

**Buzz About Bees:
Adolescents' Experiences, Knowledge, and Attitudes Toward Bees**

BY

ALEXANDRA M. SILVA
B.S., Cornell University, 2009

THESIS

Submitted as partial fulfillment of the requirements for the degree of
Master of Science in Biological Sciences in the
Graduate College of the University of Illinois at Chicago, 2015

Chicago, Illinois

Defense Committee:

Emily Minor, Chair and Advisor

Roy Plotnick, Earth & Environmental Sciences

Christopher Miller, Educational Policy Studies

ACKNOWLEDGEMENTS

I am grateful for the tremendous and sustained support I have received throughout my graduate career. Emily Minor, my advisor, has provided indispensable guidance throughout the process of crafting, implementing, and finally documenting my project. I appreciate the insight and moral support she has provided, along with her encouragement and patience. I am also indebted to the members of Emily Minor's lab, both past and present, for their ideas, advice, and critiques that have helped shape my project. I am especially grateful for the help of Amélie Davis and Amy Belaire, both of whom have encouraged me to pursue my ideas since the outset of this project. The project itself would not have been feasible without the financial support provided by the UIC Chancellor's Graduate Research Fellowship.

Thank you to my family and friends who have inspired, encouraged, and supported me, without fail, over the years. I am especially grateful to my mother, Monica Roach, and my father, George Silva. Their unwavering love and support have enabled my success and ensured that I stay on target. To my four-legged friends, both here and gone, thank you for letting me be your human.

AMS

PREFACE

Declines in biodiversity have been recorded in ecosystems worldwide. Developing and implementing successful conservation efforts will require interdisciplinary research that considers the ecological and social realities of today's world. One such method involves examining the relationships between humans and wildlife in order to identify the factors influencing engagement in conservation behavior. Positioned within the framework of human-wildlife relationships, my thesis explores the relationship between adolescents and bees.

Chapter 1 examines the relationship between humans and bees through a review of existing literature. I begin by considering the plight of invertebrates in the midst of our current global decline in biodiversity and analyze the underlying factors that slow humans' willingness to conserve these particular types of species. Bees are presented as one of the most ecologically and economically important invertebrates with which humans have a long and storied history. Humans have incorporated bees and their likeness into our lives for thousands of years, yet depictions of bees do not often represent their true morphological diversity. Despite the continued importance of bees as pollinators, bees are capable of inflicting harm upon humans and are regarded neutrally by most, which may prove problematic to future conservation efforts. My examination segues into the particular role adolescents will play in future conservation efforts, revealing that adolescence may be the best developmental stage in which to foster conservation-orientated attitudes and behaviors toward bees. This literature review provides the rationale for the study carried out in the following chapter.

Chapter 2 focuses on three primary dimensions of suburban adolescents' relationships with bees: experiences, knowledge, and attitudes. I investigate each dimension individually and

PREFACE (continued)

explore how these dimensions are related to one another based on the findings of a paper questionnaire completed by 794 eighth-grade science students. The results indicate adolescents are only somewhat knowledgeable of bee biology and services, confuse bees with other flying insects, and regard bees with a generally neutral attitude. Adolescents' knowledge and attitudes correlated in a slightly positive manner. The various types of bee-related experiences an adolescent had were linked to one's knowledge and attitudes, in some cases, and also may have influenced bee-related behavior. Of particular note, students who engaged in gardening and lawn care activities were more likely to demonstrate higher levels in both the knowledge and attitude dimensions. This study provides insight into the interrelated influences of experiences, knowledge, and attitudes upon the relationship between adolescents and bees, and suggests potential approaches to promoting bee conservation among the public.

TABLE OF CONTENTS

<u>CHAPTER</u>	<u>PAGE</u>
1. BEAUTY AND THE BEE: A BRIEF HISTORY OF HUMAN-WILDLIFE RELATIONSHIPS	1
1.1. Introduction	1
1.2. Human-Wildlife Relationships	2
1.3. Bees of Past & Present	9
1.4. Adolescents: Our best hope?	17
1.5. References	19
2. THE BUZZ ABOUT BEES: ADOLESCENTS' EXPERIENCE, KNOWLEDGE, AND ATTITUDES TOWARD BEES.....	27
2.1. Introduction	27
2.2. Purpose	30
2.3. Methods	30
2.3.1. Participants & Protocol	30
2.3.2. Survey Instrument	36
2.3.3. Analysis	34
2.4. Results	34
2.4.1. Knowledge	35
2.4.2. Attitudes	37
2.4.3. Experiences	38
2.4.4. Relationships between experience, knowledge, and attitude	40
2.5. Discussion	43
2.6. Conclusions	49
2.7. References	51
APPENDICES	59
Appendix A: "Buzz about Bees" student survey.....	60
Appendix B: Participating school data.....	74
Appendix C: Results of Institutional Review Board review.....	77
VITA	79

LIST OF TABLES

<u>TABLE</u>	<u>PAGE</u>
I. PERCENTAGE OF STUDENTS THAT CORRECTLY AND INCORRECTLY IDENTIFIED IMAGES OF BEES	37
II. TWO-WAY ANALYSIS OF VARIANCE (ANOVA) OF ADOLESCENTS' ATTITUDES TOWARD BEES	43

LIST OF FIGURES

<u>FIGURE</u>	<u>PAGE</u>
1. Distribution of factual understanding scores for all students	35
2. Distribution of attitude scores for all students	38
3. Percentage of students who reported participating in specific outdoor activities throughout the year	39
4. Percentage of female and male students that reported bee-related experiences	40
5. Relationships between attitudes toward bees and knowledge of bees	41

SUMMARY

My thesis explores the factors influencing the relationship between adolescents and bees. My research is positioned within the overarching framework of human-wildlife relationships and carried out in light of the current decline in biodiversity. I examine three broad dimensions of the relationship between suburban adolescents and bees and investigate how these dimensions are related. The dimensions include adolescents' (1) experience, (2) knowledge, and (3) attitudes toward bees.

1. BEAUTY AND THE BEE: A BRIEF HISTORY OF HUMAN-WILDLIFE RELATIONSHIPS

1.1. Introduction

The conservation of global biodiversity is increasingly important given the widespread declines in species populations we are currently experiencing (Butchart et al., 2010). However, the majority of conservation organizations focus their programs and publicity on large, vertebrate, charismatic species in order to garner the attention and support of the public (Clucas, McHugh, & Caro, 2008). Invertebrates remain largely overshadowed, if not disregarded, within conservation programs (Black, Shepard, & Allen, 2001; Dunn, 2005; Looy & Wood, 2006; Wilson, 1987), which likely reflects the pervasive, negative attitudes most people hold for these organisms (Bjerke, Ødegårdstuen, & Kaltenborn, 1998b; Kellert, 1993; Prokop, Usak, Erdogan, Fancovicova, & Bahar, 2011). Bees, vital pollinators within ecosystems worldwide (Klein et al., 2007; Ollerton, Winfree, & Tarrant, 2011), require a combination of conservation efforts if we are to sustain their abundance and diversity in the face of population declines (Grünewald, 2010; Pettis & Delaplane, 2010). To inspire conservation behavior toward any organism, we must first understand the factors that influence people's behavior, including one's knowledge, experiences, and attitudes (e.g. Aipanjiguly, Jacobson, & Flamm, 2003; Fox-Parrish & Jurin, 2008; Prokop, Kubiato, & Fančovičová, 2009). Understanding the perspectives of adolescents in particular is especially important to the conservation of bees, and biodiversity in general, as they represent the future decision-makers and, therefore, conservationists of the world (Meinhold & Malkus, 2005).

1.2. Human-Wildlife Relationships

For the past several decades, researchers have been exploring the relationships between humans and the countless organisms with which we cohabitate. Many studies have been carried out in the name of conservation under the premise that awareness, knowledge, and/or positive attitudes toward animals can potentially translate into positive conservation behaviors and/or reduce ecological issues (e.g. Fox-Parrish & Jurin, 2008; Glikman, Vaske, Bath, Ciucci, & Boitani, 2012; Prokop, Kubiato, & Fančovičová, 2008; Snaddon & Turner, 2007). At the very least, such research can provide information to address and redress conservation programs (e.g. Pitt & Shockley, 2014; Schlegel & Rupf, 2010). However, studies of human-wildlife relationships do not always yield consistent results regarding the interactions between people's knowledge, attitudes, and experiences. Oftentimes, results are specific to the focal species, geographic location, age, and education level, among other factors (e.g. Barney, Mintzes, & Yen, 2005; Kellert, Black, Rush, & Bath, 1996; Prokop, Tolarovičová, Camerik, & Peterková, 2010)

Invertebrates, and especially insects, have received comparatively little attention within this field of study, though as Wilson (1987) describes, they are the little things that run the world. Invertebrates not only outnumber all other forms of life on Earth in diversity, abundance, and sheer biomass, but they are immensely important to the functioning of the world (Black et al., 2001; Wilson, 1987). Invertebrates sustain ecosystems by providing food, carrying out pollination and seed dispersal, and disposing of waste (Looy & Wood, 2006). Wilson (1987) characterized invertebrates as being even more important in ecosystem maintenance than vertebrates. Insects, a subset of invertebrates, are conservatively estimated to provide \$57 billion worth of ecological services in the US annually (Losey & Vaughan, 2006). Nonetheless,

invertebrate populations are declining worldwide (Black et al., 2001; Wilson, 1987). While only 70 modern insect extinctions have been officially documented, thousands more are estimated to have occurred (Dunn, 2005). The lack of endangered species documentation stems, in part, from a bias toward vertebrates (Black et al., 2001). For instance, while invertebrates make up more than 94% of global animal diversity, they comprise only 33% of the species red-listed by the IUCN (*International Union for the Conservation of Nature and Natural Resources*), and only 37% of listed endangered species in the US (Black et al., 2001). Over time, the prevalence of invertebrate and insect-specific conservation programs has grown (Black et al., 2001; Snaddon & Turner, 2007; Wilson, 1987). However, in general, the public still regards invertebrate species with distaste, fear, and ignorance (e.g. Bjerke, Ødegårdstuen, & Kaltenborn, 1998; Bjerke & Østdahl, 2004; Kellert, 1993)

Kellert (1993) found limited knowledge of invertebrates among the general public (Connecticut, USA), with the exception of knowledge related to agriculture and gardening. Of the participant groups surveyed, scientists and members of conservation organizations had significantly higher invertebrate knowledge than the general public, as did college-educated respondents in comparison to those with less formal education. Children, however, have proven relatively knowledgeable of invertebrates in the past (Kellert, 1984). In comparative studies of people's knowledge of animals, children in grades 2-11 correctly answered more invertebrate-related questions than adults, earning an average score of 47.5 (range of 0-100), compared to an adult mean score of 34.7 (Kellert, 1984). Eleventh graders, scoring an average of 51.3, fared better on questions concerning invertebrates than questions related to domestic animals or endangered species. However, a large number of surveyed Slovakian students inaccurately included bones within their drawings of invertebrates' internal structures, though the prevalence

of incorrect drawings decreased with age (Prokop, Prokop, & Tunnicliffe, 2008). A different subsample of Slovakian elementary students also expressed limited invertebrate knowledge, correctly identifying only 51% of invertebrate species on average (Prokop et al., 2011).

Compounding the public's limited knowledge are negative attitudes leveled at invertebrate species, including indifference, dislike, aversion, and fear (e.g. Bjerke & Østdahl, 2004; Kellert, 1993). In a survey of Norwegian adults' preferences for urban animals, most respondents expressed a dislike of invertebrate species in comparison to other animals (Bjerke & Østdahl, 2004). In a study of adult residents from the US (Connecticut), the general public also demonstrated predominantly negative sentiments toward invertebrates, though scientists and conservation organization members expressed more positive attitudes such as appreciation and concern (Kellert, 1993). Participants with a college education indicated greater ecological concern and scientific curiosity for invertebrates than those with a high school education or less, while less-educated respondents revealed greater fear of invertebrates. When viewed along gender lines, female adults demonstrate more negative attitudes, including dislike and fear, toward most invertebrate species than do their male counterparts (Bjerke & Østdahl, 2004; Davey, 1994; Kellert, 1993). Insects (and spiders) in particular tend to elicit a host of negative attitudes from people (Kellert, 1996). While butterflies are largely exempt from this animosity (Bjerke & Østdahl, 2004; Kellert, 1993; Snaddon & Turner, 2007), people are averse to having insects in the home and express fear of stinging insects in general (Bjerke et al., 1998b; Kellert, 1993).

Adolescents express similarly negative attitudes toward invertebrates (Bjerke et al., 1998b; Prokop & Tunnicliffe, 2010; Prokop et al., 2011). When asked to rate their preference on a scale of one (really dislike) to four (really like), adolescents and children awarded dogs, cats,

and squirrels an average of 3.6 or more, while neither worm, ant, nor spider averaged more than 2.1 (Bjerke et al., 1998b). Children and adolescents also cited invertebrates less frequently than mammals, birds, and amphibians when asked to list what species they would like to encounter in nature, though boys preferred to see ants and worms more than girls. Ultimately, however, few students selected invertebrate species among those animals they would save from extinction if given the opportunity (Bjerke et al., 1998b).

When viewed along gender lines, boys tend to view unpopular invertebrates like spiders, worms, and ants more positively than girls (e.g. Bjerke et al., 1998; Prokop & Tunnicliffe, 2008; Snaddon & Turner, 2007). For instance, when children aged 2-13 were asked to draw their “favorite insect” during an insect conservation program, girls demonstrated a preference for butterflies and ladybugs, while boys preferred beetles and spiders (Snaddon & Turner, 2007). Female students also expressed higher rates of fear, disgust, and perceived danger for invertebrates that pose a disease threat and their lookalikes (Prokop et al., 2011).

Other factors influencing students’ attitudes toward invertebrates may include pet ownership and cultural background. In one survey comparing Slovakian primary school students’ preferences for popular (i.e. ladybeetle, rabbit, and squirrel) versus unpopular (i.e. potato beetle, wolf, mouse) animals, pet ownership correlated with more positive attitudes and higher knowledge of both types of animals (Prokop & Tunnicliffe, 2010). Conversely, in a cross-cultural study investigating Slovakian and Turkish students’ attitudes about invertebrates, pet ownership did not significantly influence their fear, disgust, or perceived danger (Prokop et al., 2011). Within this study, Turkish students expressed greater fear, disgust, and perceived danger than Slovakian students, leading researchers to believe the difference in attitude intensity may be due to the higher prevalence of parasitic disease in Turkey (i.e. pathogen threat) and/or

the presence of dangerous animals in one's country. Cultural differences, including school curricula and media, may have also influenced students' attitudes (Prokop et al., 2011). Snaddon & Turner (2007) found that children's preferences for insect groups positively correlated to their prevalence on the Internet.

In general, researchers have found a positive relationship between students' knowledge and attitudes regarding animals that do not pose a threat, such as birds and bats (Prokop, Kubiato, et al., 2008, 2009). In the case of bats, for instance, more knowledge of bats and less belief in myths associated with bats was associated with positive attitudes toward bats (Prokop, Kubiato, et al., 2009). Conversely, spiders and snakes were perceived negatively, regardless of knowledge level, possibly because they are associated with danger either via disease risk or physical attack (Prokop, Özel, & Uşak, 2009; Prokop & Tunnicliffe, 2008). Few studies have evaluated the relationships between knowledge and attitudes related to invertebrates, particularly insects. Prokop & Tunnicliffe (2010) found students demonstrated a better knowledge of, but more negative attitudes toward, unpopular animals compared with popular animals. However, no correlations were found between ability to identify invertebrate species and students' fear, disgust, or perceived danger of those species (Prokop et al., 2011).

Fear is considered central to mammalian evolution, as it led to avoidance of potentially deadly events or situations that threatened our ancestors (Ohman & Mineka, 2001). Human fear of animals stems from factors that are usually specific to the type of animal and may be further influenced by gender, experience, and culture (Arrindell, 2000; Davey et al., 1998). In a cross-cultural analysis of animal fears, Davey *et al.* (1998) distinguished three categories of animals: fear-irrelevant (e.g. cow, chicken, dog), fear-relevant or fierce (e.g. lion, bear, alligator), and disgust-relevant (e.g. cockroach, worm, bat). Fear of disgust-relevant animals, which are

predominantly invertebrate species, was highly correlated with an animal-independent measure of disgust sensitivity (Davey et al., 1998). This correlation supported Matchett and Davey's (Matchett & Davey, 1991) disease-avoidance model that fear of disgust-relevant animals is likely mediated by an inherent fear of disease and contamination rather than physical attack or harm (Davey et al., 1998). However, when Arrindell (2000) further deconstructed humans' fear of animals into fear relevant animals (e.g. mouse, rat, bat), dry or non-slimy invertebrates (e.g. wasp, beetle, cockroach), slimy or wet looking animals (e.g. snail, worm, frog) and farm animals (goat, cow, pig), disgust sensitivity did not prove to be a very strong explanatory mechanism.

