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Arthropods: Attitude and incorporation in preservice elementary teachers

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Аннотация

Invertebrates perform many beneficial and essential ecological services for humans. Despite this, the general public tends to view them negatively. Preservice elementary teachers often find themselves in a tenuous position because they possess the same negativity toward invertebrates as the general public but have been commissioned by United States of America national and state standards to teach their future students about the very invertebrates they distain. This study investigated the effect frequent direct contact with Madagascar hissing cockroaches (Gromphadorhina portentosa) in an educational setting had on preservice elementary teacher‟s arthropod (i.e., a subset of invertebrates) attitude and likelihood of arthropod incorporation in future science curriculum. A pre/post randomized design with a control group was used for the study. Preservice elementary teachers that received frequent direct contact with Madagascar hissing cockroaches in an educational setting during their preservice training programs had their attitudes and beliefs changed in a positive way toward that arthropod but not toward other arthropods. Implications concerning this finding, and other findings associated with the study, are discussed.

Ключевые слова: attitude, elementary, belief, arthropods, preservice

Introduction

Approximately 10 million animal species currently exist on Earth. Of these 10 million species, approximately 99% are invertebrates (Johnson, 2003). Even though invertebrates perform many essential and beneficial ecological services for humans and invertebrates live in the same spaces humans live in, the general trend observed among specific human groups is to view them negatively (e.g., Bjerke & Thrane, 2003; Bjerke, Odegardstuen, & Kaltenborn, 1998b; Bjerke, & Ostdahl, 2004; Kellert, 1993; Prokop, Usak. & Fancovicovä. 2010; Prokop, Tolarovicovä. Camerik & Peterkovä, 2010; Wagler, 2010). For example, the United States of America (USA) general public "view most invertebrates with aversion, anxiety, fear, avoidance, and ignorance” (Kellert, 1993, p.845). Even though this is the general trend observed among specific human groups, positive outcomes have been shown when children interact with animals (Bjerke, Kaltenborn & Odegardstuen, 2001; Inagaki, 1990; Prokop, Prokop, & Tunnicliffe, 2008).

Pre service elementary teachers often find themselves in a tenuous position because they possess the same negativity toward invertebrates (Prokop, U§ak & Fancovicovä, 2010; Wagler, 2010) as the general public (Kellert, 1993) but have been commissioned by USA national (AAAS, 1993, p. 102-103; NAAEE, 2004, p. 18; NRC, 1996, p. 128) and state standards to teach their future students about the very invertebrates they distain. Most often the preservice elementary teacher's attitude is the main barrier preventing them from incorporating invertebrates into their future science curriculum (Wagler, 2010).

This study investigated the effect frequent direct contact with Madagascar hissing cockroaches (Gromphadorhina portentosa) in an educational setting had on preservice elementary teacher's arthropod (i.e., a subset of invertebrates) attitude and likelihood of arthropod incorporation in future science curriculum. A pre/post randomized design with a control group was used for the study.

Theoretical Underpinnings

Human attitude has been defined as a "psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor’ (Eagly & Chaiken, 1993, p.l). Eagly and Chaiken (1998) also define human belief 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. The past beliefs of humans (1) (See Figure 1) that are linked to a particular entity (i.e., a specific animal) 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; Albarracin et al., 2005), cognitively organized (Osgood & Tannenbaum, 1955; Rosenberg, 1960; Albarracin, Johnson, & Zanna, 2005) and the outcomes of judgmental processes (Sherif, Sherif, &Nebergall, 1965; Albarracin et al., 2005).

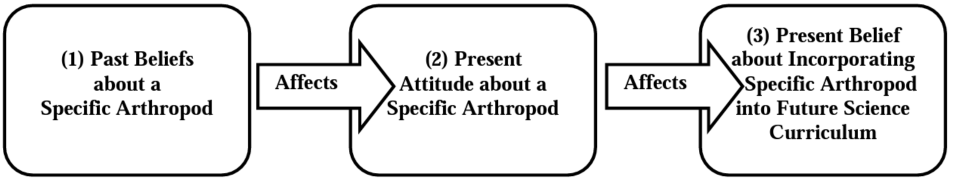

Figure 1. Association between Human's Past Beliefs, Present Attitude and Present Belief

Literature Review

Arthropods: A Brief Overview

Arthropods (Phylum Arthropodci) are invertebrate animals that are unified by a set of characteristics, with the most noticeable being a segmented body, a chitinous exoskeleton and jointed appendages (Budd & Telford, 2009; Johnson, 2003; Lewis, Gaffin, Hoefhagels, & Parker, 2002). Five of the more well-known classes of arthropods are Insecta (i.e., insects; e.g., dragonflies and butterflies), Arachnida (i.e., arachnids; e g,, scorpions and spiders), Malacostraca (i.e., crustaceans; e.g., crayfish), Diplopoda (i.e., millipedes; e.g., millipedes) and Chilopoda (i.e., centipedes; e.g., centipedes). Examples of lesser known arthropod classes include Trilobita (i.e., trilobites) and Eurypterida (i.e., sea scorpions) which are both extinct. The evolution of arthropods began in the Cambrian period (Budd & Telford, 2009), approximately 542-488 million years ago, and continues to present day. The arthropods two major body plan evolutionary innovation's, jointed appendages and a chitinous exoskeleton, have allowed them to become the most biologically successful group of organisms on Earth. As Lewis et al. (2002) state "If biological success is judged in terms of diversity, perseverance, and sheer numbers, then the phylum Arthropoda certainly qualifies as the most successful group of organisms" (Lewis et al., 2002, p. 468).

"Biologists hypothesize that more than 75% of all animal species are arthropods" (Lewis, Gaffin, Hoefnagels, & Parker, 2002, p. 468) with their distribution encompassing all continents (including Antarctica) and nearly all bodies of water on Earth. It is estimated that the number of global arthropod species is between 5 to 10 million (Odegaard, 2000). Of the five major classes of arthropods the class Insecta (i.e., the insects) has, by far, the largest number of species and the greatest number of individuals. "Scientists estimate that a quintillion (i.e., 1,000,000,000,000,000,000') insects are alive at any one time - 200 million insects for each living human!" (Johnson, 2003, p. 436).

