ATTITUDES AND PERCEPTIONS TOWARDS SNAKES: INFORMING CONSERVATION EDUCATION

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A THESIS SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS

GRADUATE PROGRAM IN PSYCHOLOGY, YORK UNIVERSITY,

TORONTO, ONTARIO

August 2025

Abstract

Public aversion to snakes poses a challenge to conservation efforts. This study explored how sociodemographic factors, emotional responses, and personal experiences influence attitudes toward snakes and willingness to engage in conservation education programs. A quantitative survey of 369 Canadian adults assessed emotional, experiential, and demographic predictors using validated and adapted measures. Regression analyses revealed that age, gender, religiosity, pet ownership, and direct experience significantly predicted attitudes. Fear and disgust emerged as distinct but overlapping predictors, with disgust exerting a stronger negative effect on conservation willingness. Participants with more positive attitudes were significantly more likely to express interest in education programs, especially live encounters. Findings suggest that tailored educational strategies addressing both emotional and demographic factors may enhance public support for snake conservation. This research contributes to the design of more effective conservation programs by identifying key predictors of public engagement and attitude change.

Keywords: Snake attitudes, Fear, Disgust, Conservation education, Public engagement, Wildlife perception, Conservation psychology

Dedication

This thesis is dedicated to my parents, Deborah Smith-Webber and Daniel Webber. Finding my path has been a journey in itself, and their unwavering support and encouragement have guided me every step of the way. To my mother, who has always been my rock and biggest cheerleader: thank you for everything you have done, and everything that you are.

Acknowledgements

I would first like to thank my supervisor, *Dr Suzanne MacDonald*. Suggesting this topic of study launched a passion and career path I might never have discovered otherwise. I am truly grateful for your insight, mentorship, and the invaluable opportunities you have provided throughout this process. It has been an absolute honour to learn from and work with you. I also want to thank you for your talent for reining in my perfectionism and reminding me that done is better than perfect.

Thank you to *Dr Kevin Kerr* for first envisioning the idea that became the foundation of this study, and for generously allowing me the opportunity to take it on and make it my own.

I'd like to thank my committee member *Dr Philip Chalmers* for the assistance with data analysis and coding. Your intuitive understanding of the statistical world is incredible, but even more so is your ability to teach and guide someone without a mathematical brain like mine.

I'd also like to thank my lab mate, *Ezekial Gading*. Your depth of knowledge and devotion to improving the world of animal welfare has been an inspiration since we met. Our long, philosophical debates were always a wonderful break to the endless writing and coding. Thank you for always being unapologetically you!

Lastly, I would like to thank *Dr Shayna Rosenbaum*. Your kind and generous offer to join the research team as an assistant is truly where my whole journey really began.

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1. Introduction

Snakes play a crucial role in maintaining the balance of ecology and biodiversity in different ecosystems. They contribute significantly to the regulation of animal populations, balancing the food web, and the overall health of their habitats (Cortés-Gomez et al., 2015; Liordos et al., 2018; Onyishi et al., 2021). Even though they are among the most at-risk animal groups worldwide, with potentially 20% of species threatened with extinction, their conservation has been insufficiently addressed (Tingley, Meiri & Chapple, 2016; Liordos et al., 2018).

The conservation of snakes is often undervalued and neglected due to widespread negative attitudes and perceptions held by the public. Many cultures harbor a strong fear and repulsion towards snakes, often stemming from a combination of evolutionary predispositions and learned behaviors (Öhman & Mineka, 2003; Özel, Prokop & Uşak, 2009). These negative attitudes impede conservation efforts and can lead to direct harm to snake populations through intentional killing or habitat destruction (Ballouard et al., 2013; Crawford & Andrews, 2016).

Addressing these issues necessitates a diverse strategy, particularly through conservation education programs. These programs aim to inform the public of the importance in protecting endangered species and providing guidance on behaviours and actions that can improve ecological welfare. Yet, the effectiveness of these programs in engaging those with negative attitudes toward snakes remains a subject of ongoing research and debate. Altering these attitudes and the resulting behaviors is even more difficult and continues to present a significant challenge within the field (Ardoin, Bowers, & Gaillard, 2020).

1.1 Importance and Conservation Status of Snakes

Snakes are essential to maintaining ecosystem balance, acting as both predators and prey. They regulate populations of various species, particularly rodents, which helps control disease transmission and prevents agricultural damage (Onyishi et al., 2021; Liordos et al., 2018). By maintaining this balance, snakes contribute to the health and stability of ecosystems. Their absence can cause significant disruptions, resulting in prey overpopulation and destabilized food webs (Seigel & Mullin, 2011; Cortés-Gomez et al., 2015).

Additionally, snakes serve as potential bioindicators of environmental health because of their sensitivity to habitat changes and pollutants. Snakes typically occupy relatively small home ranges, making them especially vulnerable to local changes in their environment (Bauerle et al.,

1975). This means that bioaccumulation of contaminants can be traced to a specific location, allowing researchers to study pollution levels and how the area is being affected (Bauerle et al., 1975; Beaupre & Douglas, 2011).

It is estimated that between 12%-20% of extant snake species are at risk of extinction (Böhm et al., 2013; Tingley, Meiri & Chapple, 2016). However, this figure is ill-informed, as reptiles are often overlooked in global conservation assessments. Despite making up roughly one-third of all land vertebrate species, the conservation status of reptiles remains grossly understudied (Ananjeva et al., 2015; Tingley, Meiri & Chapple, 2016; Roll et al., 2017). Of the over 10,000 reptilian taxa recognized by the International Union of Conservation of Nature (IUCN), only around 4700 have been assessed (Tingley, Meiri & Chapple, 2016). While some species may be difficult to locate, contributing to data deficiencies, this gap in knowledge may also reflect broader public disinterest in reptile conservation due to negative attitudes.

Snake populations face numerous threats primarily due to human activities. Environmental alterations such as deforestation, pollution, and the destruction of natural ecosystems, including wetlands, significantly impact their populations. Climate change disrupts reproductive processes and habitat suitability, particularly for species who maintain a small home range (Bauerle et al., 1975; Lourenço-de-Moraes et al., 2019). Additionally, increased instances of snakes being killed by humans and their pets further decrease their likelihood of survival (Gibbon et al., 2000). The pet trade and unsustainable harvesting for skins, meat, and medicine also contribute to population declines, especially for species targeted for their unique appearances or perceived medicinal properties (Klemens & Thorbjarnarson, 1995; Gibbon et al., 2000; Böhm et al., 2013; Auliya et al., 2016). Furthermore, invasive species pose significant threats by introducing competition and predation pressures, disrupting local ecosystems (Gibbon et al., 2000). For instance, research on the invasive small Indian mongoose in Croatia revealed that snake populations were dramatically reduced only on islands where the mongoose had become established, likely due to predation (Barun, Simberloff, & Budinski, 2010).

1.2 Cultural and Sociodemographic Influences on Snake Attitudes

1.2.1 Historical and Cultural Representations of Snakes

Snakes have a rich history of representation in human culture, both positive and negative. Bierlein (1994) found that snakes appear in global myths more frequently than any other animal. In many cultures, snakes are revered as sacred beings or bringers of good luck (Liordos et al., 2018). For example, ancient Egyptians considered the cobra a symbol of protection, knowledge, and life. However, numerous myths also depict snakes as malevolent creatures (Liordos et al., 2018). One of the most notable examples is in the stories of Judeo-Christian tradition, where the serpent in the Garden of Eden represents evil and sin (Ménez, 2003; Alves et al., 2014). Studies have found direct links between highly negative attitudes towards snakes and an individual's beliefs in myths/folklore regarding these animals (Ceríaco, 2012; Pandey et al., 2016; Onyishi et al., 2021). For instance, Ceríaco (2012) reported that folklore and misconceptions were significantly correlated to negative values and an increased likelihood of persecuting reptiles. Similarly, Onyishi et al. (2021) found the belief that snakes are evil was associated with significantly lower levels of tolerance.

1.2.2 Sociodemographic Influences on Snake Perceptions

Various sociodemographic factors influence attitudes towards snakes, including gender, education, nationality, age, and personal experiences. There are noticeable trends in attitudes towards snakes based on gender. Men tend to report that they feel more at ease with reptiles, whereas women tend to demonstrate greater levels of fear and negativity towards snakes (Pinheiro et al., 2016; Liordos et al., 2018; Castillo-Huitrón, 2020; Ogle & Devlin, 2022). A study by Alves et al. (2014) found that 74% of women reported fear of snakes, compared to 32% of men. This gender disparity is evident from childhood, with girls showing more adverse perceptions towards snakes than boys (Ballouard et al., 2013; Liordos et al., 2018). Interestingly, although females show more unfavourable opinions towards "dangerous" animals, they are consistently shown to be more supportive of conserving and less inclined to harm them (Kellert, 1985; Zinn & Pierce, 2002; Liordos et al., 2018).

Education level may also impact how people perceive snakes, although contradicting evidence makes it difficult to decisively determine its effects. Ogle and Devlin (2022) found that individuals with postsecondary degrees were less comfortable around reptiles compared to those who only completed high school. While there are many possible explanations for this effect, one consideration is that higher education is often associated with urban living, which may contribute

to lower familiarity and comfort with reptiles. In contrast, Pinheiro et al. (2016) noted that higher education resulted in less negative attitudes. It is possible that a confounding factor may be involved, such as environmental knowledge, which has also been shown to positively influence snake tolerance (Burt & Jacobson, 2012). Additionally, it may be that knowledge of snakes helps dispel fear based on inaccurate information or myths but further promotes reasons to be concerned about the dangers and risks associated with them (Burt & Jacobson, 2012).

Age is another factor influencing attitudes towards snakes. Dislike of snakes can be found in people of all ages, including young children (Mullin & Seigel, 2009; Prokop & Tunnicliffe, 2010). While not explored in depth compared to other demographic factors, a study by Lobue & Delouche (2008) showed that older adults, specifically those with less education, were less tolerant of snakes compared to younger adults with higher education.

Nationality, locality, and social conditioning can significantly shape attitudes towards snakes. In areas where venomous snakes are more prevalent, children are more likely to fear snakes (Ballouard et al., 2013). Parental influence also plays a role, through communication and experiences. Discussing snakes in a negative manner may foster phobias in children, who rely on adults for safety and protection (Conrad et al., 2021). Additionally, keeping pets and positive encounters with snakes are associated with decreased fear of snakes (Özel, Prokop, & Uşak, 2009; Ballouard et al., 2013; Pinheiro et al., 2016; Onyishi et al., 2021; Ogle & Devlin, 2022). However, parents who harbor their own fears or negative beliefs may avoid providing these positive experiences, denying their children exposure to potentially beneficial influences.

1.2.3 Media Representations of Snakes

Media representations of snakes frequently perpetuate harmful stereotypes, which in turn shape public views. Films, books, and news stories frequently depict snakes in a negative light, exacerbating fears and misconceptions (Bombieri et al., 2018; Geest, Knoch, & Shufran, 2021; Le Busque & Litchfield, 2023). This portrayal reinforces cultural biases, presenting snakes as dangerous and undesirable creatures, ultimately hindering conservation efforts (Ballouard et al., 2013; Bombieri et al., 2018). Snakes are commonly cast as villains in media, contributing to their negative perception (Geest, Knoch, & Shufran, 2021; Le Busque & Litchfield, 2023). Iconic movies, such as Anaconda, Raiders of the Lost Ark, and Snakes on a Plane, often depict snakes as deadly obstacles or enemies, instilling fear and reinforcing harmful stereotypes (Le Busque &

Litchfield, 2023). Moreover, news reports on snake encounters tend to sensationalize these events, emphasizing danger and fear rather than providing balanced information (Bombieri et al., 2018). This biased portrayal can perpetuate a cycle of fear and misunderstanding, inaccurately raising risk perception and making it challenging to promote positive attitudes towards snakes and their conservation. A study of snake venom mortality rates in 2019 found that about 63,400 people died globally from snake bites, or 0.8 deaths per 100,000 people (Roberts et al., 2022). Importantly, India alone accounted for 51,100, or 81%, of those deaths, largely in areas that are too remote to access antivenom (Roberts et al., 2022). Greene et al. (2021) found that while there are between 5000-10,000 annual venomous snake bites in the United States, only 101 resulted in fatality over 30 years (1989-2018). In terms of death by constrictor species, occurrences appear to be so rare that accurate numbers are difficult to source.

1.3 Psychological Foundations of Fear and Disgust

1.3.1 Evolutionary Basis of Fear Responses to Snakes

The fear of snakes, or ophidiophobia, is believed to have strong evolutionary origins (Öhman & Mineka, 2003; Mullin & Seigel, 2009). Historical encounters with venomous snakes have likely influenced our responses, tracing back to early human life in Africa where differentiating between harmful and harmless species was challenging. In such environments, natural selection may have favored individuals who could quickly detect any snake, leading to a general caution towards these reptiles (Mullin & Seigel, 2009).

Research on nonhuman primates supports the theory of an innate basis for snake fear, suggesting that humans could have inherited this trait from their evolutionary ancestors. Studies on bonnet macaques, for example, demonstrate that these primates maintain a safe distance from all types of snakes, regardless of the individual species' risk level. This behavior is consistent across most age groups, indicating a strong innate component (Ramakrishnan et al., 2005). The only group to display less aversion is infant macaques, who initially display curiosity rather than fear when encountering snakes. However, they quickly become cautious, shifting their attention away from the snakes, which suggests a combination of innate recognition and learned behavior (Ramakrishnan et al., 2005). This pattern is reinforced by maternal actions that limit curiosity towards snakes, supporting the idea that both instinctive and learned behaviors are involved

(Burghardt et al., 2011). Moreover, vervet monkeys have developed specific alarm calls for different predators, including snakes. These calls are used primarily for dangerous snakes such as pythons, mambas, and cobras, but not for harmless reptiles, indicating a sophisticated level of predator recognition. Even infant vervets broadly apply these alarm calls to snake-like objects, suggesting that the recognition develops at an early stage, though learning is required for accuracy (Seyfarth, Cheney & Marler, 1980).

Early studies showed that human adults were able to visually detect threat-relevant stimuli, specifically snakes, faster than nonthreatening images (Öhman, Flykt & Esteves, 2001). To determine if this bias is learned or predisposed, LoBue & DeLoache (2008) tested both adults and children. Results showed that even young children had faster detection of snakes, underscoring the evolutionary theory of snake detection (LoBue & DeLoache, 2008). It has been noted that detection studies typically do not use other reptile species, such as lizards or crocodilians, which would aid in determining how specific these biases are (Burghardt et al., 2011). Taken together, this evidence collectively points to a deep evolutionary basis for snake fear, involving both innate predispositions and learned behaviors. Understanding these evolutionary roots is essential for developing effective conservation education strategies that address both instinctive and cultural aspects of snake fear.

1.3.2 Distinction Between Fear and Disgust Towards Snakes

Effectively distinguishing between fear and disgust can significantly influence our understanding of attitudes towards snakes and determining how to address them. Fear and disgust elicit distinct physiological and psychological responses and may require different approaches to mitigate or change these reactions (Polák et al., 2020). While fear is connected to perceived danger, disgust arises from aversion to appearance, features, and lack of cleanliness (Klieger & Siejack, 1997; Polák et al., 2020). Women consistently show higher levels of disgust across all disgust-provoking stimuli tested, yet the understanding of the causes behind this pattern are poorly understood (Rohrmann, Hopp & Quirin, 2008; Al-Shawaf, Lewis, & Buss, 2018). Evolutionary accounts suggest that ancestral responsibilities for childcare and food preparation selected for heightened contamination sensitivity in females (Al-Shawaf et al., 2018). If biology were the sole cause, however, one would expect parallel gender differences in physiological indicators of disgust, which are not consistently observed (Rohrmann, Hopp, &

Quirin, 2008). Rohrmann, Hopp, & Quirin (2008) found that although women reported stronger disgust, their physiological responses did not differ significantly from men's, implying additional psychological and social influences. Men may be more likely to suppress intense emotions, and cultural norms may make expressions of disgust more acceptable for women, reinforcing the observed self-report gap (Rohrmann, Hopp, & Quirin, 2008).

