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Beautiful Bugs, Bothersome Bugs, and FUN Bugs: Examining Human Interactions with Insects and Other Arthropods

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ABSTRACT Because the ostensible majority of incidental human–insect (and other arthropods) interactions are negative, any interest in non-pretty "bugs" appears to be inherently demotivated. Three complementary studies explored US college students' perceptions, knowledge, and experiences of insects to better understand folk classifications and to identify potentially new ways to present them to motivate human interest. Study 1, an open-ended survey (*n* = 236), found that knowledge of insects is limited to a mean of 13 insects. Of these 13 insects, most were also dichotomized as liked (beautiful bugs) or disliked (bothersome bugs). The second study, using semi-structured interviews (*n* = 60), revealed similar categories as found in the first study, providing further details about positive and negative perceptions of, attitudes to, and types of experiences people have with, insects and other closely related arthropods. The last study (*n* = 200) used a paired forced-choice scale with 10 silhouettes of insects and related arthropods to replicate and expand the findings from the first two studies. This study tested whether respondents would report interest in novel and unknown arthropods over commonly known and preferred ones. The results indicate little knowledge of the diversity of insects among a young, elite, middle-class sample of college students and the existence of two robust but small folk categories of insects/arthropods (beautiful, bothersome). Results from the third study indicated there is a group of potentially fascinating unfamiliar (FUN) insects/arthropods/bugs that could evoke interest if people were simply exposed to them. Implications for informal recreation and educational programming and a research agenda are presented.

Keywords: bug, human dimensions of insects, human–insect interactions, insects, natural history, STEM

For every two known living species on this planet, one is an insect (Black, Shepard, & Allen, 2001; Chapman, 2009). Insects, the most biologically diverse group of organisms on the planet,

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are often perceived by humans in terms of aversion, dislike, disgust, and fear (Arrindell, 2000; Davey, 1994a; Kellert, 1993; Schlegel & Rupf, 2010; Scudder, 2009). However, other beautiful insects, such as butterflies, dragonflies, bees, and fireflies, are commonly viewed favorably (Schlegel & Rupf, 2010). Understanding how humans perceive insects and other arthropods and why perceptions of them are simplistic can help in shaping and expanding the frequency, diversity, and quality of human–insect interactions. Since insects can play practical, recreational, educational, ecological, and cultural roles in society, they provide for largely unrecognized opportunities to enrich human experiences (Shipley & Bixler, 2016). This study describes student's knowledge of insects and then explores possible avenues for expanding awareness of the most diverse group of animals on earth.

Literature Review

The term "bug," is a commonly used category or folk taxonomy for most small land arthropods. Folk taxonomies, or folk biological classifications, are a product of cultural constructions different from scientific classifications (Berlin, Breedlove, & Raven, 1973). Shepardson (2002) found that younger children consider any organism that is shaped like a bug to be an insect. When children were asked to draw an insect, they drew other invertebrates such as spiders, scorpions, centipedes, millipedes, and snails, along with insects (Snaddon & Turner, 2007). Children use folk taxonomies when they reason about insects, even though the scientific characteristics of different phyla of animals is taught early on in elementary school. Results from Shepardson (2002) and Snaddon and Turner (2007) reveal that children are not referencing scientific classification systems, suggesting that there is value in understanding how and which characteristics of "bugs" are used by people without scientific training in classifying them. Understanding how people naturally classify bugs into groups should reveal the underlying psychological unconscious and socially imposed perceptions of insects and other land arthropods. For the purposes of this research, "bug" was defined as any terrestrial invertebrate, excluding crustaceans (e.g., crabs). The informal nonscientific classification of "bug" includes: arthropods (e.g., insects, arachnids, and millipedes), mollusks (e.g., snails and slugs), and annelids (e.g., earthworms).

Empirically, there is evidence that people dichotomize bugs (insects and small arthropods) they know into good and bad ones (Byrne, Carpenter, Thoms, & Cotty, 1984; Schlegel, Breuer, & Rupf, 2015; Schlegel & Rupf, 2010; Wagler & Wagler, 2011). Of the bugs that are often given low affinity ratings, Breuer, Schlegel, Kauf, and Rupf (2015) identified those that are considered disgusting (millipedes), bugs that are considered frightening (bumblebees), and bugs that are considered disgusting and frightening (spiders). Additional studies document that males report less dislike for bugs (Byrne et al., 1984; Prokop, Prokop, & Tunnicliffe, 2008; Schlegel & Rupf, 2010; Schlegel et al., 2015; Snaddon & Turner, 2007), people more knowledgeable of bugs will assign higher preference scores to them (Schlegel & Rupf, 2010; Schlegel et al., 2015), and those who participate more in nature-related leisure assign higher preference scores to bugs (Schlegel et al., 2015). These studies suggest that the general public knows about bugs that catch their attention or are bothersome, but are unaware of a vast number of them.

