EURASIA Journal of Mathematics, Science and Technology Education
ISSN: 1305-8223 (online) 1305-8215 (print)
OPEN ACCESS 2018 14(3):721-729 DOI: 10.12973/ejmste/80817

Effects of Hands-on Activities on Conservation, Disgust and Knowledge of Woodlice

Jana Fančovičová [1*], Pavol Prokop [1]

[1] Department of Biology, Faculty of Education, Trnava University, Priemyselná, Trnava, SLOVAKIA

Received 1 August 2017 ▪ Revised 27 September 2017 ▪ Accepted 12 November 2017

ABSTRACT

Although hands-on activities significantly improve achievement and attitudes toward animals, the use of the aesthetically unpleasant is questionable. We investigated whether the use of woodlouse, as an example of an unpopular animal, alters children's conservation attitudes, disgust for and knowledge of woodlice. The experimental group (n = 116), but not the control group (n = 110), achieved a better woodlouse conservation score with hands-on activities, but the intentions for woodlouse conservation were not generalized for conserving other animals. Disgust for woodlice was not influenced by the treatment, but females, albeit more disgust sensitive than men, showed higher conservation scores than men. Woodlouse knowledge scores significantly increased in both groups. In summary, this study demonstrates both the benefits and limits of using animals which are aesthetically unpopular, but essential parts of biodiversity and food chains.

Keywords: achievement, emotion, pupils, woodlice

INTRODUCTION

One of consequence of the current environmental crisis is deforestation and biodiversity loss around the globe (Betts et al., 2017; Wang and Loreau, 2016). A critical task of biology and science educators is to develop students' positive attitudes toward living organisms (Iozzi, 1989; Tomažič et al., 2017) which may be crucial in their pro-environmental decisions later in life (Kellert, 1997). The use of typical flagship species (Clucas et al., 2008; Senzaki et al., 2017), however, does not guarantee any changes in attitudes toward less popular, but equally important animals in ecosystems (Douglas and Winkel, 2014; Thomas-Walters and Raihani, 2017). Thus, a focus on perception of unpopular animals is required.

Invertebrates traditionally meet with a negative perception by people, irrespective of age or gender (Borgi and Cirulli, 2015; Kellert, 1993; Schlegel and Rupf, 2010; Wagler, 2010; Wagler and Wagler, 2011). Indeed, invertebrates receive lower conservation support (Black et al., 2001; Cardoso et al., 2011) and less attention by scientists in respected wildlife journals (Grodsky et al., 2015) than vertebrates. The assumed reasons for disliking invertebrates lie in their high phylogenetic distance, small size and morphological/behavioural dissimilarity with humans (Kellert, 1993). The ultimate reasons may stem in disease avoidance. Many invertebrates can be found, for example, in neglected places, and, thus, could be associated with dirt (Davey, 1994). Indeed, attitudes toward invertebrates are predominantly influenced by the emotion of disgust (Davey, 1994; Lorenz et al., 2014; Prokop and Jančovičová, 2013; but see Breuer, 2015) which evolved in order to protect ourselves against a potential pathogen threat (Curtis et al., 2004; Oaten et al., 2009; Tybur et al., 2013).

Research on the views of students revealed that invertebrates are heavily underestimated parts of ecosystems, although they are an essential part of biodiversity and food chains (Snaddon and Turner, 2007; Yli-Panula and Matikainen, 2014). Guidance on how to implement invertebrates into science education has been published (Matthews, Flage, and Matthews, 1997) and research on hands-on activities has emerged. It has been shown, for example, that hands-on activities improve both attitudes to and knowledge of invertebrates (Klingenberg, 2014; Prokop and Fančovičová, 2017; Randler, Hummel, and Wüst-Ackermann, 2013). Surveys have demonstrated a positive association between knowledge of insects and attitudes toward them (Kellert, 1993; Silva and Minor, 2017). These delicate relationships, however, could easily be broken due to negative experiences with invertebrates

✉ jana.fancovicova@truni.sk **(*Correspondence)** ✉ Pavol.Prokop@savba.sk

Contribution of this paper to the literature

- Hands-on activities with aesthetically unpleasant, unpopular animals positively influenced children's willingness to protect them, particularly with females.
- Disgust sensitivity remained unchanged even after manipulation with woodlice in the experimental group.

