faculty of Animal Sciences and Biotechnologies, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania, alina.rusu@usamvcluj.ro

2015) Despite the warnings from the scientific community about the loss of biodiversity and the harmful effects of human activities on the environment (Díaz et al., 2006, Naeem et al., 2016), and even though there is a continuous effort in terms of education and prevention, there has been little progress in changing society's behaviour in the direction of biodiversity conservation (Balmford et al., 2021). Among many factors that can be considered in designing effective educational programs towards functional interactions with the environment, studies indicate that emotions, specifically positive feelings towards nature, can have a significant impact on encouraging environmentally friendly actions (Castillo-Huitrón et al., 2020; Chawla, 2007; Kals et al., 1999).

The human-nature relationship, depending on the nature of emotions, is often defined in terms of biophilia and biophobia. The concept of biophilia, originally proposed by Wilson (1984), refers to an innate and positive human predisposition to belong to the natural environment, which allows human individuals to experience benefits from interactions with other forms of life. When functional, these interactions can facilitate their development, adaptation, and survival (Gelter, 2000; Or, 1993). In contrast, biophobia is defined as the perception of elements of nature as anxiogenic, disgusting, or irrelevant (Orians, 2007; Orr, 1993), thus having the potential of impeding the development of functional human-nature interactions.

One factor identified in the literature that can influence the relationship between humans and nature is the frequency with which humans interact directly with nature (Soga et al., 2020). According to Miller (2005), this "extinction of experience" phenomenon, which was first discussed by Pyle in 1993, has been intensifying. It has been observed that more and more people, globally, and especially children, spend less and less time in direct interactions with nature (Soga & Gaston, 2016; Soga et al., 2020). Hence, outdoor activities have been replaced by screen-based activities, and this trend is concerning in terms of missing the evidence-based benefits of spending time in natural environments, which is known to improve the executive attention, to reduce the stress level and increase the general quality of life (for example, Gelter, 2000; Zhang et al., 2014). More and more authors state that if people do not have the opportunity to develop positive attitudes and responsible behaviour towards the environment through direct interactions, there is the risk that the future generations may be unable to recognise and/or ignore environmental problems, leading to long-term negative implications for human health and nature conservation (Johansson et al., 2012; Soga & Gaston, 2016; Zhang et al., 2014).

Insects as a tool for environmental education

In general, the importance and values given to species are closely related to people's experiences and familiarity with the species in question (Colléony et al., 2017; Martín-López et al., 2007). Conservation actions are often driven by public perception and species charisma (Bellon, 2019; Colléony et al., 2017), creating inequalities in research and conservation. These inequalities in terms of public attention can be harmful for less popular groups, such as insects and other types of invertebrates (Cardoso et al., 2011). The attitudes of humans, especially those that are shaped by early education, can become a major impediment to the development of a mindset (translated in functional behaviors) oriented to global conservation of insect biodiversity (Cardoso et al., 2011; Samways, 2015).

The decline of insects, which has been a long-standing phenomenon, has only received increased attention from the scientific community in the last decade. In 2017, an article was published which presented the drastic situation of insects in Germany (Hallmann et al., 2017). The results of the study were surprising, showing a 76% decrease in the biomass of flying insect species in just 27 years. In line with their findings, the authors discuss the importance of creating awareness towards the vital roles of insects in ecosystem, such as pollinators, food resources for other taxa, maintaining of sole structure etc.

Insects and other terrestrial arthropods, commonly referred to as "insects," are one of the most underappreciated taxonomic groups of living organisms in the world, especially in developed countries (Lockwood, 2013; Prokop et al., 2010; Prokop & Randler, 2018; Shipley & Bixler, 2017). Studies show that negative emotions towards insects are shaped by culture and various forms of education (for example, parental, peer-based education, school provided education), as well as by the availability of information and direct experiences (Bjerke & Østdahl, 2004; Kellert, 1993; Soga et al., 2020). An important role in offering scientific knowledge and shaping appropriate attitudes and behaviours towards insects is played by the approach in the school curriculum. Thus, preconceptions regarding insects, and negative attitudes can be changed through education, more precisely through environmental education (Gralton et al., 2004). Innovative and critical education that arouses children's curiosity can achieve the goals of environmental education.

Environmental education (EE) is becoming an increasingly important facet of contemporary education systems (UNESCO, 1976). EE aims to equip learners with the knowledge, skills, and attitudes necessary for understanding and addressing environmental issues that affect society (Kaiser et al., 2008).

Problem Statement

The importance of changing society's behaviour towards the environment cannot be overstated, particularly given the pressing environmental challenges that we are today. To accomplish this goal, we require appropriate tools at our disposal, and one of the most important tools that allows reaching out to all categories of individuals is education.

Designing an effective educational program requires a meticulous examination and analysis of previous programs implemented. This approach enables us to identify successful initiatives and areas for improvement (Peters et al., 2015; Webster & Watson

2002). By building on the successes of previous initiatives and learning from their shortcomings, we can create more effective and impactful educational programs (Snyder, 2019), especially when dealing with topics that have a global relevance, such as insect conservation. With the right tools and strategies, we can work towards changing societal attitudes and behaviours towards the environment, which is critical in the face of the ongoing environmental challenges we face.

In order to design successful environmental education programs in the future, the aim of this study is to identify key characteristics associated with effective programs. To achieve this, we conducted a scoping review of studies that evaluated environmental education programs, specifically those targeting the enhancement of students' awareness of insects and their significance in the ecosystem. Our focus was on analysing the effects of intervention programs and the key program characteristics that contributed to their efficiency.

2. Method

Scoping studies can play a crucial role in providing an overview and critical analysis of the existing evidence. This category of studies examines the extent, range, and nature of research activity, clarifies concepts, draws conclusions, and identifies gaps in the existing literature. Researchers such as Arksey and O'Malley (2005), Davis et al. (2009), and Levac et al. (2010) have emphasized the importance of scoping studies in identifying and analyzing the formulated research questions, methods, and findings of existing studies, ultimately leading to a better understanding of the research landscape and informing future research directions.