Females tend to demonstrate significantly greater fear toward most animals (Arrindell, 2000; Davey et al., 1998). Females expressed significantly greater fear than males toward disgust-relevant animals in every surveyed country except for Korea (Davey et al., 1998), but no gender difference was found with regard to fear-relevant (fierce) animals. Disgust sensitivity is also higher among women, on average, than men (Curtis, 2011), leading some researchers to speculate that the disgust (and therefore fear) disparity stems from the evolutionary role of female as protector of the next generation (Curtis, Aunger, & Rabie, 2004; Davey et al., 1998). Other researchers, however, contend that females exhibit greater fear because they are not as physically able to escape threats or predation (Prokop, Özel, et al., 2009; Prokop et al., 2010).

Researchers have contended that people's distaste, aversion, and fear of invertebrates are likely provoked by how behaviorally and morphologically dissimilar invertebrates are from humans (Kellert, 1993; Knight, Nunkoosing, Vrij, & Cherryman, 2003; Wagler & Wagler, 2012). For example, Wagler & Wagler (2012) found the external morphology of butterfly larva, lady beetle larva, and dragonfly nymphs negatively influenced the attitudes of pre-service elementary teachers. In one study, a positive trend was found between the similarity of an

animal to humans and a recommended fine for abuse of that animal (Hobbins et al., 2002). Participants recommended the lowest fine and least amount of jail time for insect abuse as compared with fish, reptiles, birds, mammals, and primates.

Regardless of why humans fear invertebrates, including insects, invertebrate life consistently garners less value than vertebrate life (e.g. Ascione, Thompson, & Black, 1997; Hobbins et al., 2002; Pagani, Robustelli, & Ascione, 2007). For instance, in the course of evaluating adolescents' behavior toward animals, killing insects, either by accident or because they were bothersome, was deemed a "socially acceptable cruel act," reflecting societal norms (Pagani et al., 2007). Similarly, a psychological assessment of childhood cruelty directed interviewers to score the trapping of an insect and prevention of its return to the wild as the least severe form of cruelty, on par with blowing into a dog's face (Ascione et al., 1997). There is little available data regarding people's experiences with invertebrates, much less insects, but 11% of sampled Italian adolescents reported committing socially acceptable cruel acts that include killing insects, along with accidentally killing a mammal or killing animals for food (Pagani et al., 2007).

It should come as no surprise then that invertebrates seldom become flagship species or are used to promote nature conservation programs (Schlegel & Rupf, 2010). Invertebrate conservation will benefit from further research into people's knowledge, experiences, and attitudes toward invertebrates. Understanding how these dimensions interact to influence positive conservation behaviors (e.g. encouraging environmental policy, contributing financial support, providing suitable habitat) is also needed. Bees represent an interesting focal species for this type of study because while bees are largely considered the most important global pollinator (e.g. Klein et al., 2007), they are also capable of inflicting harm upon humans, even inducing

death (Klotz, Klotz, & Pinnas, 2009). Furthermore, certain bee species share a likeness with other, more aggressive insects (Antonicelli, Bilò, & Bonifazi, 2002), leaving room for confusion and the potential to attribute the acts of other aggressive insects to less-aggressive bees. Yet we continue to rely on the services and products provided by bees (e.g. Klein et al., 2007), even incorporating them into our cultural artifacts (e.g. Hickner & Smith, 2007), as humans have done for thousands of years.

1.3. Bees of Past & Present

*It was the bee's knees.
~ Author Unknown*

Bees have figured in human history since ancient times, in mythologies, religions, and governments worldwide. In Ancient Egypt, honeybees were thought to have originated from the tears of the sun god, Ra, and represented royalty (Kritsky & Cherry, 2000). They featured in Egyptian hieroglyphs dating to as early as 3,100 BCE (Crane, 1999). Bees are associated with Artemis, goddess of the ancient Greek city Ephesus, and appear on the coins of her city dating back to the 5th Century (Elderkin, 1939). In Ancient Greece, the Great Mother was known as the Queen Bee and her priestesses the “Melissae,” Greek for honeybee (Hogue, 2009). In one tradition, the first Melissa is responsible for nursing the infant Zeus, while in others he is nourished by bees (Elderkin, 1939). The bee is also a symbol of Indra, Krishna and Vishnu, the nectar-born gods of Hinduism (Kritsky & Cherry, 2000), and was incorporated into the Mayan book of the dawn of life, the Popul Vuh (Hogue, 2009). Bees were represented on the coat of arms of Pope Urban VIII during the 1600s and relief carvings of bees can still be found adorning structures in St. Peter's Basilica today (Hogue, 2009). Since the 1970s, sixteen US states have adopted the European honeybee (*Apis mellifera*) as their official state insect, including Utah. Nicknamed the Beehive State, Utah's state flag and seal feature multiple bees circling a beehive,

which is thought to represent the hard-working and industrious nature of the state's citizens (Hogue, 2009).

The extensive presence of bees throughout human history reflects our longtime use of the resources bees provide. As early as 15,000 BCE, humans were procuring honey as depicted in rock paintings around the world (Crane, 1999; Crittenden, 2011). From Spain to South Africa to India, surviving paintings portray the activities of honey hunters, those people who raid wild bee hives without providing care for the bees or exerting ownership over hives (Crane, 1999). Active engagement in beekeeping, as described by Crane (1999), began as early as 3,100 BCE in Egypt, where it was used for cosmetics and a source of food to be stored in tombs. Other ancient cultures, such as the Assyrians, Chinese, Greeks, and Romans, as well as the Egyptians, employed honey to heal wounds and remedy gut ailments (Zumla & Lulat, 1989). Mead, a mixture of fermented honey and water, has long been used to create alcoholic beverages (Crane, 1999). Indeed, the term "medicine" has its origins in mead due to the supposed healing properties of the intoxicant (Hogue, 2009). While methods of beekeeping have evolved over time, becoming a generally more efficient enterprise, different cultures still use a variety of techniques to harvest the golden liquid (Crane, 1999).

Honey is not the only product created by bees that humans have exploited over the centuries. Wax has served multiple roles in human society, beginning with the lost-wax castings used to create metal sculptures in the Judean desert approximately 3,500-3,000 BCE (Crane, 1999). Aborigines in the Northern Territory of Australia and Western Australia relied on wax from native bees to create rock art designs as early as 4,000 BP, some of which still survive today (Taçon et al., 2010). Various cultures have also used wax to seal documents, dye textiles, and provide pharmaceutical aid over the centuries (Crane, 1999). Humans have also relied on

propolis, an adhesive, resin-based substance produced by bees, since at least 300 BCE (Burdock, 1998). While bees create propolis to maintain the honeycomb (e.g. patch holes or smooth walls), humans have used it as a sealant, toothpaste, and medicine, given its reputed anti-septic and anti-inflammatory properties (Burdock, 1998; Crane, 1999). In addition to products created by bees, humans have also made use of the bees themselves. Bee brood, or larva, was likely a source of sustenance for early hominids in the Upper Paleolithic period (Crittenden, 2011). Given its energy, protein, and fat content, bee brood continues to be sought out by foraging groups across South America, Africa, Asia, and Australia today. Humans have also made use of bees during times of warfare, from Paleolithic skirmishes to the Vietnam War (Lockwood, 2012). The Mayans, for example, attacked their enemies using “bee grenades,” transportable pottery containers colonized by bees, while the English subverted tunneling intruders by filling passageways with hives.

It is no surprise then that the bee remains ubiquitous within today’s culture given our consumption and use of bees and their products throughout history. In 1580, the author John Lyly penned the line “busie as a bee,” which still lives as an idiom in today’s English language (albeit with an altered spelling) (Johnson, 1961). Bees have also played roles in musical compositions, as with Nicolas Rimsky-Korsakov’s still-recognizable interlude, *Flight of the Bumblebee* (Hogue, 2009) and animated features. In Disney’s adaptations of *Winnie the Pooh*, for example, bees often play an integral part of the story as they are routinely robbed of their golden honey by the eponymous talking bear (e.g. Geurs, 1997). Anthropomorphized bees play leading roles in DreamWorks’ animated *Bee Movie*, sporting black-and-yellow banding patterns as they attempt to save the world’s flowers from extinction (Hickner & Smith, 2007). One particularly charismatic and recognizable bee has graced our television commercials and grocery

store aisles for decades: Honey Nut Cheerios' Buzz. Dressed in a yellow shirt with a black-and-yellow banded bottom, Buzz has even begun to use Twitter and Instagram to remind viewers that his product is an integral part of a healthy diet ("Buzz the Bee", n. d.). Bees even ranked #8 of planned pet costumes for the 2013 Halloween season in the US, outcompeting Batman in popularity (Grannis, 2014). Despite their portrayal, however, the stereotypical caricature of bees as black and yellow insects belies the true diversity of the organisms.

Globally, over 17,000 species of bee exist, living on every continent save for Antarctica (Michener, 2007). Bees evolved roughly alongside angiosperms during the early to mid-Cretaceous period, and phylogenetic analysis suggests Africa as the likely point of origin (Danforth, Sipes, Fang, & Brady, 2006). The oldest known bee within the fossil record dates to the early-Cretaceous period, and the specimen's physical characteristics indicate that many morphological traits of extant species were present by 100 Ma (Poinar Jr. & Danforth, 2006). Bees have diversified enormously since their appearance, but all are classified as Apiformes, and along with sphecoid wasps constitute the superfamily Apoidea within the order Hymenoptera (Michener, 2007).

As described by Michener (2007), bees demonstrate high morphological diversity across species. While some bees do resemble their portrayals in animated feature films and commercials, not all sport the stereotypical black-and-yellow banding like that of bumble bees or honeybees. However, other species within the order Hymenoptera do have similar black-and-yellow colorations, including some species of *Vespula* (yellowjackets) and *Polistes* (paper wasps). Such morphological similarity may be a source of confusion and misidentification for some, though *Vespula* species are known to be more aggressive than other Hymenoptera (Antonicelli et al., 2002). The coloration of other bees ranges from the all-black coat of some

carpenter bees to the iridescent green and purple hues of sweat bees. Body sizes of bees also vary, measuring less than 2mm to over 30mm depending on the species.

High morphological diversity of bee species is mirrored by their variability in social behavior (Michener, 1974). Bee behavior exists in gradations from solitary to social, and is characterized based on a number of variables, including proximity of nests, degree of cooperative brooding, and divisions of labor. As Michener describes, some females nest alone and die before their offspring emerge, whereas others, like many carpenter bees (*Xylocopa sp.*), nest alone but may be present when offspring emerge. Bees may also form aggregations or communal groups in which each bee operates independently, but lives within the immediate vicinity of others. Still other bees may live cooperatively, forming colonies. Highly eusocial bees, for example, display the highest levels of cooperative brooding and stark divisions of labor. Nest placement varies with species and social behavior. Nests can be found in tree cavities, crevices of human-made structures, and ground soil; however, colonies rarely construct the type of hive that hangs from tree branches, as is often depicted in *Winnie the Pooh* stories.

Bees subsist on a diet of pollen (for protein) and nectar (for energy) collected from flowering plants (Michener, 2007). As they forage for food, bees enable fertilization and reproduction of countless flowering plant species by transferring pollen between plant reproductive organs. The pollination that occurs represents a key ecosystem service provided to humans (Daily, 1997; Klein et al., 2007). Indeed, the majority of global food crops demonstrate increased fruit or seed set with animal pollination, and of the 57 animal species identified as true pollinators of the global crops directly consumed by humans, the majority were bees (Klein et al., 2007). Many crops grown in urban areas, such as community gardens, benefit from bee pollination (Matteson & Langellotto, 2009). Worldwide, 10-70% of urban households engage in

agriculture, with poor households disproportionately represented (Zezza & Tasciotti, 2010). As such, the agricultural production that occurs in public and private urban spaces (Taylor & Lovell, 2012) may provide food security for some impoverished households and is associated with a more nutritious diet (Zezza & Tasciotti, 2010).

Losey & Vaughan (2006) conservatively estimate that native pollinators in the US, which are almost exclusively bees, produce approximately \$3.07 billion worth of fruits and vegetables annually (in 2003 dollars). In California, researchers estimate that native bees are responsible for 35-39% of pollination services within the state (Chaplin-Kramer, Tuxen-Bettman, & Kremen, 2011). However, managed honeybees (*Apis mellifera*) remain the most economically valuable pollinators upon which commercial agricultural operations are increasingly dependent (Allsopp, de Lange, & Veldtman, 2008). Managed honeybees are maintained by keepers and transported between locations, which are oftentimes monocultures lacking an abundance of natural bee habitat (Grünewald, 2010) and wild bees (Kremen, Williams, Bugg, Fay, & Thorp, 2004). Within the US alone, pollination from honeybees is estimated to support \$15 billion worth of agricultural production (Morse & Calderone, 2000).

Worldwide, bee diversity and abundance is declining, presenting a significant conservation concern given the importance of bees as pollinators (Grünewald, 2010; Kearns, Inouye, & Waser, 1998). A general decline of pollinators in North America was reported by the National Resource Council (2007), and up to 65% of bee species are red-listed in some European countries (Patiny, Rasmont, & Michez, 2009). Managed honeybee populations have also declined throughout the world (Grünewald, 2010; Pettis & Delaplane, 2010; Potts et al., 2010). Declines in diversity and abundance of wild and managed bees are being driven by several factors, including pathogens and parasites, invasive plant and animal species, and pesticides

(Grünewald, 2010). Intensive land use is another factor, as it results in the loss or fragmentation of habitats (Grünewald, 2010). Agricultural intensification, for example, has been shown to negatively impact wild bee communities (Kremen, Williams, & Thorp, 2002). In the future, climate change may negatively impact bees, as changing weather patterns may disrupt lifecycles or induce migration, even altering the distribution of parasites or pathogens (Grünewald, 2010; Potts et al., 2010). Improved conservation strategies will be needed to reverse pollinator declines, including increased research of bees and education of the public (Brown & Paxton, 2009; Grünewald, 2010; Pettis & Delaplane, 2010).

Despite their global importance as pollinators, bees can also represent a danger to humans. Female bees, along with other females of the order Hymenoptera (e.g. female hornets, yellow jackets, and wasps) defend themselves with venom delivered via their stinger, a modified ovipositor (Klotz et al., 2009). For people sensitive to Hymenoptera venom, an immunologic reaction can result in an acute and possibly fatal systemic allergic reaction, also known as anaphylaxis (Klotz et al., 2009). An estimated 9.3-28.7% of the adult population demonstrates some sensitization to Hymenoptera stings (Antonicelli et al., 2002), though the prevalence of systemic reactions among US adults is only 0.5-3.3% (Bilò & Bonifazi, 2008). Sensitization to Hymenoptera stings is associated with exposure, which correlates to the length of time spent outdoors (Antonicelli et al., 2002). Anaphylaxis fatalities are more common among older adults, partially a result of comorbidity (Antonicelli et al., 2002), and there is a higher rate of admission and mortality among males (Bradley, 2008; Liew, Williamson, & Tang, 2009; Pumphrey, 2004). However, Bradley (2008) found the highest rate of admission among 5-to 9-year-olds. In countries with a moderate climate, over half of the people will be stung by age 20 (Antonicelli et al., 2002). Of the quarter of all Australian bite and sting admissions attributed to bees, the

overwhelming majority (93.5%) were attributed to an unspecified bee species (Bradley, 2008). Six of ten reported cases of bumble bee stings were reported in Victoria, though bumble bees are only found in Tasmania (Bradley, 2008), indicating that misidentification of bees does occur. In the US, yellow jackets (*Vespula* and *Dolichovespula*) and honeybees (*Apis*) are most responsible for allergic reactions (Klotz et al., 2009), though honeybee stings are more dangerous than vespid stings (Antonicelli et al., 2002).

Stings may act as conditioning experiences that provoke fear of bees and wasps (Davey, 1994). Unlike other invertebrate species, fear of bees and wasps did not correlate with disgust sensitivity, meaning it may be determined more by individual conditioning experiences and therefore a product of associative learning. In Davey's analysis (1994), 31% of respondents expressed a dislike of bees, and 21.9% expressed anxiety about bees, while 36% and 39.5% expressed dislike of and anxiety about wasps, respectively. No significant gender difference was found. In a similar survey of Dutch residents, Arrindell (2000) found 93.5% of respondents self-reported at least a little fear of wasps, making them the second most feared animal behind snakes. In an animal preference survey of Norwegian residents, bumblebees were distinguished from the bees/wasps category and received a slightly positive rating, while bees/wasps were disliked (Bjerke & Østdahl, 2004). Gender differences in fear of bees have been demonstrated in some studies (Bjerke & Østdahl, 2004), but not in others (Arrindell, 2000). Preference for bumblebees, bees, and wasps positively correlated with age and education level of Norwegian respondents (Bjerke & Østdahl, 2004). In an animal preference study specific to children and adolescents aged 9-15, bumblebees were again among the least preferred animals (beating out only ants and spiders), with females expressing even more dislike of bumblebees than males (Bjerke, Ødegårdstuen, & Kaltenborn, 1998a). In the same survey, only 5% of students selected

bumblebees as one of the 5 of 16 species to save from extinction (Bjerke et al., 1998a).

Similarly, bees were represented in less than 10% of children's "favorite insect" drawings (Snaddon & Turner, 2007).