(Schonfelder and Bogner, 2017; Silva and Minor, 2017) and elicit disgust which inhibits intrinsic motivation (Randler et al., 2013). This is particularly important when considering females who are more disgust sensitive than males (e.g., Curtis et al., 2004; Oaten et al., 2009, Prokop and Fančovičová, 2010) and dislike unpopular animals more than males (Bjerke, Østdahl, and Kleiven, 2003; Jimenez and Lindemann-Matthies, 2015; Lindemann-Matthie, 2005; Prokop et al., 2009a; Prokop et al., 2009b; Prokop and Tunnicliffe, 2010; Prokop and Fančovičová, 2010).

In the present study we investigated how hands-on activities influence knowledge of and attitudes to woodlice, one of the least popular animals (Randler, Hummel, and Prokop, 2012; Randler, Hummel, and Wüst-Ackermann, 2013). These creatures are very advantageous, however, from the view of educational needs, being common, widespread, and easily observed, and not subject to significant seasonal variation (Hawkey, 2001). Our research questions were: Do hands-on activities with woodlice enhance participants' attitudes toward animal conservation? Do hands-on activities with woodlice improve participants' knowledge of them? Are there any gender differences in attitudes to and knowledge of woodlice?

MATERIALS AND METHODS

Participants

Research was conducted at Varín primary school with 226 participants of the age of 10 – 15 (grades 5 – 9). The survey sample consisted of a total of 10 classes, 5 groups constituting an experimental group (116 students) and five classes of a control group (110 students). The control group did not work with the woodlouse *Porcelio scaber*, and the experimental group worked with the animal during the lessons of biology within the experiment.

Research Instruments

We used a questionnaire as a research tool which contained statements about knowledge of woodlice. The questionnaire was anonymously distributed in September 2016 as a pretest and in October 2016 as a posttest. The same questionnaire was completed by the control and experimental groups before the experiment and after the treatment. The total time needed to complete the tests was ~ 20 minutes.

The questionnaire consisted of similar items as in Prokop and Fančovičová (2017). The validity and reliability were sufficient. The first part was related to gender and individual signs for matching tests. The second part was made up of statements relating to measuring animal conservation (one item: "It is important to protect all animals"), measuring woodlice conservation (six items, example: "Protection of woodlice is very important", pre-test Cronbach's $\alpha = 0.75$), measuring disgust for woodlice (seven items, example: "It is disgusting to handle woodlice", pre-test Cronbach's $\alpha = 0.84$) and measuring knowledge of woodlice (11 items, example: "Woodlice breathe with their gills", pre-test Cronbach's $\alpha = 0.45$). Pathogen Disgust, which refers to disgust elicitors caused by sources of various pathogens, was adopted from Tybur et al. (2009). This domain consists of seven Likert scale items (pre-test Cronbach's $\alpha = 0.77$). All items were rated by children on the Likert scale (1 = completely disagree, 5 = absolutely agree). We calculated the individual scores of all the scales by averaging the responses to the constituent items. The negative statements were scored in reverse.

Procedure

Students gained new knowledge about woodlice through an active approach in the experimental group, or with a traditional transmissive way in the control group. In both groups, a 45 min long lesson was held in accordance with the educational standard. All groups were guided by the same trained teacher.

The lesson in the control group began with a discussion about animals living in human surroundings. An exposition of the lesson then followed. We specifically used methods of interpretation and description. The students were passive listeners, who occasionally answered questions. The presented information by the teacher contained the basic characteristics of life, the characteristics of the conditions necessary for life and also information about their usefulness and meaning in nature. Woodlouse images were used instead of living individuals. The children in the experimental group were divided into groups according to the number of students in each class. One group of children had a maximum of four members. Since they manipulated living organisms, they were instructed how to carefully handle animals, with the need to return them to nature and also with safety at work. The students received the necessary tools, worksheets, and 10 woodlice placed in Petri dishes.

The children in the experimental group used worksheets in order to record the results of their research. A problem task was formulated at the beginning which students were supposed to predict. All the tasks were discussed in advance so that each student was clear about what to verify. Students then verified the predictions of all the research tasks. Finally, each task was discussed and evaluated with all the children together. The conclusions for each activity were written down.

Brief Description of the Hands-on Activities

Students gained new knowledge about woodlice through an active approach in the experimental group, or with a traditional transmissive way in the control group. In both groups, a 45 min long lesson was held in accordance with the educational standard. All groups were guided by the same trained teacher.

Morphology of the wooodlouse

The first research task was focused on an external morphological structure of the body of an adult. The role of the students was to observe morphological features using a magnifying glass. Data were recorded by the students in the table in the worksheet. After careful observation of the external construction of the body and its morphological features, the students had to draw an adult woodlouse and describe the external structure of the body.

