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Knowledge of Arthropod Carnivory and Herbivory: Factors Influencing Preservice Elementary Teacher's Attitudes and Beliefs toward Arthropods

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Abstract: Human negativity toward arthropods has been well documented but the factors that contribute to this negativity have been elusive. This study explored knowledge of arthropod carnivory and herbivory as possible casual factors that contribute to the negative tendencies preservice elementary teachers have toward most arthropods. Specifically, this study investigated the effect knowledge of arthropod carnivory and herbivory had on United States kindergarten through sixth grade preservice elementary teacher attitude toward that arthropod and belief concerning the likelihood of incorporating information about that specific arthropod into their future science classroom. A cluster randomized design with a control group was used for the study. The treatment group consisted of 147 preservice elementary teachers and the control group consisted of 151. Unique to this study is the finding that arthropod carnivory and herbivory are causal factors that strongly affect preservice elementary teacher attitude and belief toward arthropods. When the participants of the study were made aware that an arthropod they thought was a herbivore was actually a carnivore, their attitude and likelihood of incorporation significantly declined. When the participants of the study were made aware that an arthropod they thought was a carnivore was actually a herbivore, their attitude and likelihood of incorporation significantly increased. Implications and future research are discussed.

Keywords: *Arthropod; Attitude; Carnivory; Elementary; Herbivory; Preservice*

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Introduction

Human negativity toward arthropods has been well documented (e.g., Kellert, 1993; Prokop, Tolarovičová, Camerik & Peterková, 2010; Wagler, 2010; Wagler & Wagler, 2011) with the classic example being fear of spiders (e.g., Gerdes, Uhl, & Alpers, 2009). Previous research has shown preservice elementary teachers have no plans to teach their future students about the vast majority of Earth's arthropods (Wagler, 2010; Wagler & Wagler, 2011) even though a quality science education begins in the elementary classroom with curriculum that exposes students to biodiverse groups of animals (e.g., AAAS, 1993; NRC, 1996; NRC, 2011; NAAEE, 2004). Although human negativity toward arthropods has been documented, the underlying factors that contribute to this negativity have been elusive. Identifying

Table 1. *Adult Arthropods Used in the Study*

Type of Arthropod	**Common Name**	**Scientific Name**	**Carnivore**	**Herbivore**	**Primary Diet**	**Terrestrial Food Chain Trophic Level**[d]
Beetle	Asian Lady Beetle	*Harmonia axyridis*	✓[a]		Arthropods	Level 3: Secondary Consumer
Dragonfly	Dragonhunter	*Hagenius brevistylus*	✓		Arthropods	Level 3: Secondary Consumer
Spider	Daring Jumping Spider	*Phidippus audax*	✓		Arthropods	Level 3: Secondary Consumer
Spider	Unknown	*Bagheera kiplingi*		✓[b]	Beltian[c] Bodies	Level 2: Primary Consumer

[a]Predominantly Carnivorous; [b]Predominantly Herbivorous; [c]Beltian body*:* a protein-rich structure produced by and found on the leaflets of the ant-acacia plant (*Vachellia spp.*) (Meehan, Olson, Reudink, Kyser & Curry, 2009);
[d]Level 1: Plants, that make their own food, are called *primary producers*;
Level 2: Herbivores, that eat plants, are called *primary consumers*;
Level 3: Carnivores, that eat herbivores, are called *secondary consumers*.

Figure 1. *The predominantly herbivorous spider Bagheera kiplingi eating a protein-rich Beltian body it has harvested from an ant-acacia plant (Vachellia spp.). Note the other Beltian bodies on the tips of the plants leaflets. (*Photograph by David Jordan and used with his permission)

these factors can assist science educators in constructing effective learning environments that foster students understand of ecosystem interactions.

This study explored knowledge of arthropod carnivory and herbivory as possible casual factors that contribute to the negative tendencies preservice elementary teachers have toward most arthropods (Wagler, 2010; Wagler & Wagler, 2011). Specifically, this study investigated the effect knowledge of arthropod carnivory and herbivory had on United States (U.S.) kindergarten through sixth grade (K-6) preservice elementary teacher attitude toward that arthropod and belief concerning the likelihood of incorporating information about that specific arthropod into their future science classroom (henceforth referred to as “likelihood of incorporation”). A cluster randomized design with a control group was used for the study. Four arthropods were used in the study (See Table 1).

They were the Asian lady beetle, the dragonhunter dragonfly, the daring jumping spider and the only known predominantly herbaceous spider, *Bagheera kiplingi* (See Figure 1).

Theoretical Underpinnings of the Study

Human attitude is defined as a “psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor” (Eagly & Chaiken, 1993, p.1). Human belief is defined as an estimate of the likelihood that the knowledge one has about an entity is correct or, alternatively, that an event or a state of affairs has or will occur (Eagly & Chaiken, 1998). The past beliefs of humans (1) (See Figure 2) that are linked to a particular entity (i.e., an arthropod) affect the individual’s present attitude (2) toward that entity.

That attitude, in turn, affects present beliefs (3) associated with that entity (Kruglanski & Stroebe, 2005; Marsh & Wallace, 2005). The mechanisms by which beliefs influence attitudes and attitudes influence beliefs is based on the way attitudes and beliefs are perceptually organized (Heider, 1958; Albarracín et al., 2005), cognitively organized (Osgood & Tannenbaum, 1955; Rosenberg, 1960; Albarracín et al., 2005) and the outcomes of judgmental processes (Sherif, Sherif, & Nebergall, 1965; Albarracín et al., 2005).