The approach taken in this study to conduct a scoping review was based on the five-stage framework developed by Arksey and O'Malley (2005). The framework provides a systematic and transparent process for mapping a research area (Arksey & O'Malley, 2005). The five stages of the framework are: (1) identifying the initial research questions; (2) identifying relevant studies; (3) study selection; (4) charting the data and (5) collating, summarising, and reporting the results.

Stage 1: Identifying the Research Questions

The aim of this review was to identify and analyse environmental programs that target increasing awareness of and changing attitudes towards the decline of insects in order to shape pro-environmental behaviour. To achieve this, the scoping review was guided by the following research questions:

1. What are the objectives of environmental educational programs (EEP) focused on insect conservation?

2. What is the optimal duration of an EEP to achieve the objectives associated with insect conservation, including developing pro-environmental behaviour, changing attitudes towards insects, and increasing knowledge about insects and their decline?

3. What kind of population was targeted by the intervention programs, and by whom were the programs delivered?

4.What variables were used to evaluate the impact of these programs on participants, and what assessment tools were commonly employed?

5.Which groups of insects were targeted in these programs, and what specific activities were implemented to achieve the objectives?

6. What types of training methods were most frequently used in EEP interventions?

7. What were the recorded effects of the EEP's implementation?

Stage 2: Identifying relevant studies

Educational programs focused on insect conservation can be developed and implemented by researchers from various fields, including education or biology, i.e. the fiedl of entomology. Therefore, to identify studies conducted by researchers from both categories, we established two different sets of key search words. These search terms were determined by analysing some relevant studies previously identified. We included articles written by both entomologists and researchers/ practitioners from the education field in order to comprehensively capture relevant research in the field of insect conservation.

In the initial stage of the search method, we identified the following sets of keywords: "insects" AND "environmental education" AND "educational programs" (to identify studies from the education field) (Fig. 1), and "entomology" AND "outreach" AND "environmental education" (to capture studies related to entomology and outreach in environmental education) (Fig. 2). In our analysis, we included peer-reviewed studies published in English between 2000 and 2022 that evaluated the impact of educational programs aimed at increasing awareness about insect conservation among students from pre-university education. We used the Google Scholar electronic database with advanced search functions and saved relevant studies in “My library”. Figure 1 and Figure 2 summarize the screening procedure we followed, applying the aforementioned inclusion and exclusion criteria.

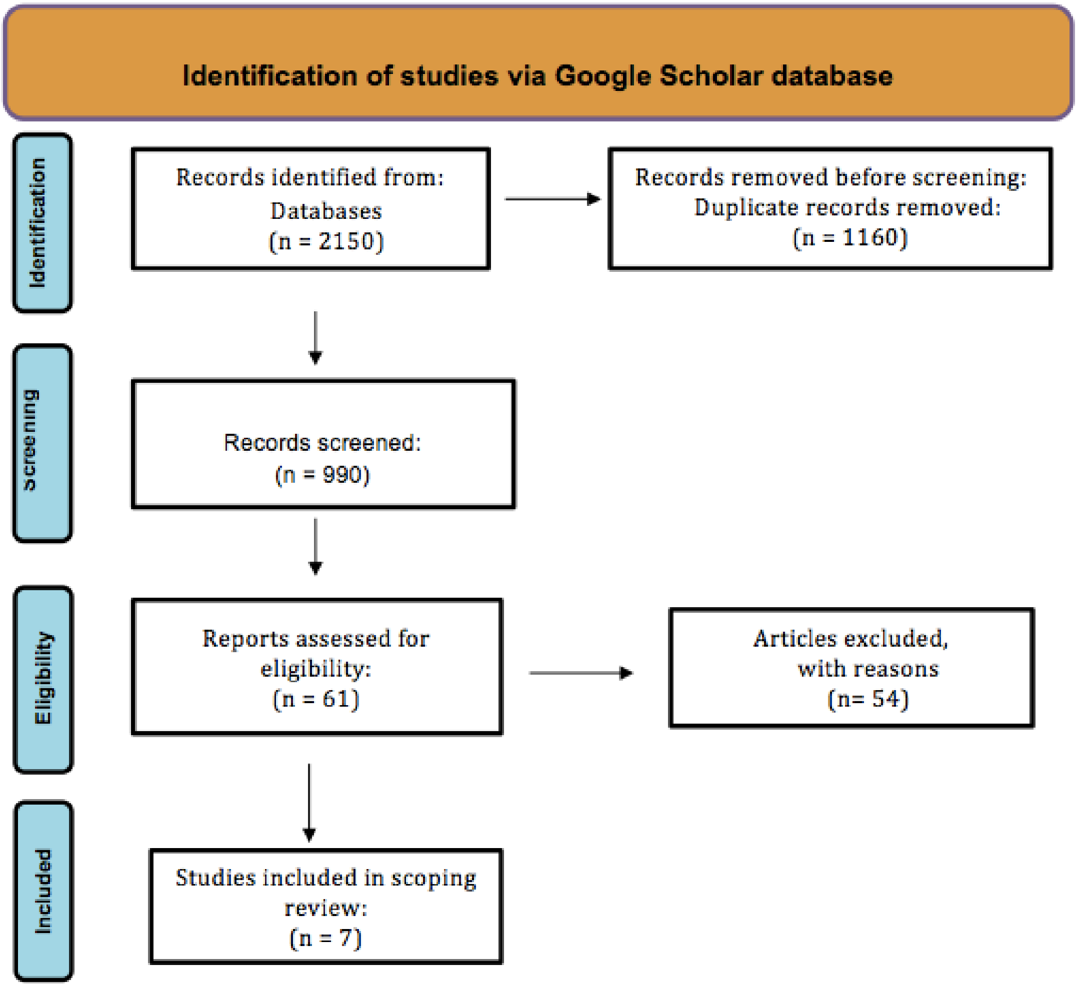

Figure 1. *PRISMA flow diagram (adapted from Moher et al., 2009) for the inclusion of articles relevant to the field of education (using the key search words: "insects" AND "environmental education" AND "educational programs").*

Stage 3: Study selection

During the study selection process, we noticed that although the Google Scholar database registers all available versions of an article, it displays only one version after a search. However, it does offer the option to view other versions if desired, which facilitated our screening process.