The natural environment

The second research task was to find out what conditions are natural to the life of woodlice. The students intentionally changed the environment: temperature, light intensity, humidity, and observed the reaction of woodlice to the changes in the environment. The results of their observations were recorded in the prepared table at the end of the worksheets.

• The influence of temperature

Children divided the Petri dish in half and labelled the border with a marker. Children then put 10 woodlice in a Petri dish with warm water in half and an ice cubes in the second half of the Petri dish. The students then observed in which part of the Petri dish the woodlice were more concentrated. The observations were repeated at 1 minute intervals every 4 minutes, and the data was recorded in the worksheets.

• Light intensity

Children placed 10 woodlice on the Petri dish, with half of the Petri dish covered with black coloured paper and the other half uncovered. Similar as in the previous experiment, children recorded the number of woodlice in each half of the Petri dish within a time interval.

• Humidity

Ten woodlice were, once again, placed in the Petri dish. One half of the Petri dish was covered with a damp filter paper and the other half with dry filter paper. Children recorded the transfer woodlice movement between the dry damp filter paper at time intervals. The total number of woodlice in each type of filter paper was recorded on the worksheets.

Summary of the experiments

There was a short text about woodlice at the end of the worksheet. Students filled in the empty spaces with the text based on their observations and manipulation with the particular woodlice. The aim of the activity was to repeat and fix the knowledge acquired during the practical activities.

Statistical Analyses

Mean pre-test and post-test scores from animal conservation, woodlice conservation, disgust from woodlice, and knowledge of woodlice were defined as dependent variables in a series of Generalized Linear Models (GLM). The influence of pre-test and post-test was treated as a within-subject factor. Categorical predictors were treatment (experimental and control group), gender and grade (5 – 9). Mean Pathogen disgust (PD) pre-test score was defined as covariate.

RESULTS

Animal Conservation

Mean pre-test (M = 3.89, SD = 1.10, n = 226) and post-test (M = 4.02, SD = 0.10, n = 226) animal conservation scores suggested that children have positive attitudes toward conservation. None of the measured variables significantly influenced the mean animal conservation scores (all $p > 0.1$) except for the Test-Retest Conservation × Treatment interaction term ($F(1, 218) = 5.15$, $p = 0.02$). This result was somewhat unexpected because mean conservation post-test scores of children from the control group were significantly lower than in the pre-test scores. In contrast, children from the experimental group displayed similar mean scores in both the pre-test and post-test.

Woodlice Conservation

There were no differences in the woodlice conservation score between the experimental and control group ($F(1,218) = 1.11$, $p = 0.29$). The Test-Retest Woodlice Conservation × Treatment interaction term ($F(1, 218) = 7.54$, $p = 0.007$) suggests, however, that the mean post-test conservation score significantly increased in the experimental, but not in the control group (**Figure 1**). Females demonstrated higher conservation scores than males ($F(1,218) = 4.53$, $p = 0.03$) and younger children manifested higher conservation scores than older children ($F(1,218) = 10.44$, $p < 0.001$). The interaction term Test-Retest Woodlice Conservation × Grade means that ninth graders achieved much higher post-test scores than children from other grades ($F(4,218) = 7.36$, $p < 0.001$). The influence of pathogen disgust (covariate) approached a statistical significance ($F(1,218) = 3.46$, $p = 0.06$) suggesting that higher conservation scores correlated reversely with pathogen disgust (pre-test and post-test, $\beta = -0.05$ and 0.13, $p = 0.39$ and < 0.05, respectively). The remaining effects were not statistically significant.