1.4. Adolescents: Our best hope?

As an adult, an individual's attitude toward a particular species correlates with his or her willingness to provide financial support for their conservation (Martín-López, Montes, & Benayas, 2007). This does not bode well for bee conservation given the negative and, at best, neutral attitudes people hold. However, Prokop & Tunncliffe (2010) suggest that adolescence, or the 10-15 age range, is critical to the development of attitudes toward animals. Indeed, Kellert (1984) found students aged 10 to 13 undergo a major increase in cognitive and factual understanding of animals, followed by an increase in ethical concern and ecological awareness of animals, from ages 13 to 16. As such, adolescence likely presents the greatest opportunity to bolster conservation of bees through improvements in knowledge and attitudes.

Though adolescence may represent the prime developmental stage to education and inspire students about bees, today's adolescents (and people in general) spend far greater time indoors wired to technological devices than they do outdoors engaged with nature (Louv, 2005). Even for those adolescents who would venture outdoors, biodiversity is often impoverished in the most populated urban areas (Turner, Nakamura, & Dinetti, 2004). Coupled together, these factors are thought to perpetuate a cycle in which biologically impoverished areas inspire isolation and indifference to the natural world, which subsequently beget evermore homogenized environments with few people invested in environmental conservation (Miller, 2005). Conversely, childhood experiences engaging in "wild" nature (i.e. hiking in the woods, camping,

hunting, etc.) and “domesticated” nature (i.e. planting trees, picking flowers, caring for plants, etc.) positively associated with the individuals’ environmental attitudes as adults and, to different extents, their behaviors (Wells & Lekies, 2006). Similarly, proenvironmental behavior exhibited by adolescents is predicted by their proenvironmental attitudes, while environmental knowledge acts as a moderating influence (Meinhold & Malkus, 2005). These findings indicate that knowledge, experiences, and attitudes play roles in general environmental behaviors, and thus they may also play roles in adolescents’ and adults’ behaviors toward bees.

Preserving global bee abundance and diversity will largely depend on today’s youth, who will be responsible for making decisions, creating policies, and instituting programs to protect the environment (Meinhold & Malkus, 2005). While some studies have found that exposure and direct physical contact with unpopular or disliked organisms (i.e. snakes, mice, snails, and wood lice) improved students’ attitudes toward the organisms (Ballouard, Provost, Barré, & Bonnet, 2012; Randler, Hummel, & Prokop, 2012), this type of experience is likely not feasible with bees. Still, the successful conservation of bees requires that today’s adolescents engage in positive bee-related behaviors and carry these behaviors into adulthood. Exploring adolescents’ knowledge, experiences, and attitudes is the first step toward developing meaningful education and conservation programs that can precipitate such behaviors.

1.5 References

- Aipanjiguly, S., Jacobson, S. K., & Flamm, R. (2003). Conserving Manatees: Knowledge, Attitudes, and Intentions of Boaters in Tampa Bay, Florida. *Conservation Biology*, 17(4), 1098–1105.
- Allsopp, M. H., de Lange, W. J., & Veldtman, R. (2008). Valuing insect pollination services with cost of replacement. *PLoS ONE*, 3(9). doi:10.1371/journal.pone.0003128
- Antonicelli, L., Bilò, M. B., & Bonifazi, F. (2002). Epidemiology of Hymenoptera allergy. *Current Opinion in Allergy and Clinical Immunology*, 2(4), 341–346. doi:10.1097/00130832-200208000-00008
- Arrindell, W. A. (2000). Phobic dimensions: IV. The structure of animal fears. *Behaviour Research and Therapy*, 38, 509–530. doi:10.1016/S0005-7967(99)00097-2
- Ascione, F. R., Thompson, T. M., & Black, T. (1997). Childhood cruelty to animals: Assessing cruelty dimensions and motivations. *Anthrozoos*, 10(4), 170–173. doi:10.2752/089279397787001076
- 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. doi:10.1670/11-118
- Barney, E. C., Mintzes, J. J., & Yen, C.-F. (2005). Assessing Knowledge, Attitudes, and Behavior Toward Charismatic Megafauna: The Case of Dolphins. *The Journal of Environmental Education*, 36(2), 41–55. doi:10.3200/JOEE.36.2.41-55
- Bilò, B. M., & Bonifazi, F. (2008). Epidemiology of insect-venom anaphylaxis. *Current Opinion in Allergy and Clinical Immunology*, 8, 330–337. doi:10.1097/ACI.0b013e32830638c5
- Bjerke, T., Ødegårdstuen, T. S., & Kaltenborn, B. P. (1998a). Attitudes toward animals among Norwegian adolescents. *Anthrozoos*, 11(2), 79–86. doi:10.2752/089279398787000742
- Bjerke, T., Ødegårdstuen, T. S., & Kaltenborn, B. P. (1998b). Attitudes toward animals among Norwegian children and adolescents: Species preferences. *Anthrozoos*, 11(4), 227–235. doi:10.2752/089279398787000544
- Bjerke, T., & Østdahl, T. (2004). Animal-related attitudes and activities in an urban population. *Anthrozoos*, 17(2), 109–129. doi:10.2752/089279304786991783
- Black, S. H., Shepard, M., & Allen, M. M. (2001). Endangered Invertebrates : the case for greater attention to invertebrate conservation. *Endangered Species UPDATE*, 18(2), 42–50. Retrieved from http://www.xerces.org/wp-content/uploads/2008/09/endangered_paper.pdf

- Blair, D. (2009). The Child in the Garden: An Evaluative Review of the Benefits of School Gardening. *The Journal of Environmental Education*, 40(2), 15–38. doi:10.3200/JOEE.40.2.15-38
- Bradley, C. (2008). *Venomous bites and stings in Australia to 2005* (pp. 44–55). Adelaide, Australia. Retrieved from <http://nisu.fritsweb.net/pubs/reports/2008/injcat110.pdf>
- Brown, M. J. F., & Paxton, R. J. (2009). The conservation of bees: a global perspective, 40(3). doi:10.1051/apido/2009019
- Burdock, G. a. (1998). Review of the biological properties and toxicity of bee propolis (propolis). *Food and Chemical Toxicology*, 36, 347–363. doi:10.1016/S0278-6915(97)00145-2
- Butchart, S. H. M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J. P. W., Almond, R. E. a, ... Watson, R. (2010). Global biodiversity: indicators of recent declines. *Science (New York, N.Y.)*, 328, 1164–1168. doi:10.1126/science.1187512
- Chaplin-Kramer, R., Tuxen-Bettman, K., & Kremen, C. (2011). Value of Wildland Habitat for Supplying Pollination Services to Californian Agriculture. *Rangelands*, 33(3), 33–41. doi:10.2111/1551-501X-33.3.33
- Classroom Observation Hives. (n.d.). Retrieved March 15, 2015, from <http://www.classroomhives.org/>
- Clucas, B., McHugh, K., & Caro, T. (2008). Flagship species on covers of US conservation and nature magazines. *Biodiversity and Conservation*, 17, 1517–1528. doi:10.1007/s10531-008-9361-0
- Crane, E. (1999). *The World History of Beekeeping and Honey Hunting* (0th ed.). New York, NY: Taylor & Francis.
- Crittenden, A. N. (2011). The Importance of Honey Consumption in Human Evolution. *Food and Foodways*.
- Curtis, V. (2011). Why disgust matters. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366, 3478–3490. doi:10.1098/rstb.2011.0165
- Curtis, V., Aunger, R., & Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease. *Proceedings. Biological Sciences / The Royal Society*, 271 Suppl, S131–S133. doi:10.1098/rsbl.2003.0144
- Daily, G. (1997). *Nature's Services: Societal Dependence On Natural Ecosystems* (1st ed.). Washington, DC: Island Press.

- Danforth, B. N., Sipes, S., Fang, J., & Brady, S. G. (2006). The history of early bee diversification based on five genes plus morphology. *Proceedings of the National Academy of Sciences of the United States of America*, 103(41), 15118–15123. doi:10.1073/pnas.0604033103
- Davey, G. C. (1994). Self-reported fears to common indigenous animals in an adult UK population: the role of disgust sensitivity. *British Journal of Psychology (London, England : 1953)*, 85 (Pt 4), 541–554.
- Davey, G. C., McDonald, A. S., Hirisave, U., Prabhu, G. G., Iwawaki, S., Jim, C. I., ... Reimann, B. C. (1998). A cross-cultural study of animal fears. *Behaviour Research and Therapy*, 36(7-8), 735–50. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/9682528>
- Dunn, R. R. (2005). Modern insect extinctions, the neglected majority. *Conservation Biology*, 19, 1030–1036. doi:10.1111/j.1523-1739.2005.00078.x
- Elderkin, G. W. (1939). The Bee of Artemis. *The American Journal of Philology*, 60(2), 203–213. Retrieved from <http://www.jstor.org.proxy.cc.uic.edu/stable/291201>
- Fox-Parrish, L., & Jurin, R. R. (2008). Students' Perceptions of a Highly Controversial yet Keystone Species, the Black-Tailed Prairie Dog: A Case Study. *The Journal of Environmental Education*, 39(March 2014), 3–14. doi:10.3200/JOEE.39.4.3-14
- Frye, M., & Alpert, G. (2014). Paper Wasps: Friend or Foe? Retrieved February 05, 2015, from http://www.nysipm.cornell.edu/factsheets/buildings/paper_wasp.pdf
- Geurs, K. (1997). *Pooh's Grand Adventure: The Search for Christopher Robin*. Walt Disney Home Video.
- Glikman, J. A., Vaske, J. J., Bath, A. J., Ciucci, P., & Boitani, L. (2012). Residents' support for wolf and bear conservation: The moderating influence of knowledge. *European Journal of Wildlife Research*, 58, 295–302. doi:10.1007/s10344-011-0579-x
- Grannis, K. (2014). Disney's Frozen Characters and Teenage Mutant Ninja Turtles Top Children's Costume List. Retrieved October 05, 2014, from <https://nrf.com/media/press-releases/disneys-frozen-characters-teenage-mutant-ninja-turtles-top-childrens-costume>
- Grünewald, B. (2010). Is pollination at risk? current threats to and conservation of bees. *Gaia*, 19, 61–67. doi:10.1046/j.1440-1819.2002.00998.x
- Hickner, S., & Smith, S. J. (2007). *Bee Movie*. DreamWorks Animation.
- Hmelo-Silver, C. E. C. E. . B. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, 16(3), 235–266. doi:10.1023/B:EDPR.0000034022.16470.f3

- Hobbins, T., Waerstad, J., Wikner, B., Allen, M., Wirrel, J., Foy, E., & Hunstone, M. (2002). Human-to-Animal Similarity and Participant Mood Influence Punishment Recommendations for Animal Abusers. *Society & Animals*.
- Hogue, J. N. (2009). Cultural Entomology. In V. H. Resh & T. C. Ring (Eds.), *Encyclopedia of Insects* (Second, pp. 239–245). doi:10.1016/B978-0-12-374144-8.00072-2
- Johnson, J. W. (1961). That neo-classical bee. *Journal of the History of Ideas*, 22(2), 262–266. Retrieved from <http://www.jstor.org/stable/2707837>
- Kearns, C. a., Inouye, D. W., & Waser, N. M. (1998). ENDANGERED MUTUALISMS: The Conservation of Plant-Pollinator Interactions. *Annual Review of Ecology and Systematics*, 29(1998), 83–112. doi:10.1146/annurev.ecolsys.29.1.83
- Kellert, S. R. (1984). Attitudes toward Animals: Age-Related Development among Children. *The Journal of Environmental Education*, 16, 29–39. doi:10.1080/00958964.1985.9942709
- Kellert, S. R. (1993). Values and perceptions of invertebrates. *Conservation Biology*, 7(4), 845–855. doi:10.1046/j.1523-1739.1993.07040845.x
- Kellert, S. R. (1996). *The Value of Life: Biological Diversity and Human Society*. *Environmental Ethics* (p. 282). doi:10.2307/3802153
- Kellert, S. R., Black, M., Rush, C. R., & Bath, A. J. (1996). Human Culture and Large Carnivore Conservation in North America, 10(4), 977–990.
- Klein, A.-M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. a, Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings. Biological Sciences / The Royal Society*, 274(October 2006), 303–313. doi:10.1098/rspb.2006.3721
- Klemmer, C. D., Waliczek, T. M., & Zajicek, J. M. (2005). Growing minds: The effect of a school gardening program on the science achievement of elementary students. *HortTechnology*, 15(September), 448–452.
- Klotz, J. H., Klotz, S. a., & Pinnas, J. L. (2009). Animal Bites and Stings with Anaphylactic Potential. *Journal of Emergency Medicine*, 36(2), 148–156. doi:10.1016/j.jemermed.2007.06.018
- Knight, S., Nunkoosing, K., Vrij, A., & Cherryman, J. (2003). Using grounded theory to examine people's attitudes toward how animals are used. *Society & Animals : Social Scientific Studies of the Human Experience of Other Animals*, 11(4), 307–327.
- Kremen, C., Williams, N. M., Bugg, R. L., Fay, J. P., & Thorp, R. W. (2004). The area requirements of an ecosystem service: Crop pollination by native bee communities in California. *Ecology Letters*, 7, 1109–1119. doi:10.1111/j.1461-0248.2004.00662.x

- Kremen, C., Williams, N. M., & Thorp, R. W. (2002). Crop pollination from native bees at risk from agricultural intensification. *Proceedings of the National Academy of Sciences of the United States of America*, 99(26), 16812–16816. doi:10.1073/pnas.262413599
- Kritsky, G., & Cherry, R. (2000). *Insect Mythology* (pp. 49–63). Lincoln, NE: iUniverse.
- Liew, W. K., Williamson, E., & Tang, M. L. K. (2009). Anaphylaxis fatalities and admissions in Australia. *Journal of Allergy and Clinical Immunology*, 123(2), 434–442. doi:10.1016/j.jaci.2008.10.049
- Lockwood, J. a. (2012). Insects as Weapons of War, Terror, and Torture. *Annual Review of Entomology*, 57, 205–227. doi:10.1146/annurev-ento-120710-100618
- Looy, H., & Wood, J. R. (2006). Attitudes Toward Invertebrates: Are Educational “Bug Banquets” Effective? *The Journal of Environmental Education*, 37(March 2014), 37–48. doi:10.3200/JOEE.37.2.37-48
- Losey, J. E., & Vaughan, M. (2006). The Economic Value of Ecological Services Provided by Insects. *BioScience*, 56(4), 311. doi:10.1641/0006-3568(2006)56[311:TEVOES]2.0.CO;2
- Louv, R. (2005). *Last Child in the Woods: Saving our Children from Nature-Deficit Disorder*. Chapel Hill, North Carolina: Algonquin Books of Chapel Hill.
- Martín-López, B., Montes, C., & Benayas, J. (2007). The non-economic motives behind the willingness to pay for biodiversity conservation. *Biological Conservation*, 139, 67–82. doi:10.1016/j.biocon.2007.06.005
- Matchett, G., & Davey, G. C. (1991). A test of a disease-avoidance model of animal phobias. *Behaviour Research and Therapy*, 29(1), 91–94.
- Meinhold, J. L., & Malkus, A. J. (2005). Adolescent Environmental Behaviors: Can Knowledge, Attitudes, and Self-Efficacy Make a Difference? *Environment and Behavior*, 37(4), 511–532. doi:10.1177/0013916504269665
- Michener, C. D. (1974). *The social behavior of the bees: a comparative study* (1st ed.). Harvard University Press.
- Michener, C. D. (2007). *The Bees of the World* (2nd ed.). Baltimore, MD: Johns Hopkins University Press.
- Miller, J. R. (2005). Biodiversity conservation and the extinction of experience. *Trends in Ecology and Evolution*, 20(8), 430–434. doi:10.1016/j.tree.2005.05.013
- Morse, R. A., & Calderone, N. W. (2000). The value of honeybees as pollinators of US crops in 2000. *Bee Culture*, 128(3), 1–15.