Literature Review

A Brief Overview of Arthropods

Arthropods (Phylum *Arthropoda*) are invertebrate animals that are united by a set of characteristics, with the most visible being a segmented body and jointed appendages that are covered with an exoskeleton made of chitin (Budd & Telford, 2009; Johnson, 2003; Lewis, Gaffin, Hoefnagels & Parker, 2002). Common examples include insects (Class: *Insecta*), spiders (Class: *Arachnida*) and shrimp (Class: *Malacostraca*). Arthropod evolution began approximately 542-488 million years ago in the Cambrian period (Budd & Telford**,** 2009). Based upon life history, global biodiversity and sheer numbers, arthropods are arguably the most evolutionarily and biologically successful animal phylum on Earth.

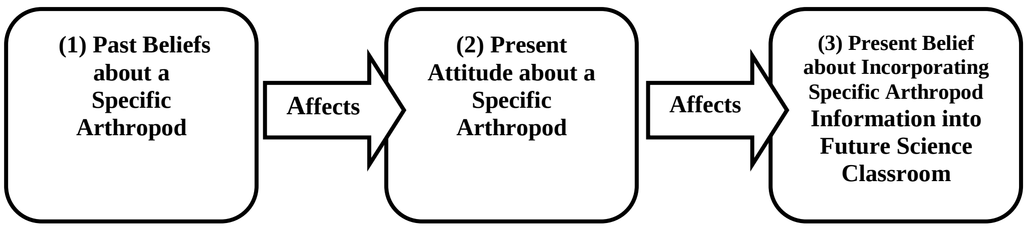

Figure 2. *Association between Human’s Past Beliefs, Present Attitude and Present Belief*

Arthropod global species distribution includes all continents and nearly every body of water on Earth. It is hypothesized that more than 75% of all animal species on Earth are arthropods (Lewis, Gaffin, Hoefnagels & Parker, 2002) with the class Insecta (i.e., the insects) having the largest number of species and the greatest number of individuals. Beetles alone account for more than 300,000 species. Arthropods perform many essential ecological services for humans that range from the pollination of flowering plants by bees, to the consumption of massive global detritus by cockroaches to a myriad of other phenomenon that make human existence possible (Wilson, 1987). Even though arthropod species diversity is large, the conservation status of many of Earth's arthropod species ranges from vulnerable to extinct (International Union for Conservation of Nature, 2012) as they are part of the current human-induced global mass extinction of plant and animal life (e.g., Jackson, 2008; Wagler, 2011; Wagler, 2012; Wake & Vredenburg, 2008).

Human Psychological Tendencies and Beliefs toward Invertebrates

The general public and farmers possess a limited knowledge of invertebrates. They also tend to express fear and anxiety toward most invertebrates, particularly insects and spiders. Scientists and conservation organization members tend to have a more positive attitude and possess more knowledge about arthropods (Kellert, 1993). The majority of the general public indicate a dislike of cockroaches, bugs, ticks, ants, beetles and crabs; a dislike of insects in the home; a fear of scorpions, spiders and stinging insects; a desire to eliminate cockroaches, spiders, fleas, mosquitoes and moths; and a view of the cockroach and octopus as a highly unattractive animal. In a general sense, farmers expressed similar views to those of the general public (Kellert, 1993).

A more positive view of specific invertebrates occurs when that invertebrate is deemed by a human to have utilitarian value (e.g., shrimp). Farmers, in a general sense, tend to display more emotionally detached, antagonistic and pragmatic attitudes toward invertebrates and largely view them as a source of material gain or a threat. Scientists and conservation organization members had a protective and appreciative attitude toward invertebrates. They also had a greater interest in recreational contact with invertebrates (Kellert, 1993). Kellert's study (1993) showed how different societal groups (e.g., the general public, farmers, scientists and conservation members) perceive and value invertebrates.

Bjerke, Odegardstuen and Kaltenborn (1998) explored Norwegian children and adolescents degree of preference for animals. They found that the degree of preference for animals varies depending on the type of animal (Bjerke, Odegardstuen & Kaltenborn, 1998). The worm, spider, bee and crow were found to be the least favorite species. The cat, dog, rabbit and horse were the favorite species (Bjerke, Odegardstuen & Kaltenborn, 1998). Very few of the studies participants were willing to save ecologically-significant insects (i.e., ants, bees and lady beetles) from going extinct (Bjerke, Odegardstuen & Kaltenborn, 1998).

Prokop and Tunnicliffe (2008) assessed spider and bat attitudes in Slovakia children ranging in age from 10-16 years. Children had more negative attitudes toward spiders than bats with female participants having greater negativity than male participants. Irrespective of children's age or gender, alternative conceptions and knowledge of bats and spiders were distributed randomly (Prokop & Tunnicliffe, 2008). A moderate correlation between attitude and knowledge of bats was found. No similar tendency was found with spiders (Prokop & Tunnicliffe, 2008).

Among university entry level psychology students spiders tend to elicit significantly greater fear, disgust and perceived danger when compared to beetles, bees/wasps and butterflies/moths (Gerdes, Uhl, & Alpers, 2009). Ratings of disgust and fear of spider pictures significantly predicted the questionnaire scores for fear of spiders. Dangerousness ratings of other arthropods and spiders did not provide any predictive power. Gerdes, Uhl and Alpers (2009) results showed that the potential harmfulness of a spider cannot explain why spiders are feared so often.