In the first search using the keywords "insects," "environmental education," and "educational programs," we initially found a number of 2150 articles. After eliminating duplicates and excluding conference proceedings, books, book chapters, and articles that didn't fit our topic, a number of 61 potentially relevant studies were included in the next step of the analysis. These studies were read in full and evaluated for suitability, resulting in only 7 studies that met all the inclusion criteria.

In the second search using the keywords "entomology," "outreach," and "environmental education," we found 7500 articles, but only 997 were unique entries after removing duplicates. We followed the same steps as in the first search to identify relevant studies, resulting in 140 potential articles after the initial screening, and ultimately identifying two relevant studies.

After completing the entire process, we have identified a number of 9 papers that are relevant to our research and that met all the inclusion criteria.

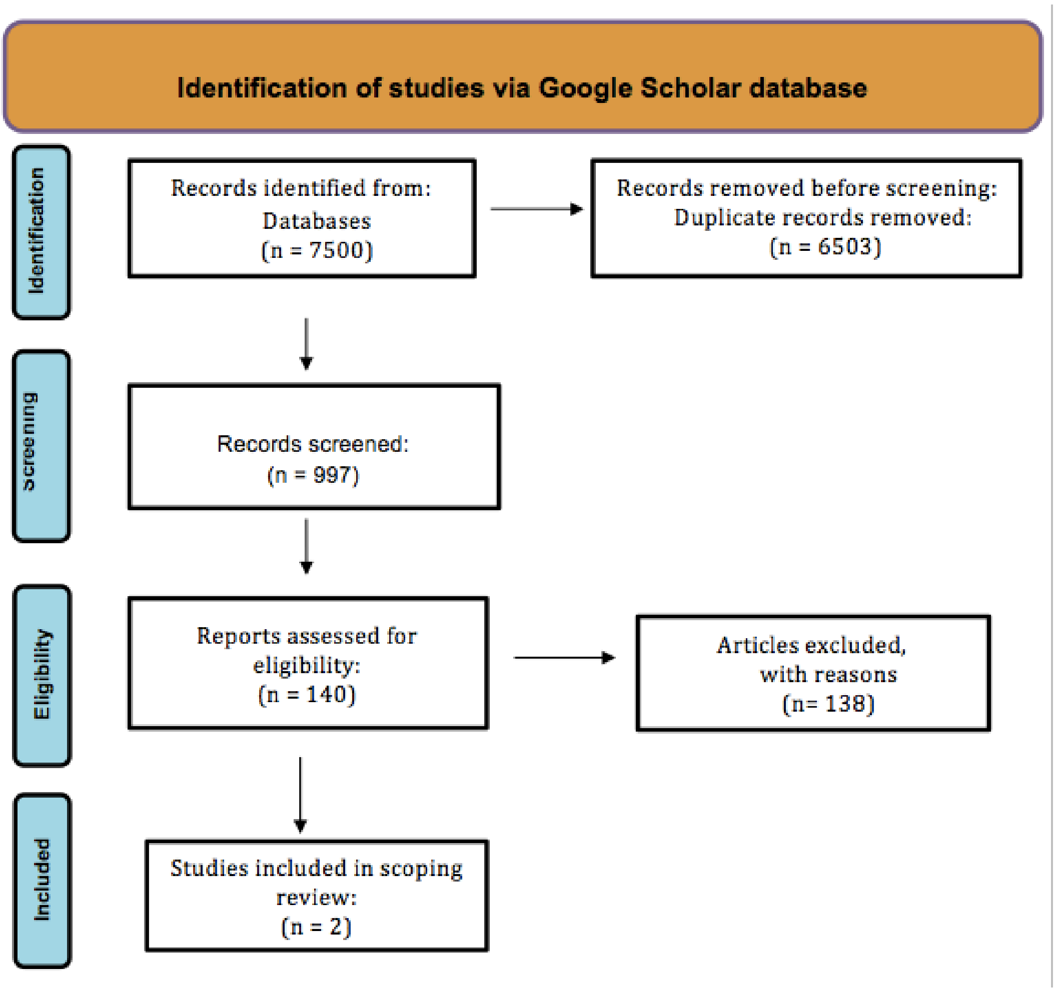

Figure 2. *PRISMA Flow Diagram (Adapted from Moher et al., 2009) for the inclusion of articles relevant to entomology and environmental education outreach (using the key search words: "entomology" AND "outreach" AND "environmental education")*

Stage 4: Charting the data

We charted the data by extracting the following information from the 9 studies: author, year of publication, aim and objectives of the study, details of the target group (including age and number of participants), implementation period of the program or duration of the intervention, evaluation of the impact of the educational program (including variables and tools used), structure of the program, type of didactic training / pedagogical method, and the outcomes /effects recorded after the intervention. The key characteristics identified in the EPP are presented in Table 1, while data related to EPP impact evaluation, variables, measurement tools, and recorded effects are presented in Table 2.

Stage 5: Collating, summarising and reporting the results

Initially, a narrative synthesis was conducted to provide a fundamental numerical analysis of the studies' extent, methods, and distribution included in this review. Subsequently, a critical analysis of these articles was performed to identify key characteristics associated with effective environmental educational programs. The results of this analysis are presented in the "Findings" and "Conclusion" sections.