- Ohman, a, & Mineka, S. (2001). Fears, phobias, and preparedness: toward an evolved module of fear and fear learning. *Psychological Review*, 108(3), 483–522. doi:10.1037/0033-295X.108.3.483
- Ollerton, J., Winfree, R., & Tarrant, S. (2011). How many flowering plants are pollinated by animals? *Oikos*, 120(321), 321–326. doi:10.1111/j.1600-0706.2010.18644.x
- Pagani, C., Robustelli, F., & Ascione, F. R. (2007). Italian Youths' Attitudes toward, and Concern for, Animals, 20(3), 275–293.
- Patiny, S., Rasmont, P., & Michez, D. (2009). A survey and review of the status of wild bees in the West-Palaeartic region. *Apidologie*, 40, 313–331. doi:10.1051/apido/2009028
- Patrick, P., Byrne, J., Tunnicliffe, S. D., Asunta, T., Carvalho, G. S., Havu-Nuutinen, S., ... Tracana, R. B. (2013). Students (ages 6, 10, and 15 years) in six countries knowledge of animals. *Nordic Studies in Science Education*, 9(1), 18–32.
- Pettis, J. S., & Delaplane, K. S. (2010). Coordinated responses to honey bee decline in the USA. *Apidologie*, 41(3), 256–263. doi:10.1051/apido/2010013
- Pitt, D. B., & Shockley, M. (2014). Don't Fear the Creeper: Do Entomology Outreach Events Influence How the Public Perceives and Values Insects and Arachnids? *American Entomologist*, 60(2), 97–100.
- Poinar Jr., G. O., & Danforth, B. N. (2006). A Fossil Bee from Early. *Science*, 314(October), 2006. doi:10.1126/science.1134103
- Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology and Evolution*, 25(6), 345–353. doi:10.1016/j.tree.2010.01.007
- Prokop, P., Kubiato, M., & Fančovičová, J. (2008). Slovakian pupils' knowledge of, and attitudes toward, birds. *Anthrozoos*, 21(3), 221–235. doi:10.2752/175303708X332035
- Prokop, P., Kubiato, M., & Fančovičová, J. (2009). Vampires Are Still Alive: Slovakian Students' Attitudes toward Bats *. *Anthrozoös*, 22(1), 19–30.
- Prokop, P., Özel, M., & Uşak, M. (2009). Cross-Cultural Comparison of Student Attitudes toward Snakes. *Society & Animals*, 17, 224–240. doi:10.1163/156853009X445398
- Prokop, P., Prokop, M., & Tunnicliffe, S. D. (2008). Effects of Keeping Animals as Pets on Children's Concepts of Vertebrates and Invertebrates. *International Journal of Science Education*, 30(790627092), 431–449. doi:10.1080/09500690701206686

- Prokop, P., Tolarovičová, A., Camerik, A. M., & Peterková, V. (2010). High School Students' Attitudes Towards Spiders: A cross- cultural comparison. *International Journal of Science Education*, 32(January 2013), 1665–1688. doi:10.1080/09500690903253908
- Prokop, P., & Tunnicliffe, S. D. (2008). “Disgusting” animals: Primary school children’s attitudes and myths of bats and spiders. *Eurasia Journal of Mathematics, Science and Technology Education*, 4(2), 87–97.
- Prokop, P., & Tunnicliffe, S. D. (2010). Effects of having pets at home on children’s attitudes toward popular and unpopular animals. *Anthrozoos*, 23(1), 21–35.
- Prokop, P., Usak, M., Erdogan, M., Fancovicova, J., & Bahar, M. (2011). Slovakian and Turkish Students’ Fear, Disgust and Perceived Danger of Invertebrates. *Hacettepe Universitesi Egitim Fakultesi Dergisi-Hacettepe University Journal of Education*, 344–352. Retrieved from <Go to ISI>://000292177600031
- Pumphrey, R. (2004). Anaphylaxis: can we tell who is at risk of a fatal reaction? *Current Opinion in Allergy and Clinical Immunology*, 4, 285–290. doi:10.1097/01.all.0000136762.89313.0b
- Randler, C., Hummel, E., & Prokop, P. (2012). Practical Work at School Reduces Disgust and Fear of Unpopular Animals. *Society & Animals*, 20, 61–74. doi:10.1163/156853012X614369
- Schlegel, J., & Rupf, R. (2010). Attitudes towards potential animal flagship species in nature conservation: A survey among students of different educational institutions. *Journal for Nature Conservation*, 18, 278–290. doi:10.1016/j.jnc.2009.12.002
- Snaddon, J. L., & Turner, E. C. (2007). A child’s eye view of the insect world: perceptions of insect diversity. *Environmental Conservation*, 34(1), 33. doi:10.1017/S0376892907003669
- Taçon, P. S. C., May, S. K., Fallon, S. J., Travers, M., Wesley, D., & Lamilami, R. (2010). A minimum age for early depictions of Southeast Asian praus in the rock art of Arnhem Land, Northern Territory, (71), 1–10.
- Taylor, J. R., & Lovell, S. T. (2012). Mapping public and private spaces of urban agriculture in Chicago through the analysis of high-resolution aerial images in Google Earth. *Landscape and Urban Planning*, 108, 57–70. doi:10.1016/j.landurbplan.2012.08.001
- Tunnicliffe, S. D., & Reiss, M. J. (1999). Building a model of the environment: how do children see animals? *Journal of Biological Education*, 33(3), 142–148.
- Turner, W. R., Nakamura, T., & Dinetti, M. (2004). Global Urbanization and the Separation of Humans from Nature. *BioScience*, 54(6), 585. doi:10.1641/0006-3568(2004)054[0585:GUATSO]2.0.CO;2

- Vosniadou, S., Vamvakoussi, X., & Skopeliti, I. (2008). The framework theory approach to the problem of conceptual change. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (1st ed., pp. 3–34). New York, NY: Routledge.
- Wagler, R., & Wagler, A. (2012). External insect morphology : A negative factor in attitudes toward insects and likelihood of incorporation in future science education settings. *International Journal of Environmental & Science Education*, 7(2), 313–325.
- Wells, N. M., & Lekies, K. S. (2006). Nature and the Life Course: Pathways from Childhood Nature Experiences to Adult Environmentalism¹. *Children, Youth and Environments*, 16(1), 1–25.
- Wilson, E. O. (1987). The Little Things That Run the world* (The Importance and Conservation of Invertebrates). *Conservation Biology*, 1(4), 344–346. doi:10.1111/j.1523-1739.1987.tb00055.x
- Zeza, A., & Tasciotti, L. (2010). Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries. *Food Policy*, 35(4), 265–273. doi:10.1016/j.foodpol.2010.04.007
- Zumla, a, & Lulat, a. (1989). Honey--a remedy rediscovered. *Journal of the Royal Society of Medicine*, 82(July), 384–385. doi:10.1177/014107688908200703

2. THE BUZZ ABOUT BEES: ADOLESCENTS' EXPERIENCE, KNOWLEDGE, AND ATTITUDES TOWARD BEES

2.1. Introduction

The majority of today's biodiversity conservation programs are focused on popular, charismatic vertebrates (Clucas et al., 2008), leaving little room for the spineless creatures that truly run the world, invertebrates (Wilson, 1987). The enormity of invertebrate biomass that exists on earth is matched only by the enormous importance of invertebrates to the functioning of the world; yet the declining populations of invertebrates have received comparatively little attention from conservationists (Black et al., 2001; Dunn, 2005; Looy & Wood, 2006; Wilson, 1987). Understanding how to promote positive behaviors toward animals of conservation concern often involves exploring people's knowledge, experiences, and attitudes toward the focal species, as these factors are thought to ultimately influence one's behavior (e.g. Fox-Parrish & Jurin, 2008; Glikman, Vaske, Bath, Ciucci, & Boitani, 2012; Prokop, Kubiak, & Fančovičová, 2008; Snaddon & Turner, 2007). Invertebrates represent morphologically distinct creatures that tend to inspire ignorance, fear, and revulsion within the general public (e.g. Bjerke, Ødegårdstuen, & Kaltenborn, 1998; Bjerke & Østdahl, 2004; Kellert, 1993), meaning it is often difficult to elicit support for the conservation measures they require (Black et al., 2001).

Bees are undoubtedly one of the most ecologically and economically important invertebrates worldwide, as both managed and wild bees provide essential pollination services to countless flowering plant species (Allsopp et al., 2008; Chaplin-Kramer et al., 2011; Klein et al., 2007). Like most invertebrates, however, bees are generally disliked (Arrindell, 2000; Bjerke & Østdahl, 2004; Davey, 1994). In comparison studies of multiple animal species, bees are usually among the most feared or least preferred species listed (Bjerke et al., 1998b; Davey, 1994;

Snaddon & Turner, 2007). Davey (1994) suggested that experiences being stung by bees may provoke fear in humans through associative learning. Still, humans have incorporated symbols, myths, and representations of bees into our cultural artifacts for thousands of years, and continue to do so today (e.g. Crittenden, 2011; Elderkin, 1939; Hickner & Smith, 2007; Hogue, 2009).

Bees are currently undergoing a global decline in abundance and diversity (Grünewald, 2010; Patiny et al., 2009; Pettis & Delaplane, 2010; Potts et al., 2010), like many other invertebrates. Drivers of bee decline include the fragmentation and loss of habitats, use of pesticides, and the presence of pathogens, parasites, and invasive species (Grünewald, 2010; Kremen et al., 2002; Potts et al., 2010). A variety of conservation strategies have been proposed to stem the declines of bees and other pollinators (Grünewald, 2010; Pettis & Delaplane, 2010), but understanding people's knowledge, experiences, and attitudes toward bees will likely be instrumental toward promoting positive conservation behaviors. Thus far, several studies have demonstrated a link between knowledge of an animal species and their attitudes toward that animal species (e.g. Prokop, Kubiato, & Fančovičová, 2008, 2009), though not in the case of species associated with danger or physical attack (Prokop, Özel, et al., 2009; Prokop & Tunnicliffe, 2008). Though bees are responsible for pollinating many of the global food crops (Klein et al., 2007), they are also capable of inducing anaphylaxis and death in those they sting (Klotz et al., 2009). Furthermore, despite the vast diversity of bee species that exist (Michener, 2007), cultural artifacts predominantly portray bees with a standard yellow-and-black banded coloration (e.g. Hickner & Smith, 2007). This prevailing representation of bees may lead to misidentification of some similarly colored, though more aggressive, wasps as bees.

The conservation of bees, other pollinators, and global biodiversity will largely depend on today's adolescents, as they are the world's future decision-makers (Meinhold & Malkus,

2005), and ultimately conservationists. Research suggests that adolescence is the prime developmental stage during which students' knowledge and attitudes toward animals can be shaped, since adolescents demonstrate increases in factual understanding, ethical concern, and ecological awareness of animals between ages 10 to 16 (Kellert, 1984; Prokop & Tunnicliffe, 2010). Yet today's adolescents (and people in general) are abandoning the outdoors in droves and engaging less with nature as a result (Louv, 2005). The gap developing between people and nature is leading to the "extinction of experience," which may diminish interest in conservation of the environment (Miller, 2005). Inspiring positive conservation behavior toward bees in adolescents (and their future selves) will require an exploration of adolescents' knowledge, experiences, and attitudes toward the buzzing pollinators, as these factors may work to precipitate or inhibit such behavior and can be used to address education and conservation programs.

2.2. Purpose

The present study used a survey questionnaire to explore three broad dimensions of the human-bee relationship as it pertains to eighth-grade adolescents and investigated how these dimensions are related to one another. The dimensions encompass adolescents' experiences, knowledge of bees, and attitudes toward bees. Our guiding research questions were: (1) What types of experiences have adolescents had with bees or the outdoors? (2) What do adolescents know about bees, including identification abilities? (3) What are adolescents' attitudes toward bees? and (4) How are adolescents' experiences, knowledge and attitudes related to one another? The results of this study can be used to develop or enhance educational programming and curricula that pertain to conservation of bees and other pollinators.

2.3. Methods

2.3.1 Participants & Protocol

The study was conducted between May and June of 2013 in the suburbs of a large Midwestern city in the U. S. I invited 20 schools to join and seven elementary and middle school principals from six school districts agreed to participate. The proportion of low-income students within each school ranged from 6% to 89% of the student population. Three schools were composed of a predominantly Hispanic population, and three were predominantly White, while the seventh did not have a racial/ethnic majority.

Nine teachers chose to distribute the survey questionnaire within 41 eighth-grade science classrooms. All students enrolled in participating classrooms were invited to participate regardless of interest in science or academic standing. Parents and guardians had the opportunity to withdraw their student(s) from the study by signing and returning an *Opt Out* form, which was sent home a week prior to survey administration. Students of consenting parents and guardians were able to withdraw themselves from the study by leaving the questionnaire blank. Conversely, students gave their consent to be a study participant by voluntarily completing the questionnaire.

A total of 794 students returned completed or partially-completed questionnaires. Four teachers chose to self-administer the questionnaire according to a specific protocol, while the Primary Investigator administered the questionnaire for the remaining teachers following the same procedure. Students were advised of their rights as participants and reminded that participation was completely voluntary and anonymous. Administrators emphasized that the questionnaire would not be graded and would have no impact on his/her standing as a student.

Administrators allotted 20 minutes for students to complete the questionnaire and then collected all questionnaire booklets. All completed and partially-completed questionnaires were transcribed into an electronic database for analysis. I offered to lead an interactive, post-survey bee lesson for each class, but not all teachers had available class time.

2.3.2. Survey Instrument

The study instrument consisted of a paper-based, 48-item questionnaire designed for eighth-grade students according to techniques described in Dillman & Groves (2011). I modified item structure and content based on performance and feedback from a series of pilot tests completed by seventh-and eighth-grade volunteers. I took care to ensure that the sociodemographic backgrounds of pilot tests volunteers reflected those of prospective participants. The University of Illinois at Chicago Survey Research Laboratory reviewed the questionnaire and resulting suggestions were incorporated into the final version. The questionnaire was restricted to 48 closed-ended items and an optional open-ended item, requiring an average of less than 15 minutes to complete, due to limited availability of class time. The questionnaire contained three categories of items related to: (1) knowledge of bees, (2) attitudes toward bees, and (3) general background information.

Knowledge

Knowledge of bees was evaluated based on two elements: students' factual understanding of bees, and ability to visually identify bees. I used 16 multiple-choice and true-false items focused on bee biology, ecosystem services, myths, and misconceptions in order to assess students' factual understanding. Items about bee biology and services pertain to science

concepts that students are to learn by the end of grade eight, according to state-mandated science standards (Illinois State Board of Education, 2013). Items concerning myths and misconceptions are derived from issues that arose during pilot testing and commonly held beliefs known to researchers. Each item and possible answer was reviewed for accuracy and plausibility by an experienced entomologist. Answers to each item included an “I don’t know” option in order to limit guessing. Answers were scored as correct (1) vs. incorrect or “I don’t know” (0). I assessed individuals’ factual understanding by dividing number of correct responses (range 0 to 16) by total number of items ($n = 16$), with unanswered items scored as zero. I examined student performance overall and on individual items.

I assessed students’ ability to identify bees using binary selection items. Students evaluated life-sized, color images of eight flying insects and determined which images were of bees and which were not, thereby visually differentiating bees from other flying insects. The images included four morphologically-diverse bee species: a honey bee *Apis mellifera*, carpenter bee *Xylocopa sp.*, sweat bee *Agapostemon sp.*, and bumblebee *Bombus sp.* I also selected four other flying insects that have similar coloration to that of the quintessential bee (i.e. yellow and black). Three were species of wasp common to the Midwest (yellow jacket *Vespula sp.*, Eastern cicada killer *Sphecius speciosus*, and paper wasp *Polistes sp.*), in addition to one bald-faced hornet *Dolichovespula maculata*. Students selected *Yes, this is a bee* or *No, this is not a bee* for each image and the answers were scored as correct (1) vs. incorrect (0). An “I don’t know” option was omitted in order to force students to decide if the organism was or was not a bee in an attempt to imitate those judgments made when encountering a real flying insect. I assessed individuals’ abilities to visually identify bees by dividing number of correct responses (range 0 to

8) by total number of items ($n = 8$), with unanswered items scored as zero. I evaluated overall student performance and identification rates for individual insects.

I produced a composite knowledge score by dividing students' combined number of correct responses to factual understanding and visual identification items (range 0 to 24) by total number of knowledge items ($n = 24$).

Attitudes

General attitudes toward bees were gauged via student responses to a series of 19 statements that varied in content from general characterizations of bees to hypothetical situations involving bees. Students evaluated each statement using a 5-point, Likert-style response that ranged from strongly disagree (1) to neutral (3) to strongly agree (5). I assessed an individual's attitude toward bees by averaging responses (range 1 to 5) to all statements. Negatively formulated statements (i.e. *Bees are dangerous*) were scored in reverse order to maintain a unidirectional attitude scale. A high average attitude score indicated positive attitudes toward bees, while a low score indicated negative attitudes toward bees. I measured the overall internal consistency, or statistical coherence, of attitude-related items using Cronbach's Alpha and calculated a coefficient of 0.85, indicating an acceptable level of reliability.

Background Information

Questionnaire items pertaining to students' background information inquired about bee-related experiences, outdoor activities, and sociodemographic characteristics. For example, students documented whether they had seen the *Bee Movie*, previous bee stings, allergies to bee stings, and attempts at saving and/or killing bees. I also collected information regarding the

types of outdoor activities students engage in (i.e. playing sports, gardening, etc.) and the amount of time students spent outside in the two weeks prior to completing the questionnaire. Finally, students responded to items about their sex, race/ethnicity, and parental education level. Percentage of students who selected each response item was calculated out of total number of respondents to that item rather than total number of students. An open-ended prompt at the end of the questionnaire provided students the opportunity to share any questions, thoughts, or stories related to bees.

2.3.3. Analysis

Statistics were performed using R 3.0.2 and SigmaPlot 11.0. I used Spearman's rank correlations to assess the relationships between knowledge and attitude dimensions (e.g. Do students who know more about bees have more positive attitudes toward them?), while Mann-Whitney rank-sum tests and t-tests were used to compare students' experiences in light of these dimensions (e.g. Do students who garden have more positive attitudes toward bees?) Finally, I employed Chi-square tests and two-way ANOVAs to examine the role of gender in experiential differences (e.g. Are female or male students more likely to be stung by a bee?).

2.4. Results

Survey participants included 386 females, 399 males, and 9 unidentified grade eight students aged 11 to 15. When asked to identify their race/ethnicity, 46% of students selected only Hispanic/Latino, 27% only Caucasian/White, and 9% only Black/African-American. Fifteen percent of students identified with multiple races/ethnicities.