In Western cultures, butterflies are well known and often considered the most popular insect (Breuer et al., 2015; Byrne et al., 1984; Schlegel et al., 2015). Additional beautiful insects such as dragonflies, fireflies, and lady bugs are commonly displayed in many forms of art (Hogue, 1987). Hobbies involving beautiful insects have also become popular, such as butterfly or dragonfly watching and insect festivals (Hvenegaard, 2016; Hvenegaard, Delamere, Lemelin, & Auger, 2010; Lemelin, 2007; Lemelin, 2009; Pyle, 1992). Likewise, these popular insects are a focus of some citizen science programs (Devictor, Whittaker, & Beltrame, 2010).

Unfortunately, for every positive interaction with bugs, people have seemingly hundreds of negative experiences (Lockwood, 2013). After all, some bugs are pests: they bite and sting people, infest our food, and invade our personal space. In a sample of Florida home owners, 90% of pesticide buyers indicated that just seeing insects in or around the home was reason to buy pesticides (Baldwin, Koehler, Pereira, & Oi, 2008). While human aversion toward pest bugs is not misplaced, negative attitudes toward them seems to generalize to other harmless but similar looking arthropods, evoking unnecessary fears and demotivating a more expansive interest in bugs. Other small arthropods, such as spiders, are also commonly negatively perceived. People who are phobic of spiders often display irrational reactions to them, a vast majority of which are harmless to humans (Arntz, Lavy, Van den Berg, & Rijsoort, 1993; Mayer, Merckelbach, & Muris, 2000).

To understand negative perceptions of insects, Lockwood (2013) argues that personal experiences, social influence, and evolutionary preparedness shape how people perceive insects. Repeated and direct experiences with harmful bugs, observation of negative reactions of friends and family toward bugs, watching TV commercials, news, and movies which emphasize the potential harm of bugs, and human genetics all work against having positive experiences with insects (Lockwood, 2013). Additional research suggests that negative conceptions of bugs are an amalgam of not just fear but also disgust (Bixler, Carlisle, Hammitt, & Floyd, 1994; Bixler & Floyd, 1997; Breuer et al., 2015; Davey, 1994b; Davey et al., 1998; Lemelin, Harper, Dampier, Bowles, & Balika, 2016; Öhman & Mineka, 2001; Prokop, Usak, Erdogan, Fancovicova, & Bahar, 2011; Seligman, 1971). Human perceptions of bugs are so strongly negative that the term "insect" is a standard negatively valanced term used in psychological tests such as the Implicit Association Test (IAT) (Greenwald, McGhee, & Schwartz, 1998).

Given the evidence that many bugs are commonly perceived as negative by the general public, there is value in evaluating strategies useful in shaping positive human–insect encounters. Suggestions from research include the development of curricula for teachers, increased use of insects in early childhood education, science education, recreation, and tourism settings (Bryne et al., 1984; Lemelin, 2007; Lemelin et al., 2016; Matthews, Flage, & Matthews, 1997; Prokop, Tolarovičová, Camerik, & Peterková, 2010; Sammet, Andres, & Dreesmann, 2015; Schlegel et al., 2015; Shepardson, 2002; Wagler, 2010; Wagler & Wagler, 2012). Lemelin and Yen (2015) propose increasing educational efforts directed at children and adults through school, citizen science, and research as methods to alter societal-wide fear of spiders. Shipley and Bixler (2016) argue that informal, playful childhood interactions with insects must occur in order to promote fascination for insects, before sensationally negative cultural messages about insects generate fear and disgust. Due to accessibility, novel morphology, low costs of owning, and behavior, bugs can be an ideal animal to promote interest in nature, natural history, natural places, and science, technology, engineering, and mathematics (STEM), while also increasing comfort in wildland areas through habituation to bothersome insects (Shipley & Bixler, 2016).