Table 1. *Synthesized data on key characteristics from reviewed studies (N=9; C = control, E = experimental)*

Authors & year	The aim and objectives	Program length	Target group	Training method	Insect species	Program content
Fisher-Maltese 2016	To measure changes in environmental attitudes as a result of a school garden experience.	11lessons in 4 weeks	66 Second-graders students	Garden-based science curriculum/ classroom-based action hands-on activities	Different species of insects	Classroom and garden insect lessons were conducted daily during the curriculum, facilitated by a support teacher, and co-taught in the school garden. The lessons centred on week-long themes such as anatomy, life cycles, helpful and harmful insects, butterfly, and larva identification, and designing a butterfly garden.
Schönfelder & Bogner 2017	Increasing individual willingness to protect honeybees as crucial pollinators evaluating two approaches: 1. encountering living animals while learning2. seeing animals via eLearning	There were four modules, each lasting around 135 minutes.	354 seventh and eighth graders	Student-centred learning Hands-on activities	Honeybee	The lessons were designed in the same way for both approaches (living bees at a local beehive versus an interactive online portal linked to a beehive), with the only difference being the way in which the students interacted with the bees. The 4 modules included 2 working stations: - one with analogue materials, - second one that involved direct experience with honeybees (at the beehive) or gathering and analysing original data (from an online hive)

Cho & Lee 2018	To change fear towards insects into affinity through an environmental educational program with hands-on activities. To increase students' connectedness to nature.	2 hours/ week for 3 weeks	104 students from third graders	Learning through hands-on activities	Honeybee	The program includes 3 lessons. The structure of each lesson consists of an introduction, which involves short lectures on important ecological aspects of honeybees. In the development section, students participate in different activities, i.e., harvesting honey from the hive. The lesson concludes with a discussion on various topics, including the life of a honeybee colony, and so on.
Weeks & Oseto 2018	One research objectives was to assess whether students exhibit a higher interest in environmental and entomological topics and issues when taught by an entomologist, by teachers trained by an entomologist, or by teachers with no entomological training.	Four lessons	15 teachers 28 to 57 years old 518 students from fifth grade (9 to 12 years old)	Lectures hands-on activities	Arthropods, including bees beetles, ladybugs, butterflies, mealworms	The research team created four lessons focused on insects and ecosystems, which utilized live arthropods to provide a hands-on learning experience. The lessons explored the basics of ecosystems, insect characteristics, and their roles in ecosystem health. The program was delivered through three methods: by an entomologist, a teacher trained by an entomologist, or a teacher who completed an online training program without direct interaction with an entomologist.
Healy, K. 2019	The goal was to actively involve and educate students about various fields of entomology, such as forensic, agricultural, and medical/ veterinary entomology.	45-60 min	50 high-school students	Game-based pedagogy escape-room-based activity		In a single hour, the students were able to explore various aspects of entomology, such as forensic entomology, post-mortem intervals, rice insect pests, and dichotomous keys. They also learned about the different ways that insects can cause harm to humans and animals and worked together to apply problem-solving strategies towards their objective.
Sieg & Dreesmann 2021	To increase willingness for pro-environmental behaviour intentions towards bumblebees. To implement bumblebees as a flagship species in biology classes;	3-5 weeks (during biology classes)	188 students from five to seven grades	Learning through hands-on activities	Bumblebee	The activities were divided into two units. Unit 1 included a theoretical component with information on the ecological importance of pollinators, the biological cycle and body language of bumblebees. The practical component involved hands-on activities such as handling bumblebees and recognizing their behaviours. Unit 2 focused on ecology, neurobiology, and ethology with a theoretical component covering the decline of insects, and a practical component involving experiments with bumblebee colonies to determine their diversity and density in different habitats, such as pheromonal communication.
Markee et al. 2021	The program named Frass in the Class aims to captivate children's attention and cultivate a love for nature by introducing live insect rearing in the classroom.	One month	70 students from five, seven, and nine grades	Hands-on activities	Painted lady butterfly	The program began with an introductory visit by researchers from the Florida Museum, who distributed butterfly larvae and materials for their growth and gave a presentation about insects. Virtual meetings were held every two weeks for students to discuss their progress and challenges with the researchers.

						At the end of the project, the adult butterflies were released during a short trip.
Asli et al. 2022	The aim of the study was to investigate how learning science through project-based teaching strategies affects students' perceptions of the climate in the scientific classroom	The program consisted of six 45-minute lessons and one 90-min lesson	28 students as C group 32 students as E group All students were in eight grades.	project-based teaching strategies	bees	The program consisted of six study units, with the initial units focused on testing and introducing the theme of bee biodiversity and decline. In the experimental group, students were divided into smaller groups and assigned a project to develop throughout the remaining lessons. They had access to a laboratory with computers and participated in online sessions with an expert, followed by a discussion session. Before presenting their projects, the experimental group conducted direct observations of bees and their habitats during a field trip. In the final lesson, the experimental group presented their projects to the rest of the class.
Christ et al. 2022	To develop among students a positive attitude towards, as well as a comprehensive knowledge about, wild bee.	The project was implemented from April to July, with the actual activities integrated into biology classes. An exact number of hours is not specified.	437 students from five to seven grades	learning through hands-on activities lectures	bumblebee	The program includes 2 learning units: a basic unit, where students receive information about the importance of pollinators and biodiversity, as well as the morphology and biology of bumblebees. In the second learning unit, called Citizen Science, students are involved in activities to monitor and identify the species of wild bees/bumblebees present in the schoolyard

Table 2. *Extracted data on the evaluation of EPP impact in the reviewed studies (N=9)*

Authors & year	Variables	Instruments used to evaluate the impact of the program	Implementation effects
Fisher-Maltese 2016	Science content knowledge Student attitudes toward the environment and insects	To identify improvements in information and changes in attitudes towards insects, a questionnaire was administered both before and after the intervention. In addition, the author conducted semi-structured interviews and recorded class discussions.	The results of the quantitative survey data did not show any statistically significant changes in attitudes in this study. However, data collected from pre/post-tests, interviews, and student conversations indicated a positive shift in students' attitudes towards a more empathetic view of nature. These findings suggest that the program may have helped prepare students to become environmental stewards.