Slovakian primary school children possessed better knowledge of unpopular animals (i.e., potato beetle, wolf and mouse) compared to popular animals (i.e., rabbit, lady beetle and squirrel) even though they had less favorable attitudes towards unpopular animals (Prokop & Tunnicliffe, 2010). Participants that had pets in their house had better knowledge and more positive attitudes of both popular and unpopular animals. Boys were more favorably inclined than girls to animals that may pose a threat, danger or disease to them (Prokop & Tunnicliffe, 2010).

Attitudes towards spiders and the level of knowledge of spiders of high school students from Slovakia and South Africa have also been compared (Prokop, Tolarovičová, Camerik & Peterková, 2010). Biology teaching in Slovakia is based on systematic zoology and botany while the South African system is based on ecosystems. A statistically significant but low correlation between knowledge and attitude was found among the Slovakian students. Based on Kellert's (1996) categories of attitude (scientistic, negativistic, naturalistic, and ecologistic), South African students had higher scores in the categories of scientistic, naturalistic, and ecologistic attitudes. Prokop, Tolarovičová, Camerik and Peterková (2010) also found that Slovakian students have less fear of spiders than South African students.

Randler, Hummel and Wüst-Ackermann (2012) investigated situational disgust during a university course using a wide range of living animals, prepared mounts and methods. The mammalian skull, microscopy, bird flight and honeybee dance activities were rated as the least disgusting. The dissection of a trout activity was evaluated as the most disgusting, followed by the living terrestrial isopod activity, living earthworm activity and living snail activity. Dissection was found to be the most disgusting, followed by experiments with living animals, followed by experiments without animals and observations through a microscope were perceived as being least disgusting. Disgust was positively correlated with boredom and pressure and negatively correlated with competence, well-being and interest. Therefore, higher disgust was related to higher pressure and boredom while low disgust was related to high interest, well-being and competence. The results of their study show the necessity to measure situational disgust in addition to survey studies. They also suggest intrinsic motivation is negatively affected by perceived disgust.

Hummel and Randler (2012) conducted a meta-analysis and performed a treatment-control study with over 400 middle school students. The film versus animal study differed only by the presence of the living animal. In the meta-analysis they found that living animal treatments scored significantly better than a control group. This was not the case when they compared living animals with alternative treatments. In the treatment–control study, both treatments produced a significant increase in knowledge but no differences were observed between film and living animal treatment. Previous grading and pretest had a significant influence on the posttest and two follow-up tests. With the mouse lesson, students of the living animal group displayed lower values in pressure and higher values in competence and interest. Student competence and interest correlated negatively with pressure, while competence and interest correlated positively with achievement.

Preservice Teachers Attitudes and Likelihood of Incorporation toward Arthropods

A strong statistically significant association has been found between kindergarten through fourth grade (K-4) preservice elementary teacher's attitudes towards a specific animal and their likelihood to include or exclude information about that animal from their future science classroom (Wagler, 2010). Specifically, if a non-science major K-4 preservice elementary teacher had a positive attitude toward an animal they were much more likely to believe they would incorporate information about that animal into their future science classroom. Conversely, if a K-4 preservice elementary teacher had a negative attitude toward an animal they were much more likely to believe they would not incorporate information about that animal into their future science classroom.

Based on these beliefs the science learning environment that the vast majority of the preservice elementary teachers in the study would construct for their future students would be dominated by mammals (Wagler, 2010). The learning environment would be void of any invertebrates (e.g., sponges, corals, worms, mollusks, insects [Excluding the butterfly], crustaceans, and arachnids), amphibians and reptiles. Wagler's study (2010) provided the first empirical evidence that a preservice elementary teacher's attitude toward an animal affected their belief about using that animal in their future science curriculum.

Non-science major K-4 preservice elementary teachers that received frequent direct contact with Madagascar hissing cockroaches *(Gromphadorhina portentosa)* in an educational setting during their preservice training programs had their attitudes and likelihood of arthropod incorporation in future science curriculum changed in a positive way toward the Madagascar hissing cockroaches but not toward other arthropods that they did not have contact with (Wagler & Wagler, 2011). A pre/post randomized design with a control group was used for the study. The non-contact arthropods included a butterfly, lady beetle, dragonfly, grasshopper, spider, crayfish, millipede, centipede and scorpion. This finding provided evidence that in order to positively change preservice elementary teacher attitudes and incorporate beliefs toward a specific animal, frequent direct contact in an educational setting with that specific animal is needed (Wagler & Wagler, 2011).

The general trend observed was that the preservice elementary teachers displayed two different types of attitudes and incorporation rates depending on what arthropod picture they were shown (Wagler & Wagler, 2011). Specifically, the preservice elementary teachers had positive to extremely positive attitudes toward the butterfly, lady beetle and dragonfly and negative attitudes toward the Madagascar hissing cockroach (i.e., pretest only), spider, crayfish, centipede, grasshopper, millipede and scorpion (Wagler & Wagler, 2011). The preservice elementary teachers also had likely to extremely likely belief of future science classroom incorporation rates for the butterfly, lady beetle, dragonfly and unlikely incorporation rates for Madagascar hissing cockroach (i.e., pretest only), spider, crayfish, centipede, grasshopper, millipede and scorpion (Wagler & Wagler, 2011).