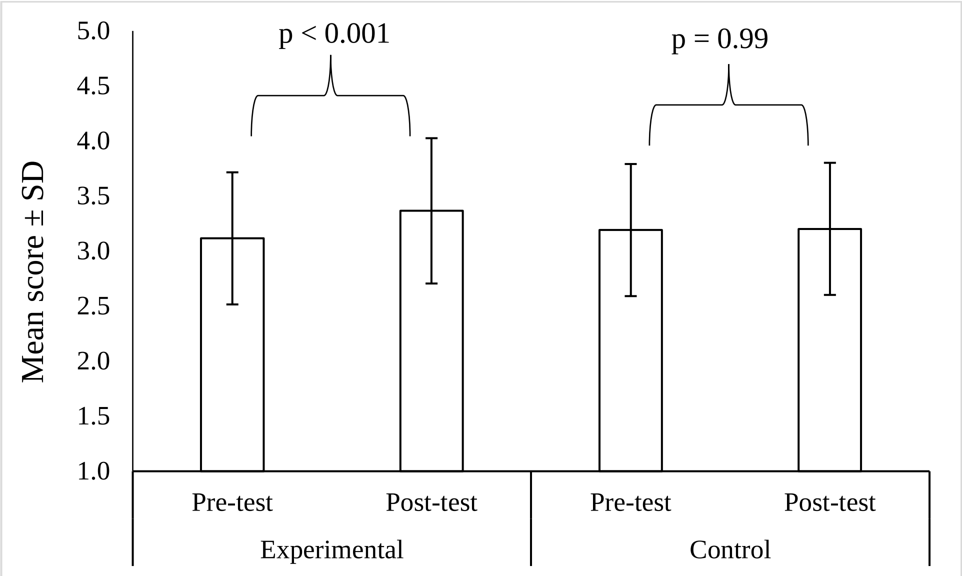

Figure 1. Differences in mean scores for woodlice conservation with respect to treatment. Differences between means were calculated with Tukey post-hoc test

Disgust for Woodlice

Females scored higher in disgust for woodlice than males (**Figure 2**). Pathogen disgust (covariate) significantly and positively correlated with disgust for woodlice ($F(1,218) = 73.6$, $p< 0.001$) both in the pretest and post-test ($\beta = 0.48$ and 0.40, both $p < 0.001$, respectively). Other effects, including interaction terms, were not statistically significant (all $p > 0.13$). Note that the exclusion of PD from the model did not influence these results.

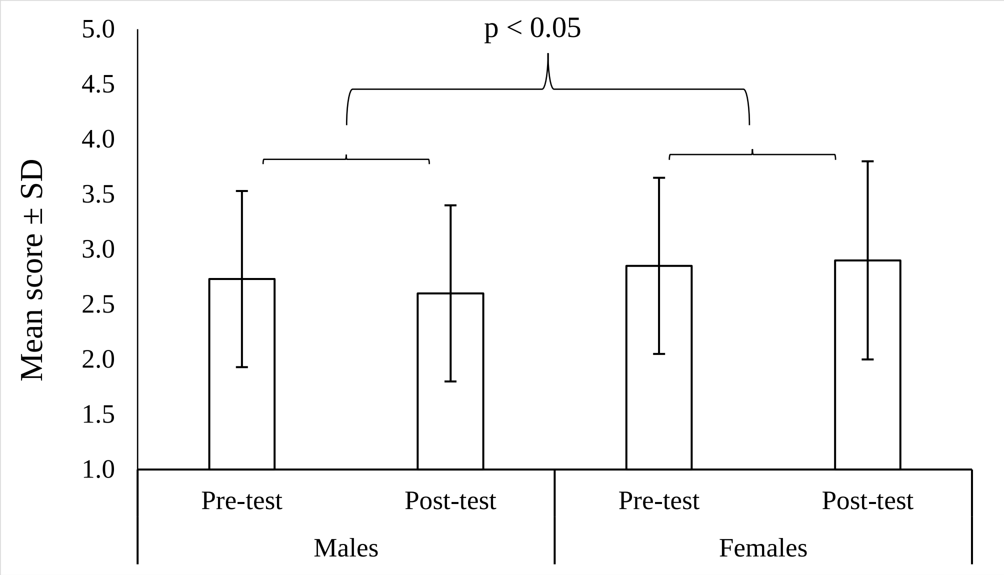

Figure 2. Gender differences in disgust from woodlice

Knowledge of Woodlice

The woodlice knowledge score was significantly influenced by the effect of grade (F(4,218) = 10.14, p < 0.001), while the effect of treatment approached a statistical significance (F(1,218) = 3.56, p = 0.07). The effect of grade is of low educational importance, because it only showed that seventh graders had higher scores than fifth, sixth and ninth graders and eighth graders displayed lower scores. Pathogen disgust (covariate) and gender were not associated with the knowledge score (F(1,218) = 0.42 and 1.75, p = 0.52 and 0.18, respectively). The post-test knowledge score significantly increased in both groups (F(1,218) = 23.8, p < 0.001, **Figure 3**), albeit somewhat higher in the experimental group (Test-Retest Knowledge × Treatment interaction term, F(1,218) = 6.41, p < 0.05). Test-Retest Knowledge × Gender interaction term (F(1,218) = 3.97, p < 0.05) suggests that the knowledge score of girls increased more than the knowledge score of boys. The remaining Test-Retest Knowledge × PD interaction term was not statistically significant (p = 0.89).