Schönfelder & Bogner 2017	Specific aspects of attitudes towards bees as: 1. Interest 2. the perceived danger 3. the willingness to protect bees Situational learning emotions: 1. situational interest 2. well-being 3. boredom	A semantic differential on the perception of bees with eight bipolar items. The situational emotion questionnaire proposed by Randler et al. (2011) was used to measure the situational learning emotions. This instrument is based on a 5-point Likert scale.	The intervention had a positive impact on students' interest in bees and decreased their perception of danger associated with bees in the short and long term. The willingness to protect bees also improved, but the effect decreased from medium to small over time. Comparing live animal and digital tools interventions, the only significant difference was observed in the short-term decrease in perceived danger, with direct experiences with bees leading to a greater decrease. Students who had direct contact with bees also had significantly higher well-being and lower boredom compared to online participants.
Cho & Lee 2018	Connectedness to nature	Connectedness to nature was measured using 2 scales: Schultz's INS scale (2002) and CNS by Mayer and Frantz (2004). The first scale was modified from the Inclusion of Others in Self Scale, which is based on self-report. The participants had to choose a single graphic element that best represented the relationship between them and nature, using 7 pairs of circles with different degrees of overlap. The CNS (Connectedness to Nature Scale) measures the degree to which individuals feel connected to nature. It consists of 14 items that are rated on a five-point Likert scale (1-5). The aim is to capture the "we-ness" of individuals' experiences with nature	There was a significant increase in connectedness between the pre-test and post-test as measured by the INS scale, with a medium effect size. This effect was also maintained in the retention test. In contrast, a comparison of the CNS scale scores from the pre-test and post-test revealed a large effect size, which decreased to a medium effect size after three weeks.
Weeks & Oseto 2018	Students' intrinsic motivation Teacher self-efficacy	To determine the impact of the program towards students' intrinsic motivation was used a multi-scaled instrument named Intrinsic Motivation Inventory (IMI): 4 of seven subscales: Interest/Enjoyment, Effort/Importance, Value/Usefulness. Pressure/Tension 27 questions answered using a 7-point Likert scale. Teacher self-efficacy was evaluated using The Teachers' Sense of Efficacy Scale developed by Tschannen-Moran and Woolfolk Hoy, 2001, which consists of 24 questions on a 9-point Likert scale: the sub-scales are: Efficacy in Student Engagement (ESE), Efficacy in Instructional Strategies (EIS), and Efficacy in Classroom Management (ECM).	Students' intrinsic motivation Overall, students' intrinsic motivation towards the environment and entomology increased with each completed lesson. However, when comparing the three outreach delivery methods, there were no significant differences in intrinsic motivation. Still, students in the Online curriculum treatment found the lessons to be more interesting and enjoyable compared to students in the other two treatments. Additionally, when comparing the pressure and tension among the three treatments, students in the Online curriculum treatment reported higher levels than students in the other two treatments.
Healy, K. 2019	Students' subjective experience during the workshop	The students' experiences were evaluated using a 5-point Likert scale questionnaire consisting of 5 statements ranging from strongly disagree (1) to strongly agree (5).	The results indicate that the exercise was well-received by high school students and they found it informative.

Sieg & Dreesmann 2021	1. Pro-bumblebee behaviour intentions 2. Knowledge about bumblebees 3. insects decline 4. Attitude 5. Interest 6. Fear 7. Learning	To evaluate pro-bumblebee intentional behaviour, a scale containing 19 items was used, with a five-tier Likert scale ranging from 'agree' to 'do not agree'. The evaluation of knowledge about bumblebees and the decline of insects was carried out through closed questions, but there were also some open-ended questions related to the causes and consequences associated with the decline of insects. Attitudes towards bumblebees were measured using a five-tier Likert scale. Learning enjoyment was also measured through a five-tier Likert scale, ranging from 1 (lowest joy) to 5 (highest joy)	Overall, there was a significant increase in pro-environmental behaviour intentions with a medium effect size. No significant difference between the pre-test and follow-up test. In the pre- and post-test, there was a medium effect size correlation between knowledge about bumblebees and pro-environmental behaviour intentions. No significant correlation between the pre- and follow-up test. There was a correlation between knowledge about the decline of insects and pro-environmental behaviour intentions. Strong correlation between attitudes and pro-environmental behaviour.
Markee et al. 2021	Learners' perspectives and their experiences during the program	The students' experience was evaluated in an informal manner by asking them questions related to their learning, perception of insects, and the importance of insects. To assess the learners' perception, eight students were interviewed.	After the program, some students who did not like butterflies before changed their opinion about them. Others gained a better understanding of the role of butterflies in the ecosystem, and some even expressed interest in participating in similar programs or volunteer activities at the museum.
Asli et al. 2022	Classroom climate	A mixed-methods approach was employed to evaluate the classroom climate and student learning experience. A quantitative method was used to assess the classroom climate using a questionnaire with 35 statements and a 5-point Likert scale, which were divided into 7 factors: Cohesion of Students Teacher Support Involvement Collaboration Fairness Personal Relevance Material Environment General Learning Atmosphere To evaluate the students' learning experience, a structured interview was conducted (about the topic studied and the study method). Questionnaire and interview were administered pre- and post-intervention.	The project-based learning had a highly positive impact on the learning atmosphere: the learning atmosphere was found to be more positive in all dimensions. Students in the experimental group demonstrated a significant improvement in the learning atmosphere compared to those in the control group.
Christ et al. 2022	1. Knowledge about bumblebees, pollination, biodiversity, and insect decline 2. Attitude 3. Fear 4. Learning Enjoyment 5. pro-environmental-behaviour intentions	To evaluate students' knowledge of the topic, 16 closed questions were designed: 9 questions were about bumblebees, and 7 were about biodiversity, pollination, and the decline of insects. Attitudes towards bumblebees were measured using a five-tier Likert scale proposed by Sieg et al. Learning enjoyment was also measured through a five-tier Likert scale, ranging from 1 (lowest joy) to 5 (highest joy).	A significant increase in students' knowledge. A change in attitude among female students; no significant difference between the pre-test and post-test among male students. No significant change in the intention to act in an environmentally friendly manner across all evaluated items. A significant change for students' motivation to become active members.

3. Findings

This scoping review has revealed that between 2000 and 2022, only 9 articles met the inclusion criteria. These articles were published between 2016 and 2022. The findings according to the research questions are presented below.