Larger predatory species like lions and bears typically elicit fear due to the immediate physical threat they pose, while disgust tends to be associated with small animals thought to carry diseases (Polák et al., 2020). The aesthetics of an animal has been found to be an important factor in whether it is rated highly for fear or disgust. Reptiles lacking legs, dull in colour, and perceived to be less visually appealing are significantly more likely to generate disgust (Janovcová et al., 2019; Castillo-Huitrón et al., 2020). Contrastingly, snakes with bright colours and interesting patterns tend to be highly feared even though they are described as beautiful (Castillo-Huitrón et al., 2020). These dual emotional responses can create a particularly strong aversion, making it more challenging to change negative attitudes towards snakes. Understanding this distinction is important for developing targeted conservation education programs and can indicate whether prioritizing myth-busting around safety or addressing aesthetic aversions will be more successful (Polák et al., 2020).

1.3.3 Impact of These Emotions on Attitudes and Behaviors

Public attitudes toward snakes have direct consequences for their conservation. Feelings of fear, disgust, and cultural beliefs associating snakes with evil all contribute to a low public tolerance for snakes as well as a higher likelihood of intentionally killing a snake when encountered (Ceríaco, 2012; Onyishi et al., 2021). Lower tolerance and negative attitudes towards snakes were found to be positive predictors of supporting their conservation (Pinheiro et al., 2016; Liordos et al., 2018). Research indicates that an individual's emotional response to a particular animal directly influences their willingness to support protecting that species (Liordos et al., 2018). For example, a person's positive or negative feelings towards various animal species directly correlated with their likelihood of wanting to provide funds towards conservation programs for those species (Martín-López, Montes, & Benayas, 2007).

Fear and negativity towards snakes often result in deliberate harm. Drivers are more likely to intentionally run over a snake and show less remorse or upset towards these collisions

than with any other animal (Langley, Lipps, & Theis, 1989; Paul Ashley, Kosloski, & Petrie, 2007; Crawford & Andrews, 2016). Furthermore, negative attitudes can impede the implementation of effective conservation measures, as fear and misinformation reduce public support for these initiatives (Seigel & Mullin, 2011).

Given that personal attitudes appear to be a stronger driver of conservation support than factual ecological knowledge, improving public snake perceptions is crucial for generating support for snake protection programs (Martín-López, Montes, & Benayas, 2007). Therefore, conservation educators must find effective ways to involve and positively influence people who express fear or dislike of snakes through their programs.

1.4 Measuring Snake Attitudes

Measuring public attitudes towards snakes helps in understanding and addressing the widespread fear and aversion that impact snake conservation efforts. Several psychometric tools have been developed and validated to assess fear and disgust towards snakes, each contributing to a more nuanced understanding of these emotions.

The Snake Anxiety Questionnaire (SNAQ) is a widely used tool designed to measure specific fears related to snakes. Introduced by Klorman et al. (1974), the SNAQ comprises 30 true-or-false statements that participants respond to, reflecting their attitudes towards snakes. While the SNAQ is effective in identifying individuals who report fear of snakes, Klieger and Siejak (1997) identified a significant limitation in its ability to accurately detect true ophidiophobia. Their study revealed that many individuals with high SNAQ scores did not display corresponding behavioural avoidance when presented with a live snake, suggesting the presence of a confounding variable. Klieger and Siejak (1997) demonstrated that participants with high self-reported fear also exhibited elevated disgust sensitivity, such as heightened discomfort when handling objects associated with snakes, including a neutral pen that had been placed in a snake's terrarium. These participants often showed facial expressions of disgust yet approached snake-related stimuli without significant hesitation. This pattern indicates that the SNAQ may capture disgust reactions that are misinterpreted as fear, leading to false-positive classifications of ophidiophobia. Consequently, the SNAQ may overestimate the prevalence of snake fear by conflating disgust-based aversion with true fear-based avoidance behavior.

Developed by Özel, Prokop, and Uşak (2009), the Snake Attitude Questionnaire (SAQ) is an adaptation of similar Attitude Questionnaires for other common phobic animals. The SAQ is made up of 58 Likert scale statements that assess various dimensions of snake attitudes, knowledge, and beliefs. The *negativistic* dimension evaluates if dislike or fear result in deliberate avoidance. The *scientistic* dimension measures enthusiasm for biology and the desire to learn more about snakes. The *naturalistic* dimension evaluates participants' enthusiasm for hands-on interactions with snakes and their interest in exploring nature. The *ecologistic* dimension gauges concern for the ecological role of snakes and their interactions with humans. Consideration of cultural and demographic factors was highlighted in the interpretation of SAQ results, as they can be significantly influential. University student participants were often found to have high levels of dislike or fear and showed little interest in direct interaction with snakes. Factors such as nationality, pet ownership, gender, and study major were all associated with varied attitude ratings (Özel, Prokop & Uşak., 2009).

The Disgust Scale-Revised (DS-R), adapted by Olatunji et al. (2007) from the original scale created by Haidt, McCauley, and Rozin (1994), assesses disgust sensitivity in relation to different groups of disgust-inducing stimuli, including animals, food, and body products. Research using the DS-R in snake attitude studies has shown that disgust can significantly influence fear responses, with some individuals exhibiting high disgust towards snakes despite low fear (Rádlová et al., 2020). This highlights the importance of measuring both emotions to fully understand attitudes towards snakes. Rádlová et al. (2020) used both the SNAQ and Disgust Scale-Revised (DS-R) to distinguish between fear and disgust responses in participants. Their findings indicated that individuals who reported high fear towards snakes also exhibited high levels of disgust, suggesting a complex interplay between these emotions.

1.5 Conservation Education Strategies

1.5.1 Providers of Conservation Education

Conservation education is delivered through various platforms and organizations, each playing a crucial role in raising awareness and promoting sustainable behaviors. Many educational plans now incorporate environmental topics, aiming to educate students about biology, ecology, and conservation. While these curricula often outline broad areas of study, the

specific methods and lessons are typically left to the discretion of individual teachers. This approach allows for flexibility in teaching styles but can result in varying levels of emphasis on key topics such as conservation (Jacobson, 2010). Educators with an aversion to snakes are less inclined to incorporate them into their teaching plans, emphasizing the importance of including teachers in conservation education programs (Torkar, 2015).

Conservation agencies and organizations engage the public through outreach and education. They utilize publications, community dialogues, and educational programs, to raise awareness about conservation issues and promote conservation behaviours. Many modern zoos and aquariums are increasingly focusing on educating the public about global wildlife and encouraging pro-conservation behaviors. While entertainment remains a priority for many visitors, the educational aspect is also highly valued (Ballantyne & Packer, 2005, 2016). These institutions employ various methods to engage audiences, such as informative signs, animal interactions, shows, and education programs. Despite these efforts, some environmentalists criticize zoos for keeping animals in captivity. This criticism has led to a rise in non-captive wildlife tourism, such as safaris and birdwatching tours, which are seen as more ethical alternatives (Ballantyne et al., 2007).

Universities contribute significantly through research and community partnerships, linking scientific findings with public education to promote conservation awareness and engagement. Research institutes often involve both the scientific community and the public to broaden knowledge and extend their reach (Brewer, 2002; Merenlender et al., 2016).

Local organizations implement culturally relevant programs that resonate with community members, enhancing the impact of conservation education and making issues more relatable (Brewer, 2002). Digital platforms significantly expand the reach of environmental education by engaging audiences that may not participate in traditional activities such as visiting zoos or attending school courses. Social media, in particular, serves as a primary source of information on conservation issues for many people, making information, solutions, and policies accessible and understandable to those who might not otherwise encounter this content (Robelia, Greenhow, & Burton, 2011; Andersson & Öhman, 2017; Loury et al., 2021). Although some argue that the best way to encourage pro-conservation behaviors is through direct sensory experiences in nature, digital tools can complement these activities and provide opportunities for

involvement to those unable to physically participate (Greenwood & Hougham, 2015; Schönfelder & Bogner, 2017).

1.5.2 Types and Evaluation of Conservation Education Programs

Conservation education programs vary widely, targeting different audiences and employing various methods to foster environmental awareness and sustainable behaviors. Evaluating these programs is essential to ensure their effectiveness and refine strategies for maximum impact.

Formal education programs integrated into school curricula aim to cultivate essential ecological knowledge and foster positive conservation attitudes. Utilizing various techniques, these initiatives engage students and promote critical environmental thinking (Jacobson, 2010). The choice of teaching methods significantly affects the outcomes of these lessons, particularly when it comes to snakes. Studies indicate that for animals perceived as dangerous to humans, merely providing factual biological knowledge is insufficient to positively influence attitudes (Morgan, 1989; Slagle et al., 2013; Torkar, 2015). This may be because understanding the potential dangers these species pose can transform an "irrational" fear into a "rational" one. Slagle et al. (2013) found that including explanations about the ecological and economic benefits that black bears, another species that locals often view with caution, to nearby communities significantly increased tolerance towards conservation efforts for this species.

Research shows that interactive, hands-on activities greatly enhance students' understanding and attitudes of negatively viewed species (Prokop & Fančovičová, 2017; Kos, Jerman & Torkar, 2023). Programs featuring live animal encounters or nature explorations report increased student engagement and pro-conservation behaviors (Ballouard et al., 2012). Such experiences are crucial for fostering a deeper connection to nature, which is essential for lifelong conservation commitment (Skupien, 2016). However, challenges like inadequate teacher training and limited resources can hinder the effective delivery of environmental content (Jacobson, 2010).

Outreach programs are vital in raising public awareness and engaging diverse audiences in snake conservation by reaching people in informal and unique settings outside traditional education channels. These programs include a range of approaches, such as community action projects and citizen science initiatives, interactive workshops and public lectures, and mobile

education units that bring conservation education directly to people in their everyday environments.

Community action projects and citizen science initiatives actively involve local populations in activities such as habitat restoration, wildlife monitoring, and data collection. These efforts foster a sense of community ownership and enhance investment in conservation outcomes (Merenlender et al., 2016). These programs not only expand ecological knowledge but also encourage ongoing pro-environmental behaviors among participants (Merenlender et al., 2016). By engaging participants in the design and execution of research, such as field studies and monitoring projects, these initiatives contribute to scientific knowledge and build a deeper personal connection to conservation (Bolt & Schreier, 2023). Reliance on volunteer participation in citizen science can result in data quality issues and inconsistencies, and may not fully engage all demographic groups, limiting overall effectiveness (Merenlender et al., 2016; Brown & Williams, 2019; Hadad et al., 2023).

Mobile conservation education units deliver interactive experiences to communities with limited access to mass media or low income/education levels. These units increase conservation awareness, with evaluations indicating improvements in participants' knowledge towards wildlife (Hansel et al., 2010). Media and technology-based programs are also essential in snake conservation education, offering innovative ways to engage diverse audiences. Social media serves as a powerful tool for fostering discussions and encouraging pro-environmental behaviors. Platforms like Facebook have shown success in increasing users' knowledge and motivation to engage in conservation activities (Robelia, Greenhow & Burton, 2011; Chung et al., 2020). Video resources, including short clips and documentaries, effectively convey complex ecological topics. These formats engage audiences visually and emotionally, making environmental issues more relatable and accessible (Chung et al., 2020).

eLearning platforms have proven effective, as demonstrated by Schönfelder & Bogner (2017), who evaluated the effects of using an online learning platform compared to live bee encounters in students. Both approaches successfully increased conservation knowledge, with eLearning particularly engaging those with initially low environmental interest. This highlights the potential of digital platforms to educate without the constraints of physical interaction.

Podcasts broaden the scope of conservation education, enabling audiences to access information in a convenient format that suits multitasking lifestyles. They have the potential to

engage diverse listener groups, including those who may not participate in more traditional educational formats, such as workshops, lectures, or field experiences. Moreover, podcasts offer an alternative mode of learning for individuals with high levels of fear or aversion to direct encounters with wildlife or visual content, allowing them to engage with conservation topics in a less intimidating manner (Strickland, 2021).

Looking to the future, emerging technologies such as augmented reality (AR) promise even more engaging and interactive educational experiences, potentially enhancing conservation outcomes (Buchanan, Pressick-Kilborn & Maher, 2018).

While media and technology-based programs offer significant advantages, they also face several challenges. Critics argue that these programs may lack the richness of direct, sensory experiences in nature, which can be essential for fostering meaningful, long-term behavior change (Greenwood & Hougham, 2015). To maximize their impact, digital tools should be used in combination with direct experiences whenever feasible. Nonetheless, the ability to reach large audiences and raise awareness about conservation efforts should be considered a net positive overall.

Educational displays in zoos, aquariums, and museums are crucial for conservation education. They include traditional signage and interactive elements, all designed to enhance visitor understanding of ecological issues. Traditional signage provides foundational information about wildlife, such as snake behavior and habitat conservation. These displays convey essential facts and context, complementing interactive elements and ensuring that all visitors can engage with the content (Ballantyne & Packer, 2016). Interactive exhibits, including touch screens, educational activities, and augmented reality, offer engaging ways to explore complex topics. These hands-on experiences help visitors form connections with the natural world, fostering empathy and promoting conservation awareness (Lindemann-Matthies & Kamer, 2006). Research shows that educational displays significantly improve visitor engagement and knowledge retention, with interactive components, in particular, encouraging longer interactions, making complex topics more accessible and enjoyable (Lindemann-Matthies & Kamer, 2006). However, critics note that interactive displays can sometimes oversimplify issues or distract visitors from engaging with the live animals (Webber et al., 2017). Additionally, maintaining technology and ensuring accessibility for all visitors can be challenging.

Direct wildlife experiences, including animal shows, feeding programs, one-on-one encounters, and wildlife tourism, play a significant role in conservation education. These interactions allow visitors to engage closely with animals, enhancing their understanding and empathy for wildlife. Animal shows and feeding programs in zoos and aquariums engage audiences by showcasing behaviors and providing entertainment. These experiences increase visitor interest and knowledge about conservation issues (Randler, Ilg, & Kern, 2005). Observing animals up close helps visitors develop a deeper connection, fostering positive attitudes towards conservation (Ballouard et al., 2012). However, ethical concerns exist regarding potential mistreatment, exploitation and the promotion of unnatural behaviors for entertainment (Ballantyne et al., 2007). Ensuring that these programs prioritize education and animal welfare is crucial (Spooner et al., 2019).

One-on-one encounters offer participants personal experiences with animals, such as handling snakes or participating in guided nature activities. These direct interactions are effective in reducing fear and increasing empathy, leading to more favorable attitudes towards conservation (Ballouard et al., 2012; Prokop & Fančovičová, 2017; Kos, Jerman & Torkar, 2023). Such encounters provide memorable learning opportunities that deeply impact participants' views on wildlife.

Wildlife tourism, including safaris and bird-watching tours, provides unique opportunities to observe animals in their natural habitats and mitigate many ethical issues of captive animal shows. These activities promote a greater appreciation for biodiversity and conservation efforts (Ballantyne et al., 2007). Direct encounters in the wild can reduce negative attitudes and increase commitment to conservation (Skupien, 2016). However, the potential environmental impacts and the risk of disturbing wildlife must be managed carefully.

1.5.3 Designing Conservation Education Programs

Effective conservation education programs are essential in fostering public understanding and support for wildlife preservation. Designing impactful programs involves integrating essential components that engage participants and foster long-term behavioural change.

The first step in designing an effective conservation education program is understanding the target audience. This involves conducting a comprehensive audience analysis to identify the demographic characteristics, knowledge levels, attitudes, and motivations of the intended

participants. Factors such as age, gender, educational and economic background, cultural beliefs, and prior experiences with wildlife are valuable in determining how effectively specific fears and misconceptions can be addressed (Jacobson & McDuff, 1997; Burghardt et al., 2011). Additionally, it is strategic to focus on individuals who do not have deep-seated snake phobias, as they are more likely to be receptive to changing their attitudes and behaviors. While increased knowledge can reduce fear and indifference in some people, truly phobic individuals often require therapeutic interventions beyond the scope of educational programs (Burghardt et al., 2011).