People who are uninterested in bugs are unlikely to seek out recreational, leisure, or nonformal educational experiences with them. A constructivist paradigm asserts that an ideal learning environment relates an educational topic, using real-world objects and events, to the learner's past experiences (Eshach, 2007; Taylor, 2006). Identifying "gateway" bugs that resonate with people's past experiences and/or dispositions has some potential to engage the uninterested person (Bixler, Crosby, Howell, & Tucker, 2016). The empirical literature has established that most people have positive perceptions of butterflies (Breuer et al., 2015; Byrne et al., 1984; Schlegel et al., 2015) as butterflies are beautiful and not irritating. Yet existing empirical work demonstrates that butterflies are different enough from other insects that they are not considered insects by some people (Schnabel, 2004). Therefore, butterflies could just as easily be superfluous as a charismatic flagship species, since they are too different for people to transfer their preference for them to other not-so-beautiful insects. Responding to Estren's (2012) call to better understand how people might begin to care about the not-so-cute animals, Bixler et al. (2016) demonstrate that images of faces of jumping spiders were ranked as least scary if not "cute" when contrasted with other spider families. Bixler et al. (2016) speculate that due to neotenic traits of the jumping spider (i.e., two large forward-facing eyes, short legs, reduced mandibles, etc.), they can be used as a "first-impressions" spider in non-formal educational programming and media.

Many questions remain about what types and number of experiences people need to have with bugs in order to develop positive human perceptions of these negatively viewed creatures. Wagler (2011) demonstrates that positive attitudes among student teachers in college could be developed toward one insect species commonly perceived as negative (i.e., a hissing cockroach) after semester-long repeated exposure and interactions. Yet, the achieved positive shift in attitudes toward hissing cockroaches, did not affect student teachers' perceptions of other insects. The Bixler et al. (2016) and Wagler (2011) studies illustrate the need to better understand the differing perceptions of insects (species, families, across genome structural similarities (i. e., spines on legs), situation-dependent reactions, etc.) with a goal of informing the design and evaluation of recreational, educational, and therapeutic interventions focused on insects and other arthropods.

Objectives

The present studies sought to replicate and extend previous research on human perceptions of bugs, using a convenience sample of elite, middle- and upper-class, young adults in college. Using this well-educated sample, the studies describe their knowledge of insect diversity, and evaluate how background, personal experiences, and personal recreational interests are related to knowledge of bugs. Additionally, these studies sought to determine how heterogeneous the sample was in terms of interest in bugs and whether interest existed in bugs beyond those that are well known. Lastly, due to the relationship between heightened disgust sensitivity and aversion to bothersome bugs, such as spiders, in the final study we evaluated disgust sensitivity as a possible explanatory variable for interest in little known, common, and interesting bugs (de Jong & Merckelbach, 1998; Sawchuk, Lohr, Tolin, Lee, & Kleinknecht, 2000; Tolin, Lohr, Sawchuck, & Lee, 1997).

Research Overview

Three complementary exploratory studies addressed preferences and categorization of insects and other small arthropods, while examining background and experiential variables. By using a multi-method design, using both qualitative and quantitative approaches, results from each study provide complimentary and expanding results (Green, Caracelli, & Graham, 1989). The first and second studies addressed knowledge and perceptions of bugs. The first study focused on insects, with the intent of identifying non-insect arthropods commonly listed as insects. The second study replicated the first study by exploring personal stories recalled by participants about their experiences with bugs. Lastly, the third study used a structured questionnaire to retest for folk taxonomies and whether interest existed in little known bugs not mentioned by participants in the previous two studies. All studies were reviewed by the institutional review board at Clemson University and received IRB approval prior to their execution (IRB #2015-273, #2015-410, and #2016-109).

Study One

Methods

Participants & Procedure: Students (n = 236) from a public university in the United States were asked to list the names of all the "insects" that they could recall. Participants who were currently or previously enrolled in an entomology class were removed from the analysis (n = 16). Participants were primarily undergraduate (n = 209), female (48%), and between 18 and 44 years old (M = 21.33; SD = 3.08). Undergraduate students enrolled in a special projects course administered the paper-and-pencil survey in classrooms across campus. Participants were given three minutes to complete the open-ended section of the survey, and then answer additional questions.

Survey Instrument: The one-page questionnaire provided 30 spaces for participants to list as many names of insects that they could. Participants were asked to list names of "insects," not "bugs." This instruction was designed to test whether respondents would list animals that are not insects, even though they were asked for names of insects. The second task involved choosing two insects from their own list that they most liked and two insects they most disliked. Additional questions asked if and when the participant had made an insect collection in school and whether they had ever owned a pet insect, and if so, what type. Participants were asked about their participation in outdoor recreation in terms of the frequency of attendance at overnight summer camp, participation in tent camping, and to list their three favorite recreational activities. Recreational activities were recoded as outdoor, sports, or indoor. If respondents listed any outdoor recreational activity, they were coded as being an outdoor recreationist. Demographic, school, and recreation-related questions allowed for testing whether individual differences and experiences were related to how many insect names participants could recall.

Results

Overall, 134 unique bug names were listed; 25 were not insects. Of the names listed, 19 comprised the majority (see Table 1). Butterfly was the most liked bug, followed by ladybug and firefly (see Table 2). Cockroach was the most disliked bug, followed by wasp and spider (see Table 3).