Wagler and Wagler (2012) conducted a study to investigate if the external morphology of an insect had a negative effect on preservice elementary teacher's attitudes toward insects and beliefs concerning the likelihood of incorporating insects into future science education settings. Non-science major kindergarten through sixth grade preservice elementary teachers participated and a randomized design with a control group was used for the study. The participants were shown pictures of three insects (i.e., butterfly, lady beetle or dragonfly) and were asked to rate their attitude toward the insects and beliefs concerning the likelihood of incorporating the insects into future science education settings. The treatment group was shown a picture of the larva and adult stage of the insect. The control group was only shown the adult stage of the insect. Unique to the study, was the finding that the external morphology of an insect was a causal factor that could negatively affect preservice elementary teacher's attitudes toward insects and beliefs concerning the likelihood of incorporating insects into future science education settings.

Methodology

Research Questions

Research Question 1: Does knowledge that an arthropod is carnivorous or herbivorous affect K-6 preservice elementary teacher attitude toward that arthropod?

Research Question 2: Does knowledge that an arthropod is carnivorous or herbivorous affect K-6 preservice elementary teacher belief concerning the likelihood of incorporating information about that arthropod into their future science classroom?

Study Participants

The participants for the treatment and control group were registered in an elementary science methods course and enrolled in the last year of their bachelor's degree program at a midsized urban southwestern U.S. border region university with a predominantly Hispanic/Latino population. The treatment group consisted of 147 U.S. K-6 preservice elementary teachers and the control group consisted of 151. All of the participants were non-science majors training to teach K-6 grade students (i.e., approximately 5 to 12 years of age) and had not taken a university course in invertebrate biology. Of the 147 participants in the treatment group, 138 were female and 9 were male. The participants mean age was 27.94 years. 135 were Hispanic/Latino, 10 were White and 2 were Black. Of the 151 participants in the control group, 137 were female and 14 were male. The participants mean age was 28.91 years. Of the 151 participants, 142 were Hispanic/Latino, 6 were White and 3 were Black.

Randomization of Study

All university science education methods course sections were randomized into a treatment or control group. The sections, and hence, treatment and control groups were homogenous with respect to gender, age and ethnicity. Homogeneity tests comparing the ethnicity, age and gender of the preservice teacher groups demonstrate that the treatment and control group were very similar with respect to these demographic characteristics ($p_{ethnicity}$=0.57, p_{age}=0.27, p_{gender}=0.42). Due to the homogeneity of the treatment and control groups and random assignment of these sections, any observed difference in the attitude or likelihood of incorporation between the treatment and control groups is attributable to the additional information provided to the treatment group (i.e., viewing a color video of the animal *eating* in a natural setting). The order that the color videos were shown, was also randomized.

Study Procedure

The data collection for the treatment and control group occurred in university classrooms on the first day of the elementary science methods course before any course information had been presented. For the treatment group, a color picture of the Asian Lady Beetle was shown. The participants were then asked "What does this animal eat?" The participants wrote down their answer or circled "I Do Not Know." The participants were then shown, using a projector and laptop computer, a color video of the Asian Lady Beetle *eating* in a natural setting. They were then asked to rate their attitude (Likert scale: Extremely Negative [1], Negative [2], Neutral [3], Positive [4], Extremely Positive [5]) toward the animal shown by circling their response on the data collection sheet. The participants were then asked to rate the likelihood of incorporating (Likert scale: Extremely Unlikely [1], Unlikely [2], Likely [3], Extremely Likely [4]) information about the animal shown into their future science classroom. This *treatment* procedure was then repeated for the other three arthropods (i.e., Dragonhunter, Daring Jumping Spider and *Bagheera kiplingi*) used in the study (See Table 1). The procedure for the *control* group was identical to the treatment group *except* they were shown color videos of the four arthropods in a natural setting but *not* eating.

It was explained to the students that the "likelihood of incorporating information about the animal shown into their future science classroom" could take any form that referenced the animal. Examples were given that included bringing or allowing the actual animal into the classroom, developing or using a science activity that utilized the animal, reading a classroom story that discussed the animal, showing a video with the animal present in the video, having a picture of the animal in the classroom, having the students write a paragraph or draw pictures that incorporated the animal or any other type of media that addressed the animal in any way. It was further clarified to the participants that these were some examples and that they may be thinking of other examples of incorporating information about the animal into their future science classroom and that any of these "ways of incorporating" would apply to rating the likelihood of incorporating information about the animal shown into their future science classroom.

Selection of Arthropod Pictures and Videos

Four arthropods were used in the study (See Table 1 and Figure 1). The Asian lady beetle and the dragonhunter dragonfly were chosen because of the population's (i.e., preservice elementary teachers) ability to visually recognize these insects and because the insects are carnivores. These characteristics are essential attributes needed to answer the research questions of the study. The daring jumping spider and *Bagheera kiplingi* were chosen because of the population's (i.e., preservice elementary teachers) ability to visually recognize these spiders as spiders but not to identify the specific species. The carnivorous daring jumping spider and only known predominantly herbaceous spider *Bagheera kiplingi* were chosen to contrast one another (carnivorous spider versus predominantly herbaceous spider). These characteristics are essential attributes needed to answer the research questions of the study. For further justification see the Findings section.

Limitations of the Study

The arthropods appeared bigger than they actually are because the color pictures and videos of the four arthropods were projected on a screen. The color pictures and videos were also two dimensional compared to the actual arthropods which are three dimensional.

Results

Arthropod Food Consumption Type

Table 2 presents the overall percent correct for all participants' response to the question "What does this Animal Eat?" A large percentage of the answers for the dragonfly were "I Do Not Know." A large percentage of the answers for the lady beetle were associated with some form of plant material.