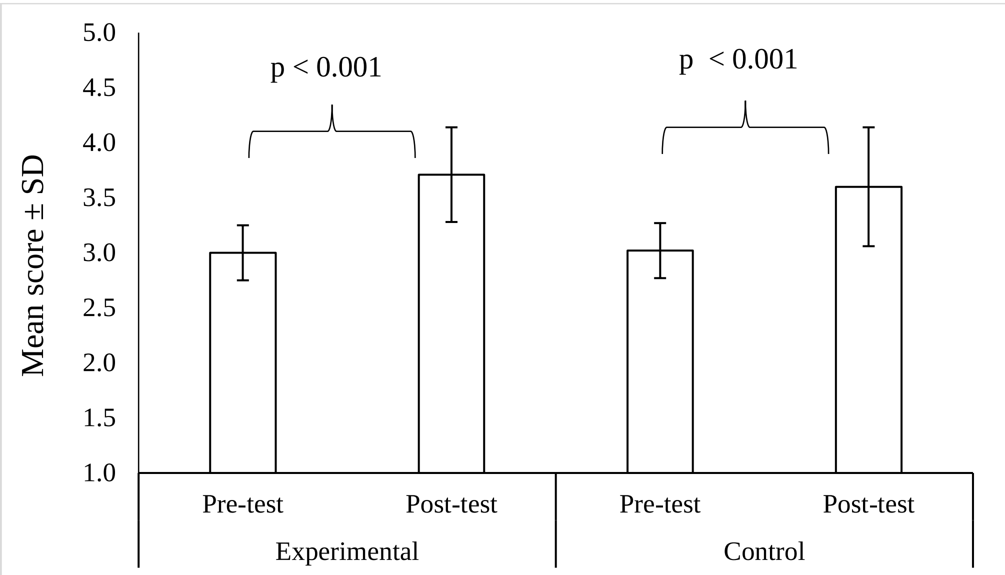

Figure 3. A comparison of knowledge scores with respect to pre-test/post-test and treatment

DISCUSSION

This study investigated the effect of hands-on activities on animal conservation, particularly woodlice, disgust and knowledge of woodlice. We found that although hands-on activities manifested positive influences on woodlice conservation and knowledge, there was not an influence on willingness to protect animals in general, nor on perceived disgust for woodlice. Females seemed to be influenced by hands-on activities more than males.

Animal / Woodlice Conservation

Animal conservation scores did not increase which suggests that hands-on activities with woodlice do not improve children's willingness to protect animals. It is possible that the influence of hands-on activities is very specific and only focused on focal animal(s), or that working with unpopular animals is not efficient in improving conservation attitudes. To support the latter, people are generally willing to protect predominantly charismatic, and aesthetically pleasant, animals (Gunnthorsdottir, 2001; Knight, 2008; Martín-López et al., 2007; Prokop and Fančovičová, 2013; Thomas-Walters and Raihani; 2017). It may be that more organisms should be involved in hands-on activities to better explain ecological relationships between the focal animal (here: the woodlouse) and its environment. Alternatively, perhaps the selection of a charismatic, flagship animal may produce different results. It should also be noted that the use of only one item scale to measure willingness to protect animals might not be sensitive enough to detect possible changes.

The mean scores for woodlice conservation, however, significantly increased in the experimental group, suggesting that although the woodlouse is an unpopular animal (Randler, Hummel, and Prokop, 2012; Randler, Hummel, and Wüst-Ackermann, 2013), attitudes toward it can be successfully improved. This result is in agreement with research showing that physical contact with animals has a positive impact on attitudes toward them (e.g., Ballouard et al., 2012; Morgan and Gramann, 1989; Randler et al., 2005; Tomažič, 2008).

Disgust Sensitivity

Conservation scores negatively correlated with pathogen disgust demonstrating that more disgust sensitive people are less willing to protect unpleasant animals. This finding extends our current knowledge about the role of disgust sensitivity in conservation attitudes (Jacobs et al., 2014; Prokop and Fančovičová, 2013; Prokop et al., 2016).

In contrast with some previous studies (e.g. Prokop et al., 2017; Randler, Hummel, and Prokop, 2012), we failed to find a decrease in disgust scores among children in the experimental group. Although this result seems to be in sharp contract with previous research, it can be explained with the relatively higher popularity of snails (Prokop et al., 2017; Randler, Hummel, and Prokop, 2012) or mice (Randler, Hummel, and Prokop, 2012) used in hands-on activities. Another possibility is that children need more time to work with woodlice to decrease disgust for them.