Respondents listed a mean of 13 different names of bugs (M = 12.89, SD = 5.86). Participants reported, on average, owning one can of insect repellant (M = 1.18, SD = 0.98), one can of insect spray (M = 1.25, SD = 0.996), having tent camped one-and-a-half times in the last two years (M = 1.43, SD = 1.84), and having stayed at a traditional residential summer camp twice (M = 2.31, SD = 2.07). Reported favorite recreation (e.g., hiking, camping, playing football, reading a book) was used to put participants into two groups: outdoor recreationists (n = 147) and non-outdoor recreationists (n = 73). Lastly, reported academic majors ranged from biological and environmental sciences, to psychology, sociology, business, architecture, and engineering. Academic focus was categorized into outdoor-related majors (n = 143) and non-outdoor related majors (n =76).

Table 1. Frequency of the most listed insects in the open-ended survey (n = 220).

Insect Name	Frequency	Percent
Ant	161	73.2
Cockroach	149	67.7
Bee	141	64.1
Fly	132	60.0
Grasshopper	131	59.5
Spider	126	57.3
Butterfly	124	56.4
Beetle	110	50.0
Lady Bug	109	49.5
Wasp	107	48.6
Mosquito	101	45.9
Cricket	96	43.6
Praying Mantis	90	40.9
Caterpillar	87	39.5
Gnat	74	33.6
Moth	68	30.9
Stink Bug	63	28.6
Yellow Jacket	61	27.7
Hornet	59	26.8
Firefly	58	26.4
Centipede	54	24.5

Note: 133 different insect names were listed; the 21 shown here represent the majority (75%) of these.

Table 2. Frequency of the most "liked" bugs indicated in the open-ended survey (n = 134).

Bug Name	Frequency	Percent
Butterfly	58	43.3
Lady Bug	37	27.6
Fire Fly	25	18.7
Praying Mantis	22	16.4
Dragonfly	19	14.2
Bee	17	12.7
Grasshopper	17	12.7
Caterpillar	11	8.2

Note: displays the majority (75%) of favorite bugs. Twenty-five bug names were marked as being participants' favorites.

Table 3. Frequency of the most "disliked" bugs indicated in the open-ended survey (n = 110).

Bug Name	Frequency	Percent
Cockroach	42	38.2
Wasp	33	30.0
Spider	30	27.3
Mosquito	28	25.5
Ant	19	17.3
Bee	15	13.6

Note: displays the majority (75%) of disliked bugs. Forty bug names were marked as being disliked.

Data were analyzed using correlations, *t*-tests, and ANOVA. There were small correlations with the number of bug names listed, with the strongest correlation being with the number of times the respondent had camped in a tent over the last two years ($r = 0.187$, $p = 0.006$). Overall, there were few statistical relationships between any background-related data. The difference between the number of bugs listed by males ($M = 11.97$, $SD = 6.13$) and females ($M = 13.95$, $SD = 5.31$) was statistically significant ($t_{(217)} = 2.55$, $p = 0.011$, $d = 0.345$). Aside from gender, only tent camping was a statistically significant predictor of the number of bugs listed ($F_{(5,207)} = 3.683$, $p = 0.003$, $r^2 = 0.082$), with those who reported a higher number of times having tent camped reporting a higher number of bug names.

Discussion

The students, with a range of different experiences, hobbies, and disciplines, all shared limited knowledge of insect diversity. This well-educated, middle-class, college student sample's overall knowledge of insect diversity was limited to about 13 bug names. Of the 13 most listed bugs, only one bug ("beetle") was not commonly listed as either liked or disliked (see Tables 1, 2, and 3). This suggests that common knowledge of familiar insects is most likely restricted and dichotomized into two groups: beautiful bugs and bothersome bugs. When asked to list names of insects, participants sometimes listed other invertebrates such as spider, centipede, and tick, indicating that to some people, non-insects are perceived to be insects. This not infrequent categorization of other arthropods as insects suggests that including other small arthropods in the study of human–insect interactions is worthwhile. Henceforth, we use the term "bug" to refer to an informal, nonscientific category of insects and other small arthropods.

Study Two

Methods

Participants & Procedure: A different sample of students and staff at a medium-sized southeastern university and community (non-academic) members participated in a semi-structured face-to-face interview ($n = 60$). Age of participants ranged from 18 to 50 years, gender was equally distributed (female, $n = 31$), and the majority were students ($n = 36$). The interviewers approached participants and asked if they had a few minutes for a brief interview. Interviews lasted from approximately 2 to 17 minutes and were recorded and transcribed. Due to IRB concerns about protecting confidentiality, participant names and other identifying information are not reported with the results; they are replaced with an identification number.