Even though Arthropods have the greatest number of species and individuals of any animal group they too, as most global organismal groups, are experiencing declining species numbers (IUCN, 2010; MEA, 2005; Pimm, Russell, Gittleman, & Brooks, 1995; Pimm & Raven, 2000; Rockström et al., 2009; WWF, 2008) as part of the current global mass extinction (Alroy, 2008; Jackson, 2008; Lewis, 2006; McDaniel & Borton, 2002; Rockström et al., 2009; Rohr et al., 2008; Steffen, Crutzen & McNeill, 2007; Thomas et al., 2004; Wagler, 2011: Wake & Vredenburg, 2008; Zalasiewicz, Williams, Steffen, & Crutzen, 2010) brought on (indirectly and directly) by excessive global human activities (Crutzen & Stoermer, 2000; Crutzen, 2002; Crutzen & Steffen, 2003; Le Quere et al., 2009; MEA, 2005; MEA, 2005a; Tripati, Roberts & Eagle, 2009; Wilson, 1987; WWF, 2008; Zalasiewicz et al., 2008).

Arthropods are both beneficial and detrimental to humans. For instance, arthropods (e.g., crustaceans and/or insects) are consumed by humans in most cultures but insects are also vectors for infectious agents such as protists. Malaria, which involves the transmission of a protist (e.g., Plasmodium falciparum) to humans by mosquitoes, globally kills between one and three million humans a year (Snow, Guerra, Noor, Myint & Hay, 2005). Ecologically, arthropods play a fundamental role in many processes with one of the most notable being food (directly or indirectly) for animal species. Without arthropods serving as this food source it is highly probable major pathways of food webs on Earth would collapse, seriously impacting the quality of life of humans and possibly effecting human's very survival as a species (Wilson, 1987). Without a doubt, arthropods are a remarkable, important and sometimes feared group of animals.

An Overview of Beliefs, Attitudes,Preferences and Knowledge toward Animals

Research carried out over the last four decades, from multiple countries, has shown there is a general trend among children to more frequently believe the conceptual understanding of an animal refers to common well-known mammals. Children also have a tendency to have difficulty classifying invertebrate and vertebrate animals (Yen, Yao & Mintzes, 2007).[2]

Children who raised goldfish possessed more factual and conceptual knowledge about goldfish that children that had not raised goldfish (Inagaki, 1990). The children who raised goldfish were able to use this knowledge to make predictions concerning the anatomy of an unfamiliar frog. Inagaki concluded that the difference in factual and conceptual knowledge
between these two groups was "primarily due to the specific experience of raising goldfish'’ (Inagaki, 1990, p. 119).

Bjerke, Odegardstuen and Kaltenborn (1998) conducted a study assessing Norwegian children and adolescents attitudes toward animals. A questionnaire, based on Kellert’s (1996) attitude typology toward animals, was developed and administered. Findings included that the "humanistic attitude type ranked first, followed by the moralistic, ecologistic, naturalistic, negativistic, dominionistic, and utilitarian attitude types. Gender differences appeared on the moralistic and negativistic (girls highest), and the naturalistic, dominionistic, and utilitarian (boys highest) sub-scales. Scores on the ecologistic, naturalistic, and dominionistic sub-scales decreased with increasing age. Urban respondents had higher moralistic, and rural respondents had higher dominionistic sub-scale scores. Respondents who owned a pet had higher humanistic^ moralistic, and lower utilitarian sub-scale scores than had non-owners” (Bjerke, Odegardstuen & Kaltenborn, 1998, p. 79).

Bjerke, Odegardstuen and Kaltenborn (1998a) also conducted a study assessing Norwegian children and adolescents "degree of preference for various animal species” (Bjerke, Odegardstuen & Kaltenborn, 1998a, p. 224). The "crow, worm, bee, and spider” were found to be the least favorite species while the "dog, cat, horse, and rabbit were the favorite species” (Bjerke, Odegardstuen & Kaltenborn, 1998a, p. 224). "Girls were more positive toward horses, and were more pet-orientated than boys, while more boys than girls preferred wild animals. Younger respondents liked animals more than did 15-year-olds, with a few exceptions: the wolf, bear, and whale. Urban respondents liked animals more than rural respondents did, a finding which applied to the large carnivores in particular. Interests in wildlife decreased with increasing age, and few respondents wished to save ecologically-significant species (ants, bees, ladybirds) from extinction” (Bjerke, Odegardstuen & Kaltenborn, 1998a, p. 224).

Bjerke, Kaltenborn and Odegardstuen (2001) assessed Norwegian children and adolescents "degree of preference for various animal species, participation in animal-related activities, and the presence of pets at home” (Bjerke, Kaltenborn & Odegardstuen, 2001, p. 86). They found that 71% of the participants had an animal at home, 72% were involved in fishing, 72% fed birds and 66% read about animals. Animal-related activity participation decreased as the children and adolescents got older. Participants without pets disliked farm and wild animals more than those that owned pets. Positive correlations were found between participation in animal-related activities and the liking of animal species. Children and adolescents "who reported allergic reactions to animals, or had been injured by an animal, liked animals as much as, or more than, did the other respondents” (Bjerke, Kaltenborn & Odegardstuen, 2001, p.86). Uastly, "gender differences were largest for horseback riding (girls most) and for fishing and hunting (boys most)” (Bjerke, Kaltenborn & Odegardstuen, 2001, p.86). All three studies used data collected from”562 children and adolescents, aged between 9 and 15 years, from one urban and two rural areas in Southern Norway” (Bjerke, Odegardstuen & Kaltenborn, 1998, p. 79).

Prokop, Prokop and Tunnicliffe (2008), in a study addressing the effects of keeping pet's on children's concepts of invertebrates and vertebrates, found a "significant proportion of children showed misunderstandings of internal organs of invertebrates and ascribed an internal skeleton to them in their drawings. This drawing of bones inside invertebrates was mostly among younger children (up to age of 10)” (Prokop, Prokop & Tunnicliffe, 2008, p. 444). Of the 2,438 animals reported as pets, by the 1,252 participating children, only ten were invertebrates. Prokop, Prokop and Tunnicliffe (2008) suggest that "biology/science teachers should encourage children to keep a diverse range of animals, particularly invertebrates that can be obtained and reared easily” (Prokop, Prokop & Tunnicliffe, 2008, p. 446) and "that science activities with animals should be more focused on rearing invertebrates and improving children's attitudes and knowledge about them" (Prokop, Prokop & Tunnicliffe, 2008, p. 431).

Prokop and Kubiatko (2008) investigated Slovakian children's attitudes toward a wolf (i.e., predator) and a rabbit (i.e., prey). The children in the study ranged from 10-15 years of age. They found that children 10-11 years of age "showed significantly more positive attitude toward a rabbit (prey) relative to wolf (predator)" (Prokop & Kubiatko, 2008, p. 1) but as children's age increased positive attitudes toward the wolf and rabbit generally decreased. Prokop and Kubiatko hypothesized "that these patterns could reflect either greater children's ‘ecological thinking' or, more simply, decreasing interest toward animals in older children" (Prokop & Kubiatko, 2008, p. I).