Effective conservation education programs should be tailored to meet the specific needs of their target audience, community, and environment. Involving the audience and local communities in the development and implementation of these programs can enhance relevance, foster engagement, and improve the chances of successful outcomes and sustained support (Jacobson, 2010). An essential aspect of designing these programs is understanding the local ecological context and identifying specific conservation challenges faced by the community, while also aligning with cultural and societal norms. For example, the Wildlife Acceptance Capacity (WAC) represents the maximum level of wildlife a community is willing to tolerate, which can be influenced by factors such as perceived damage, danger, or value associated with a species (Decker & Purdy, 1988). By assessing a community's WAC, organizations can identify which localities are more likely to support and participate in conservation efforts (Espinosa & Jacobson, 2012).

Engaging stakeholders, including community leaders, educators, conservationists, and local government officials, is essential in the program design process. Stakeholder consultation ensures that the program is relevant, culturally sensitive, and supported by those who play a critical role in its implementation and sustainability (Kainer et al., 2009).

The educational content of conservation programs should be well-researched, accurate, and engaging. It should cover key ecological concepts, the importance of conservation, and practical ways individuals can contribute to wildlife preservation. Developing a robust curriculum involves selecting appropriate content that covers both theoretical and practical aspects of conservation. The curriculum should include interactive and experiential learning activities that foster critical thinking and problem-solving skills.

To achieve long-term conservation goals, programs must incorporate strategies that encourage behavioural change. This involves using theoretical frameworks to understand and influence behavior, designing practical activities that promote conservation actions, and implementing monitoring and reinforcement techniques to sustain these behaviors (Maynard et al., 2020). Theoretical frameworks, such as the Theory of Planned Behavior, can provide valuable insights into how attitudes and behaviors are formed and changed. These frameworks can guide the development of interventions that target specific behaviors and promote positive conservation actions (Ajzen, 1985).

Effective implementation of conservation education programs involves careful planning and coordination. This includes training educators and facilitators, developing a detailed schedule and timeline, and ensuring that the necessary facilities and resources are available. Training educators and facilitators is essential to ensure that they are well-prepared to deliver the program content effectively. Training should cover both the theoretical aspects of conservation education and practical teaching techniques (Jacobson, 2010).

Developing a detailed schedule and timeline helps ensure that the program is implemented smoothly and efficiently. This includes planning the timing of activities, setting milestones, and coordinating with stakeholders (Moss & Esson, 2013). Selecting appropriate locations and facilities for program activities is important for providing a conducive learning environment. This can include schools, community centers, nature reserves, and online platforms (Ballantyne & Packer, 2016).

Incorporating evaluation criteria from the start is crucial for assessing the program's effectiveness and making necessary improvements. Evaluation should measure both short-term and long-term outcomes, including knowledge gains, attitude changes, and behavioural impacts. Developing a comprehensive monitoring and evaluation plan ensures that the program's progress is tracked, and its impact is assessed (Jacobson & McDuff, 1997; Thomas et al., 2019). This plan should outline the evaluation methods, data collection tools, and key indicators of success (Ardoin, Bowers, & Gaillard, 2020). Integrating evaluation criteria into the program design helps ensure that the program's goals and objectives are met. This involves setting clear benchmarks and using both qualitative and quantitative methods to measure outcomes (Ballantyne & Packer, 2007).

Ensuring the sustainability and adaptability of conservation education programs is essential for their long-term success. This involves developing maintenance plans, adapting to changing needs and conditions, and securing funding and resources. Developing long-term maintenance plans helps ensure that the program continues to operate effectively over time. This can include regular updates to the curriculum, ongoing training for educators, and continuous engagement with the community (Jacobson & McDuff, 1997). Conservation education programs must be flexible and adaptable to changing needs and conditions. This involves regularly reviewing and updating the program content and delivery methods to ensure they remain relevant and effective (Buxton et al., 2021). Securing funding and managing resources effectively is crucial for the sustainability of conservation education programs. This can involve seeking grants, forming partnerships, and developing fundraising strategies to support the program's activities (Ballantyne et al., 2007).

Effective communication and outreach are essential for raising public awareness and support for conservation education programs. This includes using various media platforms, organizing public awareness campaigns, and disseminating the program's results and achievements. Organizing public awareness campaigns can help raise the profile of conservation issues and encourage community involvement. These campaigns should use engaging and accessible messaging to reach a broad audience (Chung et al., 2020). Maintaining a strong social media and online presence is important for reaching a wider audience and promoting the program's activities. This can include creating informative and engaging content, using social media platforms, and developing a dedicated website (Robelia, Greenhow, & Burton, 2011). Reporting and disseminating the results of conservation education programs helps build credibility and attract support. This can involve publishing reports, presenting findings at conferences, and sharing success stories with the community (Ballouard et al., 2012).
By incorporating these elements, conservation education programs can effectively engage participants, foster positive attitudes towards wildlife, and promote sustainable behaviors that support conservation efforts.

1.5.4 Evaluating Conservation Programs

The evaluation of conservation programs is a critical component in ensuring their success and justifying the allocation of limited funds. Effective evaluation provides essential

accountability, demonstrating the worth of programs to funding sources, the community, and other stakeholders (Jacobson, 1991). Despite its importance, comprehensive assessment is often absent from many conservation education programs, leading to less effective outcomes. Programs incorporating systematic evaluation tend to achieve significantly higher success rates (Jacobson & McDuff, 1997).

A primary challenge in evaluating conservation programs lies in aligning the types of issues addressed with appropriate success metrics. This alignment is crucial to accurately measure and report outcomes, thereby refining and improving future programs (Thomas et al., 2019). Evaluating both successes and failures can reveal institutional barriers and processes that contribute to more positive conservation outcomes (Buxton et al., 2021).

However, data collection, monitoring, and management practices remain inconsistent, complicating the sharing of valuable information among government departments, jurisdictions, researchers, and the public (Buxton et al., 2021). These inconsistencies hinder the ability to form a cohesive understanding of program effectiveness across different contexts and settings. Methodological challenges further complicate the evaluation process. For instance, the effect sizes of conservation messages may be small because visitors tend to focus more on animals than on the educational content provided (Ballantyne et al., 2007). Additionally, while changes in visitors' knowledge and intentions regarding conservation can be measured on-site, tracking actual behavior changes over time proves more difficult (Ballantyne et al., 2007).

The empirical literature often emphasizes behavioural antecedents due to the inherent difficulties in documenting environmental improvements and linking these outcomes directly to educational interventions. This challenge underscores the need for robust frameworks that can trace causal links from educational programs to broader social and environmental impacts (Ardoin, Bowers, & Gaillard, 2020).

To address these challenges, conservation education programs must integrate evaluation criteria from the start, ensuring ongoing assessment and adaptability. By systematically accounting for both successes and failures, and by improving data consistency and methodological approaches, conservation programs can enhance their effectiveness, ultimately contributing to more sustainable and impactful conservation efforts.

1.6 Gaps in Current Research and Knowledge

Current research on public attitudes towards snakes has illuminated various factors influencing these attitudes, yet several significant gaps persist. Addressing these gaps is crucial for the development of effective conservation strategies and educational programs. My study aimed to address the following specific gaps.

One major gap is the lack of comprehensive exploration into how cultural, gender, educational, and national backgrounds influence perceptions of snakes. While studies have noted general trends, such as women exhibiting higher levels of fear and negativity towards snakes compared to men, and individuals with higher education levels showing more discomfort around reptiles, these findings are not deeply nuanced. My study aimed to survey diverse demographic groups and analyze how these sociodemographic factors interact and influence attitudes towards snakes across different cultural contexts (Alves et al., 2014; Ogle & Devlin, 2022; Ballouard et al., 2013).

Another significant gap is the limited research differentiating between fear and disgust towards snakes and how these emotions impact conservation attitudes. While it is established that both fear and disgust contribute to negative perceptions of snakes, the specific emotional drivers and their distinct impacts on attitudes towards conservation are not well understood. My study aims to distinguish between fear and disgust in survey questions and analyze the specific emotional drivers and their impacts on attitudes towards snake conservation (Polák et al., 2020; Castillo-Huitrón, 2020; Klieger & Siejack, 1997).

There is ongoing debate and limited empirical evidence regarding the effectiveness of conservation education programs in changing deeply rooted negative attitudes towards snakes. While some studies suggest that interactive, hands-on activities can enhance understanding and foster positive attitudes, others point out the lack of depth in these programs and their focus on theoretical knowledge rather than practical applications. My study evaluated various conservation education strategies and provided evidence-based recommendations for effective program design by assessing audience demographics and attitudes (Jacobson, 2006; Hughes, 2012; Ballouard et al., 2012; Skupien, 2016).

Research on the correlation between public attitudes towards snakes and their willingness to engage in conservation efforts is sparse. Understanding this relationship is vital as positive attitudes towards wildlife are often linked to greater support for conservation initiatives. My

study aims to assess the likelihood of public participation in snake conservation programs and correlate willingness to participate with attitudes towards snakes (Martín-López et al., 2007).

Finally, there is insufficient detailed analysis of how personal experiences and media representations influence attitudes towards snakes. While it is known that positive personal encounters with snakes can lead to higher levels of tolerance, and negative media portrayals can exacerbate fears, the extent and mechanisms of these influences are not thoroughly explored. My study included survey questions on personal experiences with snakes and other animals, as well as analyze the impact of media representations on attitudes towards snakes (Ballouard et al., 2012; Geest et al., 2021).

To address these gaps, this study aimed to examine the factors that shape public attitudes towards snakes, including the distinct emotional roles of fear and disgust, and how these perceptions influence willingness to engage in conservation efforts. By exploring these relationships across diverse demographic and experiential backgrounds, this research seeks to provide evidence-based recommendations for conservation education programs that effectively address the negative attitudes impeding snake conservation.

1.7 Research Design and Approach

A quantitative survey approach was employed to investigate the relationships between demographic factors, beliefs, experiences, emotional responses, and conservation attitudes related to snakes. The survey incorporated a combination of validated measures and newly developed questions designed to explore gaps identified in the literature, including the specific influences of gender, religiosity, and personal experiences on fear, disgust, and conservation willingness. The study design enabled statistical analysis of how these factors interact and contribute to shaping public perceptions of snakes.

2. Methods

2.1 Participants and Sampling

Participants were recruited using a snowball sampling technique, leveraging social networks and community outreach to reach individuals who met the inclusion criteria of being adults aged 18 or older residing in Canada. Recruitment channels included social media

platforms, community bulletin boards, and sharing between individuals to broaden the recruitment network. This approach provided access to a diverse population, offering insight into variations in attitudes towards snakes across different sociodemographic groups. Although snowball sampling limits the generalizability of the findings due to potential sampling bias, it was deemed appropriate given the exploratory nature of the research and the challenges of recruiting participants for studies involving potentially aversive topics such as snake conservation.

2.2 Survey Instrument

The first set of questions focused on participants' backgrounds and experiences with animals, including their environments and prior encounters with snakes. These questions were divided into two parts. The first part asked about locations where participants might be more likely to encounter snakes. "I have lived in a ___ setting:", coded (1 = urban, 2 = rural, 3 = suburban)." and "Do you visit/own a cottage?" (1 = yes, 2 = no). These questions aimed to assess potential spaces where participants could encounter snakes. The second part asked about participants' experiences with animals in general and with snakes specifically. The question "Have you ever had pets?" (1 = yes, 2 = no) was included to gather information on participants past interactions with animals. If participants answered "Yes" to owning pets, they were prompted with "Which of the following pets have you lived with?" coded (0 = none, 1 = cats, 2 = dogs, 3 = birds, 4 = rodents, 5 = reptiles, 6 = amphibians, 7 = insects/arachnids, 8 = other, 9 = fish). Participants were able to fill in “other”, which resulted in a total of 17 categories. Another question asked, "What is your experience with snakes?” coded (1 = encountered snakes in wild, 2 = seen snakes at zoos/exhibits, 3 = met a snake, 4 = owned a snake, 5 = through media). These questions helped identify participants' familiarity and level of exposure to snakes and animals in general.

The second section evaluated participants' attitudes towards snakes using Likert-scale and multiple-choice questions. These questions were designed to understand emotional responses such as fear, disgust, and perceived danger. A 5-point Likert-scale (1 = strongly agree, 5 = strongly disagree) was used to assess general feelings towards snakes. Participants rated 7 statements according to this scale: “I am afraid of snakes”, “I like snakes”, “Snakes are disgusting”, “Snakes are cool”, “Snakes are creepy”, “Snakes make me feel uncomfortable”,

“Snakes are gross”. Throughout analysis, positively phrased statements were reverse coded. An 8th statement was included in the survey “Snakes are dangerous”, however an error within the Qualtrics system did not show it to respondents and therefore could not be used in subsequent analysis. Participants were categorized as having negative attitudes if they agreed with any of the five negative statements or disagreed with either of the two positive statements. If negative attitudes were indicated, participants were prompted with a multiple-select question: “I dislike snakes because:” (1 = they could be venomous, 2 = they scare me, 3 = I don’t know enough about them, 4 = I have had a bad encounter with a snake, 5 = they could hurt me, 6 = they carry diseases, 7 = the way they are presented in the media, 8 = the way they move/slither). Another 5-point Likert scale (1 = strongly agree, 5 = strongly disagree) comprised of 4 statements: “I can’t look at photos or videos of snakes”, “I enjoy seeing snakes at the zoo”, “Some snakes are very pretty to look at, “I am only scared of venomous snakes”.

The second section also explored beliefs about snakes, as such beliefs have been found to correlate with negative attitudes and lower tolerance. “I believe that snakes are:” and “members of my family believe snakes are:” were answered with (0 = none of the above, 1 = bad luck, 2 = evil). "If you encountered a snake outdoors would you:" coded (1 = avoid it, 2 = move it away, 3 = kill it, 4 = observe it). Finally, “Do you believe snakes are important to the environment?" coded (1 = yes, 2 = no). Participants were then asked to respond to a statement: “I would consider myself to have a fear/dislike of:” with 5 options provided (1 = rats, 2 = snakes, 3 = bats, 4 = spiders, 5 = other animals (please specify). Participants had the option to leave all boxes unchecked. An additional 10 categories were created after analyzing the answers left in “other animals”.

The third section assessed participants’ attitudes regarding snake conservation. A 5-point Likert scale (1 = strongly agree, 5 = strongly disagree) prompted the following 5 statements: “endangered snakes have a right to live”, “it is important that we conserve natural environments where snakes live”, “I like learning about endangered species”, “the law should allow for killing and hunting snakes”, “it is unnecessary to protect snakes in Canada because they live in other parts of the world”. The next question asked “did you know that there are endangered snakes in Canada?" coded (1 = yes, 2 = no). To determine the potential viability of various program types, participants were asked if they “would be willing to participate in an environmental education program about snakes” (1 = yes, 2 = no), and if “yes” was selected “which of these programs

would you be open to trying?" coded (1 = live ambassador/encounter with live animal, 2 = video lessons, 3 = guided zoo tour with no animal contact, 4 = audio lessons/podcast (no pictures, 5 = other suggestions.

Several demographic variables were assessed to provide more detailed information about our sample. Highest level of education was coded as (1 = high school, 2 = some college or university, 3 = college diploma, 4 = bachelor's degree, 5 = master's degree, 6 = doctorate, 0 = none of the above). Participant religion was coded as (1 = Christian, 2 = Muslim, 3 = Hindu, 4 = Jewish, 5 = Buddhist, 6 = atheist, 7 = agnostic, 8 = other (please specify), 9 = prefer not to say). A total of 21 categories resulted, with the top 6 religions used in subsequent analysis (Christian, atheist, Jewish, agnostic, Hindu, none). Additionally, participants provided their gender, country of birth, and age.

2.3 Data Collection Procedures

Data collection took place over a two-month period, from March 2023 to April 2023, using the Qualtrics platform. Recruitment was facilitated through QR codes on posters, link sharing across social media, and direct outreach to ensure participants could easily access and complete the survey.

Ethics approval was obtained from the Human Participants Review Committee (HPRC) at York University (Approval #e2023-068). Participants were provided with a statement of informed consent, as approved by the HPRC, before proceeding with the survey (see Appendix A for a copy of the informed consent and survey). Participants could withdraw from the study at any time without penalty, and incomplete surveys or responses deemed invalid were excluded during data cleaning to ensure data quality.