Interview Format: After informed consent, each interview started with "tell us a bug story?" The word "bug" was intentionally used rather than "insect," based on the results from study 1, to capture additional variation and valance in participant response. Follow-up questions asked for specific experiences that may have occurred at home, school, camp, parks, with friends, family, schoolmates, and teachers. Participants were encouraged to expand upon recalled experiences with a "tell me more about that" probe. The sole purpose of the interviews was to acquire valanced descriptions of salient bugs and document the nature of the experience with them.

Results

Interviews were transcribed, coded, and analyzed using NVivo 11. They were coded for type of bug, matched with whether the recalled experience was positive or negative. The types of bugs

Table 4. Frequency of the most common bugs recalled during the semi-structured interview, paired with examples of direct valanced recalled attitudes, beliefs, and experiences. (n = 60).

		Recalled Experience	
Bug Name	**Frequency**	**Positive**	**Negative**
Spider	36	Excited to see them	Afraid, scream, squish them, terrified, creep me out, kill them, my least favorite
Cockroach	30	None	Hate, fly at me, crawl over my face, ugly, scary, annoying, worst, nasty, petrified of them
Ant	27	Ant farm, lighting on fire, feed to ant lions, catching them	They get everywhere, bite me, get in the house
Butterfly	27	Like catching, I like them, watch them grow, collections, my favorite, lucky, not crunchy	None
Bee	21	Have caution but not afraid	Getting stung, don't like, I am allergic, terrible
Firefly	21	Catching, love, collecting in a jar, pretty, squish, glow smear, reminds me of summer and fall	None
Lady Bug	18	I like them, pretty, good luck, collect them, harmless to me	Leave brown trails and shells everywhere in the winter
Cricket	17	I like them, used to feed to my pet bearded dragon, cricket farms, catch for fishing	I hated camel crickets
Caterpillar	16	Crawl on me, raised into a butterfly, played with on the playground	None
Wasp	13	None	Nests, getting stung, freak me out, stingers, least favorite
Beetle	13	I like big beetles, June bugs, pets, good luck	Nasty, I don't like, infestations
Mosquito	12	None	Attack me at work, least favorite, bite me, kill them
Cicada	12	Collected shells, fascinated with	Loud, chased me around, hate them, freak me out

Note: displays the majority (75%) of recalled bugs. Forty types of bugs were recalled in interviews.

recalled during interviews reflected a similar frequency to the bug names listed in study 1. Overall, 40 different bugs were recalled. The most commonly recalled bug was the spider. Recalled experiences with spiders ranged from "excited to see them" (35) and "not afraid of them" (24), to "afraid" (01) and "my least favorite" (54). Recalled negative experiences often involved fear of being bitten or stung and being disgusted by external morphology or behavioral characteristics. Positive experiences often involved capturing a bug during childhood, such as "I have really fond memories growing up as a kid going out with those little mesh cages, going to see what bugs I could catch" (09), "I used to catch fireflies in a jar when I was little. Reminds me of happy times" (14), and "I used to catch caterpillars on the playground when I was little, put them in a jar, and wait till they hatched into butterflies" (23) (see Table 4 for more examples).

One subset of quotes addressed simply not wanting to be around bugs, suggesting no animosity toward insects as long as they stayed away, accompanied by a clear statement of disinterest. Quotes such as "if they [bugs] are going to stay out of my way, I will stay out of their way" (48), "I don't really care about them that much. I don't want it on me" (18), and "Kind of a mutual respect of you leave me alone and I will leave you alone" (35) reflect an overall disinterest and situational animosity. Ultimately, quotes such as "No, I don't like bugs and I felt bad for killing the butterfly" (02), "Those places like butterfly sanctuaries, that was kind of cool. Other than that, no [positive experiences] with insects" (04), "Unless butterflies count as bugs. I guess. I don't know. I don't have any pleasant experiences with butterflies either though" (05), "I don't really like bugs" (21), and "I am not a bug fan at all. I hate bugs. I don't like spiders, terrified of spiders. I don't mess with bugs" (22) suggest that to the general public, most bugs are disgusting/feared, but butterflies are not.

Discussion

Results of the second study, using a different method, reflect similar results to the first study (see Tables 1 and 4). Overall, the majority of recalled experiences involved only a few species of bugs. The cicada was the only bug mentioned in study 2 that was not one of the most frequently listed insects in study 1, although it was listed by some respondents. In the first study, the bee was the only bug marked as liked and disliked, while the second study identified additional bugs (spider, ladybug, bee, cricket) that were experienced either negatively or positively by different people (see Table 4). Bugs recalled as either positive or negative by different respondents indicate that some may not fit distinctly into either a "good" or "bad" classification. However, the reoccurrence of the same bugs in this study as the first study, paired with verbal experiences, suggest that common and familiar bugs are few in number and are often perceived as either good or bad by any one person.