Prokop and Tunnicliffe (2008) identified bat and spider attitudes in Slovakia children 10-16 years of age. More negative attitudes toward spiders compared to bats were present in children. This was especially true in regard to the female participants. Knowledge and alternative conceptions of bats and spiders "were distributed randomly irrespective of children's age or gender" (Prokop & Tunnicliffe, 2008, p. 87). Prokop and Tunnicliffe also discovered a "moderate correlation between attitude toward and knowledge of bats, but no similar tendency was found in spiders" (Prokop & Tunnicliffe, 2008, p. 93).

Prokop, Fancovicovä and Kubiatko (2009) investigated first year Slovakian universities students' knowledge of bats, attitudes toward bats and belief in myths about bats. Positive attitudes toward bats and less belief in bat myths were found among students who possessed more biological knowledge of bats. Male participants possessed greater knowledge of bats than females. "Females had slightly more negative attitudes toward bats and greater belief in myths about them than did males. A substantial number of students reported a serious fear of bats" (Prokop, Fancovicova and Kubiatko, 2009, p. 19). Among biology majors and non-biology majors bat myths were very common and equally distributed among both groups.

Prokop, Özel and Usak (2009) investigated first-year Turkey and Slovakia college student's attitudes toward snakes. The Snake Attitude Questionnaire (SAQ) was used. All students possessed negative attitudes toward snakes. "Turkish students showed more positive Scientistic and Naturalistic attitudes than Slovakian students, and females showed more negative attitudes toward snakes than males" (Prokop, Özel & U§ak, 2009, p. 224). Beliefs about untrue myths and knowledge of snakes were similar between biology majors and nonbiology majors. Biology majors had more positive attitudes than nonbiology majors. Less fear of snakes was associated with participants that kept various pets at home. The authors stated their research "indicates that fear of snakes negatively influences other attitudinal dimensions (especially naturalistic and scientific attitudes) although no students had been injured by a snake" (Prokop, Özel & U§ak, 2009, p. 224).

Prokop and Tunnicliffe (2010) conducted research on Slovakian primary school children's attitudes and knowledge of three unpopular animals (i.e., potato beetle, wolf and mouse) and three popular animals (i.e., rabbit, ladybird beetle and squirrel). The participants possessed better knowledge of unpopular animals compared to popular animals even though they had less favorable attitudes towards unpopular animals. Participants that had pets in their house had better knowledge and more positive attitudes of both popular and unpopular animals. "Girls were less favorably inclined than boys to animals that may pose a threat, danger, or disease to them" (Prokop & Tunnicliffe, 2010, p. 21).

Prokop, Tolarovicovä, Camerik and Peterkovä (2010) compared attitudes towards spiders and the level of knowledge of spiders of high school students from Slovakia and South Africa. "Biology teaching in South Africa is based on ecosystems, but the Slovakian system is based on systematic zoology and botany" (Prokop, Tolarovicovä, Camerik, & Peterkovä, 2010, p. 1670).

A statistically significant but low correlation between knowledge and attitude was found among the Slovakian students. Based on Kellerf s (1996) categories of attitude (scientistic, negativistic, naturalistic, and ecologistic), "the South African students scored higher in the categories of scientistic, naturalistic, and ecologistic attitudes. Comparison of attitude towards spiders of indigenous Africans from coeducational Catholic schools revealed that South African students have greater fear of spiders than Slovakian students’’ (Prokop, Tolarovicovä, Camerik and Peterkovä, 2010, p. 1665).

Prokop, Usak and Fancovicova (2010) investigated "cross-cultural and interpersonal differences in behavioural immune system measured by disgust, fear and perceived danger in participants from high (Turkey) and low (Slovakia) pathogen prevalence areas” (Prokop, U§ak & Fancovicova, 2010, p. 52). The participants for the study were primary or secondary preservice teachers. Prokop, U§ak and Fancovicova found that the behavioural immune system in Turkish preservice teachers was activated more than those of Slovakian preservice teachers when they viewed photographs showing disease-relevant cues, but not when exposed to disease-irrelevant cues. However, preservice teachers from Slovakia, "where human to human disease transmission is expected to be more prevalent than in Turkey, showed lower aversion in Germ Aversion subscale supporting hypersensitiveness of the behavioural immune system” (Prokop, U§ak & Fancovicova, 2010, p. 52). Female preservice teachers displayed greater disgust, danger and fear associated with disease-relevant animals than males. Prokop, U§ak and Fancovicova propose that their results "further support the finding that cultural and inter-personal differences in human personality are influenced by parasite threat” (Prokop, U§ak & Fancovicova, 2010, p. 52).

Animal Attitude and Likelihood of Curriculum Incorporation in Preservice Elementary Teachers

Peer-reviewed research on the attitudes of preservice or inservice teachers towards specific animals and the likelihood of incorporating specific animals into their science curriculum is very limited. Wagler (2010) conducted a study to assess the association between USA kindergarten through fourth grade (K-4) preservice teacher's attitudes toward specific animals and the likelihood that the preservice elementary teachers would incorporate these specific animals in their future science curriculum. A strong statistically significant association was found between the preservice elementary teacher's attitudes towards a specific animal and their likelihood to include or exclude that animal from their future science curriculum. Specifically, if a preservice elementary teacher had a positive attitude toward an animal they were much more likely to believe they would use that animal in their future science curriculum. Conversely, if a preservice elementary teacher had a negative attitude toward an animal they were much more likely to believe they would not use that animal in their future science curriculum.

Wagler (2010) also found that the preservice elementary teachers believed they would include animals into their future science curriculum that they believed possessed positive anthropomorphic attributes (i.e., happy, smart, fun, free, etc.) and/or positive physical appearances (i.e., beautiful, adorable, cute, etc.). The preservice elementary teachers did not believe they would include animals into their future science curriculum that they believed possessed negative anthropomorphic attributes (i.e., sneaky, mean, etc.), and/or negative physical appearances or behaviors (i.e., ugly, slimy, hairy, creepy, etc.) and/or if they believed the animals could cause physical harm (i.e., poison, pinch, bite, dangerous, etc.). These animal beliefs, which formed the basis for the inclusion or exclusion of these animals, were found to be inconsistent with the scientific communities understand of the nature of these animals (Wagler, 2010).