2.4.1. Knowledge

Students' factual understanding of bees proved limited, with students only answering an average of 53% ($SD = \pm 15\%$, range 6-94%) of items correctly (Figure 1). There was no significant difference between genders ($p = 0.156$). The majority of students exhibited high proficiency in basic bee biology, with 97% correctly classifying bees as insects and 93% correctly identifying bees as most active during warmer months. Fewer students (82%) correctly identified nectar as a staple of bee diets; instead, 8% mistakenly considered flower petals to be a food source. Students also demonstrated an understanding of the pollination services provided by bees: 79% recognized that bees carry pollen between flowers, and 84% cited bees as responsible for pollinating many garden flowers. However, only 36% of students recognized that transporting pollen allows flowers to reproduce as opposed to allowing them to obtain nutrients (28%) or photosynthesize (17%). Under half (49%) characterized the relationship between bees and flowers as mutualistic.

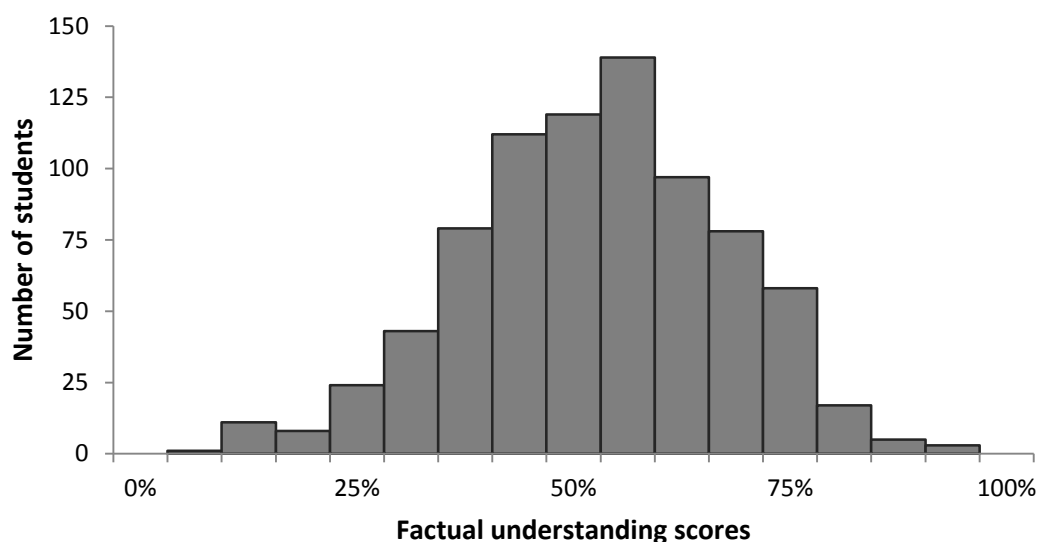


Figure 1. Distribution of average scores for all students on items pertaining to factual understanding of bees.

According to responses, myths and misconceptions regarding bees do exist. For example, only 53% of students correctly identified honey bees as the producer of the honey purchased in stores, while 62% incorrectly asserted that most bee nests are found hanging from tree branches. Similarly, more than half (60%) of students either incorrectly believe that bees carry diseases capable of infecting humans or do not know. Furthermore, students were almost equally divided on whether bees always die after stinging a person, with 39% incorrectly saying bees always die and 42% correctly saying that they do not always die.

When asked to visually identify a selection of flying insects as bees or not bees, students answered an average of 58% ($SD = \pm 17\%$; range 12.5-100%) of items correctly. Nearly all students (97%) correctly determined that the honey bee is a bee, but more than three-fourths of the students (76%) incorrectly identified the yellow jacket as a bee as well (Table A). On average, males correctly identified one more insect (62.5% of items) than females (50% of items), $U = 62165.5$; $p < 0.001$.

TABLE I
PERCENTAGE OF STUDENTS THAT CORRECTLY IDENTIFIED IMAGES OF BEES
AND INCORRECTLY IDENTIFIED IMAGES OF NON-BEE INSECTS AS BEES

Type of insect	Selected answer: "Yes, this is a bee"
Bee	(Correct)
Honey bee <i>Apis mellifera</i>	97%
Bumblebee <i>Bombus sp</i>	95%
Carpenter bee <i>Xylocopa sp.</i>	54%
Sweat bee <i>Agapostemon sp.</i>	18%
Non-bee	(Incorrect)
Yellow jacket <i>Vespula sp.</i>	76%
Paper wasp <i>Polistes sp.</i>	69%
Eastern cicada killer <i>Sphecius speciosus</i>	35%
Bald-faced hornet <i>Dolichovespula maculata</i>	20%

The two elements of students' knowledge, factual understanding, and ability to identify bees correlated in a weak, but positive, direction, $r(792) = 0.15$; $p < 0.0001$.

2.4.2. Attitudes

Overall, students demonstrated a generally neutral attitude toward bees (Figure 2). Gender significantly impacted student attitudes, $t(782) = -3.13$, $p = 0.002$, with males ($m = 3.05$) demonstrating more positive attitudes than females ($m = 2.91$).

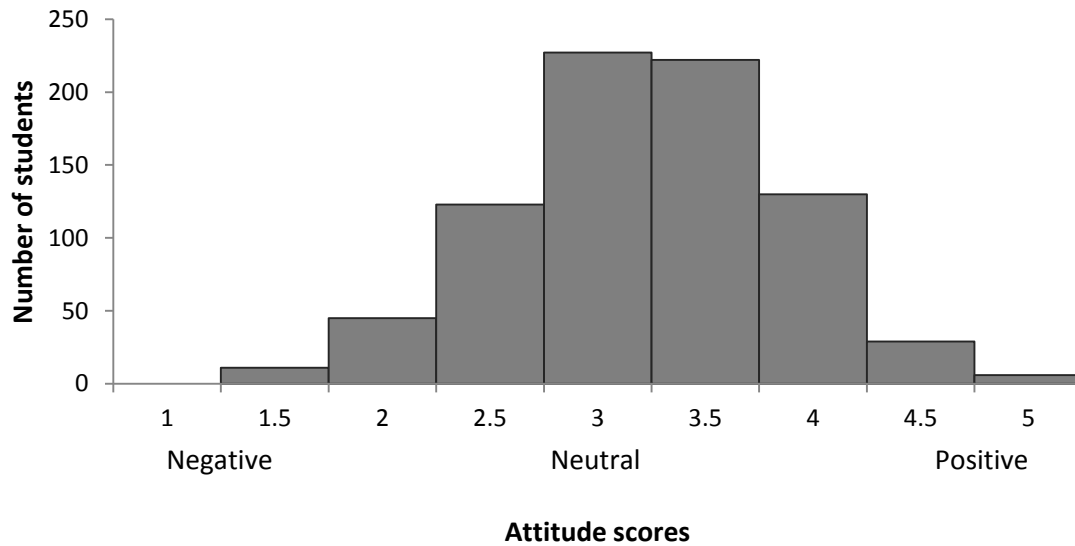


Figure 2. Distribution of average attitude scores for all students ranging from 1 (negative attitude toward bees) to 5 (positive attitude toward bees).

2.4.3. Experiences

Over 75% of students reported spending more than five total hours outside in the two weeks prior to completing the questionnaire in the late spring, with 36% of students spending more than 10 hours outside. Only 49 students reported spending fewer than two hours outside in the same period. Gardening, described as planting flowers/vegetables, watering outdoor plants, or pulling weeds, was the least popular outdoor activity overall (Figure 3), but more common among females (29%) than males (15%), $X^2 = 20.02$, $df = 1$, $p < 0.001$. Conversely, 32% of males reported performing lawn care (e.g. raking leaves or mowing grass), compared to just 21% of females, $X^2 = 11.89$, $df = 1$, $p < 0.001$.

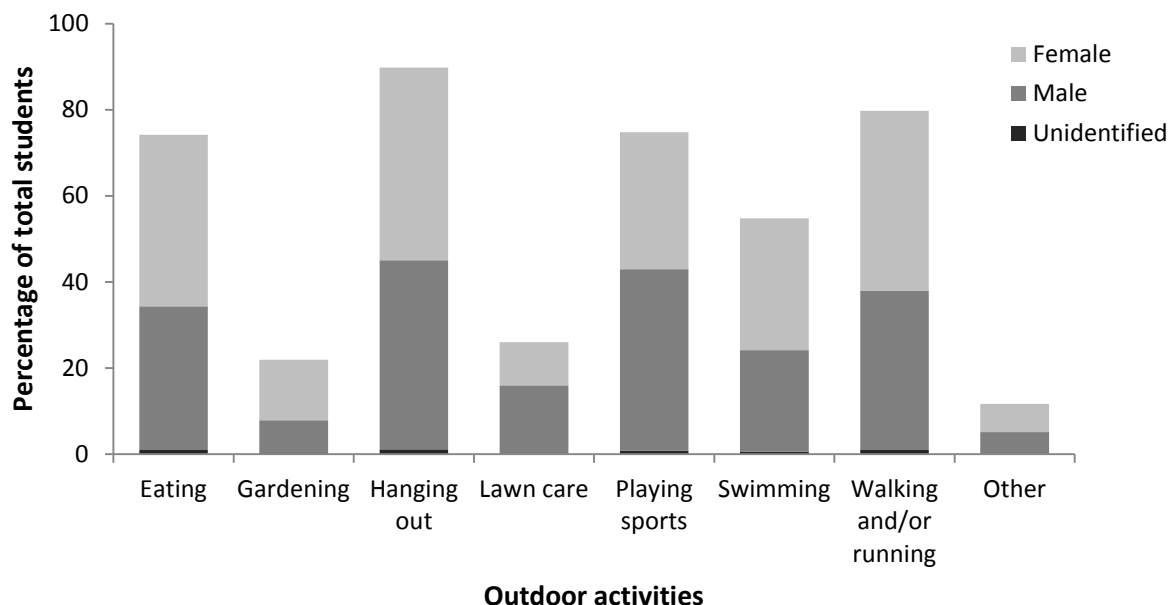


Figure 3. Percentage of female, male, and unidentified students who reported participating in specific outdoor activities throughout the year.

Of bee-related experiences, more than two-thirds (67%) of students indicated they had seen the *Bee Movie* and over half of students (57%) have been stung by a bee. While 72% of students have attempted to kill a bee at some point in the past, only 21% have ever tried to save a bee. Male students were more likely to report being stung by a bee and having tried to kill a bee, than female students (Figure 4). Experiencing a bee sting did not significantly affect whether students ever attempted to save a bee, $X^2 = .01$, $df = 1$, $p = 0.933$, but those who had been stung were more likely to attempt to kill a bee (77%) than those who had not been stung (70%), $X^2 = 9.68$, $df = 1$, $p = 0.002$. Only 5% of students reported an allergy to bee stings, though nearly 25% of students were unsure of having an allergy. Eleven students reported allergies to bee stings despite also reporting that they had never been stung or were uncertain about having been stung.

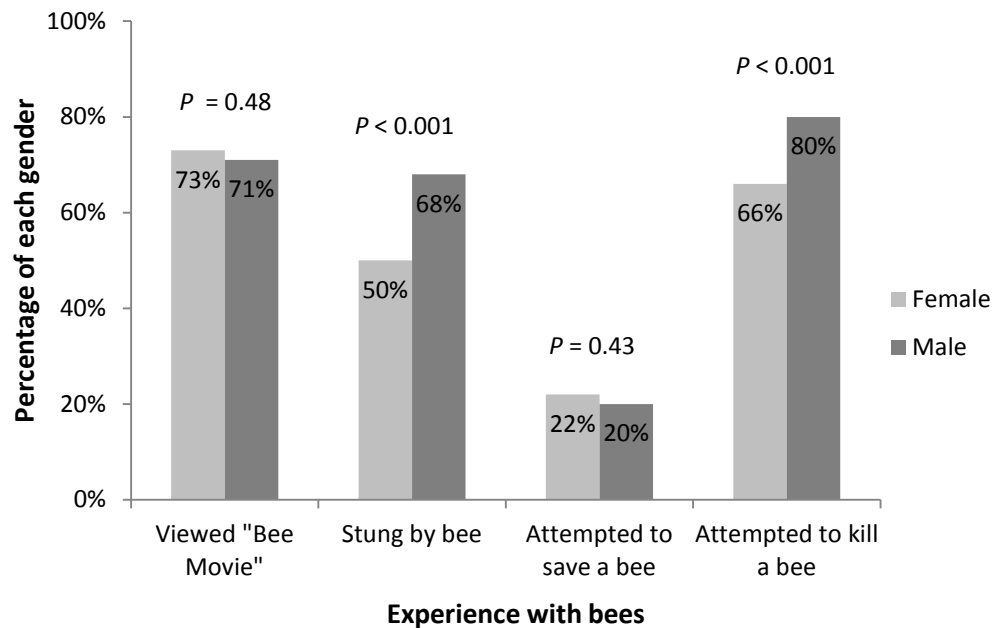


Figure 4. Percentage of female and male students that reported bee-related experiences. Males are more likely than females to be stung by a bee, $X^2 = 23.44$, $df = 1$, $p < 0.001$, and attempt to kill a bee, $X^2 = 19.20$, $df = 1$, $p < 0.001$. Gender differences did not significantly affect attempts to save a bee, $X^2 = 0.62$, $df = 1$, $p = 0.43$, nor a history of seeing the *Bee Movie*, $X^2 = 0.50$, $df = 1$, $p = 0.48$.

2.4.5. Relationships between experience, knowledge, and attitude

Greater knowledge of bees, including factual understanding and visual identification, was associated with slightly more positive attitudes toward bees (Figure 5). Students who reported seeing the *Bee Movie* did not demonstrate statistically different levels of factual understanding ($p = 0.666$) or ability to identify bees ($p = 0.856$) as compared to those students who did not see the movie; however, students who viewed the *Bee Movie* demonstrated a more positive attitude toward bees ($m = 3.038$) than others ($m = 2.834$), $t(732) = 3.971$, $p < 0.001$. Attitudes toward bees did not differ between students who had been stung by a bee and those who had not ($p =$

0.208). On average, students who reported having tried to save a bee demonstrated a more positive attitude ($m = 3.42$), higher level of factual understanding ($m = 56.3\%$), and better ability to identify bees ($m = 62.5\%$) than those who had not tried to save a bee ($m = 2.89$; $m = 50\%$; $m = 50\%$), $U = 26460.50$, $p < 0.001$; $U = 43337.00$, $p = 0.001$; $U = 46266.50$, $p = 0.035$. Students who reported having tried to kill a bee held more negative attitudes ($m = 2.87$) than those who had not ($m = 3.26$), $t(786) = -7.93$, $p < 0.001$. While there was no statistical difference in factual understanding between those who had or had not tried to kill a bee ($p = 0.161$), students who reported trying to kill a bee also had a poorer ability to identify bees ($m = 50\%$) compared to others ($m = 62.5\%$), $U = 52871.50$, $p < 0.001$.

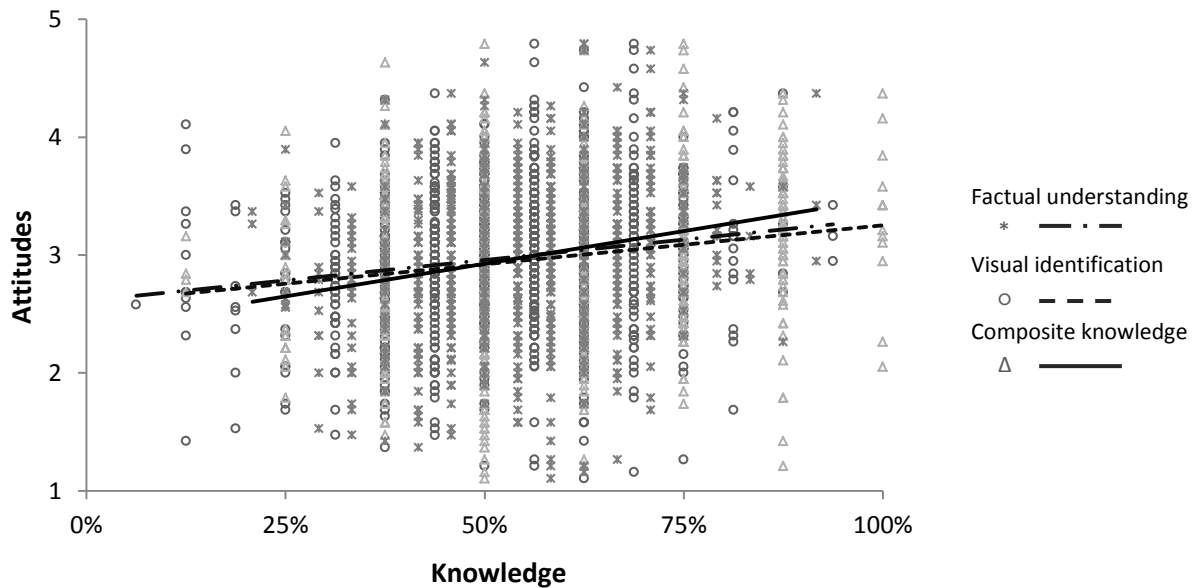


Figure 5. Relationships between attitudes toward bees and factual understanding of bees ($r(791) = 0.150$, $p < 0.0001$), visual identification of bees ($r(791) = 0.176$; $p < .0001$) and composite knowledge of bees ($r(791) = 0.213$, $p < 0.001$).