Gender

Females demonstrated higher disgust sensitivity to woodlice, but, paradoxically, their conservation scores increased significantly more than scores of males. A similar situation occurred in a survey on attitudes toward frogs where females were similarly more disgust sensitive, but promoted conservation more than males (Prokop et al., 2016). Interestingly, gender differences in willingness to protect animals are sometimes completely missing (Knight, 2008; Prokop and Fančovičová, 2013). It might be argued that deeper environmental concerns which were not examined in this study might be responsible for the higher willingness to protect woodlice by females. Clearly, further in-depth research in this field is required.

Knowledge

Both the experimental and control group achieved higher knowledge scores after the treatment, although previous research showed that higher achievement scores occurred predominantly in the experimental groups (e.g., Prokop et al. 2017; Randler, Ilg, and Kern, 2005). At first look, it could be suggested that hands-on activities are meaningless in this case, because certain alternatives, such as videos, can be viable alternatives to work with live animals (Sammet, Kutta, and Dreesmann, 2015). Several researchers, however, reported positive correlations between attitudes to animals and knowledge (Kellert, 1993; Prokop, Kubiatko, and Fančovičová, 2008; Silva and Minor, 2017). In our study, knowledge increased in both groups, but conservation scores increased only in the experimental group. Thus, it is possible that not knowledge *per se*, but knowledge strengthened by physical experiences improved conservation attitudes. This explanation seems to be invalid, however, because correlations between attitudes and knowledge were statistically significant in both the experimental and control group as well as for pre-test and post-test scores (results not shown). An increase in conservation attitudes seems to be independent from the influence of knowledge, at least in the present study.

Pre-test Cronbach's α for the knowledge domain was 0.45 which is below recommended minimum (Nunnaly, 1978). Lower reliabilities for knowledge domains are common in this kind of research (e.g., Prokop et al., 2007; Prokop and Fančovičová, 2008; Prokop, Fančovičová, and Kubiatko, 2009). Thus, some caution must be made when interpreting these data.

CONCLUSION

Biology lessons may benefit from inclusion of hands-on activities with living organisms, but these benefits are not limitless (Holstermann, Grube, and Bögeholz, 2010). Hands-on activities with woodlice, as an example of an unpopular, but common and easily observed animal, provide benefits in terms of improved conservation efforts, but these efforts seem to be generalized to other animals. Disgust for woodlice was not influenced by hands-on activities and the knowledge gain was similar between the experimental and control group. Further research is required to test whether the use of animals differing in popularity influences perception of other, wild animals.

ACKNOWLEDGEMENTS

David Livingstone improved the English of the manuscript. This research was supported by the university grant no. 5/TU/2017 and 9/TU/2017 and by grant APVV-14-0070.

REFERENCES

Ballouard, J. M., Provost, G., Barré, D., & Bonnet, X. (2012). Influence of a field trip on the attitude of schoolchildren toward unpopular organisms: an experience with snakes. *Journal of Herpetology*, *46*(3), 423-428.

Betts, M. G., Wolf, C., Ripple, W. J., Phalan, B., Millers, K. A., Duarte, A., Butchart, S. H. M., & Levi, T. (2017). Global forest loss disproportionately erodes biodiversity in intact landscapes. *Nature*, *547*(7664), 441-444.

Bjerke, T., Østdahl, T., & Kleiven, J. (2003). Attitudes and activities related to urban wildlife: Pet owners and non-owners. *Anthrozoös*, *16*(3), 252-262.

Black, S. H., Shepard, M., & Allen, M. M. (2001). Endangered invertebrates: the case for greater attention to invertebrate conservation. *Endangered Species Update*, *18*(2), 41-49

Borgi, M., & Cirulli, F. (2015). Attitudes toward animals among kindergarten children: species preferences. *Anthrozoös*, *28*(1), 45-59.

Breuer, G. B., Schlegel, J., Kauf, P., & Rupf, R. (2015). The Importance of Being Colorful and Able to Fly: Interpretation and implications of children's statements on selected insects and other invertebrates. *International Journal of Science Education*, *37*(16), 2664-2687.

Cardoso, P., Erwin, T. L., Borges, P. A., & New, T. R. (2011). The seven impediments in invertebrate conservation and how to overcome them. *Biological Conservation*, *144*(11), 2647-2655.