Study Three

Methods

Participants & Procedure: A different sample of students at a medium-sized southeastern university (*n* = 200) were asked to indicate one bug as "more interesting" of each of 45 possible pairings of 10 bugs. Participants were 48.7% female, aged between 18 and 39 years (*M* = 21.64, *SD* = 4.76). The survey was administered in classroom settings.

Survey Instrument: The survey included a structured forced-choice section using pairs of silhouettes of bugs, a sensitivity to disgust scale, and demographic questions. The structured forced-choice section was designed to test for the beautiful/bothersome bugs dichotomy identified in studies 1 and 2.

The forced-choice section was comprised of all possible pairings of 10 silhouettes of bugs (see Figure 1). These were used to measure participants' first impression of the bug since there is little other information in a silhouette (DiGirolamo & Hintzman, 1997; Willis & Todorov, 2006). Using silhouettes reduced potential sources of bias such as the well-documented role of color in human preferences for animals (Stokes, 2007). Each bug silhouette was paired with another bug for all 45 possible combinations. Three of the silhouettes were of widely reported and positively perceived bugs identified in the previous two studies (butterfly, ladybug, and dragonfly). The fourth silhouette was of a snail which was only mentioned three times in the first study and once in the second. Since snails are common invertebrates (bugs) and are often

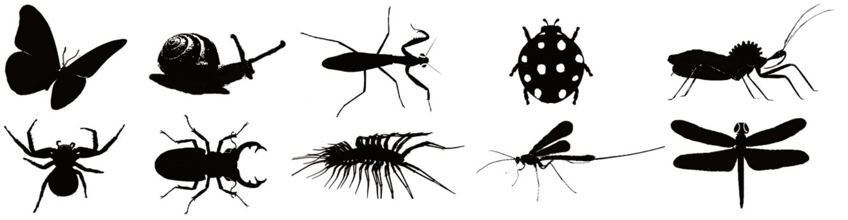

Figure 1. Silhouettes of invertebrates (bugs) used in the forced-choice study. Top row left to right: butterfly, snail, mantis, lady beetle, wheel bug. Bottom row: spider, stag beetle, house centipede, ichneumon wasp, dragonfly.

positively depicted in children's books (More, 1984), we hypothesized that they would be significantly associated with the three beautiful bugs. Two silhouettes were of bugs that had received a mix of both positive and negative ratings in the two previous studies (spider and praying mantis). The remaining four silhouettes were bugs that are common in temperate North America, yet were never mentioned in studies 1 and 2. These bugs belong to a group that is little known yet potentially intriguing to people (wheel bug, house centipede, ichneumon wasp, and stag beetle (see Figure 1)).

The sensitivity- to-disgust scale consisted of four items and operationalized around freedom from disgust, contamination sensitivity, and some fears being a function of access to modern indoor comforts. The scale was modified from a scale used in Bixler & Floyd (1997). The response categories were from 0 ("Not like me at all") to 4 ("Exactly like me"). The items were "I am most comfortable sleeping in my own bed," "I have to have a shower every day," "I become disgusted more easily than other people," and "I really love air conditioning." Cronbach's alpha for the scale was 0.73. A regression factor score was calculated for each respondent. Additional demographic information requested included age, gender, and listing of two favorite recreational activities.

Results

For each possible pair, the bug that was indicated as "more interesting" by the participant was assigned one point. The maximum possible score for any single bug was nine points. Average scores for each bug in rank order are presented in Table 5. Butterfly, dragonfly, and ladybug received the highest scores, while spider, ichneumon wasp, and house centipede received the lowest scores. Scores and their rank order reveal similar results to the first and second studies. Bugs that are relatively well known, attractive, and harmless were highest ranked.

A k-means cluster analysis (see Table 6) using bug silhouette scores identified two clusters. The first cluster (group 1, 59.5% of participants) was composed of those with higher scores for butterfly, ladybug, dragonfly, and snail. The second cluster (group 2, 40.5% of participants) was composed of participants with higher scores for praying mantis, wheel bug, stag beetle, spider, and house centipede. The praying mantis silhouette received a higher mean rating from cluster two but the absolute scores were close (4.14 of 9 for cluster one vs. 4.44 of 9 for cluster two). The silhouette of the ichneumon wasp received the lowest score in both clusters and was not statistically significantly different between them. Ichneumon wasps are common primitive wasps with a long harmless ovipositor that can be mistaken for a stinger. Correlations, *t*-tests, and ANOVA were conducted. We found no significant relationships between age or recreation participation with the clusters. A *t*-test revealed a statistically

Table 5. Mean number of votes for invertebrates (bugs) chosen from all possible pairings of 10 bugs, ranked by mean vote counts.