Overall Mean Attitude and Overall Mean Likelihood of Incorporation

Table 3 presents the overall mean attitude and overall mean likelihood of incorporation for all four arthropods for the treatment and control group.

Analysis of Attitude and Likelihood of Incorporation

The attitude and likelihood of incorporation responses are ordinal level random variables. For modeling ordinal data, the proportional odds logistic regression model is fit to the data (Agresti, 2004). Model 1 has attitude towards the arthropods as the response and treatment vs. control groups and animal as explanatory variables. Similarly, model 2 has likelihood of incorporation as the response and also treatment vs. control groups and animal as explanatory variables. Both models were fit in the software package *R* (R Development Core Team, 2010) using the *lrm* function in the *Design* package (Harrell, 2009). Tables 4 and 5 contain the parameter estimates resulting for modeling attitude and likelihood of incorporation.

Table 2. *Percent Correct to the Question "What does this Animal Eat?"*

Arthropod	Treatment Group	Control Group
Lady Beetle[a]	9%	7%
Dragonfly	12%	14%
Carnivorous Spider	97%	96%
Predominantly Herbivorous Spider[a]	4%	2%

Note: Percentages include participants that chose "I Do Not Know" or included an incorrect answer to the question. [a]The participants were asked "What does this animal predominantly eat?"

Table 3. *Overall Mean Attitude and Mean Likelihood of Incorporation*

	Treatment Group		Control Group	
Arthropod	Attitude	Likelihood of Incorporation	Attitude	Likelihood of Incorporation
Lady Beetle	3.46	2.95	4.51	3.69
Dragonfly	2.97	2.85	4.39	3.49
Carnivorous Spider	1.80	2.12	1.91	2.26
Predominantly Herbivorous Spider	3.02	3.29	1.89	2.13

Note: Attitude Likert Scale (Extremely Negative [1], Negative [2], Neutral [3], Positive [4], Extremely Positive [5]); Likelihood of Incorporation Likert Scale (Extremely Unlikely [1], Unlikely [2], Likely [3], Extremely Likely [4]).

Table 4 contains the parameter estimates resulting from model 1, i.e., attitude scores. The p-values are adjusted for multiplicity using the Holm procedure for adjusting the pointwise error rates (Hsu, 1996). Also note that the reference levels for the two explanatory variables (animal and group) are the carnivorous spider and control group, respectively. Thus, there is no slope estimated for main effects or interactions involving these levels. Focusing first on the explanatory variable statistics, note that statistical significance is detected aligning with the interaction effects of the model. This demonstrates that there are differences in the attitudes for respondents in the treatment group when rating attitude for the dragonfly, herbaceous spider and lady beetle versus the carnivorous spider. In contrast, the test for the main effects for the animals demonstrate that for the control group, the dragonfly and lady beetle are rated differently with respect to attitude than the carnivorous spider (reference level). However, no difference is detected between the herbaceous spider and carnivorous spider for the control group. This means that without taking into account the interactions, there is evidence that the

Table 4. *Proportional Odds Model Results for Attitude*

Slope	**Coefficient**	**Standard Error**	**Z**	**p-value (adjusted p)**
Y≥2	0.283	0.152	1.86	0.063 (0.189)
Y≥3	-1.082	0.158	-6.81	0.000 (0.000)**
Y≥4	-2.776	0.182	-15.23	0.000 (0.000)**
Y≥5	-4.353	0.205	-21.23	0.000 (0.000)**
Treatment	-0.132	0.211	-0.62	0.533 (1.000)
Dragonfly	4.592	0.252	18.25	0.000 (0.000)**
Herbaceous Spider	0.030	0.209	0.14	0.886 (1.000)
Lady Beetle	4.850	0.255	19.04	0.000 (0.000)**
Treat X Dragonfly	-2.522	0.313	-8.05	0.000 (0.000)**
Treat X Herbaceous Spider	2.156	0.309	6.99	0.000 (0.000)**
Treat X Lady Beetle	-1.901	0.311	-6.11	0.000 (0.000)**

** Corresponds with a Wald Z test with an observed significance level less than 5% when controlled for multiplicity

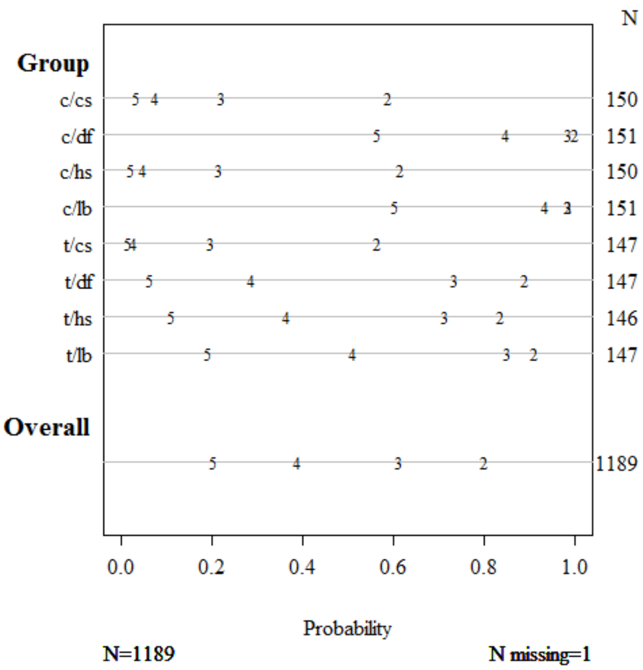

Figure 3. *Probability of Attitude Greater Than or Equal to Level j (P[Y≥j] Where j Corresponds to the Symbol Plotted)*