I also assessed how two specific types of outdoor experiences (i.e. gardening and lawn care) relate to students' knowledge and attitudes of bees. Students who reported participating in gardening activities during the year held more positive attitudes toward bees ($m = 3.16$) than non-gardening students ($m = 3.00$), $U = 44075.50$, $p < 0.001$. Gardening students also demonstrated a higher level of factual understanding ($m = 56.3\%$) than non-gardening students ($m = 50\%$), $U = 48467.00$, $p = 0.039$, though the act of gardening did not have a significant effect on students' ability to visually identify bees ($p = 0.253$). Similar to gardening, students who reported engaging in lawn care activities throughout the year held more positive attitudes toward bees ($m = 3.16$) than those who did not ($m = 2.95$), $U = 51040.50$, $p < 0.001$. Both factual understanding, $U = 46358.00$, $p < 0.001$, and ability to identify bees, $U = 55305.50$, $p = 0.048$, differed among students who performed lawn care ($m = 56.3\%$ and 62.5% , respectively) and those who did not ($m = 50\%$ each). A two-way ANOVA failed to uncover significant interactions between gender and gardening or gender and lawn care on students' attitudes (Table II).

TABLE II
TWO-WAY ANALYSIS OF VARIANCE (ANOVA) OF ADOLESCENTS' ATTITUDES
TOWARD BEES

	DF	SS	MS	F	P
Gardening					
Gender	1	4.833	4.833	12.503	<0.001
Gardening	1	6.534	6.534	16.902	<0.001
Gender x Gardening	1	0.265	0.265	0.684	0.408
Residual	780	301.526	0.387		
Lawn Care					
Gender	1	1.793	1.793	4.585	0.033
Lawn Care	1	3.015	3.015	7.709	0.006
Gender x Lawn Care	1	0.117	0.117	0.298	0.585
Residual	780	305.041	0.391		

2.5 Discussion

One step toward the conservation of Earth's biodiversity has been to examine the relationships between humans and animals, especially as it pertains to the effects of a person's knowledge and attitudes on their behavior (e.g. Aipanjiguly, Jacobson, & Flamm, 2003; Barney, Mintzes, & Yen, 2005). I investigated the link between these two dimensions with regard to bees, an oftentimes charismatic, sometimes troublesome, organism that provides humanity with vital ecosystem services (Klein et al., 2007). Students' knowledge of bees, subdivided into a factual understanding component and identification ability component, correlated in a weak, but positive direction with their attitudes toward bees. Each knowledge component positively correlated with attitude, but the strongest correlation emerged when the components were

considered together. Building students' knowledge of bees may then prove helpful in promoting positive attitudes toward bees. Alternatively, students who have already formed positive attitudes toward bees may be more likely or willing to augment their knowledge.

I found that students' factual understanding of bees was generally mediocre and not significantly different between males and females. Students proved knowledgeable of basic biological facts such as taxonomic identification, seasonal activity patterns, and diet composition, but failed to demonstrate a more in-depth understanding of bee behavior and services. For example, the majority of students identified pollen as the substance bees carry between flowers and labeled this activity "pollination" (both basic biological facts), but far fewer students understood that this activity enables plant reproduction. These findings suggest students have a superficial understanding of pollination and are largely unaware of the functional role of bees within ecosystems, which may simply reflect a limited knowledge of bee pollination services or a greater deficiency of plant ecology knowledge. Similarly, only about half of students recognized that the honey consumed by humans is produced by honeybee species, further highlighting students' lack of understanding of bee services. Students' understanding of bee nesting behavior also proved limited, with the majority of students incorrectly believing that most bee nests hang from tree branches, when in reality most species nest in cavities or ground soil (Michener, 2007).

The sources of students' factual understandings, including misconceptions, remain unclear. Formal schooling, informal educational experiences, personal experiences, and cultural artifacts are all potential sources of animal knowledge (Patrick et al., 2013; Tunnicliffe & Reiss, 1999). Recognizing the seasonal activity patterns of local bees, for example, may stem from personal experience while outdoors in the summer as opposed to the winter. The belief that most

bee nests hang from trees may originate in personal experiences with the nests of yellow jackets and bald-faced hornets, which are conically shaped and do hang from tree branches (Frye & Alpert, 2014). Alternatively, this misunderstanding of bee nesting behavior may have been gleaned from cultural artifacts such as cartoon portrayals of Winnie the Pooh harvesting honey from low-hanging bee nests. Having seen the *Bee Movie* did not impact students' factual understanding of bees, but this does not preclude other cultural artifacts from having an impact on students' perceptions, especially if they are viewed repeatedly, as may be the case with the commercials (i.e. Honey Nut Cheerios). Students' knowledge of bees may benefit from problem-based learning within science classrooms, especially if it is augmented with hands-on, meaningful experiences in school gardens (Hmelo-Silver, 2004). Students' misconceptions require perhaps the greatest attention, as misconceptions can be deeply ingrained and difficult to rectify since students often incorporate new knowledge without removing or altering incorrect prior knowledge (S. Vosniadou, Vamvakoussi, & Skopeliti, 2008).

Cultural artifacts depicting bees may play a role in students' ability to correctly identify bee species as well. The honeybee and bumble bee, both of which possess a black-and-yellow banded coloration, were correctly identified as bees by the vast majority of students. Though the bumble bee is more rotund than the honeybee, both were correctly identified as bees by a similar proportion of students. Carpenter bees and bumble bees closely resemble one another in size and shape, but the carpenter bee featured in the questionnaire was entirely black in color and was subsequently identified as a bee by just over half of students. Sweat bees are somewhat smaller than the other featured bees, with a distinct, iridescent green coloration. A mere 18% of students identified the sweat bee as a bee. Given the low rate of positive identification for non-black-and-yellow bees, especially given the decrease in positive identification between the otherwise

similar carpenter bee and bumble bee, it would appear that many students relied on coloration to positively identify bees.

A similar pattern of identification based upon coloration was found among the featured wasps and hornets. Specifically, a large portion of students misidentified yellow jackets and paper wasps, the two wasp species resembling the quintessential bee in size, shape, and coloration. The eastern cicada kill wasp, however, is considerably larger, with less pronounced yellow markings, and was misidentified as a bee by a much smaller proportion of students. Finally, the bald-faced hornet, a predominantly black flying insect, was misidentified as a bee by an even smaller proportion of students, despite being a relatively similar size to the yellow jacket.

Based on students' patterns of identifications and misidentifications, it seems that an insects' coloration may play an important role in determining which flying insects are bees. Specifically, a black-and-yellow banded coloration tended to elicit identification of the insect as a bee. Since bees are rarely, if ever, represented as morphologically diverse within cultural artifacts, this tendency may derive from experiences with cultural artifacts in which bees are largely represented with the quintessential black-and-yellow banded coloration. While viewing the *Bee Movie* had no significant impact on students' identification abilities, I did not measure the frequency with which the movie was viewed, nor did I investigate what other artifacts students may have been exposed to (e.g. Honey Nut Cheerios). Due to time constraints within classrooms, I chose to focus on students' abilities to identify bees from other insects within the order Hymenoptera; however, future studies may benefit by incorporating non-flying insects with similar black and yellow coloration to determine how important insect shape and the presence of wings are to correct identification. Furthermore, the format of our questionnaire

prevented us from investigating how flight patterns and insect sounds may influence identification of bees.

Overall, students expressed a positive-leaning, but generally neutral attitude toward bees. However, students with more difficulties identifying bees exhibited more negative attitudes toward bees, which may be a result of confusing bees with their related, albeit more aggressive and bothersome counterparts (Antonicelli et al., 2002), yellow jackets and paper wasps. In our study, male students held generally more positive attitudes than did female students, concurring with previous research about male and female adolescents' attitude differences toward invertebrates and insects in general (e.g. Bjerke et al., 1998; Prokop & Tunnicliffe, 2008; Snaddon & Turner, 2007), and bumblebees in particular (Bjerke et al., 1998b). Previous research on adults did not find a gender difference in attitude toward bees, though females remained more fearful of wasps than males (Davey, 1994). Considering females demonstrated poorer ability to identify bees and more negative attitudes than males as adolescents, it may be that females learn to differentiate bees from wasps by the time they reach adulthood, resulting in the same adulthood attitudes as males.

Davey (1994) suggested being stung may act as a conditioning experience that provokes fear of bees (and wasps), and therefore negative attitudes. Just over half of students reported being stung by a bee, but those that were stung did not demonstrate significantly different attitudes toward bees than other students in our study. Moreover, if stings did act as a conditioning experience, I would have expected male adolescents to have more negative attitudes toward bees, because they reported being stung more often than females. Instead, the opposite was true as males demonstrated more positive attitudes than female. Thus, I found being stung

did not act as a conditioning experience that precipitated negative attitudes for these adolescents. However, the students who had been stung by a bee proved more likely to attempt to kill a bee.

Seventy-two percent of students have attempted to kill a bee at some point in their lives. I did not investigate the circumstances of students' attempts to kill a bee, meaning this negative behavior may have occurred as a reaction to being stung or otherwise bothered. Alternatively, students may have been behaving in a proactive and potentially unprovoked manner. Regardless of the circumstances, students who had attempted to kill a bee also expressed more negative attitudes toward bees and demonstrated a poorer ability to identify bees. It is possible, then, that attempts to kill bees are precipitated not by bees themselves, but by misidentified, more aggressive wasps that may prove bothersome or harmful to adolescents. These negative-type interactions may breed negative attitudes within adolescents, but rather than assigning blame to wasps, they mistakenly place blame on bees. If these attitudes and behaviors are carried into adulthood, they may manifest in negative-bee related behavior (e.g. active extermination of bees, use of pesticides), rather than the positive behaviors necessary for bee conservation (e.g. planting pollinator-friendly gardens).

Engaging adolescents in gardening and lawn care practices may provide one method of increasing knowledge and fostering more positive attitudes toward bees, which is especially important for female adolescents given their tendency to demonstrate negative attitudes toward bees and invertebrates in general (Prokop et al., 2011). Female students reported gardening more often than males, while gardening in general was positively associated with a higher level of factual understanding and more positive attitudes toward bees. Lawn care, performed more often by male students, was also linked with greater factual understanding and more positive attitudes toward bees as well as a greater ability to identify bees. Thus, it may be that gardening and lawn

care activities promote knowledge of bees and foster positive attitudes toward bees, which may subsequently influence behavior. However, it is also possible that students who already have positive views toward nature (whether intrinsic or parent-inspired) may be more inclined to garden or perform lawn care.

In general, few students reported participating in these activities, and for those who did, it is unknown if it was compulsory or elected. School gardens provide the opportunity for students to engage in experiential learning (Blair, 2009) and may provide a structured environment in which to engage students in gardening and lawn-care activities. School gardens have already been successfully used to enhance science achievement in younger students (Klemmer, Waliczek, & Zajicek, 2005). As an extension of gardening activities, schools might also invest in building self-contained, secure observation beehives within classrooms. Observation beehives have a port to the outdoors, allowing honey bees to venture outdoors and return to their nest within the classroom where students can directly and safely observe them (e.g. “Classroom Observation Hives,” n.d.). Direct experience with bees and horticultural activities, coupled with explicit instruction as to the role of bees within ecosystems and bee identification, may foster more positive attitudes toward bees. In turn, students’ knowledge and attitudes may translate into positive bee-related behaviors as adolescents and, eventually, as adults.

2.6. Conclusion

Despite the burgeoning presence of insect conservation programs and initiatives (Snaddon & Turner, 2007), the successful conservation of bees will largely depend on adolescents, the world’s future decision-makers (Meinhold & Malkus, 2005). It will be necessary to improve students’ knowledge of bees and inspire more positive attitudes toward

bees in order to motivate similarly-positive conservation behaviors. Correcting students' misconceptions, especially those pertaining to the roles bees play within ecosystems, and helping students to differentiate bees from wasps will likely move students toward becoming more knowledgeable, bee-friendly adolescents, and eventually adults. The potential for school gardens and observational beehives to provide meaningful engagement with bees (i.e. propagation of student-planted flowers and crops) has yet to be investigated, though such in-school and after-school activities have the potential to influence students' knowledge, attitudes, and behaviors. Through informed, educational programming, we have the opportunity to inspire the conservation of bees within adolescents so that in the future they may display the knowledge and sentiments already shared by one of our participants, who stated: "I love bees so much! I think they are really cute and adorable and I really wish bees would stop being killed because we need them in our life..."

2.7 References

- Aipanjiguly, S., Jacobson, S. K., & Flamm, R. (2003). Conserving Manatees: Knowledge, Attitudes, and Intentions of Boaters in Tampa Bay, Florida. *Conservation Biology*, 17(4), 1098–1105.
- Allsopp, M. H., de Lange, W. J., & Veldtman, R. (2008). Valuing insect pollination services with cost of replacement. *PLoS ONE*, 3(9). doi:10.1371/journal.pone.0003128
- Antonicelli, L., Bilò, M. B., & Bonifazi, F. (2002). Epidemiology of Hymenoptera allergy. *Current Opinion in Allergy and Clinical Immunology*, 2(4), 341–346. doi:10.1097/00130832-200208000-00008
- Arrindell, W. A. (2000). Phobic dimensions: IV. The structure of animal fears. *Behaviour Research and Therapy*, 38, 509–530. doi:10.1016/S0005-7967(99)00097-2
- Ascione, F. R., Thompson, T. M., & Black, T. (1997). Childhood cruelty to animals: Assessing cruelty dimensions and motivations. *Anthrozoos*, 10(4), 170–173. doi:10.2752/089279397787001076
- 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. doi:10.1670/11-118
- Barney, E. C., Mintzes, J. J., & Yen, C.-F. (2005). Assessing Knowledge, Attitudes, and Behavior Toward Charismatic Megafauna: The Case of Dolphins. *The Journal of Environmental Education*, 36(2), 41–55. doi:10.3200/JOEE.36.2.41-55
- Bilò, B. M., & Bonifazi, F. (2008). Epidemiology of insect-venom anaphylaxis. *Current Opinion in Allergy and Clinical Immunology*, 8, 330–337. doi:10.1097/ACI.0b013e32830638c5
- Bjerke, T., Ødegårdstuen, T. S., & Kaltenborn, B. P. (1998a). Attitudes toward animals among Norwegian adolescents. *Anthrozoos*, 11(2), 79–86. doi:10.2752/089279398787000742
- Bjerke, T., Ødegårdstuen, T. S., & Kaltenborn, B. P. (1998b). Attitudes toward animals among Norwegian children and adolescents: Species preferences. *Anthrozoos*, 11(4), 227–235. doi:10.2752/089279398787000544
- Bjerke, T., & Østdahl, T. (2004). Animal-related attitudes and activities in an urban population. *Anthrozoos*, 17(2), 109–129. doi:10.2752/089279304786991783
- Black, S. H., Shepard, M., & Allen, M. M. (2001). Endangered Invertebrates : the case for greater attention to invertebrate conservation. *Endangered Species UPDATE*, 18(2), 42–50. Retrieved from http://www.xerces.org/wp-content/uploads/2008/09/endangered_paper.pdf

- Blair, D. (2009). The Child in the Garden: An Evaluative Review of the Benefits of School Gardening. *The Journal of Environmental Education*, 40(2), 15–38. doi:10.3200/JOEE.40.2.15-38
- Bradley, C. (2008). *Venomous bites and stings in Australia to 2005* (pp. 44–55). Adelaide, Australia. Retrieved from <http://nisu.fritsweb.net/pubs/reports/2008/injcat110.pdf>
- Brown, M. J. F., & Paxton, R. J. (2009). The conservation of bees: a global perspective, 40(3). doi:10.1051/apido/2009019
- Burdock, G. a. (1998). Review of the biological properties and toxicity of bee propolis (propolis). *Food and Chemical Toxicology*, 36, 347–363. doi:10.1016/S0278-6915(97)00145-2
- Butchart, S. H. M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J. P. W., Almond, R. E. a, ... Watson, R. (2010). Global biodiversity: indicators of recent declines. *Science (New York, N.Y.)*, 328, 1164–1168. doi:10.1126/science.1187512
- Chaplin-Kramer, R., Tuxen-Bettman, K., & Kremen, C. (2011). Value of Wildland Habitat for Supplying Pollination Services to Californian Agriculture. *Rangelands*, 33(3), 33–41. doi:10.2111/1551-501X-33.3.33
- Classroom Observation Hives. (n.d.). Retrieved March 15, 2015, from <http://www.classroomhives.org/>
- Clucas, B., McHugh, K., & Caro, T. (2008). Flagship species on covers of US conservation and nature magazines. *Biodiversity and Conservation*, 17, 1517–1528. doi:10.1007/s10531-008-9361-0
- Crane, E. (1999). *The World History of Beekeeping and Honey Hunting* (0th ed.). New York, NY: Taylor & Francis.
- Crittenden, A. N. (2011). The Importance of Honey Consumption in Human Evolution. *Food and Foodways*.
- Curtis, V. (2011). Why disgust matters. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366, 3478–3490. doi:10.1098/rstb.2011.0165
- Curtis, V., Aunger, R., & Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease. *Proceedings. Biological Sciences / The Royal Society*, 271 Suppl, S131–S133. doi:10.1098/rsbl.2003.0144
- Daily, G. (1997). *Nature's Services: Societal Dependence On Natural Ecosystems* (1st ed.). Washington, DC: Island Press.