Bug Name	Mean Votes[a]	*SD*
Butterfly	6.13	2.77
Dragonfly	5.91	2.03
Ladybug	5.31	2.79
Snail	4.51	2.40
Stag Beetle	4.51	2.89
Praying Mantis	4.26	2.13
Wheel Bug	4.05	1.87
Spider	3.73	2.69
House Centipede	3.14	2.61
Ichneumon Wasp	2.95	2.03

Note: participants chose one of two bugs as more interesting from each of all possible pairings of bug silhouettes (see Figure 1).

[a]Based on scores ranging from 0 to 9.

Table 6. K-means cluster analysis of invertebrate (bug) silhouette paired choices.[a]

Bug Name	Cluster One	Cluster Two
Butterfly	**7.82**	3.65
Ladybug	**6.94**	2.91
Dragonfly	**6.89**	4.47
Snail	**5.28**	3.38
Praying Mantis	4.14	**4.44**
Wheel Bug	3.30	**5.16**
Stag Beetle	2.86	**6.94**
Spider	2.34	**5.78**
House Centipede	2.14	**4.62**
Ichneumon Wasp	2.97	2.94
Disgust Factor Score[b]	0.153	–0.214

Note: cluster one *n* = 119 and cluster two *n* = 87. Bug names belonging to each cluster are in bold.

[a]Based on scores ranging from 0 to 9.

[b]Factor score calculated from four scale items (scored 1 to 4); statically significant between cluster one and cluster two ($t_{(192)} = 2.495$, $p = 0.013$).

significant difference between the two clusters on disgust sensitivity scores ($t_{(192)} = 2.495$, $p = 0.013$, $d = 0.368$), indicating that reported level of disgust sensitivity was higher for members of the first cluster who preferred beautiful bugs than members of the second cluster (group 1 $M = 0.153$, $SD = 1.001$, group 2 $M = –0.214$, $SD = 0.986$).

Discussion

This structured study with closed-ended questions replicated the beautiful-bothersome bug dichotomy. While there are many explanations for differences in the two groups, a higher level of disgust was found with the cluster preferring the beautiful bugs. Additionally, the study identified two groups of people, one more interested in the beautiful bugs, the other interested in the bothersome and little known bugs. Both clusters had similar moderate mean preference scores for the praying mantis, suggesting that it may be a gateway insect. Both clusters had overall low preference scores for the ichneumon wasp. This is likely due to the presence of a conspicuous stinger-like (yet harmless) ovipositor that is longer than the wasp's body. This structure is probably being misinterpreted as a large stinger, as this evolutionarily primitive wasp looks like many modern wasps that have stingers.

General Discussion & Implications

Using a multi-method approach, these three studies replicated previous findings (Breuer et al., 2015; Byrne et al., 1984; Kellert, 1993; Lemelin et al., 2016; Schlegel & Rupf, 2010; Schlegel et al., 2015; Wagler & Wagler, 2011). Study 1 and study 2 documented that our well-educated sample knows only a miniscule number of the over 82,000 species of insects in North America or the one million species worldwide (Black et al., 2001; Chapman, 2009; Sabrosky, 1953). Both studies demonstrate that people tend to categorize and reason about bugs based on either having had an aesthetically novel experience with them (butterflies, lightning bugs) or finding bugs bothersome (mosquito, tick). Study 2, using a "tell me a bug story" questioning strategy, demonstrated that awareness of bugs is derived primarily through direct personal experiences, rather than formal education. This finding is consistent with the results of Schnabel (2004), who found no relationship between experiences in school and knowledge of, or attitudes toward, insects.

Relationships between gender and insect preferences and knowledge were similar to those reported by Byrne et al. (1984), Prokop et al. (2008), Schlegel and Rupf (2010), and Schlegel, Breuer and Rupf (2015). However, we did not find a relationship between preferences for insects and outdoor recreation, which was found by Schlegel et al. (2015).

The most structured of the three studies, study 3, measured sensitivity to disgust using a desire-for-modern-comforts scale. A significant difference of moderate effect size ($d = 0.36$) was identified between the two clusters of respondents. This result replicates studies showing aversion to spiders, indicating that disgust helps explain aversion (Davey, 1994b; Davey et al., 1998).