respondent have a more positive overall attitude toward lady beetles and dragonfly than the carnivorous spider. Conversely, the main effect tests, which was not statistically significant, suggests that there is no overall effect between the treatment and control groups and the herbaceous and carnivorous spider. However, this does not imply that the treatment and control groups do not differ when taking into account the animal of interest. For example, the interaction test for those in the treatment group and the dragonfly demonstrate a statistically significant decrease in attitude. This implies that there is a significant decrease in attitude for those who were exposed to the dragonfly eating in a natural setting (i.e., treatment group). Similarly, there is an observed decrease in attitude for those exposed to the lady beetle eating in a natural setting (i.e., treatment group). In contrast, there is a statistically significant increase in attitude for those who are made aware that the herbaceous spider consumes plant material rather than animals. There was no effect on attitude with respect to the carnivorous spider when comparing the treatment and control groups.

Figure 3 displays the probability of Likert responses for the different treatment and animal combinations. The numbers *j = 2, 3, 4* and *5* in the plot refer to the probability of the rating being greater than or equal to *j* in the analysis. Note that *1* does not appear in the plot because $P(Y \geq 1)=1$ for a Likert scale ranging from 1 to 5. On the left y-axis are the labels for the groups being analyzed. For example, the first group c/cs is the carnivorous spider in the control group. The right y-axis has the sample sizes for each group. Values on the left side of the scale indicate the $P(Y \geq j)$ is relatively low while values on the right side of the scale indicate $P(Y \geq j)$ is fairly high. Examination of the plot reveals that the response pattern was very similar for the carnivorous spider (cs) for both the treatment (t) and control (c) groups. See the lines labeled t/cs and c/cs to observe that the distributions of probabilities are very similar. In contrast, the dragonfly (df) probabilities (see t/df and c/df) show a large difference with respect to response pattern. In particular, slightly less than 10% of respondents in the treatment group respond with a 5 (strongly agree) while over 50% in the control group respond with a 5. Similarly, only around 35% of respondents in the treatment group assign a 4 (agree) to the dragonfly while around 85% do for the control group. Overall, it is clear than the treatment group gives the high attitude rating much less frequently than the control group when rating the dragonfly. A very similar pattern of responses is found for the lady beetle (lb). A high attitude rating (either a 4 or 5) is fairly unusual for the treatment group (around 20% and 50%) when compared to the control (around 60% and 95%) with respect to the lady beetle. Lastly, the herbaceous spider (hs) also has a different response pattern between the treatment and control groups, but with an opposite effect. Namely, the probability of a positive attitude is extremely low for the control group (less than 10% probability of a 4 or 5) while this probability increases to around 15% of a 5 rating and nearly 40% chance of a 4 or greater rating for the treatment group. Thus, the treatment (i.e., being told the herbaceous spider consumes plant material) increased the probability of a positive attitude of the respondents.

Table 5 contains the estimated model parameters for likelihood of incorporation. These yield very similar results to the model for animal attitude. Again, the carnivorous spider and control groups are the reference levels and all p-values are adjusted for multiplicity for the set of comparisons made. For this model, all interaction tests are statistically significant indicating there is a significant difference between how those in the treatment group rate their likelihood of incorporation for the dragonfly, herbaceous spider and lady beetle versus the carnivorous spider. For those in the control group, there is only a difference in likelihood of incorporation for the lady beetle and dragonfly versus the carnivorous spider. Figure 4 also shows the cumulative probabilities for each level of the Likert scale for each group and animal combination. Note the difference in the response probabilities for the treatment (t) versus control (c) groups of the lady beetle (lb), dragonfly (df) and

Table 5. *Proportional odds Model Results for Likelihood of Incorporation*

Slope	**Coefficient**	**Standard Error**	**Z**	**p-value (adjusted p)**
Y≥2	0.766	0.158	4.84	0.000 (0.000)
Y≥3	-0.147	0.156	-0.94	0.346 (0.625)[a]
Y≥4	-2.120	0.171	-12.42	0.000 (0.000)[a]
Y≥5	-5.130	0.242	-21.18	0.000 (0.000)[a]
Treatment	-0.274	0.218	-1.26	0.208 (0.346)
Dragonfly	2.245	0.223	10.06	0.000 (0.000)[a]
Herbaceous Spider	-0.221	0.213	-1.04	0.300 (0.600)
Lady Beetle	2.811	0.229	12.28	0.000 (0.000)[a]
Treatment X Dragonfly	-1.015	0.303	-3.35	0.001 (0.003)[a]
Treatment X Herbaceous Spider	2.258	0.314	7.20	0.000 (0.000)[a]
Treatment X Lady Beetle	-1.091	0.311	-3.50	0.001 (0.003)[a]

[a] Corresponds with a Wald Z test with an observed significance level less than 5% when controlled for multiplicity