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 which the preservice elementary teachers believe possess positive anthropomorphic attributes and/or positive physical appearances. Small percentages of other nonmammalian animals (i.e., monarch butterfly) would also be included into the learning environment if the teacher believed these animals possess these same positive attributes and positive physical appearances. This was found to be most evident with the inclusion of the monarch butterfly and the non inclusion of the monarch caterpillar. Lastly, it was found that the learning environment would be void of any invertebrates (sponges, corals, worms, mollusks, insects^, crustaceans, and arachnids), amphibians and reptiles because of the preservice elementary teacher's tendency to believe these animals possessed negative anthropomorphic attributes, and/or negative physical appearances/behaviors and/or the ability to cause harm. Wagler's study (2010) provided the first empirical evidence that a pre service elementary teacher's attitude toward an animal affected their belief about using that animal in their future science curriculum.

Methodology

Research Questions

Research Question 1: Does frequent direct contact with Madagascar hissing cockroaches (Gromphadorhina portentosa) in an educational setting affect K-4 preservice elementary teacher attitude toward Madagascar hissing cockroaches and belief concerning likelihood of incorporating Madagascar hissing cockroaches into future science curriculum?

Research Question 2: Does frequent direct contact with Madagascar hissing cockroaches (Gromphadorhina portentosa) in an educational setting affect K-4 pre service elementary teacher attitude toward other arthropods and belief concerning likelihood of incorporating other arthropods (i.e., dragonfly, lady beetle, grasshopper, monarch butterfly, spider, scorpion, crayfish, millipede and centipede) into future science curriculum?

Study Participants

Treatment Group

The participants for the treatment group (i.e., enrolled in the elementary science methods course) consisted of 202 K-4 pre service elementary teachers enrolled in the last year of their bachelors degree program at a midsized urban southwestern USA border region university with a predominantly Hispanic/Latino population. All of the participants were non-science majors training to teach K-4 grade students (i.e., approximately 5 to 10 years of age) and had not taken a university course in invertebrate biology. The treatment group predominantly consisted of Hispanic/Latino females. Of the 202 participants in the treatment group, 194 were female (96.04%) and 8 were male. The participants mean age was 26.29 years. Of the 202 participants, 186 were Hispanic/Latino (92.08%), 13 were White, 2 were Black and 1 Asian/Pacific Islander. All of the participants were participating in their senior level university public school teaching internship and were simultaneously enrolled in two university education courses that consisted of an elementary science methods and elementary social studies methods course. The participants of the study did not choose what sections of their senior level university education courses they were enrolled in. They were placed in these sections by the university.

Control Group

The participants for the control group (i.e., not enrolled in the elementary science methods course) consisted of 101 K-4 preservice elementary teachers enrolled in the last year of their bachelors degree program at a midsized urban southwestern USA border region university with a predominantly Hispanic/Latino population. All of the participants were non-science majors training to teach K-4 grade students (i.e., approximately 5 to 10 years of age) and had not taken a university course in invertebrate biology. The control group predominantly consisted of Hispanic/Latina females. The treatment and control groups are homogenous with respect to gender and ethnicity. Of the 101 participants 97 were female (96.04%) and 4 (3.96%) were male. The participants mean age was 27.78 years. Of the 101 participants, 94 were Hispanic/Latino (93.07%), 6 were White and 1 was Black. All of the participants were participating in their senior level university public school teaching internship and were simultaneously enrolled in an elementary mathematics methods course. The participants of the study did not choose what sections of their senior level university education course they were enrolled in. They were placed in these sections by the university. This is taken into consideration in the statistical analysis.

Randomization of Study

For the purposes of data collection all senior level university education course sections were randomized through the use of a true random number generator (TRNG) website that generates true random numbers based on the earth's random atmospheric noise. Based on the outcome of these random numbers, a random selection of sections (i.e. treatment and control groups) was chosen from which to gather data.

Selection of Animal Pictures

Ten arthropods (see Table 1) were chosen for the study so that at least one representative of each of the five major arthropod classes (i.e., Insecta, e.g., monarch butterfly; i.e., Arachnida, e.g., spider; i.e., Malacostraca, e.g., crayfish; i.e., Diplopoda, e.g., millipede and i.e., Chilopoda, e.g., centipede) was chosen. The lady beetle, dragonfly and monarch butterfly, all insects, were chosen to further test Wagler's (2010) findings that pre service elementary teachers had low attitude (i.e., Wagler, 2010, p. 363) and low incorporation (i.e., Wagler, 2010, p. 366) scores for all invertebrates presented except for the monarch butterfly, which scored the second highest on attitude and highest on incorporation out of all thirty animals pictures presented.

Table 1. Study Arthropods

[a]Domain: *Eukarya*, Kingdom: *Animalia*, Phylum: *Arthropoda*						
Class Insecta		Class Arachnida		Class Malacostraca	Class Diplopoda	Class Chilopoda
Order	Animal	Order	Animal	Animal	Animal	Animal
Dictyoptera	*Madagascar Hissing Cockroach*	Araneae	*Spider*	*Crayfish*	*Millipede*	*Centipede*
Odonata	*Dragonfly*	Scorpiones	*Scorpion*			
Coleoptera	*Lady Beetle*					
Orthoptera	*Grasshopper*					
Lepidoptera	*Monarch Butterfly*					

The Madagascar hissing cockroach (Gromphadorhina portentosa) was chosen as the arthropod of frequent direct contact in an educational setting because it had the lowest attitude (i.e., Wagler, 2010, p. 363) and incorporation (i.e., Wagler, 2010, p. 366) score of all thirty animal pictures presented. In addition, the Madagascar hissing cockroach was chosen because of its unique and versatile characteristics. Madagascar hissing cockroaches are slow moving, do not bite or fly, are easy to handle, do not transmit disease, reduce misconceptions about insects, produce little odor and can be used in many different scientific inquiry activities (NRC, 1996). They are extremely inexpensive to care for and have a fascinating social structure that is ideal for observational studies (Wagler, 2011b). One of the more noteworthy aspects about Madagascar hissing cockroaches is that it appears they can actually be "tamed'’ and can discriminate between different humans (Davis & Heslop, 2004). These characteristics make Madagascar hissing cockroaches' idea arthropods for preservice teachers to incorporate into their future classrooms.