3.1. What are the objectives of environmental programs focused on insect conservation?

As indicated in table 1, three of the studies aimed to improve students' attitudes towards insects by increasing their knowledge and direct experiences (Christ et al., 2022; Fisher-Maltese, 2016; Cho & Lee, 2018). The other two studies focused on developing a pro-environment and pro-insect behaviour, also by improving knowledge and direct experiences (Schönfelder & Bogner, 2018; Sieg and Dreesmann, 2021). The remaining studies aimed to increase students' interest in entomology (Weeks & Osero, 2018, Aslli et al., 2022, Healy, 2019, Markee at al., 2021). Additionally, one study aimed to investigate whether project-based learning could improve classroom climate and influence students' motivation to learn about bees (Aslli et al., 2022).

The studies conducted by entomologists or biologists primarily aimed to develop knowledge about insects and their role in the ecosystem, as well as to increase students' interest in entomology (Fisher-Maltese, 2016, Weeks & Osero, 2018, Markee at al., 2021). On the other hand, our analysis indicates that the studies conducted by researchers and practitioners in the field of education focused more on attitudes and behaviour, which are important aspects in the learning process (Schönfelder & Bogner, 2018, Christ et al., 2022, Sieg and Dreesmann, 2021, Cho and Lee, 2018, Aslli et al., 2022, Healy, 2019).

3.2. What is the optimal duration of an EEP to achieve the objectives associated with insect conservation (pro-environmental behaviour, attitudes towards insects, and knowledge about insects and their decline)?

Regarding the duration of the programs/interventions, the results varied from one hour (Healy, 2019) to 4 weeks (Fisher-Maltese, 2016, Sieg and Dreesmann, 2021, Markee at al., 2021), and in some studies, the actual time intended for the activities with the students was not clearly specified (Christ et al., 2022). The programs that lasted between 3 and 4 weeks were implemented during biology classes, so the total number of hours varied between 4 and 10-11 hours.

3.3. What kind of population was targeted by the intervention programs, and by whom were they delivered?

The intervention programs in the majority of the studies were aimed at primary and secondary school students (Schönfelder & Bogner, 2018; Fisher-Maltese, 2016; Christ et al., 2022, Sieg and Dreesmann, 2021; Cho and Lee, 2018, Weeks & Osero, 2018, Markee at al., 2021). One of the studies targeted high school students (Healy, 2019), while another study had both fifth-grade students and teachers as the target group (Aslli et al., 2022).

Four out of the nine studies relied on teachers to deliver the EEP content (Christ et al., 2022, Sieg and Dreesmann, 2021, Aslli et al., 2022, Healy, 2019), who had been trained in advance by an expert. Two studies had the researcher deliver the program content (Schönfelder & Bogner, 2018, Cho and Lee, 2018), while in the remaining studies, the teacher received assistance from a researcher (Fisher-Maltese, 2016, Markee at al., 2021). In one of the studies (Weeks & Osero, 2018), all three ways of content delivery were implemented, and the outcomes were further compared to evaluate which one was more effective in achieving the program's objectives.

3.4. What types of training methods were most frequently used in environmental education programs?

Most of the studies used hands-on activities to achieve their objectives, such as improving attitudes towards insects, increasing interest in learning more about them, and generating pro-environmental behaviour (Table 1). Living animals were frequently used in almost all the programs, allowing children to interact with them directly and create memorable experiences. In addition to hands-on activities, some of the analysed studies also utilized project-based teaching strategies (Aslli et al., 2022) and game-based pedagogy, such as escape-room-based activities (Healy, 2019).

While hands-on activities are commonly used for primary and lower secondary education students, as they help children explore the surrounding world through play, teaching methods for 8th grade and high school students must be more cognitively demanding. These students are at a more advanced stage of cognitive development and require more sophisticated strategies that can challenge their critical thinking and problem-solving skills.

3.5. Which groups of insects were targeted in the EEP interventions, and what specific activities were implemented to achieve the objectives?

In this study, honeybees and bumblebees were the most used insects (Schönfelder & Bogner, 2018; Fisher-Maltese, 2016; Christ et al., 2022, Sieg and Dreesmann, 2021; Cho and Lee, 2018, Weeks & Osero, 2018, Aslli et al., 2022). They were chosen because they are two important pollinator species that play a critical role in maintaining ecosystem biodiversity. In addition to honeybees and bumblebees, three of the analysed studies also used butterflies (Fisher-Maltese, 2016, Weeks & Osero, 2018, Markee at al., 2021). Butterflies are part of the charismatic insect group, which includes insects that are adored by the public for their beauty, uniqueness, and fascinating life cycle.

Most of the activities included in the educational programs analysed in this study fall under the category of informal learning activities (Table 1). Although most of the lessons had a formal component, where students were introduced to the topic, they were followed by hands-on activities, where students interacted with live insects or conducted direct observations.

In one study (Aslli et al., 2022), the teacher designed the lesson using project-based teaching strategies, which stimulated teamwork, research, and communication skills among students.

3.6. What variables were used to evaluate the impact of these programs on participants, and what assessment tools were commonly employed?

Five of the analysed studies measured variables related to attitudes towards insects, intentions for pro-environmental behaviour, knowledge acquisition, and interest in studying insects. The other four studies focused on students' experiences during the program and measured variables such as intrinsic motivation, classroom climate, learner perspectives, and overall program experiences. In one study, teacher self-efficacy was also included as a variable, in addition to students' intrinsic motivation. Finally, one study evaluated attitudes towards insects in the context of connectedness to nature.

As indicated in Table 1, the assessment tools used in the EEP interventions were various, corresponding to the following aspects: attitudes, situational emotions, knowledge and behaviors. Hence, the tools were: questionnaires (most of them based on Likert-scale items) on intrinsic motivation, on teaching efficacy, on situational emotions, semantic differentials, on level of interest and engagement, as well as direct observations of students being involved in several activities. Some of the questionnaires were standard tools already existing in the literature, e.g., Connectedness to Nature Scale (Cho and Lee, 2018), while others were created by the authors, e.g. semi-structured interviews. The experimental approach was either quantitative, qualitative (e.g. content analysis of transcripts of recorded materials) or combined (mixed research method; Fisher-Maltese, 2016).