To ensure confidentiality, data were anonymized by assigning each participant a unique random identification code. Data cleaning involved removing incomplete and invalid responses, ensuring that the dataset was suitable for analysis.

3. Results

3.1 Sample Characteristics

The study comprised 369 participants, selected from an initial sample of 416 respondents. Exclusions were made for incomplete surveys, where any analysis-relevant question was left unanswered, and for responses judged invalid due to inappropriate answers or apparent misunderstanding of the questions. Participants ranged in age from 18 to 87 years (M = 37.31, SD = 20.29), and were sorted into three age groups for analysis. A significant proportion of the sample (n = 183; 49.6%) fell within the 18-27 age group, with 29.3% (n = 108) in the 28-54 age range, and 21.1% (n = 78) in the 55+ range. Gender distribution was predominantly female (n = 237; 64.2%), with males comprising 29.8% (n = 110) of the sample, and 4.9% identifying as non-binary or third gender (n = 18). Four participants (1.1%) selected "prefer not to say" for their gender. Due to the relatively small sample size of non-binary respondents, gender-based analyses were conducted using only male and female participants.

Participants reported varying levels of educational attainment. A bachelor's degree was the most common level of education, held by 34.9% of respondents (n = 129), followed by 25.7% (n = 95) who reported some college or university experience. Additionally, 15.2% (n = 56) of the sample had earned a master's degree, and 6.2% (n = 23) held a doctorate. The majority of participants (n = 249; 67.2%) were born in Canada, with notable representation from the United Kingdom (n = 33; 8.9%) and the United States (n = 24; 6.5%). Overall, participants hailed from 40 different countries, demonstrating a diverse geographic representation.

In terms of religious affiliation, participants identified with a variety of faiths and beliefs. The six most frequently reported affiliations included Christian (n = 75; 20.3%), Atheist (n = 74; 20%), Jewish (n = 72; 19.5%), Agnostic (n = 72; 19.5%), Hindu (n = 21; 5.7%), and None (n = 14; 3.8%). Smaller religious groups were also represented, including Muslim (n = 12; 3.3%) and Catholic (n = 7; 1.9%), with other specific religious traditions being reported by fewer than five participants. Due to the distribution of responses, religion-based analyses were conducted using two broad groupings: religious (including Christian, Jewish, Muslim, and Catholic respondents; *n* = 166) and non-religious (including Atheist, Agnostic, and those identifying with no religion; *n* = 160). These groupings were informed by prior literature indicating that certain religious traditions, particularly those within the Abrahamic faiths, often associate snakes with negative symbolism, which may influence individual attitudes toward snakes

Participants' residential settings varied, with the majority residing in urban areas (n = 282; 76.4%). Suburban areas were reported by 47.4% (n = 175), while 17.3% (n = 64) lived in

rural areas. Many participants reported living in more than one type of residential setting (n = 115; 31.2%). Additionally, 34.4% (n = 127) reported visiting or owning a cottage. Pet ownership was prevalent among the sample, with 85.1% of participants indicating they owned pets. Dogs (n = 233; 63.2%) and cats (n = 183; 49.6%) were the most commonly owned pets, followed by rodents (n = 134; 36.3%), birds (n = 116; 31.4%), and reptiles (n = 65; 17.6%).

Participants reported a variety of snake-related experiences. A large majority (n = 328; 88.9%) had encountered snakes in controlled environments such as zoos or exhibits, and 287 participants (77.8%) had been exposed to them through media. Encounters with wild snakes were also relatively common, with 262 participants (71%) reporting such experiences. Additionally, 164 participants (44.7%) had met someone who owned a pet snake, though only 25 participants (6.8%) had personally owned one.

3.2 Descriptive Statistics

In terms of attitudes toward snakes, 159 participants (43.1%) expressed some level of fear, and 51 participants (13.8%) reported feelings of disgust. Overall, 220 participants (61%) held negative views, indicated by agreement with negative statements about snakes in Q6. In contrast, 254 participants (68.8%) expressed positive attitudes, demonstrated by their agreement with favorable statements. Once distributed into attitude groups, 190 belonged to the Positive group (51.5%), 92 to the Neutral group (23.2%), and 87 to the Negative group (23.6%), as seen in Figure 1.

Of the 220 participants who indicated reasons for disliking snakes, the most commonly selected concern was that snakes could be venomous (n = 174, 79.1%). A substantial number also reported disliking snakes because they could hurt them (n = 137, 62.3%), they are frightening (n = 119, 54.1%), or because of the way they move or slither (n = 114, 51.8%). Additional reasons included a lack of knowledge about snakes (n = 66, 30.0%), their portrayal in media (n = 61, 27.7%), the belief that they carry diseases (n = 30, 13.6%), and having had a prior negative encounter with a snake (n = 12, 5.5%).

Only 2 participants (0.5%) believed that snakes were bad luck, while 24 (6.5%) reported this belief in family members. Similarly, 10 participants (2.7%) believed that snakes were evil, while 60 (16.3%) reported this belief in family members.

When asked what action might be taken if a snake was encountered, almost all participants responded that they would either observe the snake (n = 184, 49.9%) or avoid the snake (n = 179, 48.5%). 5 participants said they would move the snake away (1.4%), while only 1 said they would kill the snake (0.3%).

Regarding animal-related fears, 197 participants (53.4%) identified spiders as a source of fear, followed by 126 participants (34.1%) who reported a fear of snakes. Other commonly reported fears included rats (n = 160; 43.4%) and bats (n = 115; 31.2%). Notably, all participants responded to this question, suggesting that fear of animals was a shared experience across the sample.

The majority of participants believed that snakes were important to the environment (n = 340, 92.1%). However, fewer participants were aware that some Canadian snakes are endangered (n = 241, 65.3%).

Overall, conservation attitudes were positive (Figure 2). 51 participants noted some level of disagreement with positive statements or agreement with negative statements in Q14 (13.8%). Notably, 25 participants agreed to some extent that the law should allow for killing/hunting snakes (6.8%).

When asked whether the participant would be willing to participate in an environmental education program about snakes, 196 responded yes (53.1%). Amongst those who selected yes, 158 were open to an encounter with a live animal (80.6%), 136 to a guided zoo tour with no animal contact (69.4%), 134 to video lessons (68.4%), and 90 to audio lessons/podcasts (45.9%). While participants were also asked for other suggestions, only 13 provided additions. Books was the only additional suggestion to be heard from 2 participants (1%).

3.3 Factors Influencing Snake Attitudes

To explore the underlying contributors to participants' attitudes toward snakes, a series of ordinal logistic regression models were conducted.

3.3.1 Demographic Predictors

Demographic factors, including gender, age group, and religiosity, were examined to determine their association with snake attitudes (Figure 3). The model met the proportional odds assumption (Brant test $\chi^2(4) = 1.91$, $p = .75$) and was statistically significant overall, $\chi^2(4) =$

15.98, $p < .01$. Participants aged 55 and older were significantly more likely to report negative attitudes compared to those aged 18–27 ($\beta = 0.92$, SE = 0.28, $p < .01$). Religious participants also reported significantly more negative attitudes than non-religious participants ($\beta = 1.27$, SE = 0.24, $p < .001$). Gender was a marginal predictor, with females showing a trend toward more negative attitudes than males ($\beta = 0.42$, SE = 0.25, $p = .091$).

A separate model including only gender as a predictor found a significant effect ($\beta = 0.53$, SE = 0.24, $p = .026$), suggesting that gender-related differences in attitudes may be attenuated when controlling for age and religiosity.

Exploratory analyses also examined education level, country of birth, and continent of birth. These variables did not significantly predict snake attitudes (all $ps > .10$) and are not discussed further.

A follow-up analysis was conducted to determine whether fear and disgust ratings were predicted by demographics. Age was excluded from the final models due to a violation of the proportional odds assumption in preliminary analyses, as indicated by the Brant test. In the model predicting fear responses, both religious affiliation and gender were significant predictors. Participants who identified as religious were significantly more likely to report higher levels of fear compared to non-religious participants ($\beta = 1.02$, SE = 0.21, $p < .001$). Female participants also reported significantly higher fear ratings than male participants ($\beta = 0.51$, SE = 0.22, $p = .020$). In contrast, for disgust responses, only religious affiliation was a significant predictor. Religious participants were more likely to report higher disgust ratings than non-religious participants ($\beta = 1.24$, SE = 0.23, $p < .001$), while gender was not significantly associated with disgust ($\beta = –0.06$, SE = 0.23, $p = .79$). Both final models met the proportional odds assumption, as confirmed by the Brant test.

3.3.2 Residential Background

Residential setting was evaluated to determine whether the type of environment participants had lived in influenced their attitudes toward snakes. Four categories were included: rural only, urban only, mixed (lived in multiple settings), and suburban only (reference group). The model met the proportional odds assumption (Brant test omnibus $\chi^2(3) = 2.00$, $p = .57$). Participants with mixed residential experience were significantly more likely to report positive attitudes ($\beta = −0.86$, SE = 0.29, $p < .01$). Urban-only and rural-only residence were not

significant predictors (β = −0.19, SE = 0.26, p = .46; β = 0.55, SE = 0.67, p = .41, respectively), though the rural-only group was notably small (n = 9), limiting the reliability of that estimate.

Cottage ownership or visitation was also examined but did not significantly predict attitudes, either independently or in models including residential setting (all ps > .60).

3.3.3 Pet Ownership

The role of pet ownership in shaping attitudes was analyzed in two stages. General pet ownership was first assessed and found to be associated with more positive attitudes toward snakes (β = −0.83, SE = 0.27, p < .01), with the model meeting the proportional odds assumption (Brant test $\chi^2(1) = 1.33$, p = .25).

A follow-up model explored specific pet types, including dog, cat, rodent, bird, and reptile ownership. This model also met assumptions (Brant test $\chi^2(5) = 3.97$, p = .55), though data sparsity (28 combinations of pet type and attitude did not occur) suggests cautious interpretation. Reptile ownership was associated with significantly more positive attitudes (β = −1.31, SE = 0.34, p < .001), while cat ownership predicted more negative attitudes (β = −0.68, SE = 0.22, p < .01). Dog, rodent, and bird ownership were not significant predictors (ps > .05).

3.3.4 Direct Experience with Snakes

To assess the influence of firsthand exposure, four types of snake-related experiences were included: direct interaction, zoo exhibit viewing, media exposure, and prior ownership. The model met the proportional odds assumption (Brant test $\chi^2(4) = 2.20$, p = .70), and all four predictors were statistically significant. Direct interaction (β = −1.14, SE = 0.22, p < .001), media exposure (β = −0.94, SE = 0.25, p < .001), and prior snake ownership (β = −3.30, SE = 1.06, p < .01) predicted more positive attitudes. Viewing snakes in zoo exhibits had a weaker but marginal effect (β = −0.57, SE = 0.33, p = .084). Snake sightings in the wild were excluded from the final model due to non-significant effects in preliminary testing.

3.3.5 Conservation Knowledge

Ecological beliefs and conservation awareness were also evaluated as potential predictors of snake attitudes. The model included two binary variables: belief that snakes are important to the environment and awareness that some Canadian snakes are endangered. The overall model

was significant ($\chi^2(2) = 10.86$, $p = .004$). Belief in snakes' environmental importance strongly predicted more positive attitudes ($\beta = -2.18$, $SE = 0.42$, $p < .001$), as did knowledge of endangered Canadian snakes ($\beta = -0.53$, $SE = 0.22$, $p = .015$). Interaction effects were tested but excluded due to multicollinearity concerns.

3.4 Factors Influencing Conservation Attitudes

This section was originally intended to examine predictors of participants' conservation-related attitudes toward snakes. However, responses across all five items were highly skewed toward agreement with conservation-supportive statements. This resulted in insufficient variability in the composite outcome variable, limiting the ability to conduct meaningful statistical analyses using ordinal regression.

3.5 Behavioural Intentions Towards Snake Conservation

To identify the factors that predict participants' willingness to engage in snake-related conservation education programs, a series of binomial logistic regression models were conducted. Predictors were organized into three primary domains: demographic characteristics, experiential variables, and attitudinal measures.

3.5.1 Demographic Predictors of Participation

Demographic characteristics were assessed to determine their association with participants' willingness to participate in snake-focused environmental education (EE) programs (Figure 4). The model, which included gender, age group, and religious affiliation, was statistically significant, $\chi^2(4) = 35.74$, $p < .001$, and demonstrated good model fit (AIC = 401.90). Female participants were significantly more likely than males to report willingness to participate ($\beta = 0.84$, $SE = 0.26$, $p = .001$), while religious participants were significantly less likely to participate compared to non-religious participants ($\beta = -0.79$, $SE = 0.25$, $p = .002$). Age group was a marginal predictor: participants aged 28–54 did not differ significantly from the youngest group ($\beta = 0.33$, $p = .24$), but those aged 55 and older were significantly less likely to participate ($\beta = -0.77$, $SE = 0.32$, $p = .015$). Estimated marginal means revealed that non-religious females aged 18–27 had the highest predicted probability of participation (0.81, 95% CI [0.69, 0.89]), while religious males aged 55 and older had the lowest (0.33, 95% CI [0.20, 0.48]).

3.5.2 Experiential Predictors of Participation

Snake-related experiences were also examined. The model included direct interaction with a snake, viewing snakes in a zoo exhibit, media exposure, and prior snake ownership. An interaction term between interaction and zoo exhibit exposure was included. The full model was statistically significant and showed improved fit compared to the additive model (AIC = 479.83 vs. 482.12). All four main effects were significant. Participants who had directly interacted with a snake ($\beta = 2.35$, SE = 0.89, $p = .008$), seen snakes in a zoo exhibit ($\beta = 1.60$, SE = 0.52, $p = .002$), encountered snakes through media ($\beta = 0.60$, SE = 0.28, $p = .034$), or previously owned a snake ($\beta = 1.32$, SE = 0.56, $p = .017$) were significantly more likely to report willingness to participate. A significant interaction between interaction experience and zoo exhibit exposure was also observed ($\beta = -1.85$, SE = 0.92, $p = .044$), suggesting that the combined effect of both experiences was less than additive. Post hoc analyses of estimated marginal means clarified the nature of this interaction. Participants with neither experience had a predicted probability of participation of 23.8%. This increased to 76.6% for those with interaction experience only, 60.8% for those with zoo exhibit exposure only, and 71.8% for those with both experiences.

3.5.3 Attitudinal Predictors of Participation

Attitudes toward snakes were tested as predictors of willingness to participate in EE programs. Participants with Neutral ($\beta = -1.07$, SE = 0.26, $p < .001$) and Negative attitudes ($\beta = -2.17$, SE = 0.30, $p < .001$) were significantly less likely to express willingness compared to those with Positive attitudes. The model was significant, $\chi^2(2) = 63.30$, $p < .001$. Predicted probabilities were 71.1% for participants with Positive attitudes (95% CI [64.2%, 77.1%]), 45.7% for those with Neutral attitudes (95% CI [35.8%, 55.9%]), and 21.8% for those with Negative attitudes (95% CI [14.4%, 31.7%]). A second model controlling for gender, age group, and religiosity remained significant ($\chi^2(5) = 79.78$, $p < .001$), see Figure 5. In this model, both attitudes and gender remained significant, while age and religiosity did not (p's > .20). The highest predicted probability was observed among non-religious females aged 28–54 with Positive attitudes (probability = 0.87, SE = 0.04). In contrast, the lowest predicted probability was observed among non-religious males aged 55 and older with Negative attitudes (probability = 0.06, SE = 0.03).

Fear and disgust ratings were analyzed to assess the differences in effects on participants' willingness to participate in an educational program about snakes. Both predictors were statistically significant (AIC = 434.96; $\chi^2(2) = 81.15$, $p < .001$); however, disgust emerged as the stronger predictor. Higher disgust ratings were associated with a substantial decrease in participation likelihood ($\beta = –0.695$, SE = 0.13, $p < .001$), corresponding to a 50–60% reduction in odds for each 1-point increase. Fear ratings also showed a significant negative effect ($\beta = –0.225$, SE = 0.10, $p = .024$), though the effect was more modest. Including an interaction term between fear and disgust did not improve model fit (AIC = 435.43) and was not statistically significant ($p = .215$), suggesting the two factors contribute independently to reduced willingness to participate.