Study Procedure

Treatment group

The pretest was administered in university classrooms on the first day of the elementary science methods course (i.e., treatment) before any course information had been presented. The participants of the treatment group (i.e. enrolled in the elementary science methods course) were shown ten pictures of arthropods (see Table 1) using a Microsoft PowerPoint presentation. All of the arthropod pictures presented were in color, were the same size, were in non-aggressive positions and were of single adults in natural environments. The ten arthropod pictures were randomized through the use of a TRNG. Based on the true random numbers generated, the ten arthropod pictures were placed on the PowerPoint slides and shown to the participants. For each picture the participants were first asked to rate their attitude (Likert scale: Extremely Negative [1], Negative [2], Neutral [3], Positive [4], Extremely Positive [5]) toward the arthropod 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]) the arthropod shown into their future science classroom curriculum. This same procedure was repeated on the last day of the elementary science methods course after all information had been presented (i.e., posttest).

Control group

The study procedure for the control group was identical to the treatment group except the pretest was administered on the first day of the elementary mathematics methods course (i.e., control) before any course information had been presented and the posttest was administered on the last day of the elementary mathematics methods course after all information had been presented (i.e., posttest).

Elementary Science Methods Course: Preservice Elementary Teacher and Madagascar Hissing Cockroach Contact

The elementary science methods course was one semester long (i.e., 16 weeks). The contact between the preservice elementary teachers and the Madagascar hissing cockroaches began during the first week of the semester, occurred each week, and ended during the last week of the semester. A brief overview of the contact between the preservice elementary teachers and the Madagascar hissing cockroaches during the elementary science methods course follows. The contact below occurred in sequential order.

Before any contact occurred between the preservice elementary teachers and Madagascar hissing cockroaches the pre service elementary teachers read the article "The Little Things that Run the World'' (Wilson, 1987) to understand the importance of invertebrates and the need for their conservation. They then discussed the article with their instructor. After this discussion the preservice elementary teacher and Madagascar hissing cockroach contact began with a brief fifteen minute PowerPoint presentation about cockroaches in general. This led to a class discussion on common misconceptions about cockroaches (e.g., all cockroaches will cohabitate with humans and all cockroaches can cause diseases in humans).

The preservice elementary teachers then read the USA National Science Teachers Association position statement on "Responsible Use of Live Animals in the Science Classroom'' (NSTA, 2009) to prepare them for working with the Madagascar hissing cockroaches. This document was then discussed in the context of the preservice elementary teacher's future classroom. The Madagascar hissing cockroaches were then brought out in a clear plastic box with a secure lid. The instructor demonstrated how to properly pick up and hold a Madagascar hissing cockroach. Preservice elementary teachers who felt comfortable holding the Madagascar hissing cockroaches did so and then brought one clear plastic box containing five Madagascar hissing cockroaches back to their table. Other preservice elementary teachers, at the tables, held the Madagascar hissing cockroaches if they felt comfortable. No preservice elementary teacher was required to touch a Madagascar hissing cockroach if they did not want to. The preservice elementary teachers then conducted a scientific inquiry (NRC, 1996; NRC, 2000) general insect anatomy activity and a food preference activity with the Madagascar hissing cockroaches (Wagler, 2011b). Both activities included observational data collection.

The students then read the article "Cockroaches in the Classroom: Incorporating the Madagascar Hissing Cockroach into your science curriculum” (Wagler, & Moseley, 2005) which provided a general overview of Madagascar hissing cockroach biology and information on how to set up, caring for, and maintain a healthy Madagascar hissing cockroach colony. This was followed by the class setting up and maintaining a Madagascar hissing cockroach colony throughout the semester.

Throughout the semester classroom discussions and activities occurred that addressed how Madagascar hissing cockroaches can be effectively incorporated into a K-4 class; how to properly align Madagascar hissing cockroach activities to USA national (NAAEE, 2004; NRC, 1996) and state science education standards and research associated with children's beliefs, attitudes and preferences toward animals (Bjerke, Odegardstuen & Kaltenborn, 1998a; Prokop,

Prokop, & Tunnicliffe, 2008; Prokop & Tunnicliffe, 2008; Yen, Yao & Mintzes, 2007).

Throughout the semester K-4 Madagascar hissing cockroach observational scientific inquiry (NRC, 1996; NRC, 2000) activities were performed (Wagler, 2011b). These activities included but were not limited to inducing grooming behavior in Madagascar hissing cockroaches; temperatures effect on Madagascar hissing cockroach movement; adult male Madagascar hissing cockroach behavior associated with establishing and defending territories; and nocturnal behavior in Madagascar hissing cockroaches. Throughout the semester two experimental studies were conducted. These included a shortened version of the main activity presented in "Chow down! Using Madagascar hissing cockroaches to explore basic nutrition concepts” (Wagler, 2009) and a Madagascar hissing cockroach negative/positive stimulus activity with a randomized design and a control group. After the preservice elementary teachers had participated in all of the scientific inquiry (NRC, 1996; NRC, 2000) Madagascar hissing cockroach activities, they were required to develop their own age appropriate scientific inquiry (NRC, 1996; NRC, 2000) K-4 Madagascar hissing cockroach activity.

The semester culminated in the pre service elementary teachers building their own "trash terrariums'’ based on the article "Home sweet home: How to build a Madagascar hissing cockroach habitat out of recycled materials” (Wagler, 2010a). They then used this habitat to house Madagascar hissing cockroaches. Each preservice elementary teacher took five Madagascar hissing cockroaches home for 14 days. During this time the preservice elementary teachers cared for the Madagascar hissing cockroaches, periodically conducted observational activities and recorded the data from these observations (Wagler, 2011b).

Limitations of the Study

Because the pictures of the ten arthropods were projected on a screen, the arthropods appeared bigger than they actually are. The pictures were also two dimensional compared to the actual animals that are three dimensional.

Results

The data is analyzed as a linear mixed model for animal attitude and likelihood of incorporation. Two models are estimated: (1) a mixed effects model for animal attitude with time as a fixed effect and group within animal and animal modeled as a random effects and (2) a mixed effects model for likelihood of incorporation with time as a fixed effect and group within animal and animal as a random effects. Animal is considered a random effect in the models since ten arthropod species are selected out of potentially millions of species. Group is considered random in the model since students were allowed to freely enroll in either a science methods course or a mathematics methods course that semester. Allowing these two factors to be random rather than fixed more appropriately accounts for any extraneous variability contributed by these factors and thus allows better estimation of the random error in the model. As the effects for group and animal are random, we estimate just the variability associated with these factors and do not have slopes associated with these factors. Only the fixed effect (i.e., time) has an estimated slope available for interpretation.