- Danforth, B. N., Sipes, S., Fang, J., & Brady, S. G. (2006). The history of early bee diversification based on five genes plus morphology. *Proceedings of the National Academy of Sciences of the United States of America*, 103(41), 15118–15123. doi:10.1073/pnas.0604033103
- Davey, G. C. (1994). Self-reported fears to common indigenous animals in an adult UK population: the role of disgust sensitivity. *British Journal of Psychology (London, England : 1953)*, 85 (Pt 4), 541–554.
- Davey, G. C., McDonald, A. S., Hirisave, U., Prabhu, G. G., Iwawaki, S., Jim, C. I., ... Reimann, B. C. (1998). A cross-cultural study of animal fears. *Behaviour Research and Therapy*, 36(7-8), 735–50. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/9682528>
- Dunn, R. R. (2005). Modern insect extinctions, the neglected majority. *Conservation Biology*, 19, 1030–1036. doi:10.1111/j.1523-1739.2005.00078.x
- Elderkin, G. W. (1939). The Bee of Artemis. *The American Journal of Philology*, 60(2), 203–213. Retrieved from <http://www.jstor.org.proxy.cc.uic.edu/stable/291201>
- Fox-Parrish, L., & Jurin, R. R. (2008). Students' Perceptions of a Highly Controversial yet Keystone Species, the Black-Tailed Prairie Dog: A Case Study. *The Journal of Environmental Education*, 39(March 2014), 3–14. doi:10.3200/JOEE.39.4.3-14
- Frye, M., & Alpert, G. (2014). Paper Wasps: Friend or Foe? Retrieved February 05, 2015, from http://www.nysipm.cornell.edu/factsheets/buildings/paper_wasp.pdf
- Geurs, K. (1997). *Pooh's Grand Adventure: The Search for Christopher Robin*. Walt Disney Home Video.
- Glikman, J. A., Vaske, J. J., Bath, A. J., Ciucci, P., & Boitani, L. (2012). Residents' support for wolf and bear conservation: The moderating influence of knowledge. *European Journal of Wildlife Research*, 58, 295–302. doi:10.1007/s10344-011-0579-x
- Grannis, K. (2014). Disney's Frozen Characters and Teenage Mutant Ninja Turtles Top Children's Costume List. Retrieved October 05, 2014, from <https://nrf.com/media/press-releases/disneys-frozen-characters-teenage-mutant-ninja-turtles-top-childrens-costume>
- Grünewald, B. (2010). Is pollination at risk? current threats to and conservation of bees. *Gaia*, 19, 61–67. doi:10.1046/j.1440-1819.2002.00998.x
- Hickner, S., & Smith, S. J. (2007). *Bee Movie*. DreamWorks Animation.
- Hmelo-Silver, C. E. C. E. . B. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, 16(3), 235–266. doi:10.1023/B:EDPR.0000034022.16470.f3

- Hobbins, T., Waerstad, J., Wikner, B., Allen, M., Wirrel, J., Foy, E., & Hunstone, M. (2002). Human-to-Animal Similarity and Participant Mood Influence Punishment Recommendations for Animal Abusers. *Society & Animals*.
- Hogue, J. N. (2009). Cultural Entomology. In V. H. Resh & T. C. Ring (Eds.), *Encyclopedia of Insects* (Second, pp. 239–245). doi:10.1016/B978-0-12-374144-8.00072-2
- Johnson, J. W. (1961). That neo-classical bee. *Journal of the History of Ideas*, 22(2), 262–266. Retrieved from <http://www.jstor.org/stable/2707837>
- Kearns, C. a., Inouye, D. W., & Waser, N. M. (1998). ENDANGERED MUTUALISMS: The Conservation of Plant-Pollinator Interactions. *Annual Review of Ecology and Systematics*, 29(1998), 83–112. doi:10.1146/annurev.ecolsys.29.1.83
- Kellert, S. R. (1984). Attitudes toward Animals: Age-Related Development among Children. *The Journal of Environmental Education*, 16, 29–39. doi:10.1080/00958964.1985.9942709
- Kellert, S. R. (1993). Values and perceptions of invertebrates. *Conservation Biology*, 7(4), 845–855. doi:10.1046/j.1523-1739.1993.07040845.x
- Kellert, S. R. (1996). *The Value of Life: Biological Diversity and Human Society*. *Environmental Ethics* (p. 282). doi:10.2307/3802153
- Kellert, S. R., Black, M., Rush, C. R., & Bath, A. J. (1996). Human Culture and Large Carnivore Conservation in North America, 10(4), 977–990.
- Klein, A.-M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. a, Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings. Biological Sciences / The Royal Society*, 274(October 2006), 303–313. doi:10.1098/rspb.2006.3721
- Klemmer, C. D., Waliczek, T. M., & Zajicek, J. M. (2005). Growing minds: The effect of a school gardening program on the science achievement of elementary students. *HortTechnology*, 15(September), 448–452.
- Klotz, J. H., Klotz, S. a., & Pinnas, J. L. (2009). Animal Bites and Stings with Anaphylactic Potential. *Journal of Emergency Medicine*, 36(2), 148–156. doi:10.1016/j.jemermed.2007.06.018
- Knight, S., Nunkoosing, K., Vrij, A., & Cherryman, J. (2003). Using grounded theory to examine people's attitudes toward how animals are used. *Society & Animals : Social Scientific Studies of the Human Experience of Other Animals*, 11(4), 307–327.
- Kremen, C., Williams, N. M., Bugg, R. L., Fay, J. P., & Thorp, R. W. (2004). The area requirements of an ecosystem service: Crop pollination by native bee communities in California. *Ecology Letters*, 7, 1109–1119. doi:10.1111/j.1461-0248.2004.00662.x

- Kremen, C., Williams, N. M., & Thorp, R. W. (2002). Crop pollination from native bees at risk from agricultural intensification. *Proceedings of the National Academy of Sciences of the United States of America*, 99(26), 16812–16816. doi:10.1073/pnas.262413599
- Kritsky, G., & Cherry, R. (2000). *Insect Mythology* (pp. 49–63). Lincoln, NE: iUniverse.
- Liew, W. K., Williamson, E., & Tang, M. L. K. (2009). Anaphylaxis fatalities and admissions in Australia. *Journal of Allergy and Clinical Immunology*, 123(2), 434–442. doi:10.1016/j.jaci.2008.10.049
- Lockwood, J. a. (2012). Insects as Weapons of War, Terror, and Torture. *Annual Review of Entomology*, 57, 205–227. doi:10.1146/annurev-ento-120710-100618
- Looy, H., & Wood, J. R. (2006). Attitudes Toward Invertebrates: Are Educational “Bug Banquets” Effective? *The Journal of Environmental Education*, 37(March 2014), 37–48. doi:10.3200/JOEE.37.2.37-48
- Losey, J. E., & Vaughan, M. (2006). The Economic Value of Ecological Services Provided by Insects. *BioScience*, 56(4), 311. doi:10.1641/0006-3568(2006)56[311:TEVOES]2.0.CO;2
- Louv, R. (2005). *Last Child in the Woods: Saving our Children from Nature-Deficit Disorder*. Chapel Hill, North Carolina: Algonquin Books of Chapel Hill.
- Martín-López, B., Montes, C., & Benayas, J. (2007). The non-economic motives behind the willingness to pay for biodiversity conservation. *Biological Conservation*, 139, 67–82. doi:10.1016/j.biocon.2007.06.005
- Matchett, G., & Davey, G. C. (1991). A test of a disease-avoidance model of animal phobias. *Behaviour Research and Therapy*, 29(1), 91–94.
- Meinhold, J. L., & Malkus, A. J. (2005). Adolescent Environmental Behaviors: Can Knowledge, Attitudes, and Self-Efficacy Make a Difference? *Environment and Behavior*, 37(4), 511–532. doi:10.1177/0013916504269665
- Michener, C. D. (1974). *The social behavior of the bees: a comparative study* (1st ed.). Harvard University Press.
- Michener, C. D. (2007). *The Bees of the World* (2nd ed.). Baltimore, MD: Johns Hopkins University Press.
- Miller, J. R. (2005). Biodiversity conservation and the extinction of experience. *Trends in Ecology and Evolution*, 20(8), 430–434. doi:10.1016/j.tree.2005.05.013
- Morse, R. A., & Calderone, N. W. (2000). The value of honeybees as pollinators of US crops in 2000. *Bee Culture*, 128(3), 1–15.

- Ohman, a, & Mineka, S. (2001). Fears, phobias, and preparedness: toward an evolved module of fear and fear learning. *Psychological Review*, 108(3), 483–522. doi:10.1037/0033-295X.108.3.483
- Ollerton, J., Winfree, R., & Tarrant, S. (2011). How many flowering plants are pollinated by animals? *Oikos*, 120(321), 321–326. doi:10.1111/j.1600-0706.2010.18644.x
- Pagani, C., Robustelli, F., & Ascione, F. R. (2007). Italian Youths' Attitudes toward, and Concern for, Animals, 20(3), 275–293.
- Patiny, S., Rasmont, P., & Michez, D. (2009). A survey and review of the status of wild bees in the West-Palaeartic region. *Apidiologie*, 40, 313–331. doi:10.1051/apido/2009028
- Patrick, P., Byrne, J., Tunnicliffe, S. D., Asunta, T., Carvalho, G. S., Havu-Nuutinen, S., ... Tracana, R. B. (2013). Students (ages 6, 10, and 15 years) in six countries knowledge of animals. *Nordic Studies in Science Education*, 9(1), 18–32.
- Pettis, J. S., & Delaplane, K. S. (2010). Coordinated responses to honey bee decline in the USA. *Apidologie*, 41(3), 256–263. doi:10.1051/apido/2010013
- Pitt, D. B., & Shockley, M. (2014). Don't Fear the Creeper: Do Entomology Outreach Events Influence How the Public Perceives and Values Insects and Arachnids? *American Entomologist*, 60(2), 97–100.
- Poinar Jr., G. O., & Danforth, B. N. (2006). A Fossil Bee from Early. *Science*, 314(October), 2006. doi:10.1126/science.1134103
- Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology and Evolution*, 25(6), 345–353. doi:10.1016/j.tree.2010.01.007
- Prokop, P., Kubiato, M., & Fančovičová, J. (2008). Slovakian pupils' knowledge of, and attitudes toward, birds. *Anthrozoos*, 21(3), 221–235. doi:10.2752/175303708X332035
- Prokop, P., Kubiato, M., & Fančovičová, J. (2009). Vampires Are Still Alive: Slovakian Students' Attitudes toward Bats *. *Anthrozoös*, 22(1), 19–30.
- Prokop, P., Özel, M., & Uşak, M. (2009). Cross-Cultural Comparison of Student Attitudes toward Snakes. *Society & Animals*, 17, 224–240. doi:10.1163/156853009X445398
- Prokop, P., Prokop, M., & Tunnicliffe, S. D. (2008). Effects of Keeping Animals as Pets on Children's Concepts of Vertebrates and Invertebrates. *International Journal of Science Education*, 30(790627092), 431–449. doi:10.1080/09500690701206686

- Prokop, P., Tolarovičová, A., Camerik, A. M., & Peterková, V. (2010). High School Students' Attitudes Towards Spiders: A cross-cultural comparison. *International Journal of Science Education*, 32(January 2013), 1665–1688. doi:10.1080/09500690903253908
- Prokop, P., & Tunnicliffe, S. D. (2008). “Disgusting” animals: Primary school children’s attitudes and myths of bats and spiders. *Eurasia Journal of Mathematics, Science and Technology Education*, 4(2), 87–97.
- Prokop, P., & Tunnicliffe, S. D. (2010). Effects of having pets at home on children’s attitudes toward popular and unpopular animals. *Anthrozoos*, 23(1), 21–35.
- Prokop, P., Usak, M., Erdogan, M., Fancovicova, J., & Bahar, M. (2011). Slovakian and Turkish Students’ Fear, Disgust and Perceived Danger of Invertebrates. *Hacettepe Universitesi Egitim Fakultesi Dergisi-Hacettepe University Journal of Education*, 344–352. Retrieved from <Go to ISI>://000292177600031
- Pumphrey, R. (2004). Anaphylaxis: can we tell who is at risk of a fatal reaction? *Current Opinion in Allergy and Clinical Immunology*, 4, 285–290. doi:10.1097/01.all.0000136762.89313.0b
- Randler, C., Hummel, E., & Prokop, P. (2012). Practical Work at School Reduces Disgust and Fear of Unpopular Animals. *Society & Animals*, 20, 61–74. doi:10.1163/156853012X614369
- Schlegel, J., & Rupf, R. (2010). Attitudes towards potential animal flagship species in nature conservation: A survey among students of different educational institutions. *Journal for Nature Conservation*, 18, 278–290. doi:10.1016/j.jnc.2009.12.002
- Snaddon, J. L., & Turner, E. C. (2007). A child’s eye view of the insect world: perceptions of insect diversity. *Environmental Conservation*, 34(1), 33. doi:10.1017/S0376892907003669
- Taçon, P. S. C., May, S. K., Fallon, S. J., Travers, M., Wesley, D., & Lamilami, R. (2010). A minimum age for early depictions of Southeast Asian praus in the rock art of Arnhem Land, Northern Territory, (71), 1–10.
- Taylor, J. R., & Lovell, S. T. (2012). Mapping public and private spaces of urban agriculture in Chicago through the analysis of high-resolution aerial images in Google Earth. *Landscape and Urban Planning*, 108, 57–70. doi:10.1016/j.landurbplan.2012.08.001
- Tunnicliffe, S. D., & Reiss, M. J. (1999). Building a model of the environment: how do children see animals? *Journal of Biological Education*, 33(3), 142–148.
- Turner, W. R., Nakamura, T., & Dinetti, M. (2004). Global Urbanization and the Separation of Humans from Nature. *BioScience*, 54(6), 585. doi:10.1641/0006-3568(2004)054[0585:GUATSO]2.0.CO;2

- Vosniadou, S., Vamvakoussi, X., & Skopeliti, I. (2008). The framework theory approach to the problem of conceptual change. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (1st ed., pp. 3–34). New York, NY: Routledge.
- Wagler, R., & Wagler, A. (2012). External insect morphology : A negative factor in attitudes toward insects and likelihood of incorporation in future science education settings. *International Journal of Environmental & Science Education*, 7(2), 313–325.
- Wells, N. M., & Lekies, K. S. (2006). Nature and the Life Course: Pathways from Childhood Nature Experiences to Adult Environmentalism¹. *Children, Youth and Environments*, 16(1), 1–25.
- Wilson, E. O. (1987). The Little Things That Run the world* (The Importance and Conservation of Invertebrates). *Conservation Biology*, 1(4), 344–346. doi:10.1111/j.1523-1739.1987.tb00055.x
- Zeza, A., & Tasciotti, L. (2010). Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries. *Food Policy*, 35(4), 265–273. doi:10.1016/j.foodpol.2010.04.007
- Zumla, a, & Lulat, a. (1989). Honey--a remedy rediscovered. *Journal of the Royal Society of Medicine*, 82(July), 384–385. doi:10.1177/014107688908200703

APPENDICES

The Buzz about Bees

- A Research Survey -

Thank you for your time and participation.

Please DO NOT write your name or date of birth anywhere on this survey.

This survey is a research project of:

UIC Department of
UNIVERSITY OF ILLINOIS Biological Sciences
AT CHICAGO COLLEGE OF LIBERAL ARTS & SCIENCES

University of Illinois at Chicago
The buzz about bees:
adolescent knowledge, attitudes, and perceptions of bees.

INFORMATION SHEET

What is the purpose of this research?

The first goal of this survey is to understand what graduating middle school students know, and how they feel, about bees. The second goal is to identify what factors might influence students' knowledge and feelings about bees.

Why am I being asked?

You are receiving this survey because you are an 8th grade student at a participating school and your parents/guardians did not sign and return the "opt-out" form, meaning they agree to let you take this survey. Approximately 900 8th grade students are participating in this research study.

What procedures are involved?

You will complete the survey within your science classroom. The survey will begin at the start of your science class and it will be collected after you are finished. This survey should take 15 minutes or less.

Is this survey voluntary?

Your participation is very important to us, but participation in this survey is totally voluntary, meaning it is your choice whether or not to participate. This survey is stand-alone (meaning there is only one part), and you will not be contacted for further information after completing this survey.

What are the potential risks of this research?

To the best of our knowledge, completing the survey has no more risk of harm than you would experience in everyday life.

What are the potential benefits of this research?

This information will allow us to better understand what middle school students know, and how they feel, about bees.

What other options are there?

If you choose not to participate, you may sit at your desk and do other school-related work, without any negative consequences.

Person to contact with questions or concerns:

Please contact me, Alexandra Silva (312-355-1051), amsilva2@uic.edu, or my advisor Dr. Emily Minor (312-355-0823, eminor@uic.edu), if you have any questions about the survey. If you have any questions about your rights as a research participant, please contact the University of Illinois at Chicago Office for the Protection of Research Subjects at 1-866-789-6215 (toll free) or 312-996-1711, or email uicirb@uic.edu.