A subset of participants who were asked what reasons they dislike snakes were examined to determine whether specific reasons for snake dislike predicted willingness to participate in an environmental education program. The model included the four most endorsed reasons: snakes can be venomous, scary, capable of causing harm, or unsettling in their movement. The model was statistically significant overall. Among these predictors, only the belief that snakes are scary was significantly associated with lower willingness to participate ($\beta = –0.62$, SE = 0.31, $p = .049$). Participants endorsing this belief were significantly less likely to express interest in EE programs. The belief that snake movement is unsettling showed a marginal negative effect ($\beta = –0.52$, SE = 0.31, $p = .091$), while beliefs that snakes are venomous ($\beta = –0.41$, $p = .24$) or capable of causing harm ($\beta = 0.16$, $p = .61$) were not significantly related to participation likelihood.

3.5.4 Predictors of Program Preferences

A set of binomial logistic regressions was conducted to assess whether demographic variables (age, gender, and religious affiliation) predicted interest in specific conservation program types. For the encounter program, older adults (55+) were significantly less likely to express interest compared to the youngest group ($\beta = –1.64$, $p = .004$). Religious affiliation was marginally associated with lower interest ($\beta = –0.79$, $p = .077$). In the tour program model, participants aged 28–54 were significantly more likely to express interest than those aged 18–27 ($\beta = 0.80$, $p = .043$). No significant demographic predictors were found in the models for video or podcast programming, suggesting that interest in these formats was relatively consistent across demographic groups.

To assess how snake attitudes influenced interest in specific types of conservation programming, four separate binomial logistic regressions were conducted (Figure 6). The model predicting interest in a live animal encounter program was statistically significant, $\chi^2(2) = 22.48$, $p < .001$. Participants with Neutral ($\beta = -1.16$, $p = .008$) and Negative ($\beta = -2.40$, $p < .001$) attitudes were significantly less likely to express interest compared to those with Positive attitudes. The model for the video program was not statistically significant, $\chi^2(2) = 5.59$, $p = .061$, though participants with Negative attitudes showed a marginally significant trend toward greater interest ($\beta = 1.41$, $p = .066$), while no significant effect was observed for Neutral attitudes ($\beta = -0.24$, $p = .511$). The model for the guided tour program was also not statistically significant, $\chi^2(2) = 2.26$, $p = .323$. Neither Neutral ($\beta = 0.61$, $p = .147$) nor Negative ($\beta = 0.08$, $p = .879$) attitudes were significantly associated with participation likelihood. In contrast, the model for the podcast program was statistically significant, $\chi^2(2) = 11.05$, $p = .004$. Participants with Neutral attitudes were significantly less likely to report interest in this program ($\beta = -1.24$, $p = .002$), while attitudes in the Negative group were not significantly associated with participation ($\beta = 0.03$, $p = .949$).

To examine whether fear and disgust toward snakes predicted willingness to engage in specific educational formats, four binary logistic regressions were conducted, one for each program type (encounter, video, tour, and podcast). The model for encounter programs was statistically significant, with higher fear ratings predicting a significantly lower likelihood of participation ($\beta = -0.50$, $SE = 0.17$, $p = .003$). Disgust also showed a marginal negative association in this model ($\beta = -0.38$, $SE = 0.22$, $p = .089$), suggesting it may contribute to reduced willingness to attend in-person encounters. In contrast, none of the other program types (video, tour, or podcast) were significantly predicted by fear or disgust.

4. Discussion

This study explored public attitudes toward snakes, examining both general perceptions and the specific roles of fear and disgust in shaping these attitudes and influencing support for conservation. The results revealed a complex and sometimes contradictory pattern of attitudes.

Sociodemographic factors significantly influenced attitudes. Religious participants reported more negative views, aligning with prior research on the effects of folklore and myths (Ceríaco, 2012; Pandey et al., 2016; Onyishi et al., 2021). However, very few participants

explicitly reported that they or their family members believed snakes were bad luck or evil. If religious teachings, particularly within Abrahamic traditions, were the primary drivers of negative attitudes, more participants would likely have endorsed these beliefs, as observed in Onyishi et al. (2021). This suggests that such attitudes may stem more from implicit cultural associations or unconscious biases formed during early exposure to religious narratives, rather than from explicit beliefs. Alternatively, other unmeasured factors may be contributing.

Gender, a consistently strong predictor in previous studies (Alves et al., 2014; Pinheiro, 2016; Liordos et al., 2018; Castillo-Huitrón, 2020; Ogle & Devlin, 2022), was only a marginal predictor of overall attitude when controlling for other variables. This unexpected finding highlights the importance of considering how multiple factors interact to shape attitudes. However, when examining fear specifically, gender emerged as a significant predictor, with women reporting higher levels of fear. In contrast, gender did not predict disgust, diverging from past research where women consistently report higher levels of disgust (Rohrmann, Hopp & Quirin, 2008; Al-Shawaf, Lewis, & Buss, 2018). This discrepancy may reflect the phrasing of the survey item “snakes are disgusting”, which may have seemed too harsh, promoting more socially acceptable responses. These results reinforce the need to examine fear and disgust as distinct emotional constructs rather than treating them as a single category of “negative attitudes.” They also suggest that understanding the nuances behind emotional drivers can improve the design of conservation education programs aimed at reducing negative perceptions of snakes.

Education level was not a significant predictor of fear, disgust, or overall attitudes. This contrasts with previous findings that have linked higher education to both more negative (Ogle & Devlin, 2022) and more positive (Pinheiro et al., 2016) views. One explanation may lie in the sample, which included a large number of young university students. Environmental knowledge, rather than formal education alone, may be a more relevant factor (Burt & Jacobson, 2012). Older adults may have more education overall, but less exposure to ecological content during their schooling. This is supported by the finding that participants aged 55 and older were more likely to report negative attitudes, consistent with Lobue and Delouche (2008).

Pet ownership, in general, was associated with more positive attitudes toward snakes but species mattered. Reptile ownership predicted greater positivity, while cat ownership predicted more negative attitudes. This may reflect a general openness among owners of less conventional

pets, who may already be more tolerant of animals that others view as aversive. In contrast, cat owners, possibly influenced by cultural narratives of cats as independent and "clean" animals, may find snakes particularly aversive.

Personal experiences with snakes were among the strongest predictors of positive attitudes. Direct interaction with a snake, exposure through zoo exhibits, media, and prior ownership all significantly predicted more favorable views These findings support the idea that familiarity reduces fear and underscore the value of experiential learning. The finding that media exposure predicted more positive attitudes was somewhat unexpected, given common portrayals of snakes as threatening or villainous (Bombieri et al., 2018; Geest, Knoch, & Shufran, 2021; Le Busque & Litchfield, 2023). One possible explanation is varied interpretation of the term "media." Participants who thought of educational content like nature documentaries may have responded more positively than those whose exposure came from horror films or sensationalized news reports. This highlights the importance of clearly distinguishing between media types in future research.

While a majority of participants recognized snakes as important to the environment, and were aware that some Canadian snakes are endangered, a significant proportion still held negative views, expressing fear, disgust, or both. This disconnect underscores the challenge of translating cognitive recognition of ecological importance into positive emotional responses and conservation action (Seigel & Mullin, 2011).

Importantly, attitudes toward snakes were a significant predictor of willingness to participate in conservation education programs. Participants with neutral or negative attitudes were significantly less likely to express interest compared to those with positive attitudes, consistent with research showing that positive attitudes are predict conservation support (Pinheiro et al., 2016; Liordos et al., 2018). Furthermore, specific reasons for disliking snakes, such as finding them scary or unsettling, were linked to lower participation rates, whereas concerns about venom or harm did not show the same predictive power. These findings emphasize the importance of addressing emotional barriers directly in conservation education, as opposed to focusing solely on factual knowledge about snake ecology (Morgan, 1989; Slagle et al., 2013; Torkar, 2015).

Fear and disgust emerged as distinct yet overlapping emotional predictors of program participation. Both emotions independently predicted lower willingness to engage in

conservation education, but disgust had a more pronounced negative effect. While fear often stems from a perception of danger, individuals high in fear may be more open to educational programs that aim to correct misconceptions or teach strategies for avoiding harm. In contrast, individuals with high levels of disgust may exhibit a more generalized aversion toward snakes, making them less receptive to conservation messaging altogether (Klieger & Siejack, 1997; Polák et al., 2020). This highlights the need for conservation strategies that address the unique challenges posed by disgust, such as aesthetic aversions and associations with disease or contamination.

Participants' preferences for different types of conservation education programs revealed important distinctions based on their attitudes and emotional responses toward snakes. While demographic predictors played a limited role overall, older adults were significantly less interested in live animal encounters, suggesting that high-contact formats may be less suitable for this age group. A marginal effect of religiosity also hinted at lower interest in encounters among religious participants, consistent with patterns of greater fear and disgust (Ceríaco, 2012; Pandey et al., 2016; Onyishi et al., 2021).

Attitudes toward snakes were the strongest predictors of program preference. Individuals with negative or neutral attitudes were significantly less likely to express interest in encounter programs but showed similar levels of interest in more passive formats such as tours, videos, and podcasts. Notably, there was a trend toward greater interest in video programs among participants with negative attitudes, suggesting that digital content may serve as a more comfortable entry point for skeptical or fearful individuals (Schönfelder & Bogner, 2017).

Emotional responses further shaped these preferences. Higher fear significantly reduced interest in encounter programs, and disgust showed a marginal negative effect. However, neither emotion predicted preferences for video, tour, or podcast programs, indicating that lower-contact formats may bypass affective barriers and better engage those with aversive reactions to snakes.

Returning to the strategies outlined in Section 1.5, the current findings provide empirical support for the value of flexible, audience-specific approaches to conservation education. Section 1.5 emphasized the complementary role of mediated experiences, culturally relevant framing, and direct encounters as means of fostering more positive perceptions of snakes. The results of this study extend these arguments by showing that these strategies may map onto distinct participant profiles. While hands-on encounters are highly engaging for those with positive

attitudes, alternative approaches may be more inclusive and effective for reaching audiences who are hesitant or fearful. Tailoring conservation education to align with audience comfort and readiness can help expand participation and support for snake conservation.

4.1 Limitations

While this study provides valuable insights, several limitations must be acknowledged. The use of snowball sampling may have introduced sampling bias, as participants recruited through social networks may share similar characteristics. This limits the representativeness of the sample and affects the generalizability of the findings. In particular, the underrepresentation of rural participants and the overrepresentation of Jewish (particularly older adult) participants likely skew the results and may not reflect broader public attitudes. Additionally, due to the distribution of religious affiliation, analyses were limited to broad groupings (e.g., religious vs. non-religious), which restricted the ability to assess the influence of specific traditions on snake attitudes. A similar issue occurred with the attitude scale: rather than analyzing responses across a full Likert scale, participants had to be grouped into negative, neutral, or positive categories due to response distributions, which may have reduced the nuance and sensitivity of the analysis.

It is also important to consider potential nonresponse and self-selection biases. Individuals with strong negative attitudes toward snakes may have been less likely to participate in the survey at all. Among those who did respond, participants with the most negative views may have declined to indicate willingness to participate in conservation programs and were therefore not prompted to evaluate program types. As a result, responses regarding program interest likely underrepresent the attitudes of the very individuals such interventions are designed to reach.

The study relied exclusively on self-reported attitudes and behavioural intentions, which may not align with actual behaviors (Ballantyne et al., 2007; Rohrmann, Hopp, & Quirin, 2008). These measures are susceptible to social desirability bias, particularly in the context of conservation. Moreover, the limited variability in responses to conservation-supportive items constrained statistical analysis, suggesting a need for more nuanced and behaviourally anchored tools in future work.

The cross-sectional nature of the design also limits interpretability. Although strong associations were identified between emotions such as fear and disgust and reduced willingness

to participate in conservation education, causality cannot be inferred. It is likely that the relationship is bidirectional: negative emotions may discourage engagement, while limited exposure to snakes may in turn reinforce or intensify those emotions.

4.2 Future Research Directions

Future research should explore longitudinal designs to assess whether attitudes and behavioural intentions change following exposure to conservation education programs. Tracking participants over time would help determine the lasting impacts of various educational approaches. These should test whether interventions that distinctly target fear versus disgust yield differential improvements in attitudes and conservation behaviors. Incorporating psychophysiological indices (e.g., heart-rate variability) could further clarify whether self-reported fear and disgust correspond to unique biological signatures (Rohrmann, Hopp, & Quirin, 2008).

Further investigation is needed into the role of cultural and religious narratives in shaping snake perceptions. Understanding how particular belief systems contribute to fear and disgust can inform the design of culturally sensitive educational content that better resonates with target audiences.

Expanding research to include more diverse populations is essential for generalizing findings and tailoring interventions. Additionally, future studies could evaluate the effectiveness of specific program formats in reducing fear and disgust among different audience segments. By addressing these gaps, future work can build on the current study's findings to create more effective, targeted conservation education programs.

5. Conclusion

The results of this study have important implications for the design of conservation education programs. First, the clear distinction between fear and disgust suggests that programs must tailor their content and delivery methods to target these specific emotions. For individuals driven by fear, providing accurate information about snake behavior, safety, and the rarity of dangerous encounters may help reduce anxiety. For those experiencing disgust, interventions might focus on aesthetic appreciation, introducing participants to the beauty and ecological value of diverse snake species.

Programs offering live animal encounters were the most popular option among participants, supporting the value of hands-on, experiential learning in fostering positive attitudes. However, for participants with high levels of fear or disgust, media-based programs (e.g., videos, podcasts) may offer a more accessible starting point. Incremental exposure, beginning with photos or videos and gradually introducing live experiences, may help build comfort and willingness to engage.

Targeted outreach is essential. Older adults, religious individuals, and those with little prior exposure to snakes are key demographics for intervention. Educational content should also emphasize the role of snakes in local ecosystems, countering the misconception that conservation is only necessary for exotic species. Highlighting the presence of endangered Canadian snakes may help foster a sense of connection and responsibility.

Importantly, programs must go beyond factual knowledge to address the emotional and cultural narratives that shape snake attitudes. Incorporating storytelling, cultural reframing, and opportunities for safe, positive encounters with snakes can help bridge the gap between cognitive understanding and emotional acceptance.

Overall, these findings support the need for multifaceted conservation education strategies that combine factual information with emotional engagement, tailored to specific audience needs. By addressing the underlying drivers of negative attitudes, particularly fear and disgust, conservation programs can more effectively promote positive perceptions of snakes and encourage participation in conservation efforts.