A linear mixed effect model assumes the random effects are normally distributed (Pinheiro & Bates, 2000). This can be achieved asymptotically with the large sample size observed in this study. For both models, we first estimate a random intercept model where the random factors are group within animal and animal. This model allows for differences in mean response with regard to group and animal. However, this model does not take into account any variability in the change of response across time attributable to group or animal. Thus, a random slope is added to the model to allow for a difference in the response across time with regard to the group and animal. If the random slope is helpful in accurately modeling the data, the practical interpretation is that there is a difference in how the student responds that varies with regard to the animal in question and inclusion in the treatment or control group. We use the Aikaki Information Criterion (AIC) and the Bayesian Information Crtierion (BIC) along with the likelihood ratio test (LRT) to compare the random intercept and random intercept and slope models (Pinheiro & Bates, 2000). All statistical analysis was performed in R (R Development Core Team, 2008) using the package nlme (Pinheiro et al., 2009).

With regard to research question 1, the response variable is attitude and the explanatory variables are time (pretest and posttest), group (treatment or control) and animal (the ten arthropods) where group and animal are considered random effects and time is a fixed effect in the model. The random intercept model has model information criterion AIC=16341.11 and BIC=16381.36

and the random intercept and slopes model yields AIC=16055.85 and BIC=16143.06. Additionally, the LRT test comparing these models yields LRT=299.2600, p- value < 0001. Since both information criterions are smaller for the random intercept and slope model and the LRT is significant with a very small p-value, we prefer the fit of the mixed model with a random intercept and slope. The residuals resulting from the random intercept and slope model are very close to normal. This allows use of the linear mixed model since generalized linear mixed models with this random effect structure are very computationally intensive models and software capable of accurately estimating this model is not widely available. Now we analyze the resulting model for animal attitude.

Figure 2 shows the interval estimates for the intercepts and slopes for each animal for students in the treatment and control groups. The intercepts and slope vary according to animal and group since random effects allow for a difference in response that depends on both random factors. The slope corresponds to time where a value of 1 denotes post test and a value of 0 denotes pretest. Thus, a positive slope indicates there was an increase in attitude from the pretest to the posttest. The intercept may be interpreted as the mean attitude for each animal-group combination. Note that the Madagascar hissing cockroach has the lowest mean attitude score for any animal for both the treatment and control group. With regard to the slopes, in the control group there is no detectable change in attitude across time. This is evident since almost every confidence interval for the slope parameter contains 0. Only the confidence interval for the crayfish does not cross 0 (both the lower and upper limit are negative). However, the distance away from 0 is very small (the upper limit is -0.088) and is not considered practically significant. Now consider the estimated slope parameters for the animals and students in the treatment group. The slope for the Madagascar hissing cockroach stands out among all other estimated slopes since it is a positive interval much larger in magnitude than any other interval. This demonstrates a very statistically significant change in mean attitude for students in the treatment (i.e., elementary science methods course with frequent direct contact with Madagascar hissing cockroaches) with regard to the Madagascar hissing cockroach (95% CI for the slope: (1.57, 1.92). All other intervals for the slope in the treatment group either contain 0 or are very close to 0 and lack practical significance. However, note that the animals where we do see evidence of a slight increase in attitude are arthropods with relatively low mean attitude ratings at the pretest time point (these include the scorpion, spider and centipede).

With regard to research question 2, the response variable is likelihood of incorporation and the explanatory variables are time (pretest and posttest), group (treatment or control) and animal (the ten arthropods) where group and animal are considered random effects and time is a fixed effect in the model. For the random intercept model, the AIC is 14334.53 and the BIC is 14394.90 and the random intercept and slopes model yields an AIC equal to 14002.91 and BIC of 14090.12. Additionally, the LRT test comparing these models yields LRT=339.6157, p-value < 0001. Since both information criterions are smaller for the random intercept and slope model and the LRT is significant with a very small p-value, we prefer the fit of the mixed model with a random intercept and slope for modeling likelihood of incorporation. This is a similar model to the one employed for animal attitude and, as before, the residuals are approximately normally distributed. Now we analyze the resulting model for likelihood of incorporation.

Figure 3 presents the interval estimates for the random intercepts and slopes for the likelihood of incorporation for each arthropod in the study and with respect to group. First, note that the mean likelihood of incorporation is lowest for the Madagascar hissing cockroach for both the treatment and control groups. Then, with regard to the interval estimates for the slopes in the treatment group, the only slope that significantly differs from 0 is the slope for the Madagascar hissing cockroach. The scorpion has a nominally significant positive interval estimate that has little practical significance. Figure 3 also presents the mixed model analysis for likelihood of incorporation for the control group. Similar to the results for the attitude ratings, there is no slope that is different from 0, indicating no change in likelihood of incorporation over time for the control group.

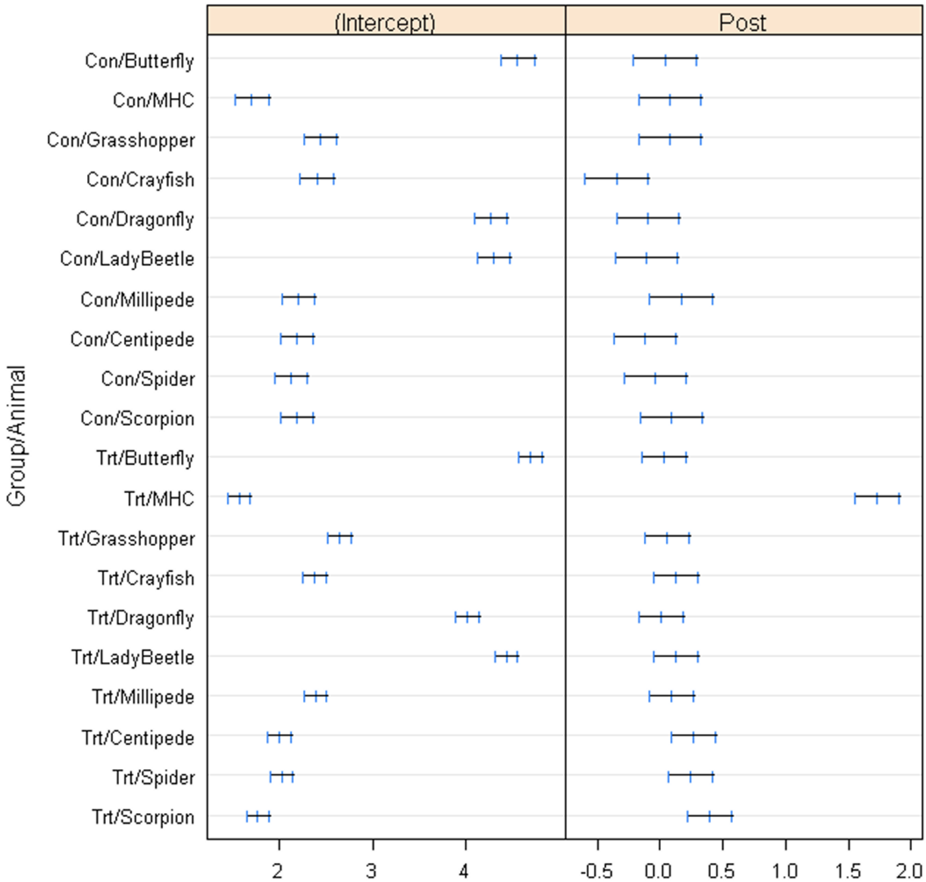

Figure 2. Mixed Model Results for Attitude (Con=Control Group and Trt=Treatment Group)