3.7. What were the recorded effects of the program's implementation?

All studies included in our scoping review reported positive effects after implementing the EEP. Specifically, studies measuring interest in insects found significant improvements both in the short and long term, and studies noted an overall positive shift in attitudes towards insects.

Regarding the perception of danger, in one study (Schönfelder and Bogner, 2018), the authors observed a significant improvement among students who had direct interaction with bees, as opposed to those who only experienced the program virtually.

However, no significant differences were recorded between the two approaches (living bees versus digital tools) in other dimensions evaluated.

Some studies reported either no significant difference in pro-environmental behaviour across the three evaluated time points (pre-test, post-test, and retention test), or a medium effect size immediately after the intervention that decreased considerably by the retention test.

The study conducted by Fisher-Maltese in 2016 utilized a mixed-methods approach, incorporating both quantitative and qualitative methods. Alongside the collection of quantitative data, the study also involved the use of interviews and audio recordings during the educational program to gather qualitative data. The quantitative results did not indicate any significant changes in attitudes towards insects. However, the qualitative methods revealed an improvement in attitudes and perceptions towards insects. For instance, one student who expressed discomfort around insects at the beginning of the program no longer showed any fear associated with insects and actively participated in all proposed activities, including capturing insects and observing them in their natural habitat.

4. Conclusion

This study provides an analysis of intervention programs aimed at improving students' attitudes towards insects by increasing their knowledge, regulating their emotions towards insects and providing direct experiences. The study summarizes the effects of environmental educational programs as reported by evaluation studies. Additionally, the study identifies several key aspects related to program design and implementation, such as aims, length, and training methods that may contribute to program effectiveness**.**

This analysis suggests that school-based emotional development interventions, such as short environmental educational programs, can be effective in improving both students' level of interest in studying insects and their attitudes towards them. However, the impact on pro-environmental behaviour appears to be more complex. While the effects reported by the analysed studies show that behaviour improves during and immediately after the intervention, it appears to fade after a period (Fisher-Maltese, 2016; Schönfelder & Bogner, 2017). Further research is needed to determine how to maintain the positive changes in pro-environmental behaviour over time.

An essential element in achieving conservation objectives for insects is the delivery of information through effective methods. Hands-on activities have been widely used, especially for primary and secondary school children, as they are efficient in promoting learning (Holstermann & Bögeholz, 2010). However, several authors indicate that methods must be tailored to suit the age group of the students. Therefore, for high school students, more cognitively demanding methods, such as project-based teaching strategies (Aslli et al., 2022) and game-based pedagogy like escape-room-based activities (Healy, 2019), would be more appropriate.

To develop an effective educational program aimed at promoting insect conservation, it is crucial to foster an interdisciplinary climate of collaboration between biologists/ entomologists and teachers. Entomologists can bring specialized knowledge of insects and their ecological roles, as well as experience in handling live insects, while teachers can offer expertise in effective teaching methods and classroom management (Weeks & Osero, 2018). The collaboration and integration of these different skill sets are essential to achieve the proposed objectives of the program.

The findings of this study provide valuable insights into the effectiveness and usefulness of environmental educational programs. Based on the analysis, several features of effective interventions were identified. These results can be used to develop intervention guidelines for improving attitudes towards insects and promoting pro-environmental behavior. However, it is important to note that the present analysis was limited by the exclusion of studies with restricted full text access, which may have resulted in the omission of relevant evaluation studies.

References

Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International journal of social research methodology*, *8*(1), 19-32.

Asli, S., Abu-Alhiga, R., Algmal, S., & Hugerat, M. (2022). Teaching and Learning about Bee Extinction through Project-Based Learning (PBL): Its Impact on the Classroom Climate (CL) among Eighth Grader Students. *Sustainability*, 14(12), 7477.

Balmford, A., Bradbury, R. B., Bauer, J. M., Broad, S., Burgess, G., Burgman, M., ... & Nielsen, K. S. (2021). Making more effective use of human behavioural science in conservation interventions. *Biological Conservation*, *261*, 109256.

Bellon, A. M. (2019). Does animal charisma influence conservation funding for vertebrate species under the US Endangered Species Act?. *Environmental Economics and Policy Studies*, *21*(3), 399-411.

Bjerke, T., & Østdahl, T. (2004). Animal-related attitudes and activities in an urban population. *Anthrozoös*, 17(2), 109-129.

Butchart, S. H., Walpole, M., Collen, B., Van Strien, A., Scharlemann, J. P., Almond, R. E., ... & Watson, R. (2010). Global biodiversity: indicators of recent declines. *Science*, 328(5982), 1164-1168.

Cardoso, P., Erwin, T. L., Borges, P. A., & New, T. R. (2011). The seven impediments in invertebrate conservation and how to overcome them. *Biological conservation*, 144(11), 2647-2655.

Castillo-Huitrón, N. M., Naranjo, E. J., Santos-Fita, D., & Estrada-Lugo, E. (2020). The importance of human emotions for wildlife conservation. *Frontiers in Psychology*, 11, 1277.

Ceballos, G., Ehrlich, P. R., Barnosky, A. D., García, A., Pringle, R. M., & Palmer, T. M. (2015). Accelerated modern human–induced species losses: Entering the sixth mass extinction. *Science advances*, 1(5), e1400253.

Chawla, L. (2007). Childhood experiences associated with care for the natural world: A theoretical framework for empirical results. *Children Youth and Environments*, 17(4), 144-170.

Cho, Y., & Lee, D. (2018). 'Love honey, hate honey bees': reviving biophilia of elementary school students through environmental education program. *Environmental Education Research*, 24(3), 445-460.

Christ, L., Hahn, M., Sieg, A. K., & Dreesmann, D. C. (2022). Be (e) Engaged! How Students Benefit from an Educational Citizen Science Project on Biodiversity in Their Biology Classes. *Sustainability*, 14(21), 14524.