References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Action Control* (pp. 11–39). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-69746-3_2

Al-Shawaf, L., Lewis, D. M. G., & Buss, D. M. (2018). Sex differences in disgust: Why are women more easily disgusted than men? *Emotion Review*, *10*(2), 149–160. https://doi.org/10.1177/1754073917709940

Alves, Silva, V. N., Trovão, D. M. B. M., Oliveira, J. V., Mourão, J. S., Dias, T. L. P., Alves, Â. G. C., Lucena, R. F. P., Barboza, R. R. D., Montenegro, P. F. G. P., Vieira, W. L. S., & Souto, W. M. S. (2014). Students' attitudes toward and knowledge about snakes in the semiarid region of Northeastern Brazil. *Journal of Ethnobiology and Ethnomedicine*, 10(1), 30–30. https://doi.org/10.1186/1746-4269-10-30

Ananjeva, N. B., Uteshev, V. K., Orlov, N. L., & Gakhova, E. N. (2015). Strategies for conservation of endangered amphibian and reptile species. *Biology Bulletin*, *42*(5), 432–439. https://doi.org/10.1134/S1062359015050027

Andersson, E., & Öhman, J. (2017). Young people's conversations about environmental and sustainability issues in social media. *Environmental Education Research*, *23*(4), 465–485. https://doi.org/10.1080/13504622.2016.1149551

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, *241*(Complete). https://doi.org/10.1016/j.biocon.2019.108224

Auliya, M., Altherr, S., Ariano-Sanchez, D., Baard, E. H., Brown, C., Brown, R. M., Cantu, J.-C., Gentile, G., Gildenhuys, P., Henningheim, E., Hintzmann, J., Kanari, K., Krvavac, M., Lettink, M., Lippert, J., Luiselli, L., Nilson, G., Nguyen, T. Q., Nijman, V., … Ziegler, T. (2016). Trade in live reptiles, its impact on wild populations, and the role of the European market. *Biological Conservation*, *204*, 103–119. https://doi.org/10.1016/j.biocon.2016.05.017

Ballantyne, R., & Packer, J. (2005). Promoting environmentally sustainable attitudes and behaviour through free-choice learning experiences: what is the state of the game? *Environmental Education Research*, *11*(3), 281–295. https://doi.org/10.1080/13504620500081145

Ballantyne, R., & Packer, J. (2016). Visitors' perceptions of the conservation education role of zoos and aquariums: Implications for the provision of learning experiences. *Visitor Studies*, *19*(2), 193–210. https://doi.org/10.1080/10645578.2016.1220185

Ballantyne, R., Packer, J., Hughes, K., & Dierking, L. (2007). Conservation learning in wildlife tourism settings: lessons from research in zoos and aquariums. *Environmental Education Research*, *13*(3), 367–383. https://doi.org/10.1080/13504620701430604

Ballouard, J.-M., Ajtic, R., Balint, H., Brito, J. C., Crnobrnja-Isailovic, J., Desmonts, D., ElMouden, E. H., Erdogan, M., Feriche, M., Pleguezuelos, J. M., Prokop, P., Sánchez, A., Santos, X., Slimani, T., Tomovic, L., Uşak, M., Zuffi, M., & Bonnet, X. (2013). Schoolchildren and one of the most unpopular animals: Are they ready to protect snakes? *Anthrozoös*, 26(1), 93–109. https://doi.org/10.2752/175303713x13534238631560

Ballouard, J.-M., Provost, G., Barré, D., & Bonnet, X. (2012). Influence of a field trip on the attitude of schoolchildren toward unpopular organisms: An experience with snakes. *Journal of Herpetology*, *46*(3), 423–428. https://doi.org/10.1670/11-118

Bauerle, B., Spencer, D. L., & Wheeler, W. (1975). The Use of Snakes as a Pollution Indicator Species. *Copeia*, *1975*(2), 366–368. https://doi.org/10.2307/1442893

Beaupre, S. & Douglas, L. (2011). 9. Snakes as Indicators and Monitors of Ecosystem Properties. In S. Mullin & R. Seigel (Ed.), *Snakes: Ecology and Conservation* (pp. 244-261). Ithaca, NY: Cornell University Press. https://doi-org.ezproxy.library.yorku.ca/10.7591/9780801459092-013

Bierlein, J. F. (1994). *Parallel myths* (1st ed). Ballantine Books.

Böhm, M., Collen, B., Baillie, J. E. M., Bowles, P., Chanson, J., Cox, N., Hammerson, G., Hoffmann, M., Livingstone, S. R., Ram, M., Rhodin, A. G. J., Stuart, S. N., van Dijk, P. P., Young, B. E., Afuang, L. E., Aghasyan, A., García, A., Aguilar, C., Ajtic, R., … Zug, G. (2013). The conservation status of the world's reptiles. *Biological Conservation*, *157*, 372–385. https://doi.org/10.1016/j.biocon.2012.07.015

Bolt, L. M., & Schreier, A. L. (2023). Student research collaboration as conservation education: A case study from the primate field school at Maderas Rainforest Conservancy. *American Journal of Primatology*, *85*(5), e23414. https://doi.org/10.1002/ajp.23414

Bombieri, G., Nanni, V., Del Mar Delgado, M., Fedriani, J. M., López-Bao, J. V., Pedrini, P., & Penteriani, V. (2018). Content analysis of media reports on predator attacks on humans: Toward an understanding of human risk perception and predator acceptance. *BioScience*, *68*(8), 577–584. https://www.jstor.org/stable/90023898

Brewer, C. (2002). Outreach and Partnership Programs for Conservation Education Where Endangered Species Conservation and Research Occur. *Conservation Biology*, 16(1), 4–6. http://www.jstor.org/stable/3061395

Brown, E. D., & Williams, B. K. (2019). The potential for citizen science to produce reliable and useful information in ecology. *Conservation Biology*, *33*(3), 561–569. https://doi.org/10.1111/cobi.13223

Buchanan, J., Pressick-Kilborn, K., & Maher, D. (2019). Promoting Environmental Education for Primary School-aged Students Using Digital Technologies. *Eurasia Journal of Mathematics, Science and Technology Education, 15*(2), em1661. https://doi.org/10.29333/ejmste/100639

Burghardt, G., Murphy, J., Chiszar, D. & Hutchins, M. (2011). 10. Combating Ophiophobia: Origins, Treatment, Education, and Conservation Tools. In S. Mullin & R. Seigel (Ed.), *Snakes: Ecology and Conservation* (pp. 262-280). Ithaca, NY: Cornell University Press. https://doi-org.ezproxy.library.yorku.ca/10.7591/9780801459092-014

Burt, J. M., Donaldson, M. R., Hruska, K. A., Hinch, S. G., & Richardson, J. S. (2012). Interactive Field Site Visits Can Help Students Translate Scientific Studies into Contextual Understanding. *Fisheries*, *37*(7), 315–319. https://doi.org/10.1080/03632415.2012.696016

Buxton, R. T., Bennett, J. R., Reid, A. J., Shulman, C., Cooke, S. J., Francis, C. M., Nyboer, E. A., Pritchard, G., Binley, A. D., Avery-Gomm, S., Ban, N. C., Beazley, K. F., Bennett, E., Blight, L. K., Bortolotti, L. E., Camfield, A. F., Gadallah, F., Jacob, A. L., Naujokaitis-Lewis, I., … Smith, P. A. (2021). Key information needs to move from knowledge to action for biodiversity conservation in Canada. *Biological Conservation*, *256*, 108983. https://doi.org/10.1016/j.biocon.2021.108983

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. https://doi.org/10.3389/fpsyg.2020.01277

Ceríaco, L. M. (2012). Human attitudes towards herpetofauna: The influence of folklore and negative values on the conservation of amphibians and reptiles in Portugal. *Journal of Ethnobiology and Ethnomedicine*, 8(1). https://doi.org/10.1186/1746-4269-8-8

Chung, C.-H., Chiu, D. K. W., Ho, K. K. W., & Au, C. H. (2020). Applying social media to environmental education: is it more impactful than traditional media? *Information Discovery and Delivery*, *48*(4), 255–266. https://doi.org/10.1108/IDD-04-2020-0047

Conrad, M., Reider, L. B., & LoBue, V. (2021). Exploring Parent–Child Conversations about Live Snakes and Spiders: Implications for the Development of Animal Fears. *Visitor Studies*, *24*(1), 58–78. https://doi.org/10.1080/10645578.2020.1865089

Cortés-Gomez, A. M., Ruiz-Agudelo, C. A., Valencia-Aguilar, A., & Ladle, R. J. (2015). Ecological functions of neotropical amphibians and reptiles: A review. *Universitas Scientiarum*, *20*(2), 229–245. https://doi.org/10.11144/Javeriana.SC20-2.efna

Crawford, B. A., & Andrews, K. M. (2016). Drivers' attitudes toward wildlife-vehicle collisions with reptiles and other taxa. *Animal Conservation*, 19(5), 444–450. https://doi.org/10.1111/acv.12261

Decker, D. J., & Purdy, K. G. (1988). Toward a concept of wildlife acceptance capacity in wildlife management. *Wildlife Society Bulletin (1973-2006)*, *16*(1), 53–57. https://www.jstor.org/stable/3782353

Espinosa, S., & Jacobson, S. K. (2012). Human-Wildlife Conflict and Environmental Education: Evaluating a Community Program to Protect the Andean Bear in Ecuador. *The Journal of Environmental Education*, *43*(1), 55–65. https://doi.org/10.1080/00958964.2011.579642

Geest, E. A., Knoch, A. R., & Shufran, A. A. (2021). Villainous snakes and heroic butterflies, the moral alignment of animal-themed characters in American superhero comic books. *Journal of Graphic Novels and Comics*, *13*(5), 735–750. https://doi.org/10.1080/21504857.2021.1998173

Gibbon, J. W., Scott, D. E., Ryan, T. J., Buhlmann, K. A., Tuberville, T. D., Metts, B. S., Greene, J. L., Mills, T., Leiden, Y., Poppy, S., & Winne, C. T. (2000). The global decline of reptiles, déjà vu amphibians. *BioScience*, *50*(8), 653. https://doi.org/10.1641/0006-3568(2000)050[0653:TGDORD]2.0.CO;2

Greenwood, D. A., & Hougham, R. J. (2015). Mitigation and adaptation: Critical perspectives toward digital technologies in place-conscious environmental education. *Policy Futures in Education*, *13*(1), 97-116. https://doi.org/10.1177/1478210314566732

Hadad, S., Zhitomirsky-Geffet, M., Shah, H., Rigler, D., Celentano, U., Tiensuu, H., Röning, J., Vallverdú, J., Csabella, E. J., Stepankova, O., Gialelis, J., Lantavou, K., Ignat, T., Masone, G., Winter, J., & Dumitrasco, M. (2023). Modeling intrinsic factors of inclusive engagement in citizen science: Insights from the participants' survey analysis of CSI-COP. PLOS ONE, 18(11), e0294575. https://doi.org/10.1371/journal.pone.0294575

Haidt, J., McCauley, C., & Rozin, P. (1994). Individual differences in sensitivity to disgust: A scale sampling seven domains of disgust elicitors. *Personality and Individual Differences*, *16*(5), 701–713. https://doi.org/10.1016/0191-8869(94)90212-7

Hansel, T., Phimmavong, S., Phengsopha, K., Phompila, C., & Homduangpachan, K. (2010). Developing and Implementing a Mobile Conservation Education Unit for Rural Primary School Children in Lao PDR. *Applied Environmental Education and Communication*, *9*(2), 96–103. https://doi.org/10.1080/1533015X.2010.482475

Hughes, C. (2012). Environmental Education for Conservation: Considerations to Achieve Success. *Natural Areas Journal*, 32(2), 218–219. https://doi.org/10.3375/043.032.0213

Jacobson, S. K. (1991). Evaluation model for developing, implementing, and assessing conservation education programs: examples from Belize and Costa Rica. Environmental Management (New York), 15(2), 143–150. https://doi.org/10.1007/BF02393846

Jacobson, S. K. (2010). Effective primate conservation education: Gaps and opportunities. *American Journal of Primatology*, *72*(5), 414–419. https://doi.org/10.1002/ajp.20792

Jacobson, S. K., & McDuff, M. D. (1997). Success factors and evaluation in conservation education programmes. *International Research in Geographical and Environmental Education*, *6*(3), 204–221. https://doi.org/10.1080/10382046.1997.9965048

Janovcová, M., Rádlová, S., Polák, J., Sedláčková, K., Peléšková, Š., Žampachová, B., Frynta, D., & Landová, E. (2019). Human attitude toward reptiles: A relationship between fear, disgust, and aesthetic preferences. *Animals*, 9(5), 238. https://doi.org/10.3390/ani9050238

Kainer, K. A., DiGiano, M. L., Duchelle, A. E., Wadt, L. H. O., Bruna, E., & Dain, J. L. (2009). Partnering for greater success: Local stakeholders and research in tropical biology and conservation. *Biotropica*, *41*(5), 555–562. https://doi.org/10.1111/j.1744-7429.2009.00560.x

Kellert, S. R. (1985). Attitudes toward animals: Age-related development among children. In M. W. Fox & L. D. Mickley (Eds.), *Advances in Animal Welfare Science 1984* (pp. 43–60). Springer Netherlands. https://doi.org/10.1007/978-94-009-4998-0_3

Klemens, M., & Thorbjarnarson, J. (1995). Reptiles as a food resource. *Biodiversity & Conservation*, *4*(3), 281–298. https://doi.org/10.1007/BF00055974

Klieger, D. M., & Siejak, K. K. (1997). Disgust as the source of false positive effects in the measurement of Ophidiophobia. *The Journal of Psychology*, 131(4), 371–382. https://doi.org/10.1080/00223989709603523

Klorman, R., Weerts, T. C., Hastings, J. E., Melamed, B. G., & Lang, P. J. (1974). Psychometric description of some specific-fear questionnaires. *Behavior Therapy*, *5*(3), 401–409. https://doi.org/10.1016/S0005-7894(74)80008-0

Kos, M., Jerman, J., & Torkar, G. (2023). Preschool children's attitude toward some unpopular animals and formation of a positive attitude toward them through hands-on activities. *Journal of Biological Education*, *57*(1), 83–100. https://doi.org/10.1080/00219266.2021.1877779

Langley, W. M., Lipps, H. W., & Theis, J. F. (1989). Responses of Kansas Motorists to Snake Models on a Rural Highway. *Transactions of the Kansas Academy of Science (1903-)*, *92*(1/2), 43–48. https://doi.org/10.2307/3628188

Le Busque, B., & Litchfield, C. (2023). Sharks, spiders, snakes, oh my: A review of creature feature films. *Journal of Environmental Media*, *4*(1), 49–75. https://doi.org/10.1386/jem_00096_1

Lindemann-Matthies, P., & Kamer, T. (2006). The influence of an interactive educational approach on visitors' learning in a Swiss zoo. *Science Education*, *90*(2), 296–315. https://doi.org/10.1002/sce.20127

Liordos, V., Kontsiotis, V. J., Kokoris, S., & Pimenidou, M. (2018). The Two Faces of Janus, or the dual mode of public attitudes towards snakes. *Science of The Total Environment*, *621*, 670–678. https://doi.org/10.1016/j.scitotenv.2017.11.311

LoBue, V., & DeLoache, J. S. (2008). Detecting the Snake in the Grass: Attention to Fear-Relevant Stimuli by Adults and Young Children. *Psychological Science*, 19(3), 284–289. https://doi.org/10.1111/j.1467-9280.2008.02081.x

Lourenço-de-Moraes, R., Lansac-Toha, F. M., Schwind, L. T. F., Arrieira, R. L., Rosa, R. R., Terribile, L. C., Lemes, P., Fernando Rangel, T., Diniz-Filho, J. A. F., Bastos, R. P., & Bailly, D. (2019). Climate change will decrease the range size of snake species under negligible protection in the Brazilian Atlantic Forest hotspot. *Scientific Reports*, *9*. https://doi.org/10.1038/s41598-019-44732-z

Loury, E. K., Eschenroeder, J. C., Seat, L., Chea, S., Chhut, C., Kritsanavarin, S., Lovgren, S., Ramsay, E. G., Thao, D., & Hogan, Z. S. (2021). Communicating for aquatic conservation in cambodia and beyond: Lessons learned from in-person and media-based environmental education and outreach strategies. *Water (Basel)*, *13*(13), 1853-. https://doi.org/10.3390/w13131853

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. https://doi.org/10.1016/j.biocon.2007.06.005

Maynard, L., Monroe, M. C., Jacobson, S. K., & Savage, A. (2020). Maximizing biodiversity conservation through behavior change strategies. *Conservation Science and Practice*, *2*(6), e193. https://doi.org/10.1111/csp2.193

Ménez, A. (2003). *The subtle beast: Snakes, from myth to medicine*. Taylor & Francis.