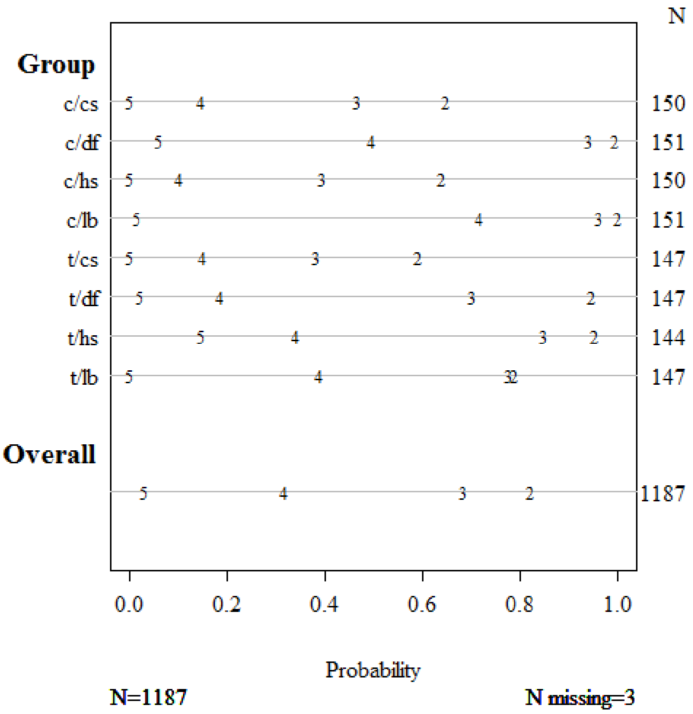

Figure 4. *Probability of Likelihood of Incorporation Greater Than or Equal to Level j (P[Y≥j] Where j Corresponds to the Symbol Plotted)*

herbaceous spider (hs). Only the carnivorous spider (cs) displays very similar response patterns for both the treatment and control groups.

Pre-planned Comparisons

It is of interest to investigate how carnivory and herbivory affects preservice elementary teacher attitude and likelihood of incorporation. Thus, some preplanned comparisons were made on the multinomial logistic model coefficients that focus on the treatment group, e.g. those that were given information about whether the arthropods were carnivorous or herbivorous. Namely, a direct comparison of the attitude toward the herbaceous spider versus the carnivorous spider and a comparison of the mean attitude of all three carnivorous arthropods (i.e., lady beetle, carnivorous spider, and dragonfly) and the attitude toward the one herbaceous arthropod (i.e., herbaceous spider) were made using linear combinations of the slope parameters for those in the treatment group. The same set of comparisons was also made with likelihood of incorporation as the response variable. The observed difference for the comparison of the herbaceous versus carnivorous spider attitudes was 2.19 (Z=9.16, p-value<0.0001) and the difference for the carnivorous versus herbaceous arthropods attitudes was 0.51 (Z=2.86, p-value=0.004) for those with knowledge about carnivory/herbivory. Thus, both tests are statistically significant indicating a difference exists between the preservice teachers attitudes toward herbaceous versus carnivorous arthropods. The difference in scores also has practical significance since a change of these magnitudes either ensure or are likely to result in a change of Likert response categories (i.e., from 'Agree' to 'Strongly Agree'). Similarly, for those in the treatment group, the observed difference when comparing the likelihood of incorporation for the herbaceous versus the carnivorous spider was 2.04 (Z=8.95, p-value<0.0001) and when comparing the carnivorous versus herbaceous arthropods overall, it was 1.04 (Z=5.87, p-value<0.0001). Thus, there is a statistically, as well as practically, significant difference between the likelihood of incorporation of these groups of arthropods. Multiplicity was not controlled in these calculations as they were pre-planned and made separately from the rest of the conclusions.

Discussion

Findings

This study, in which a randomized design with a control group was used, provides strong evidence that knowledge of arthropod carnivory and herbivory are causal factors that strongly affect preservice elementary teacher's attitudes and beliefs toward arthropods. Evidence verifying that knowledge of arthropod carnivory negatively affects human attitudes and beliefs toward arthropods is apparent with the two insects (i.e., lady beetle and dragonfly) used in the study. When the participants of the study were made aware that an arthropod they thought was a herbivore was actually a carnivore, their attitude and likelihood of incorporation changed. For example, with both the lady beetle and the dragonfly, the majority of the preservice elementary teachers in both the treatment and control group thought the arthropods ate some form of plant material (See Table 2). When the treatment group observed the video of both arthropods feeding on other arthropods (i.e., carnivory) in a natural setting their attitude and likelihood of incorporation both significantly declined (See Tables 3, 4, and 5; Figures 3 and 4). This decline in attitude and likelihood of incorporation was not observed with the control group that just observed a video of the same arthropod in a natural setting but not eating (See Tables 3, 4 and 5; Figures 3 and 4). Clearly the knowledge of carnivory, that the videos imparted to the treatment participants caused a negative decline in the preservice elementary teacher's attitude which, in turn, decreased their belief concerning the likelihood of incorporating information about that arthropod into their future science classroom.

Further evidence verifying that knowledge of arthropod herbivory positively increases human attitudes and beliefs toward arthropods is apparent with the two spiders (i.e., Daring Jumping Spider and *Bagheera kiplingi*) used in the study. When the participants of the study were made aware (by viewing the color video) that an arthropod they thought was a carnivore was actually a herbivore, their attitude and likelihood of incorporation changed (See Tables 4 and 5 or Figures 3 and 4). For example, with the carnivorous spider (i.e., Daring Jumping Spider) both the treatment and control groups were already knowledgeable of the carnivorous nature of the spider (See Table 2). After watching the spider eat in a natural setting they possessed negative attitudes and low likelihood of incorporation rates. Very few (4% [Treatment] and 2% [Control]) of the participants of the study were aware that *Bagheera kiplingi* was a predominately herbaceous spider (See Table 2). After the treatment group watched the video of the predominantly herbaceous spider *Bagheera kiplingi* harvesting Beltian bodies (i.e., plant material) their attitude and likelihood of incorporation both significantly increased (See Tables 4 and 5 or Figures 3 and 4).