Discussion

Findings

This study, to our knowledge, provides the first empirical evidence on how contact with an animal in an educational setting affects the attitudes and beliefs of preservice elementary teachers. Specifically, this study investigated the effect frequent direct contact with Madagascar hissing cockroaches in an educational setting had on preservice elementary teacher's arthropod attitude and belief concerning likelihood of arthropod incorporation in future science curriculum.

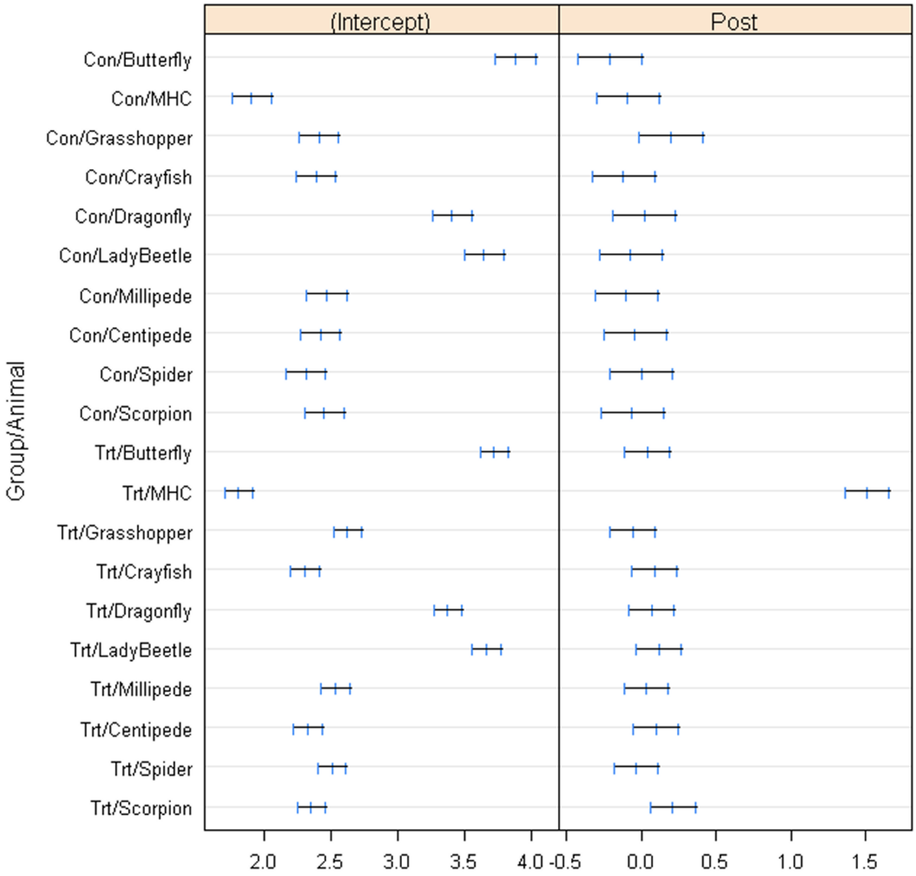

Figure 3. Mixed Model Results for Likelihood of Incorporation
(Con=Control Group and Trt=Treatment Group)

The preservice elementary teachers that had frequent direct contact with Madagascar hissing cockroaches (i.e., treatment group) in an educational setting over the study time experienced a positive increase in their Madagascar hissing cockroach attitude from extremely negative to positive (See Research Question 1). The same group also experienced a positive increase in their belief concerning likelihood of incorporating Madagascar hissing cockroaches into future science curriculum from extremely unlikely to likely. In a general sense, the treatment (i.e., frequent direct contact with Madagascar hissing cockroaches in an educational setting) affected a positive increase in the preservice elementary teachers Madagascar hissing cockroach attitude from extremely negative to positive which, in turn, affected their belief about using the

Madagascar hissing cockroach in their future science curriculum from extremely unlikely to likely (See Figure 1). No practical change was observed with the control group for either Madagascar hissing cockroach attitude or future Madagascar hissing cockroach curriculum incorporation,

The preservice elementary teacher that had frequent direct contact with Madagascar hissing cockroaches in an educational setting (i.e., treatment group) did not experience a change in their attitude toward the other nine arthropods (See Research Question 2) over the study time. Even though the ten arthropod pictures the preservice elementary teachers viewed share common observable anatomical characteristics (e.g., segmented bodies, chitinous exoskeletons and jointed appendages) the preservice elementary teacher's beliefs concerning the likelihood of incorporating the other nine arthropods (i.e., dragonfly, lady beetle, grasshopper, monarch butterfly, spider, scorpion, crayfish, millipede and centipede) into their future science curriculum also did not change in a practical sense. This finding provides evidence that frequent direct contact with another arthropod (i.e., Madagascar hissing cockroach) in an educational setting has no effect on changing attitudes and beliefs within preservice elementary teachers about other arthropods. This finding also provides evidence that in order to change preservice elementary teacher attitudes and incorporate rates beliefs toward a specific animal, frequent direct contact in an educational setting with that specific animal is needed.

As Wagler's (2010) study demonstrated, preservice elementary teacher's attitudes and beliefs toward different types of arthropods vary depending on the specific arthropod. The general trend observed (Wagler, 2010) was that the preservice elementary teachers had extremely negative to negative attitudes (i.e., Wagler, 2010, p. 363) and unlikely incorporation rates (i.e., Wagler, 2010, p. 366) for Madagascar hissing cockroaches, spiders and crayfish and an extremely positive attitude and extremely likely incorporation rate for the monarch butterfly. This study provides further evidence, validation and new arthropods associated with these findings.