Clucas, B., McHugh, K., & Caro, T. (2008). Flagship species on covers of US conservation and nature magazines. *Biodiversity and Conservation*, *17*(6), 1517-1528.

Curtis, V., Aunger, R., & Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease. *Proceedings of the Royal Society of London B: Biological Sciences*, *271*(Suppl 4), S131-S133.

Davey, G. C. (1994). The" disgusting" spider: The role of disease and illness in the perpetuation of fear of spiders. *Society & Animals*, *2*(1), 17-25.

Douglas, L. R., & Winkel, G. (2014). The flipside of the flagship. *Biodiversity and Conservation*, *23*(4), 979-997.

Grodsky, S. M., Iglay, R. B., Sorenson, C. E., & Moorman, C. E. (2015). Should invertebrates receive greater inclusion in wildlife research journals?. *The Journal of Wildlife Management*, *79*(4), 529-536.

Gunnthorsdottir, A. (2001). Physical attractiveness of an animal species as a decision factor for its preservation. *Anthrozoös*, *14*(4), 204-215.

Hawkey, R. (2001). Case Study: Walking with woodlice: an experiment in biodiversity education. *Journal of Biological Education*, *36*(1), 11-15.

Holstermann, N., Grube, D., & Bögeholz, S. (2010). Hands-on activities and their influence on students' interest. *Research in Science Education*, *40*(5), 743-757.

Iozzi, L. A. (1989). What research says to the educator: Part one: Environmental education and the affective domain. *The Journal of Environmental Education*, *20*(3), 3-9.

Jacobs, M. H., Vaske, J. J., Dubois, S., & Fehres, P. (2014). More than fear: role of emotions in acceptability of lethal control of wolves. *European Journal of Wildlife Research*, *60*(4), 589-598.

Jimenez, J. N., & Lindemann-Matthies, P. (2015). Public knowledge of, and attitudes to, frogs in Colombia. *Anthrozoös*, *28*(2), 319-332.

Kellert, S. R. (1993). Values and perceptions of invertebrates. *Conservation Biology*, *7*(4), 845-855.

Kellert, S. R. (1997). *The value of life: Biological diversity and human society*. Washington, D.C., U.S.: Island Press.

Klingenberg, K. (2014). 'Primärerfahrung'with living animals in contrast to educational videos: a comparative intervention study. *Journal of Biological Education*, *48*(2), 105-112.

Knight, A. J. (2008). "Bats, snakes and spiders, Oh my!" How aesthetic and negativistic attitudes, and other concepts predict support for species protection. *Journal of Environmental Psychology*, *28*(1), 94-103.

Lindemann-Matthies, P. (2005). 'Loveable'mammals and 'lifeless' plants: how children's interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education*, *27*(6), 655-677.

Lorenz, A. R., Libarkin, J. C., & Ording, G. J. (2014). Disgust in response to some arthropods aligns with disgust provoked by pathogens. *Global Ecology and Conservation*, *2*, 248-254.

Martín-López, B., Montes, C., & Benayas, J. (2007). The non-economic motives behind the willingness to pay for biodiversity conservation. *Biological Conservation*, *139*(1), 67-82.

Matthews, R. W., Flage, L. R., & Matthews, J. R. (1997). Insects as teaching tools in primary and secondary education. *Annual Review of Entomology*, *42*(1), 269-289.

Morgan, J. M., & Gramann, J. H. (1989). Predicting effectiveness of wildlife education programs: A study of students' attitudes and knowledge toward snakes. *Wildlife Society Bulletin (1973-2006)*, *17*(4), 501-509.

Nunnaly, J. (1978). *Psychometric Theory*. New York: McGraw-Hill.

Oaten, M., Stevenson, R. J., & Case, T. I. (2009). Disgust as a disease-avoidance mechanism. *Psychological Bulletin*, *135*(2), 303-321.

Prokop, P., & Fančovičová, J. (2010). The association between disgust, danger and fear of macroparasites and human behaviour. *Acta Ethologica*, *13*(1), 57-62.

Prokop, P., & Fančovičová, J. (2013). Does colour matter? The influence of animal warning coloration on human emotions and willingness to protect them. *Animal conservation*, *16*(4), 458-466.

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

Prokop, P., & Jančovičová, M. (2013). Disgust sensitivity and gender differences: an initial test of the parental investment hypothesis. *Problems of Psychology in the 21st Century*, *7*(7), 40-48.

Prokop, P., & Tunnicliffe, S. D. (2010). Effects of having pets at home on children's attitudes toward popular and unpopular animals. *Anthrozoös*, *23*(1), 21-35.