Colléony, A., Clayton, S., Couvet, D., Saint Jalme, M., & Prévot, A. C. (2017). Human preferences for species conservation: Animal charisma trumps endangered status. *Biological conservation*, 206, 263-269

Davis, K., Drey, N., & Gould, D. (2009). What are scoping studies? A review of the nursing literature. *International journal of nursing studies*, *46*(10), 1386-1400.

Fisher-Maltese, C. (2016). " We Won't Hurt You Butterfly!" Second-Graders Become Environmental Stewards from Experiences in a School Garden. International *Journal of Early Childhood Environmental Education*, 4(1), 54-69.

Gelter, H. (2000). Friluftsliv: The Scandinavian philosophy of outdoor life. *Canadian Journal of Environmental Education (CJEE)*, 77-92.

Gralton, A., Sinclair, M., & Purnell, K. (2004). Changes in attitudes, beliefs and behaviour: A critical review of research into the impacts of environmental education initiatives. *Australian Journal of Environmental Education*, *20*(2), 41-52.

Hall, D. M., & Martins, D. J. (2020). Human dimensions of insect pollinator conservation. *Current opinion in insect science*, 38, 107-114.

Hallmann, C. A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H., ... & De Kroon, H. (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PloS one*, *12*(10), e0185809.

Healy, K. (2019). Using an escape-room-themed curriculum to engage and educate generation Z students about entomology. *American Entomologist*, 65(1), 24-28.

Holstermann, N., Grube, D., & Bögeholz, S. (2010). Hands-on activities and their influence on students' interest. *Research in science education*, 40, 743-757.

Johansson, M., Sjöström, M., Karlsson, J., & Brännlund, R. (2012). Is human fear affecting public willingness to pay for the management and conservation of large carnivores? *Society & Natural Resources*, 25(6), 610-620.

Kaiser, F. G., Roczen, N., & Bogner, F. X. (2008). Competence formation in environmental education: Advancing ecology-specific rather than general abilities. *Umweltpsychologie*, 12(2), 56-70.

Kals, E., Schumacher, D., & Montada, L. (1999). Emotional affinity toward nature as a motivational basis to protect nature. *Environment and behavior*, *31*(2), 178-202.

Kellert, S. R. (1993). Values and perceptions of invertebrates. *Conservation biology*, 7(4), 845-855.

Levac, D., Colquhoun, H., & O'Brien, K. K. (2010). Scoping studies: advancing the methodology. *Implementation science*, *5*, 1-9.

Lockwood, J. (2013). The infested mind: Why humans fear, loathe, and love insects. *Oxford University Press*.

Markee, A., Dansby, H., Messcher, R., Hernandez, E., Kawahara, A. Y., & Storer, C. G. (2021). Frass in the class: A model for fostering interest in the natural world through insect rearing in the classroom. *American Entomologist*, 67(3), 24-29.

Martín-López, B., Montes, C., & Benayas, J. (2007). The non-economic motives behind the willingness to pay for biodiversity conservation. *Biological conservation*, 139(1-2), 67-82.

Miller, J. R. (2005). Biodiversity conservation and the extinction of experience. *Trends in ecology & evolution*, 20(8), 430-434.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., The PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine*, 6(7), e1000097. https://doi.org/10.1371/journal.pmed100009.

Naeem, S., Chazdon, R., Duffy, J. E., Prager, C., & Worm, B. (2016). Biodiversity and human well-being: an essential link for sustainable development. *Proceedings of the Royal Society B: Biological Sciences*, 283(1844), 20162091.

Orians, G. H. (2017). Human behavioral ecology: 140 years without Darwin is too long. In Evolutionary perspectives on environmental problems (pp. 259-280). *Routledge*

Orr, D. W. (1993). Love it or lose it: The coming biophilia revolution. *St. R. Kellert and EO Wilson (Eds.), The Biophilia Hypothesis, Washington (Island Press) 1993, pp. 414-440.*

Peters, M. D., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., & Soares, C. B. (2015). Guidance for conducting systematic scoping reviews. *JBI Evidence Implementation*, *13*(3), 141-146.

Prokop, P., & Randler, C. (2018). Biological predispositions and individual differences in human attitudes toward animals. In Ethnozoology (pp. 447-466). *Academic Press*.

Prokop, P., Usak, M. & Fančovičová, J. Health and the avoidance of macroparasites: a preliminary cross-cultural study. *J Ethol* 28, 345–351 (2010). https://doi.org/10.1007/s10164-009-0195-3

Pyle, R. M. (1993). The Thunder Tree: Lessons from a Secondhand Land. Houghton Mifflin.

Samways, M. J. (2015). Future-proofing insect diversity. *Current opinion in insect science*, 12, 71-78.

Schönfelder, M. L., & Bogner, F. X. (2018). How to sustainably increase students' willingness to protect pollinators. *Environmental Education Research*, 24(3), 461-473.

Shipley, N. J., & Bixler, R. D. (2017). Beautiful bugs, bothersome bugs, and FUN bugs: Examining human interactions with insects and other arthropods. *Anthrozoös*, *30*(3), 357-372.

Sieg, A. K., & Dreesmann, D. (2021). Promoting Pro-Environmental BEEhavior in School. Factors Leading to Eco-Friendly Student Action. *Sustainability*, 13(12), 6598.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of business research*, *104*, 333-339.

Soga, M., & Gaston, K. J. (2016). Extinction of experience: the loss of human–nature interactions. *Frontiers in Ecology and the Environment*, 14(2), 94-101.

Soga, M., Evans, M. J., Yamanoi, T., Fukano, Y., Tsuchiya, K., Koyanagi, T. F., & Kanai, T. (2020). How can we mitigate against increasing biophobia among children during the extinction of experience? *Biological conservation*, *242*, 108420.

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS quarterly*, xiii-xxiii.

Weeks, F. J., & Oseto, C. Y. (2018). Interest in insects: the role of entomology in environmental education. *Insects*, 9(1), 26.

Wilson, E. O. (1984). Biophilia. Harvard University Press

Zhang, W., Goodale, E., & Chen, J. (2014). How contact with nature affects children's biophilia, biophobia and conservation attitude in China. *Biological Conservation*, 177, 109-116.

2