Similar to Wagler's (2010) study, this study shows a comparable trend with an expanded group of arthropods that included a lady beetle, a dragonfly, a centipede, a millipede and a scorpion. The general trend observed was that the preservice elementary teachers again displayed two different types of attitudes and incorporation rates depending on what arthropod picture they were shown. Specifically, the preservice elementary teachers had positive to

extremely positive attitudes toward the monarch butterfly, lady beetle and dragonfly and negative attitudes toward the Madagascar hissing cockroach (i.e., pretest only), spider, crayfish, centipede, grasshopper, millipede and scorpion. The preservice elementary teachers also had likely to extremely likely belief of future curriculum incorporation rates for the monarch butterfly, lady beetle, dragonfly and unlikely incorporation rates for Madagascar hissing cockroach (i.e., pretest only), spider, crayfish, centipede, grasshopper, millipede and scorpion. These findings point out the need for future research attempting to identify specific factors (e.g. evolutionary, psychological, social and cultural) that underpin these arthropod specific attitudes and beliefs. For example, it can be speculated that one factor that may have an influence on the preservice elementary teacher's
attitudes toward the butterfly, lady beetle and dragonfly is the positive anthropomorphic way these three arthropods are presented in USA advertisements, media, and products.

Implications

Previous research has shown that the attitudes (e.g., Pedersen & McCurdy, 1992; Syh-Jong, 2007; Weinburgh, 2007; Westerback, 1982) and beliefs (e.g., King & Wiseman, 2001; Moseley & Utley, 2006; Palmer, 2006; Utley, Moseley & Bryant, 2005) of preservice elementary teachers, during their preservice training program, are malleable. This study provides further evidence of the malleability of pre service elementary teacher's attitudes and beliefs during their pre service training program. Wagler (2010) suggests that through direct contact in an educational setting with an animal, the potential existed to change preservice elementary teacher's negative attitudes and beliefs toward that animal. This study shows that preservice elementary teachers enter elementary science methods courses with negative attitudes toward many arthropods and these negative attitudes affect their beliefs about what arthropods they will not (i.e., Madagascar hissing cockroach [i.e., pretest only], spider, crayfish, centipede, grasshopper, millipede and scorpion) teach their future students about. This study also demonstrates that preservice elementary teachers that receive frequent direct contact with an arthropod in an educational setting during their preservice training programs have their attitudes and beliefs changed in a positive way toward that arthropod but not toward other arthropods.

Changing the preservice elementary teacher's attitude toward specific arthropods (i.e.., Madagascar hissing cockroach) broadened their belief about what animal content they would include in their future science class. This "broadening of the animal content" increases the probability that these future teachers can challenge their own student's invertebrate misconceptions and negative attitudes (e.g., Bjerke, Odegardstuen & Kaltenborn, 1998a ; Prokop, Prokop & Tunnicliffe, 2008; Prokop & Tunnicliffe, 2008; Prokop & Tunnicliffe, 2010; Prokop, Tolarovicovä, Camerik & Peterkovä, 2010; Yen, Yao & Mintzes, 2007) because they have acknowledged their own negative attitudes in themselves (e.g., Bjerke & Thrane, 2003; Bjerke, Odegardstuen, & Kaltenborn, 1998a; Bjerke, & Ostdahl, 2004; Kellert, 1993; Prokop, Usak & Fancovicovä, 2010; Wagler, 2010) and have changed them because of a positive ongoing experience with that animal.

The vast majority of USA K-4 pre service elementary teachers are female non-science majors as were the participants in this study. This adds merit to the generalizability of these findings. The findings of this study show the need to incorporate biodiverse groups of arthropods into preservice elementary teacher training programs to counter the attitudes that exist in preservice elementary teacher when they enter elementary science methods courses.

The preservice elementary teachers need to have ongoing contact, in a positive educational environment, with a knowledgeable qualified science methods instructor who models (Bandura, 1986; Bandura, 1997) a positive attitude toward the negatively perceived invertebrates incorporated into the course. The pre service elementary teachers should first learn how to care for the invertebrates through group participation with the instructor and then on their own. This care should be coupled with frequent scientific information about how to ethically caring for invertebrates, the ecological niches the invertebrates occupy and how the invertebrate's ecological role provides essential ecological services that, indirectly and directly, benefit the preservice elementary teachers and all of humanity. The preservice elementary teachers should also learn about the invertebrates specific characteristics that allow the invertebrate to live in a specific ecological niche. This information is best conveyed to the preservice elementary teachers through participation in and development of scientific inquiry (NRC, 1996; NRC, 2000) activities
that focus on these invertebrates. This information, when learned by the preservice elementary teachers, has the potential to assist the

preservice elementary teachers in attaching value to that specific invertebrate.

For most USA children their first experience with science, in a formal educational setting, occurs via their early childhood or elementary teacher. Today's elementary students are the future leaders of tomorrow. Current preservice elementary teachers are the "next generation'’ of inservice teachers, and as such, play an important future role in bringing quality environmental education to these elementary students. Frequent direct contact with arthropods in an educational setting can change preservice elementary teacher's attitudes and beliefs and the potential exists to infuse a "new generation” of teachers into elementary schools that present a more accurate and biodiverse picture of food chains, food webs and the current ongoing mass extinction of invertebrates.

Conclusion

The foundation for an ongoing quality science education experience begins in the elementary classroom with curriculum that exposes students to biodiverse groups of animals (e.g., AAAS, 1993; NRC, 1996; NAAEE, 2004). Preservice elementary teachers do not plan to teach their future students about the vast majority of animal groups (i.e., invertebrates) that are present in Earth's ecosystems (Wagler, 2010). Exposure to these animals changes that outcome and has the potential to provide elementary students with the foundational and essential knowledge needed to be future participants in one of humanities greatest challenges, reducing the current global mass extinction rate (Alroy, 2008; Crutzen & Stoermer, 2000; Crutzen, 2002; Crutzen & Steffen, 2003; IUCN, 2010; Jackson, 2008; Le Quere et al., 2009; Lewis, 2006; McDaniel & Borton, 2002; MEA, 2005; MEA, 2005a; Pimm, Russell, Gittleman, & Brooks, 1995; Pimm & Raven, 2000; Rockström et al., 2009; Rohr et al., 2008; Steffen, Crutzen & McNeill, 2007; Thomas et al., 2004; Tripati, Roberts & Eagle, 2009; Wagler, 2011: Wagler, 2011a; Wake & Vredenburg, 2008; Wilson, 1987; WWF, 2008; Zalasiewicz et al., 2008: Zalasiewicz, Williams, Steffen, & Crutzen, 2010).

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