Clearly the knowledge of herbivory, that the video imparted caused a positive increase in the preservice elementary teacher's attitude which, in turn, increased the belief concerning the likelihood of incorporating information about that arthropod into their future science classroom. This finding should be contrasted with the negative decrease observed with the preservice elementary teacher's attitude and likelihood of incorporation associated with the carnivorous Daring Jumping Spider and brings further evidence of how knowledge of arthropod carnivory decreases preservice elementary teacher's attitude and likelihood of incorporation rates. All of these findings, associated with arthropod carnivory and herbivory, are unique to this study.

Implications

Past research has shown that preservice elementary teachers have very low arthropod attitudes and likelihood of incorporation rates (Wagler, 2010) but the factors influencing these metrics have been elusive. This study confirms that when preservice elementary teachers learn that an arthropod is carnivorous their attitude toward that arthropod and their likelihood of incorporating that arthropod into their future classroom significantly decreases. This study also confirms that when preservice elementary teachers learn that an arthropod is herbivorous their attitude toward that arthropod and their likelihood of incorporating that arthropod into their future classroom significantly increases. The participants in this study, because of this propensity, will have a tendency to educate their future students about specific herbaceous arthropods and not about carnivorous arthropods which are an essential component to many, if not most, global food chains. In any learning environment, students cannot learn what they are not exposed to. If future elementary teachers do not expose their students to carnivorous arthropods, this will greatly impact their students understanding of the diverse types of food chains (See Table 1 for examples) because of the sheer number of arthropod species (i.e., over 75% of animal species are arthropods (Lewis, Gaffin, Hoefnagels, & Parker, 2002) and the vast number of essential ecological roles carnivorous arthropods play in global food chains. This study confirms they do not believe they will expose their students to information about carnivorous arthropods. Furthermore, if students do not receive this foundational knowledge in their K–6 classroom they will be at a great disadvantage to comprehend more complex concepts such as food webs and other ecosystem interactions that cannot be conceptualized without first knowing about the diverse types of food chains.

When the findings of this study are considered, those that train preservice elementary teachers find themselves in a dilemma. Preservice elementary teachers should know that specific arthropods are carnivorous so they can teach their future students this essential knowledge. But when preservice elementary teachers learn that a specific arthropod is carnivorous their attitude toward that arthropod decreases and the preservice elementary teacher is far less likely to incorporate information about that animal into their future science classroom. This dilemma merits future research.

Future Research

Humans tend to be uneducated about arthropods (e.g., Kellert, 1993). The preservice elementary teachers in this study are no different. They were not aware what three of the four study's arthropods (i.e., lady beetle, dragon fly and *Bagheera kiplingi*) ate (See Table 2). This is not unexpected with *Bagheera kiplingi* considering that there are over 40,000 described species of spiders on Earth and *Bagheera kiplingi* is the only known predominately herbaceous spider (Meehan, Olson, Reudink, Kyser & Curry, 2009). What is unexpected is that the majority of the study's preservice elementary teachers were not aware that lady beetles and dragonflies are carnivores even though they are very popular in the U.S. and the preservice elementary teachers had positive attitudes and likelihood of incorporation rates toward them before finding out they were carnivorous (See Table 3). Instead, the majority of the preservice elementary teachers thought they ate some form of plant material.

Future research is needed to verify if it is possible to increase preservice elementary teacher knowledge of arthropod carnivory and, at the same time, increase preservice elementary teacher attitude and likelihood of incorporation. This future research study should utilize a randomized design with a control group with an educational intervention applied only to the treatment group. This educational intervention should focus on increasing the preservice elementary teacher's knowledge of the ecological role carnivorous arthropods play in diverse food chains. It should also focus on increasing the preservice elementary teacher's knowledge of the need for global carnivorous arthropods because of the essential role they play in helping sustain global food chains, global food webs, global ecosystems and the biosphere in general. Lastly, this intervention should emphasis that, without these arthropods performing these essential ecological services, the quality of human life would be greatly diminished or not possible (Wilson, 1987). Ideally this educational intervention should allow individuals to interact with actual arthropods (Wagler & Wagler, 2011) but pictures can also be used if living arthropods are not available. An educational intervention of this nature has the potential to increase the preservice elementary teacher's attitudes toward carnivorous arthropods and thereby increasing their likelihood of incorporating information about these animals into their future science classrooms.

Conclusion

Humanity is currently in the midst of a human-induced global mass extinction of plant and animal life (e.g., Jackson, 2008; Wake & Vredenburg, 2008) with the status of many arthropods ranging from vulnerable to extinct (International Union for Conservation of Nature, 2012). Education that fosters animal preservation can potentially assist in reducing future extinctions (Wagler, 2011; Wagler, 2012). Knowledge of arthropod carnivory is one of the factors preventing preservice elementary teachers from including biodiverse arthropods in their future classrooms. Educational interventions that teach future elementary teachers about the functional and essential need for carnivorous arthropods have the potential to positively change attitudes, increase the likelihood of arthropod information incorporation in science classrooms and equip students with the skills needed to participate in the preservation of global ecosystems.

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