Participants' right to confidentiality:

Your responses will not include any personally identifying information, meaning no one will be able to link your responses to you. In addition, all responses to this survey will only be reported as a summary, with no links to individual information. Only the University of Illinois at Chicago research team will have access to your responses.

Offering of informed consent:

Choosing to complete the survey (fill it out) means that you agree (consent) to participate in this research project. If you leave the survey blank, then you do not agree to participate in this research project.

Remember: Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to withdraw at any time without affecting that relationship.

I. Check all boxes that apply to the question in this section.

1. Which outside activities do you participate in throughout the year? *Check all that apply.*
- ☐ Eating (ex: having picnics, barbecues, etc.)
 - ☐ Gardening (ex: planting flowers/vegetables, watering outdoor plants, pulling weeds, etc.)
 - ☐ Hanging out (ex: at a park, in a backyard, on a front porch, etc.)
 - ☐ Lawn care (ex: raking leaves, mowing grass, etc.)
 - ☐ Playing sports
 - ☐ Swimming
 - ☐ Walking and/or running (ex: walking your dog, walking around with friends, etc.)
 - ☐ Other (please specify): _____

II. Check only *one* (1) box for each question in this section.





2. In the past two weeks, about how many total hours have you spent outside?
- ☐ Less than 2 hours.
 - ☐ 2 – 4 hours.
 - ☐ 5 – 7 hours.
 - ☐ 8 – 10 hours.
 - ☐ More than 10 hours.
3. Bees are a type of _____.
- ☐ bird.
 - ☐ insect.
 - ☐ mammal.
 - ☐ reptile.
 - ☐ I don't know.
4. Bees are active _____.
- ☐ mainly during the warmer months of the year.
 - ☐ mainly during the colder months of the year.
 - ☐ all year long.
 - ☐ I don't know.





5. _____ is (are) part of a bee's diet.
- ☐ Grass
 - ☐ Insects
 - ☐ Flower petals
 - ☐ Nectar
 - ☐ I don't know.
6. Bee nests can be found _____.
- ☐ in the holes of tree trunks.
 - ☐ in the holes of tree trunks and in the soil on the ground.
 - ☐ in the holes of tree trunks and in standing water.
 - ☐ in the soil on the ground and in standing water.
 - ☐ I don't know.
7. When traveling between flowers, bees take _____ from one flower and leave it (them) on the next flower they visit.
- ☐ nectar
 - ☐ petals
 - ☐ pollen
 - ☐ water
 - ☐ I don't know.
8. Flowers are able to _____ as a result of being visited by bees.
- ☐ obtain nutrients
 - ☐ photosynthesize
 - ☐ reproduce
 - ☐ take in water
 - ☐ I don't know.
9. Bees and flowers have a _____ relationship.
- ☐ competitive
 - ☐ mutualistic
 - ☐ parasitic
 - ☐ predator-prey
 - ☐ I don't know.
10. Many of the flowers found in gardens are _____ by bees
- ☐ destroyed
 - ☐ infected
 - ☐ pollinated
 - ☐ protected
 - ☐ I don't know.

11. _____ produce the type of honey that is collected and then bottled for sale in stores.
- ☐ All types of bees
 - ☐ Bees do not
 - ☐ Only bumble bees
 - ☐ Only honeybees
 - ☐ I don't know.
12. There are some types of bees that cannot sting humans.
- ☐ True
 - ☐ False
 - ☐ I don't know.
13. Bees carry diseases that can infect humans.
- ☐ True
 - ☐ False
 - ☐ I don't know.
14. All bees are social animals, meaning they live with other bees.
- ☐ True
 - ☐ False
 - ☐ I don't know.
15. Bees do not always die after stinging a human.
- ☐ True
 - ☐ False
 - ☐ I don't know.
16. Most bee nests are found hanging from tree branches
- ☐ True
 - ☐ False
 - ☐ I don't know.
17. A bee's diet includes pollen.
- ☐ True
 - ☐ False
 - ☐ I don't know.
18. When some types of bees are killed, they release a smell that attracts other bees to their location.
- ☐ True
 - ☐ False
 - ☐ I don't know.

19. Each of the following pictures are life-sized, meaning they are the same size on the paper as they would be outside, in real life.

Which of the following organisms is a bee? Check all that apply.

	Yes, this is a bee	No, this is not a bee	
a.	<input type="checkbox"/>	<input type="checkbox"/>	
b.	<input type="checkbox"/>	<input type="checkbox"/>	
c.	<input type="checkbox"/>	<input type="checkbox"/>	
d.	<input type="checkbox"/>	<input type="checkbox"/>	

	Yes, this is a bee	No, this is not a bee	
e.	<input type="checkbox"/>	<input type="checkbox"/>	
f.	<input type="checkbox"/>	<input type="checkbox"/>	
g.	<input type="checkbox"/>	<input type="checkbox"/>	
h.	<input type="checkbox"/>	<input type="checkbox"/>	

III. Check the box that best describes how you feel about each statement. Select “neutral” if you do not have an opinion about the statement or if you do not know how you feel. <i>Check only one (1) box for each statement.</i>					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
20. If a bee came near me while I was eating outside, I would ignore the bee until it left.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21. I would want to destroy a bee’s nest built very close to my home.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. If I had a garden, I would want to plant flowers that attract bees.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. When a bee comes near me, I feel tense.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. If I were walking down a street and noticed a bee on a flower, I would stop to look at it.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. I would want to destroy a bee’s nest built in a public park.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26. If a bee came near me while I was reading outside, I would ignore the bee until it left.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27. If I had a garden, I would want to remove flowers that attract bees.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28. If I found a bee inside of my home, I would want to kill it.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
29. Bees are dangerous.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30. Bees are an important part of nature.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
31. When a bee comes near a friend of mine, I feel tense.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32. Bees need to be protected by humans.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
33. It is okay to kill a bee if it is flying near you	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
34. Bees are annoying.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
35. I would not care if bees went extinct.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
36. Bees are interesting.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
37. It is okay to kill a bee if it will not leave you alone.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
38. We should learn more about bees in school.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

IV. Check only *one* (1) box for each question in this section, unless it says otherwise. As a reminder, all answers are confidential.

39. Have you ever seen *The Bee Movie*?

- ☐ Yes
- ☐ No
- ☐ I don't know

40. Are you allergic to bee stings?

- ☐ Yes
- ☐ No
- ☐ I don't know

41. Are you allergic to honey?

- ☐ Yes
- ☐ No
- ☐ I don't know

42. Have you ever been stung by a bee?

- ☐ Yes
- ☐ No
- ☐ I don't know



a) If yes, have you been stung by a bee in the last 12 months?

- ☐ Yes
- ☐ No
- ☐ I don't know

43. Have you ever tried to save a bee?

- ☐ Yes
- ☐ No

44. Have you ever tried to kill a bee?

- ☐ Yes
- ☐ No

45. Please select the gender that describes you:

- ☐ Female
- ☐ Male

46. How old are you? _____ years old.

47. Please select the race/ethnicity that best describes you.

Check all that apply:

- ☐ White/ Caucasian
- ☐ Black/ African-American
- ☐ Hispanic/ Latino
- ☐ Asian
- ☐ Native Hawaiian/ Pacific Islander
- ☐ American Indian

- ☐ Other: _____ (please specify)

48. Select the highest education level your parents or guardians have completed:

Parent/Guardian 1:

- ☐ Less than high school
- ☐ High school
- ☐ Some college
- ☐ College
- ☐ Graduate school (Master's degree or PhD)
- ☐ I don't know

Parent/Guardian 2 (optional):

- ☐ Less than high school
- ☐ High school
- ☐ Some college
- ☐ College
- ☐ Graduate school (Master's degree or PhD)
- ☐ I don't know

**V. If you have any thoughts or stories about bees,
please share them here.**

Thank you for sharing your time!

Photo credits:

- 17.A – Malcolm Story/www.discoverlife.org
- 17.B – ©2012; www.toddjdreyer.com
- 17.C – Fir0002/Flagstaffotos
- 17.D – Expert Witness / Entomology
- 17.E – Laurence Packer/www.padil.gov.au
- 17.F – L. Jesse / Iowa State University
- 17.G – Duncraft Wildbird Blog
- 17.H – Entomology Department, University of Minnesota

Contact Information:

Alexandra Silva, Graduate Student
Department of Biological Sciences
University of Illinois at Chicago
SES 3326, M/C 066
845 West Taylor Street
Chicago, IL 60607
Phone: 312-355-1051
Email: amsilva2@uic.edu

APPENDIX B

Participating school data during the 2012-2013 academic school year derived from the Illinois Report Card database of the Illinois State Board of Education at <http://www.illinoisreportcard.com>.

School (District)	A (1)	B (1)	C (2)	D (3)	E (4)	F (5)	G (6)	State Average
Grades within School	6-8	6-8	6-8	PK, 6-8	PK-8	6-8	5-8	N/A
Instructional Spending (\$) *	6,211	6,211	5,820	6,024	6,611	7,759	8,572	6,974
Operational Spending (\$) **	10,420	10,420	9,531	10,012	10,013	12,969	13,639	11,842
Average Class Size	24	25	28	24	20	22	22	21
Low-Income Students (%) ***	83	72	89	24	36	27	6	50
Students with Disabilities (%) †	7	7	14	18	20	17	21	21
Chronically Truant Students (%) ‡	3	4	2.7	0	0	1	0	10

Descriptions of categories derived from the Illinois Report Card database of the Illinois State Board of Education at <http://www.illinoisreportcard.com>.

- * Instructional Spending per Pupil: The activities directly dealing with the teaching of students or the interaction between teachers and students.
- ** Operational Spending per Pupil: All costs for overall operations in this school's district, including Instructional Spending, but excluding summer school, adult education, capital expenditures, and long-term debt payments.
- *** Low-Income Students: The percentage of students, at this school, eligible to receive free or reduced-price lunches, live in substitute care, or whose families receive public aid.
- † Students with Disabilities: The percentage of students, at this school, who receive special education services through an Individualized Education Plan (IEP).
- ‡ Chronically Truant Students: the percentage of students who miss 5 percent or more of school days per year without a valid excuse.

Participating school racial/ethnic diversity during the 2012-2013 academic school year derived from the Illinois Report Card database of the Illinois State Board of Education at <http://www.illinoisreportcard.com>.

School (District)	A (1)	B (1)	C (2)	D (3)	E (4)	F (5)	G (6)	State Average
White %	8	17	6	71	47	52	75	51
Black %	3	4	13	3	16	31	7	18
Hispanic %	84	75	79	24	35	5	8	24
Asian %	1	1	2	1	2	2	4	4
American Indian%	0	0	0	0	0	0	0	0
Two or more races%	3	2	0	2	0	9	5	3
Pacific Islander	0	0	0	0	0	0	0	0

APPENDIX C

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice
Amendment to Research Protocol and/or Consent Document – Expedited Review
UIC Amendment # 3

June 28, 2013

Alexandra Silva, BS
Biological Sciences
Biological Sciences
845 W Taylor, M/C 066
Chicago, IL 60612
Phone: (708) 528-5244

RE: **Protocol # 2013-0245**
“The buzz about bees: adolescent knowledge, attitudes, and perceptions of bees”

Dear Ms. Silva:

Members of Institutional Review Board (IRB) #2 have reviewed this amendment to your research under expedited procedures for minor changes to previously approved research allowed by Federal regulations [45 CFR 46.110(b)(2)]. The amendment to your research was determined to be acceptable and may now be implemented.

Please note the following information about your approved amendment:

Amendment Approval Date: June 27, 2013

Amendment:

Summary:

UIC Amendment #3, dated May 21, 2013, received June 21, 2013, is an investigator-initiated amendment to add Komarek Middle School as a performance site. A letter of support and an Appendix K are included in the submission.

Approved Subject Enrollment #: 900

Performance Sites: UIC, Berwyn North School District 98, Percy Julian Middle School - Oak Park, IL, Freedom Middle School, Heritage Middle School, River Forest Public Schools, Berwyn School District 100, S.E. Gross Middle School, Komarek Middle School

Sponsor: Chancellor's Graduate Research Fellowship

PAF#: Not applicable

Grant/Contract No: Not applicable

Grant/Contract Title: Not applicable

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
06/21/2013	Amendment	Expedited	06/27/2013	Approved

Please be sure to:

→ Use your research protocol number (2013-0245) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the enclosure,

"UIC Investigator Responsibilities, Protection of Human Research Subjects"

(<http://tiger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0924.pdf>)

Please note that the UIC IRB #2 has the right to seek additional information, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact the OPRS at (312) 996-1711 or me at (312) 355-2764. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Betty Mayberry, B.S.

IRB Coordinator, IRB # 2

Office for the Protection of Research Subjects

cc: Emily Minor, Faculty Sponsor, Biological Sciences, M/C 066
Brian Kay, Biological Sciences, M/C 066

Alexandra M. Silva**EDUCATION**

- M.Ed. College of Education, University of Illinois at Chicago, Chicago, IL May 2015
 Department of Curriculum & Instruction: Instructional Leadership - Science Education
Licensure: Illinois Professional Educator License (Type 09)
Endorsements: Secondary Education Biology and Environmental Science (6 -12), Bilingual/ESL Education, Middle School Education
- M.S. College of Liberal Arts & Sciences, University of Illinois at Chicago, Chicago, IL May 2015
 Department of Biological Sciences: Ecology & Evolution
 Advisor: Dr. Emily Minor
 Thesis: *Buzz about Bees: adolescents' experiences, knowledge, and attitudes toward bees*
- B.S. College of Agriculture and Life Sciences, Cornell University, Ithaca, NY May 2009
 Department of Animal Science
 Animal Science major, Natural Resources minor, Spanish concentration

TEACHING EXPERIENCE

- Instituto Health Science Career Academy, Instituto del Progreso Latino, Chicago, IL Present
Student Teacher
 •Design and teach an inquiry-based curriculum for high school biology classes with special emphasis on knowledge and skills used within health professions (Grade 12)
 •Align curricular goals and assessment materials with the Next Generation Science Standards
- Learning Sciences Research Institute, University of Illinois at Chicago, Chicago, IL 2012 - Present
Research Assistant
 •Develop and deploy experimental instructional programs for elementary and middle school science classrooms using technological scaffolds to enrich educational experiences (Grades 4-8)
 •Lead or provide teacher support during instructional intervention programs
 •Code and analyze learner artifacts and discourse, incorporating findings into scholarly research publications
 •Past programs: Neighborhood Safari, RoomQuake, The Hunger Games; Future program: WallCology
- National Geographic Student Expeditions, Washington, DC 2009 - Present
Trip Leader
 •Lead international summer expeditions of high school students
 •Design and implement a curriculum integrating global conservation issues with local wildlife biology and conservation methods
 •Develop unique, interactive field assignments intended to reinforce discussion material and advise students regarding final group projects
 •Past expeditions: Australia, Costa Rica, Ecuador & the Galápagos Islands, Namibia, and Tanzania
- Department of Biological Sciences, University of Illinois at Chicago, Chicago, IL 2011 - 2012
Teaching Assistant
 •Led weekly discussion sections focused on lecture material for *Biology of Populations and Communities(101)*
 •Directed laboratory sessions, including preparation of experiments and grading of assignments and reports
- Student Learning Programs Department, Shedd Aquarium, Chicago, IL 2009 - 2013
Volunteer Educator
 •Guided school groups throughout Shedd, acting as an educational resource for teachers and students
 •Assisted with written activities and learning lab programs including animal dissections

Science Department, Fenwick High School, Oak Park, IL

Summer 2010

Teaching Assistant

- Assisted with the instruction of students participating in an accelerated biology course

PEER-REVIEWED PUBLICATIONS

Shelley, T. R., Dasgupta, C., **Silva, A.**, Lyons, L., & Moher, T. PhotoMAT: A Mobile Tool for Aiding in Student Construction of Research Questions and Data Analysis. *Technology, Knowledge and Learning*, 1-8.

Lowenstein, D. M., Matteson, K. C., Xiao, I., **Silva, A. M.**, & Minor, E. S. (2014). Humans, bees, and pollination services in the city: the case of Chicago, IL (USA). *Biodiversity and Conservation*, 23(11), 2857-2874.

PAPERS & POSTERS PRESENTED

Silva, A., Dasgupta, C., Shelley, T., Lopez Silva, B., Lyons, L., & Moher, T. 2014. Shaping the Construction of Learner Questions. *Annual Conference of the American Educational Research Association*, Philadelphia, PA. (Paper)

Silva, A. and E. Minor. 2014. The Buzz about Bees: Adolescent Knowledge, Attitudes, and Perceptions of Bees. *American Association of Geographers Annual Conference*, Tampa, FL. (Poster)

Silva, A., K. Matteson, I. Xiao and E. Minor. 2012. Pollination potential of bees in an urban environment. *International Association of Landscape Ecology: Annual Symposium*, Newport, RI. (Poster)

GRANTS AWARDED

Chancellor's Graduate Research Fellowship – \$8,000
University of Illinois at Chicago

Spring 2013 & 2014

LANGUAGES

Fluent in Spanish