Merenlender, A. M., Crall, A. W., Drill, S., Prysby, M., & Ballard, H. (2016). Evaluating environmental education, citizen science, and stewardship through naturalist programs. *Conservation Biology*, *30*(6), 1255–1265. https://doi.org/10.1111/cobi.12737

Morgan, J. M., & Gramann, J. H. (1989). Predicting Effectiveness of Wildlife Education Programs: A Study of Students' Attitudes and Knowledge toward Snakes. *Wildlife Society Bulletin (1973-2006)*, *17*(4), 501–509. http://www.jstor.org/stable/3782720

Moss, A., & Esson, M. (2013). The Educational Claims of Zoos: Where Do We Go from Here? *Zoo Biology*, *32*(1), 13–18. https://doi.org/10.1002/zoo.21025

Mullin, & Seigel, R. A. (2009). *Snakes ecology and conservation.* Comstock Pub. Associates/Cornell University Press. https://doi.org/10.7591/9780801459092

Ogle, B. W., & Devlin, S. (2022). Public perceptions of herpetofauna in zoos. *Anthrozoös*, 35(4), 515–526. https://doi.org/10.1080/08927936.2022.2027094

Öhman, Flykt, A., & Esteves, F. (2001). Emotion Drives Attention: Detecting the Snake in the Grass. *Journal of Experimental Psychology. General*, 130(3), 466–478. https://doi.org/10.1037/0096-3445.130.3.466

Öhman, A., & Mineka, S. (2003). The Malicious Serpent: Snakes as a Prototypical Stimulus for an Evolved Module of Fear. *Current Directions in Psychological Science : A Journal of the American Psychological Society*, *12*(1), 5–9. https://doi.org/10.1111/1467-8721.01211

Olatunji, B. O., Williams, N. L., Tolin, D. F., Abramowitz, J. S., Sawchuk, C. N., Lohr, J. M., & Elwood, L. S. (2007). The Disgust Scale: Item Analysis, Factor Structure, and Suggestions for Refinement. *Psychological Assessment*, *19*(3), 281–297. https://doi.org/10.1037/1040-3590.19.3.281

Onyishi, I. E., Nwonyi, S. K., Pazda, A., & Prokop, P. (2021). Attitudes and behaviour toward snakes on the part of Igbo people in Southeastern Nigeria. *Science of The Total Environment*, 763, 143045. https://doi.org/10.1016/j.scitotenv.2020.143045

Özel, M., Prokop, P., & Uşak, M. (2009). Cross-Cultural Comparison of Student Attitudes toward Snakes. *Society & Animals*, *17*(3), 224–240. https://doi.org/10.1163/156853009X445398

Pandey, D. P., Subedi Pandey, G., Devkota, K., & Goode, M. (2016). Public perceptions of snakes and snakebite management: Implications for conservation and human health in southern Nepal. *Journal of Ethnobiology and Ethnomedicine*, *12*(1), 22. https://doi.org/10.1186/s13002-016-0092-0

Paul Ashley, E., Kosloski, A., & Petrie, S. A. (2007). Incidence of Intentional Vehicle–Reptile Collisions. *Human Dimensions of Wildlife*, *12*(3), 137–143. https://doi.org/10.1080/10871200701322423

Pinheiro, L. T., Rodrigues, J. F., & Borges-Nojosa, D. M. (2016). Formal education, previous interaction and perception influence the attitudes of people toward the conservation of snakes in a large urban center of Northeastern Brazil. *Journal of Ethnobiology and Ethnomedicine*, 12(1). https://doi.org/10.1186/s13002-016-0096-9

Polák, J., Rádlová, S., Janovcová, M., Flegr, J., Landová, E., & Frynta, D. (2020). Scary and nasty beasts: Self-reported fear and disgust of common phobic animals. *British Journal of Psychology*, *111*(2), 297–321. https://doi.org/10.1111/bjop.12409

Prokop, P., & Fančovičová, J. (2017). The effect of hands-on activities on children's knowledge and disgust for animals. *Journal of Biological Education*, *51*(3), 305–314. https://doi.org/10.1080/00219266.2016.1217910

Prokop, P., & Tunnicliffe, S. D. (2010). Effects of Having Pets at Home on Children's Attitudes toward Popular and Unpopular Animals. *Anthrozoös*, *23*(1), 21–35. https://doi.org/10.2752/175303710X12627079939107

Rádlová, S., Polák, J., Janovcová, M., Sedláčková, K., Peléšková, Š., Landová, E., & Frynta, D. (2020). Emotional Reaction to Fear- and Disgust-Evoking Snakes: Sensitivity and Propensity in Snake-Fearful Respondents. *Frontiers in Psychology*, *11*, 31–31. https://doi.org/10.3389/fpsyg.2020.00031

Ramakrishnan, U., Coss, R. G., Schank, J., Dharawat, A., & Kim, S. (2005). Snake Species Discrimination by Wild Bonnet Macaques (Macaca radiata). *Ethology*, *111*(4), 337–356. https://doi.org/10.1111/j.1439-0310.2004.01063.x

Randler, C., Ilg, A., & Kern, J. (2005). Cognitive and Emotional Evaluation of an Amphibian Conservation Program for Elementary School Students. *The Journal of Environmental Education*, *37*(1), 43–52. https://doi.org/10.3200/JOEE.37.1.43-52

Robelia, B. A., Greenhow, C., & Burton, L. (2011). Environmental learning in online social networks: adopting environmentally responsible behaviors. *Environmental Education Research*, *17*(4), 553–575. https://doi.org/10.1080/13504622.2011.565118

Rohrmann, S., Hopp, H., & Quirin, M. (2008). Gender differences in psychophysiological responses to disgust. *Journal of Psychophysiology*, *22*(2), 65–75. https://doi.org/10.1027/0269-8803.22.2.65

Roll, U., Feldman, A., Novosolov, M., Allison, A., Bauer, A. M., Bernard, R., Böhm, M., Castro-Herrera, F., Chirio, L., Collen, B., Colli, G. R., Dabool, L., Das, I., Doan, T. M., Grismer, L. L., Hoogmoed, M., Itescu, Y., Kraus, F., Lebreton, M., … Meiri, S. (2017). The global distribution of tetrapods reveals a need for targeted reptile conservation. *Nature Ecology & Evolution*, *1*(11), 1677–1682. https://doi.org/10.1038/s41559-017-0332-2

Schönfelder, M. L., & Bogner, F. X. (2017). Two ways of acquiring environmental knowledge: by encountering living animals at a beehive and by observing bees via digital tools. *International Journal of Science Education*, *39*(6), 723–741. https://doi.org/10.1080/09500693.2017.1304670

Seigel, R. & Mullin, S. (2011). 11. Snake Conservation, Present and Future. In S. Mullin & R. Seigel (Ed.), *Snakes: Ecology and Conservation* (pp. 281-290). Ithaca, NY: Cornell University Press. https://doi-org.ezproxy.library.yorku.ca/10.7591/9780801459092-015

Seyfarth, R. M., Cheney, D. L., & Marler, P. (1980). Monkey Responses to Three Different Alarm Calls: Evidence of Predator Classification and Semantic Communication. *Science (American Association for the Advancement of Science)*, *210*(4471), 801–803. https://doi.org/10.1126/science.7433999

Skupien, G. M., Andrews, K. M., & Larson, L. R. (2016). Teaching Tolerance? Effects of Conservation Education Programs on Wildlife Acceptance Capacity for the American Alligator. *Human Dimensions of Wildlife,* 21(3), 264–279. https://doi-org.ezproxy.library.yorku.ca/10.1080/10871209.2016.1147624

Slagle, K., Zajac, R., Bruskotter, J., Wilson, R., & Prange, S. (2013). Building tolerance for bears: A communications experiment. *The Journal of Wildlife Management*, *77*(4), 863–869. https://doi.org/10.1002/jwmg.515

Spooner, S. L., Jensen, E. A., Tracey, L., & Marshall, A. R. (2019). Evaluating the impacts of theatre-based wildlife and conservation education at the zoo. *Environmental Education Research*, *25*(8), 1231–1249. https://doi.org/10.1080/13504622.2019.1569201

Strickland, B. K., Brooke, J. M., Zischke, M. T., & Lashley, M. A. (2021). Podcasting as a tool to take conservation education online. *Ecology and Evolution*, *11*(8), 3597–3606. https://doi.org/10.1002/ece3.7353

Thomas, R. E. W., Teel, T., Bruyere, B., & Laurence, S. (2019). Metrics and outcomes of conservation education: A quarter century of lessons learned. *Environmental Education Research*, *25*(2), 172–192. https://doi.org/10.1080/13504622.2018.1450849

Tingley, R., Meiri, S., & Chapple, D. G. (2016). Addressing knowledge gaps in reptile conservation. *Biological Conservation*, *204*(Part A), 1–5. https://doi.org/10.1016/j.biocon.2016.07.021

Torkar, G. (2015). Pre-service teachers' fear of snakes, conservation attitudes, and likelihood of incorporating animals into the future science curriculum. *Journal of Baltic Science Education*, *14*(3), 401–410. https://doi.org/10.33225/jbse/15.14.401

Webber, S., Carter, M., Smith, W., & Vetere, F. (2017). Interactive technology and human–animal encounters at the zoo. *International Journal of Human-Computer Studies*, *98*, 150–168.

Zinn, H. C., & Pierce, C. L. (2002). Values, gender, and concern about potentially dangerous wildlife. *Environment and Behavior*, *34*(2), 239–256. https://doi.org/10.1177/0013916502034002005

Appendix A

Attitudes Towards Snakes

Q0 Please read the following information and then scroll to the bottom to accept or decline your consent to participate in this survey. Thank you!

Purpose of the Research: The purpose of this survey is to assess people's feelings towards snakes. Due to the negative feelings that some people have toward snakes, it is often difficult to productively discuss conservation of these highly endangered species. Data from this study will help design educational tools for snake conservation.

What You Will Be Asked to Do in the Research: You will be asked to complete 23 short questions about your attitudes, experiences and feelings toward snakes. This should take no more than 10 minutes.

Risks and Discomforts: We do not foresee any risks or discomfort from your participation in the research, although you may feel uncomfortable or anxious when describing potentially negative feelings towards snakes.

Benefits of the Research and Benefits to You: Your opinion will be used to inform scientists and conservation specialists regarding opinions on snakes and inform the development of educational tools used for conservation. By completing this survey, you are contributing to a larger discussion between citizens and scientists about an important issue.

Voluntary Participation: Your participation in the study is completely voluntary and you may choose to stop participating at any time. Withdrawal from the Study: You can stop participating in the study at any time, for any reason, if you so decide. Your decision to stop participating, or to refuse to answer particular questions, will not affect your relationship with the researcher or York University. In the event you withdraw from the study, all associated data will be immediately deleted.

Confidentiality: All information you supply during the research will be held in confidence and you will remain anonymous to the researchers. Your data will be safely stored and backed up and only the researchers will have access to this information. The data will be archived until 1 January, 2029, and then completely deleted. Your email address will not be connected in any

way to your responses to the survey. The researcher acknowledges that the host of the online survey (Qualtrics) may automatically collect participant data without their knowledge (i.e., IP addresses). Although this information may be provided or made accessible to the researchers, it will not be used or saved without participant's consent on the researcher's system. Because this project employs e-based collection techniques, data may be subject to access by third parties as a result of various security legislation now in place in many countries and thus the confidentiality and privacy of data cannot be guaranteed during web-based transmission. Please note that at the end of the study, anonymous data may be deposited into one or more publicly accessible scientific repositories, such as York University Dataverse, and institutional research data repository, managed by York University Libraries and provided by Scholars Portal on behalf of the Ontario Council of University Libraries (OCUL), through which researchers from around the world will have access to these data for future research , through a standard data sharing license. If Dataverse is used, York University Dataverse does NOT accept content that contains confidential or sensitive information. Dataverse can be used to share de-identified and non-confidential data only. Contributors are required to remove, replace or redact such information from datasets prior to upload. Scholars Portal makes backup copies of the uploaded data regularly in the event of a server or system malfunction, malicious attack or other technical issues.

Questions About the Research? If you have questions about the research in general or about your role in the study, please feel free to contact Dr. Suzanne MacDonald, either by telephone at (416) 736-2100, extension 33970 or by e-mail at suzmac@yorku.ca. This research has been reviewed and approved by the Human Participants Review Sub-Committee, York University's Ethics Review Board, and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process, or about your rights as a participant in the study, please contact the Sr. Manager & Policy Advisor for the Office of Research Ethics, 5th Floor, York Research Tower, York University (telephone 416-736-5914 or e-mail ore@yorku.ca).

By clicking "I consent" below, you acknowledge that you have read this information and agree to participate in this research, with the knowledge that you are free to withdraw your participation at any time without penalty.

- ○ I consent
- ○ I do NOT consent

Q1 (Select all that apply) I have lived in a ____ setting:

- [ ] Urban (city)
- [ ] Rural
- [ ] Suburban

Q2 Do you visit/own a cottage?

- ○ Yes
- ○ No

Q3 Have you ever had pets?

- ○ No
- ○ Yes

Q4 Which of the following pets have you lived with?

- [ ] Cats
- [ ] Dogs
- [ ] Birds
- [ ] Fish
- [ ] Rodents (hamsters, guinea pigs, etc.)
- [ ] Reptiles (lizards, snakes, etc.)
- [ ] Amphibians (frogs, toads, etc)
- [ ] Insects/Arachnids (spiders, etc.)
- [ ] Other (please specify) _____

Q5 (Select all that apply) What is your experience with snakes?

- [ ] Encountered snakes in the wild
- [ ] Seen snakes at zoos/exhibits
- [ ] Met a pet snake
- [ ] Owned a pet snake
- [ ] Through media (screens, books, etc)

Q6 How do you feel about snakes?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I am afraid of snakes	○	○	○	○	○
I like snakes	○	○	○	○	○
Snakes are disgusting	○	○	○	○	○
Snakes are cool	○	○	○	○	○
Snakes are creepy	○	○	○	○	○
Snakes make me feel uncomfortable	○	○	○	○	○
Snakes are gross	○	○	○	○	○

Q7 (Select all that apply) I dislike snakes because:

- [ ] They could be venomous
- [ ] They scare me
- [ ] I don't know enough about them
- [ ] I have had a bad encounter with a snake
- [ ] They could hurt me
- [ ] They carry diseases
- [ ] The way they are presented in the media
- [ ] The way they move/slither

Q8 How do you feel about each of these statements?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I can't look at photos or videos of snakes	○	○	○	○	○
I enjoy seeing snakes at the zoo	○	○	○	○	○
Some snakes are very pretty to look at	○	○	○	○	○
I am only scared of venomous snakes	○	○	○	○	○

Q9 (Select all that apply) I believe that snakes are:

- [ ] Bad luck
- [ ] Evil
- [ ] None of the above

Q10 (Select all that apply) Members of my family believe snakes are:

- [ ] Bad luck
- [ ] Evil
- [ ] None of the above

Q11 If you encountered a snake outdoors would you:

- ○ Avoid it
- ○ Move it away
- ○ Kill it
- ○ Observe it

Q12 Do you believe snakes are important to the environment?

- ○ No
- ○ Yes

Q13 (Select all that apply, leave blank if none apply) I would consider myself to have a fear/dislike of:

- [ ] Rats
- [ ] Snakes
- [ ] Bats
- [ ] Spiders
- [ ] Other animals (please specify) _____

Q14 How do you feel about each of these statements?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Endangered snakes have a right to live	○	○	○	○	○
It is important that we conserve natural environments where snakes live	○	○	○	○	○
I like learning about endangered species	○	○	○	○	○
The law should allow for killing and hunting snakes	○	○	○	○	○
it is unnecessary to protect snakes in Canada because they live in other parts of the world	○	○	○	○	○

Q15 Did you know that there are endangered snakes in Canada?

○ No

○ Yes

Q16 Would you be willing to participate in an environmental education program about snakes?

- ○ Yes
- ○ No

Q17 (Select all that apply, leave blank if none apply) Which of these programs would you be open to trying?

- ☐ Live ambassador/encounter with live animal
- ☐ Video lessons
- ☐ Guided zoo tour with no animal contact
- ☐ Audio lessons/podcast (no pictures)
- ☐ Other suggestions _____

Q18 What is your highest level of education?

- ○ High school
- ○ Some college or university
- ○ College diploma
- ○ Bachelor's degree
- ○ Master's Degree
- ○ Doctorate
- ○ None of the above

Q19 What is your gender?

- ○ Male
- ○ Female
- ○ Non-binary / third gender
- ○ Prefer not to say

Q20 Were you born in Canada?

- ○ Yes
- ○ No

Q21 What country were you born in?

_____

Q22 What is your age? (In years)

_____

Q23 What is your present religion, if any?