Application

Given the results of study 1 and study 2, the lack of knowledge about insect diversity suggests that much may be easily gained from focusing on the third category of bug types, the fascinating unfamiliar (FUN) bugs. FUN bugs are little known since this large group of bugs does not interact with humans as pests and are not active and eye catching like butterflies and lightning bugs. Study 3 incorporated four FUN bugs, along with beautiful and bothersome bugs identified in the other two studies. Preferences for these insects generated interest seemingly based on novel perceptual characteristics, since they were rarely listed, if at all, in study 1 and study 2. For instance, recent empirical work suggests the jumping spider is highly preferred over other spiders, almost a category unto themselves (Bixler et al., 2016). In study 3, the praying mantis was moderately preferred by both clusters of respondents. Further research should try to identify FUN bugs like the praying mantis and jumping spider that the "beautiful bugs group" might find at least mildly intriguing.

Similar to Lemelin and Yen's (2015) recommendations about spiders, we suggest a multifaceted incorporation of FUN bugs into a variety of traditional contexts, including recreational, educational, and citizen-science settings (Byrne et al., 1984; Genovart, Tavecchia, Enseñat, & Laiolo, 2013; Matthews et al., 1997; Sammet et al., 2015; Shepardson, 2002). Existing strategies often seem limited to the sole use of beautiful, well-known bugs or justifying bugs such as bees based on instrumental values such as pollination of food plants. More recent recommendations have called for the use of bugs other than butterflies (Schlegel et al., 2015), using those that represent lesser known groups (Snaddon & Turner, 2007), and using those that are not exotic but rather native and highly accessible (Genovart et al., 2013). These recommendations seem to support the use of the FUN bug group identified in this study.

Research funding priorities seem biased toward the large, distant, and exotic. Even research directed toward ecological issues often favor the large and charismatic vertebrates (Leather, 2009), often excluding bugs from human–animal research, a term coined as "arthropod discourse disorder" (Lemelin, 2013). We suggest that understanding awareness of, perceptions of, and experiences with, FUN bugs has great value and is a better use of research dollars and the skills of social scientists than yet another study showing that people admire large charismatic wildlife.

Limitations & Future Research

Results of these studies are not measures of actual human behavior with real bugs but are self-reported behavior and perceptions. There is always the possibility with these measures that the results are artifacts of the questions being asked (Graves, 2013; Ogden, 2003). Highly structured studies are more likely to produce results that are artefactual (Ogden, 2003). Our study design was a multi-method framework that incorporated findings from the open-ended studies 1 and 2; a means of informing the design of the highly structured study 3. In study 3, silhouettes of insects were used rather than color photos. This was done to minimize the bias that color has on preferences and to establish the role of first impressions when people are exposed to insects in natural settings that they may not know (DiGirolamo & Hintzman, 1997; Willis & Todorov, 2006). However, color is important in how people perceive animals (Stokes, 2007) and colorful species within a largely disliked family of insects may be less threatening.

The percentage of people in each cluster in study 3 and the preference and knowledge rankings of insects from all three studies should not be interpreted as reflecting estimates of population parameters. Our study population was a convenience sample of mostly traditional college-age students at a top-30 ranked university with average SAT/ACT entrance scores. For programmers working with people and bugs in recreational and educational settings, this study provides enough information for them to recognize these different orientations among the small groups making up their audiences, a more useful tool than knowing population parameters (Myers, 1996).

Future research focused on FUN bugs is needed. Focused studies examining one taxonomic group of bugs that share characteristics may reveal which specific traits of bugs are preferred. Modern eye tracking methodologies (Duchowski, 2007) could provide insights into what external morphological traits of bugs people notice, prefer, or find repulsive and in what patterns people look at bugs. Methods from the psychological sciences, such as the Implicit Association Test (Greenwald et al., 1998), might reveal relationships and associations that people have with groups of bugs and identify traits of insects that they are not able to consciously acknowledge. A question critical to interpretive naturalists and non-formal educators is determining the amount, variety, and length of exposure needed to establish positive human attitudes toward bugs commonly perceived as negative (Wagler, 2011). Future research should be sensitive to human developmental stages and previous experiences of children and adults. Lastly, future research exploring positive human emotional reactions such as interest and curiosity (Berlyne, 1966; Hidi & Baird, 1986; Kashdan, Rose, & Fincham, 2004) may reveal alternative approaches that go beyond the now well-established disgust reactions to bugs. Understanding what is liked about bugs, and the different ways bugs can be liked, seems a more appropriate course of action in the attempt to foster positive human–insect interactions. The third category of FUN bugs identified in this study is one step forward in this process.

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Conflict of Interest

The authors claim no conflict of interest.

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