Prokop, P., Fančovičová, J., & Kubiatko, M. (2009a). Vampires are still alive: Slovakian students' attitudes toward bats. *Anthrozoös*, *22*(1), 19-30.

Prokop, P., Kubiatko, M., & Fančovičová, J. (2008). Slovakian pupils' knowledge of, and attitudes toward, birds. *Anthrozoös*, *21*(3), 221-235.

Prokop, P., Lešková, A., Kubiatko, M., & Diran, C. (2007). Slovakian students' knowledge of and attitudes toward biotechnology. *International Journal of Science Education, 29*(7), 895-907.

Prokop, P., Medina-Jerez, W., Coleman, J., Fančovičová, J., Özel, M., & Fedor, P. (2016). Tolerance of frogs among high school students: Influences of disgust and culture. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(6), 1499-1505.

Prokop, P., Özel, M., & Uşak, M. (2009b). Cross-cultural comparison of student attitudes toward snakes. *Society & Animals*, *17*(3), 224-240.

Randler, C., Hummel, E., & Prokop, P. (2012). Practical work at school reduces disgust and fear of unpopular animals. *Society & Animals*, *20*(1), 61-74.

Randler, C., Hummel, E., & Wüst-Ackermann, P. (2013). The influence of perceived disgust on students' motivation and achievement. *International Journal of Science Education*, *35*(17), 2839-2856.

Randler, C., Ilg, A., & Kern, J. (2005). Cognitive and emotional evaluation of an amphibian conservation program for elementary school students. *The Journal of Environmental Education*, *37*(1), 43-52.

Sammet, R., Kutta, A. M., & Dreesmann, D. (2015). Hands-on or video-based learning with anticipation? A comparative approach to identifying student motivation and learning enjoyment during a lesson about ants. *Journal of Biological Education*, *49*(4), 420-440.

Senzaki, M., Yamaura, Y., Shoji, Y., Kubo, T., & Nakamura, F. (2017). Citizens promote the conservation of flagship species more than ecosystem services in wetland restoration. *Biological Conservation*, *214*, 1-5.

Schlegel, J., & Rupf, R. (2010). Attitudes towards potential animal flagship species in nature conservation: a survey among students of different educational institutions. *Journal for Nature Conservation*, *18*(4), 278-290.

Schlegel, J., Breuer, G., & Rupf, R. (2015). Local insects as flagship species to promote nature conservation? A survey among primary school children on their attitudes toward invertebrates. *Anthrozoös*, *28*(2), 229-245.

Silva, A., & Minor, E. S. (2017). Adolescents' Experience and Knowledge of, and Attitudes toward, Bees: Implications and Recommendations for Conservation. *Anthrozoös*, *30*(1), 19-32.

Snaddon, J. L., & Turner, E. C. (2007). A child's eye view of the insect world: perceptions of insect diversity. *Environmental Conservation*, *34*(1), 33-35.

Thomas-Walters, L., & J Raihani, N. (2016). Supporting conservation: The roles of flagship species and identifiable victims. *Conservation Letters,* doi:10.1111/conl.12319.

Tomažič, I. (2008). The influence of direct experience on students' attitudes to, and knowledge about amphibians. *Acta Biologica Slovenica*, *51*(1), 39-49.

Tomažič, I., Pihler, N., & Strgar, J. (2017). Pre-service biology teachers'reported fear and disgust of animals and their willingness to incorporate live animals into their teaching through study years. *Journal of Baltic Science Education*, *16*(3), 337-349.

Tybur, J. M., Lieberman, D., Kurzban, R., & DeScioli, P. (2013). Disgust: Evolved function and structure. *Psychological Review*, *120*(1), 65-84.

Wagler, R. (2010). The association between preservice elementary teacher animal attitude and likelihood of animal incorporation in future science curriculum. *International Journal of Environmental and Science Education*, *5*(3), 353-375.

Wagler, R., & Wagler, A. (2011). Arthropods: Attitude and incorporation in preservice elementary teachers. *International Journal of Environmental and Science Education*, *6*(3), 229-250.

Wang, S., & Loreau, M. (2016). Biodiversity and ecosystem stability across scales in metacommunities. *Ecology letters*, *19*(5), 510-518.

Yli-Panula, E., & Matikainen, E. (2014). Students and student teachers' ability to name animals in ecosystems: a perspective of animal knowledge and biodiversity. *Journal of Baltic Science Education*, *13*(4).

http://www.ejmste.com