- ○ Christian
- ○ Muslim
- ○ Hindu
- ○ Jewish
- ○ Buddhist
- ○ Atheist
- ○ Agnostic
- ○ Other (please specify) _____
- ○ Prefer not to say

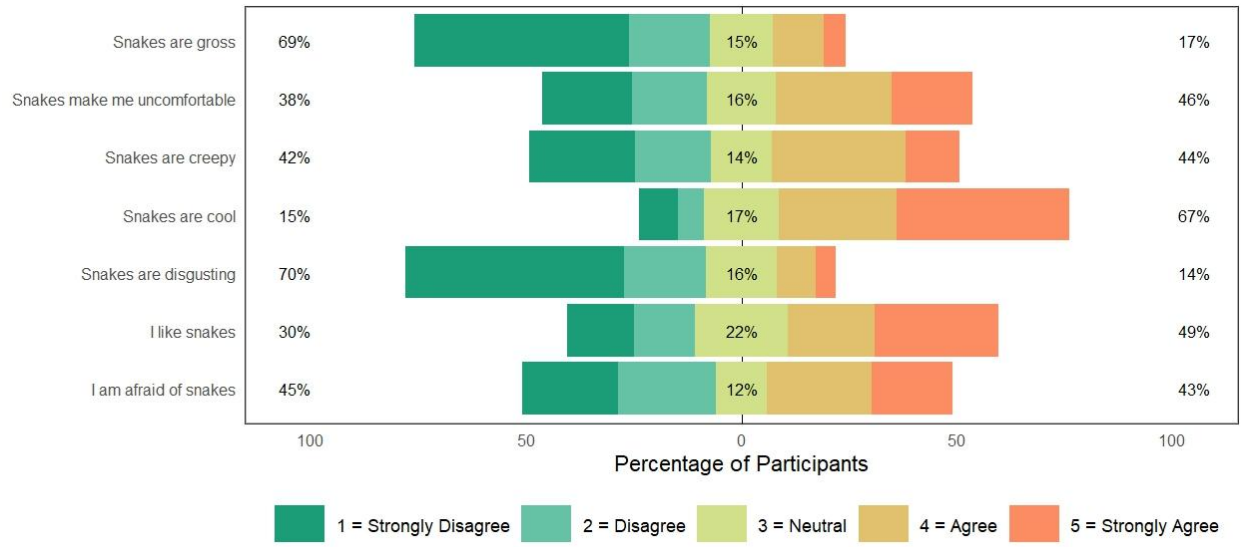

Figure 1. Distribution of participant responses to Likert-scale items measuring attitudes toward snakes (n = 369).

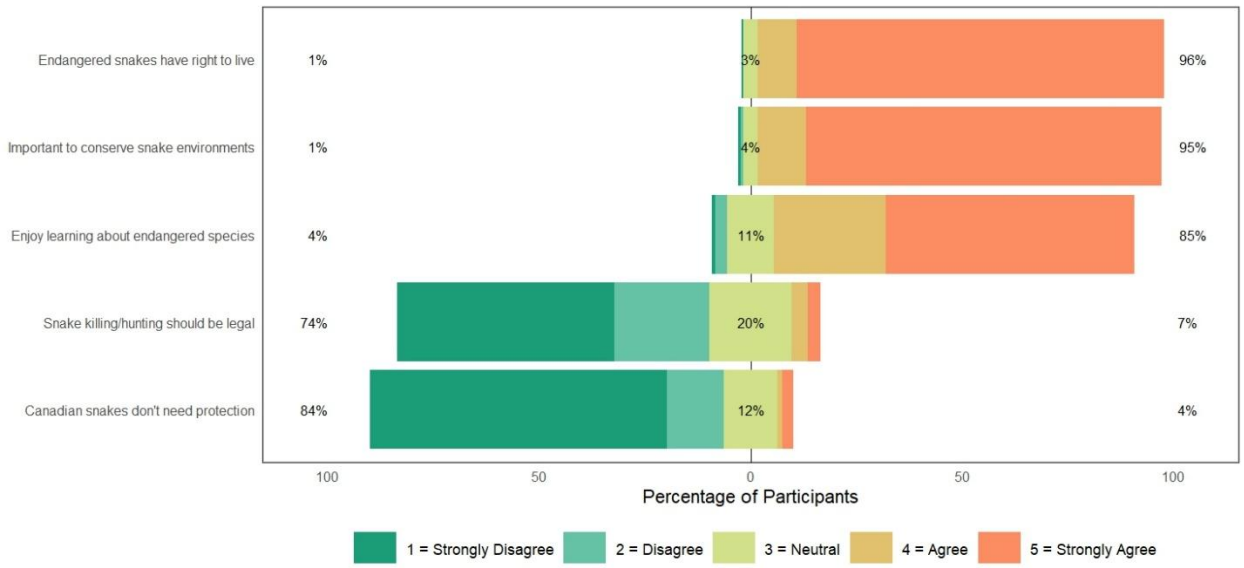

Figure 2. Distribution of participant responses measuring conservation attitudes toward snakes (n = 369).

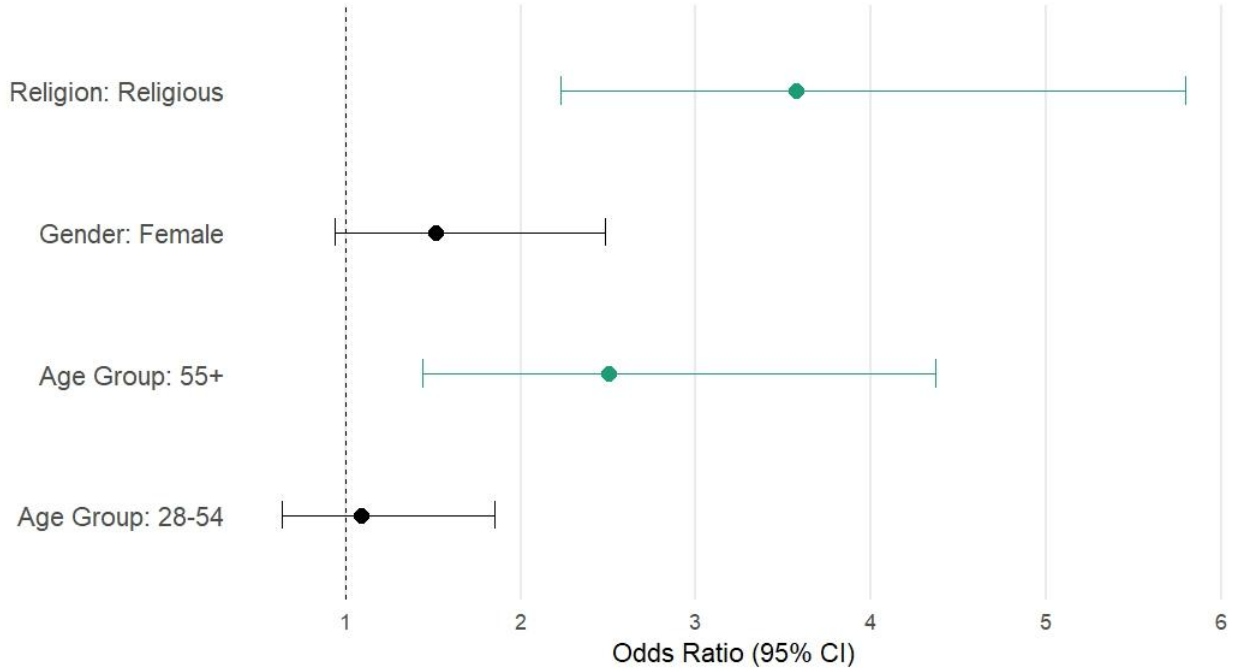

Figure 3. Odds ratios for demographic predictors of negative attitudes towards snakes (n = 369). Green markers indicate statistically significant predictors ($p < .05$); black markers indicate non-significant predictors. Odds ratios greater than 1 reflect increased likelihood of reporting negative attitudes. Reference = Non-religious, Male, 18-27.

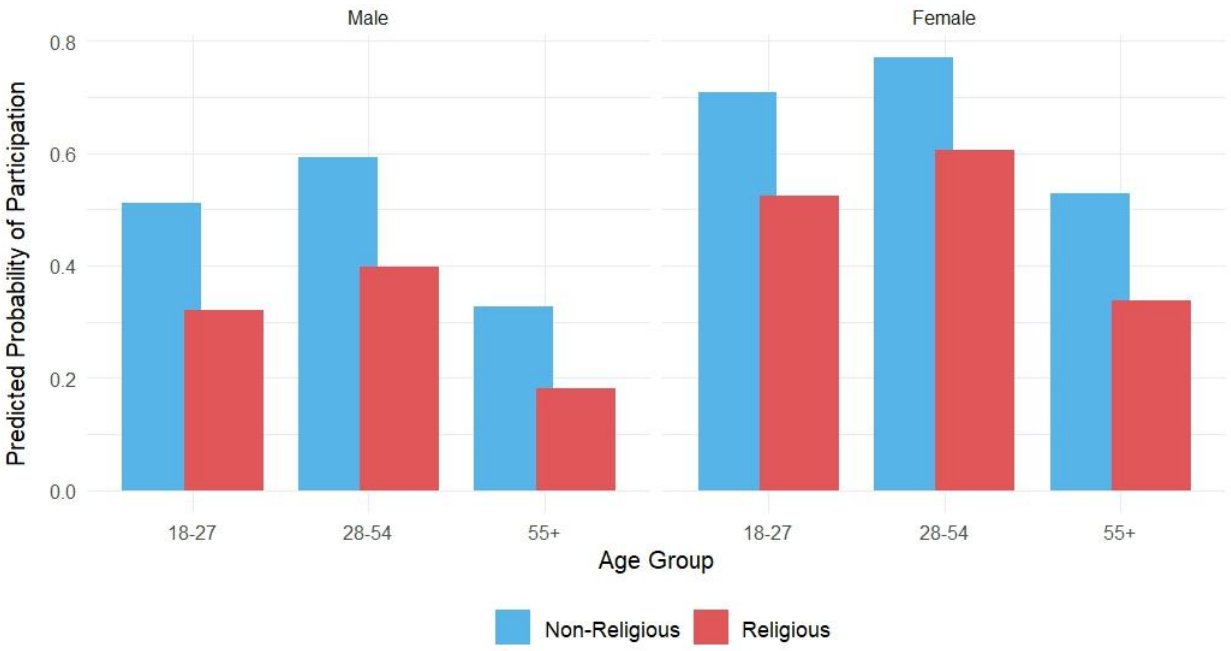

Figure 4. Predicted probability of willingness to participate in a snake conservation education program by age group, gender, and religiosity (n = 369).

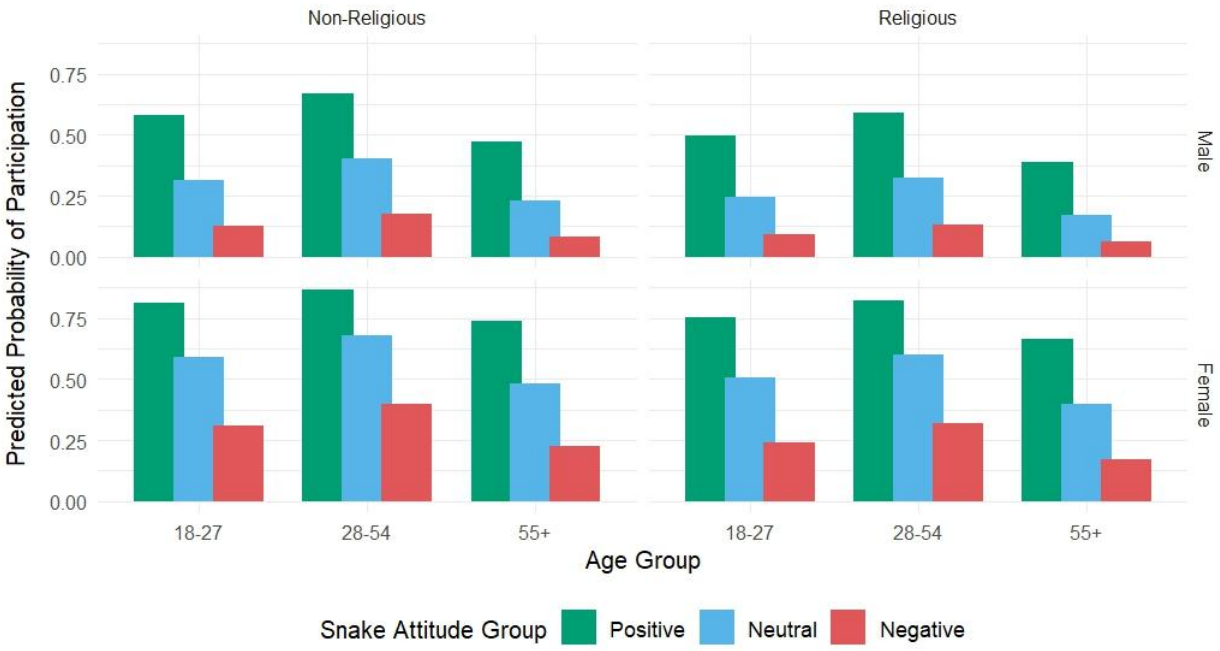

Figure 5. Predicted probability of willingness to participate in a snake conservation education program by age group, gender, religiosity, and snake attitude group (n = 369).

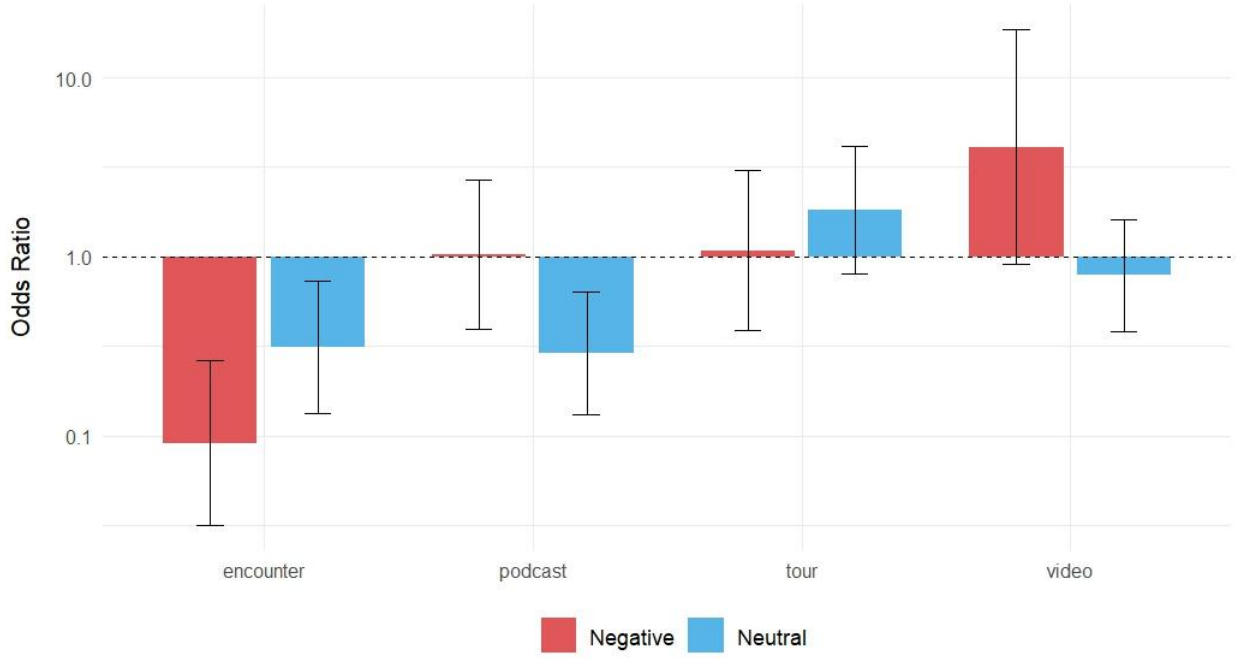

Figure 6. Odds ratios for willingness to participate in specific formats of snake conservation education programs based on attitude group (n = 196). Reference = Positive.