Original Article

The Effect of Owning Animals on Perceived Vulnerability to, and Avoidance of, Parasitic Diseases in Humans

Pavol Prokop[1,2] and Jana Fančovičová[2]

[1]Institute of Zoology, Academy of Sciences, Slovakia, [2]Faculty of Education, Trnava University, Slovakia

Abstract. The evolutionary history of humans has always been influenced by pathogens because of their ability to cause both morbidity and mortality. Natural selection should favor behavioral strategies that minimize disease transmission and consequently increase human survival. Collectively such strategies are referred to as the behavioral immune system, which is thought to be more often activated in individuals with an impaired immune system who are most vulnerable to pathogens and infectious diseases. We investigated the associations between an individual's perceived vulnerability to disease, whether they own any animals, and whether they carry out behavioral tactics to avoid parasite transmission. A sample of 285 Slovakian students participated in a questionnaire study. As predicted, antipathogen behavior was activated in individuals with a high perceived vulnerability to disease. Females showed higher antiparasitic scores than males especially when behaviors were most likely to transmit disease. Individuals who owned animals perceived themselves as less vulnerable to disease as well as less vulnerable to the perceptions of those who did not own any animals. Moreover, among animal owners scores for parasite-avoiding behaviors relevant to being in close contact with an animal (such as removing animal feces and worming animals) were higher than for parasite-transmitting behaviors relevant to being in close contact with an animal (such as allowing animals to lick). We discuss the results, further taking into account both the model of natural selection and the coevolutionary arms race model.

Keywords: animals, antiparasite behavior, disease, human, parasite

Introduction

The coevolutionary arms race model is a widely accepted theory explaining the evolution of host-pathogen interactions (Dawkins & Krebs, 1979). This model predicts that, after attack and exploitation of a host by a pathogen resulting in a reduction of host fitness, selection for a novel host defense mechanism occurs and spreads throughout the population. These effectively defended hosts decrease pathogen fitness, thus selecting for a pathogen genotype that can overcome the new host defenses. These new defense mechanisms then spread throughout the pathogen population.

For a long time microorganisms invisible to the human eye were unknown to humans but acted as powerful agents influencing them throughout evolutionary history (Park & Schaller, 2009). Recent research revealed that pathogen prevalence is responsible for a number of psychological and behavioral mechanisms in humans. Fincher, Thornhill, Murray, and Schaller (2008) found a positive association between pathogen prevalence and the cultural value of collectivism, arguing that collectivism evolved as an effective antipathogen psychology. Collectivism is associated with higher ethnocentrism (attraction and support of ingroup members) and xenophobia (i.e., avoidance of and dislike toward outgroup members) than individualism (Fincher et al., 2008; Thornhill, Fincher, & Devaraj, 2009). Collectivism is thought to act as a mechanism for pathogen evasion whereby individuals avoid strangers who may host potentially infectious diseases to which the intruded individual or community (ingroup) has no immunity. In regions that have historically suffered from high levels of infectious diseases, people report lower mean levels of extraversion and openness (Schaller & Murray, 2008). Collectivism and xenophobia are evolutionary mechanisms that cause increased religious diversity in geographic areas with high pathogen stress (Fincher & Thornhill, 2008).

Schaller (2006) and Schaller and Duncan (2007) distinguish between two mechanisms that effectively protect humans against parasites: *immune systems*, which work after pathogens attack the human body; and *behavioral immune*

DOI: 10.1027/1614-0001/a000045

systems, which are defined as a set of mechanisms that allow individuals to detect the potential presence of parasites in objects (or individuals) and act to prevent contact with those objects (or individuals). Several works showed that some emotions, especially the emotion of disgust, evolved to help humans avoid pathogen transmission (Curtis & Biran, 2001; Curtis, Aunger, & Rabie, 2004; Oaten, Stevenson, & Case, 2009; Stevenson, Case, & Oaten, 2009; Tybur, Lieberman, & Griskevicius, 2009). Disgust is defined by psychologists as an emotion that can be related to avoidance of certain animals, ill humans, feces, vomit, sexual substances and other harmful substances or events (Rozin, Haidt, & McCauley, 2000). Physiologists found that disgust may produce specific autonomic responses, such as reduced blood pressure, heart rate deceleration, and decreased skin conductance (Stark, Walter, Schienle, & Vaitl, 2005) along with changes in respiratory behavior (Ritz, Thons, Fahrenkrug, & Dahme, 2005). Most recently, Schaller, Miller, Gervais, Yager, and Chen (2010) found that just seeing disease-connoting cues can cause aggressive behavioral immune responses in humans.

The behavioral immune system is activated particularly among immunologically compromised individuals (Navarrete, Fessler, & Eng, 2007) presumably because there would be a higher cost of parasite invasion for them compared to healthy individuals. For example, humans who consider themselves more vulnerable to disease transmission have greater aversive responses to physically disabled individuals (Park, Faulkner, & Schaller, 2003), toward older adults (Duncan & Schaller, 2009), toward immigrants (Faulkner, Schaller, Park, & Duncan, 2004), or toward disease-transmitting animals (Prokop, Fančovičová, & Fedor, 2010; Prokop, Uşak, & Fančovičová, 2010a, 2010b).

Most previous work assessed only a limited selection of behaviors and did not distinguish between emotional and behavioral variables (see Prokop & Fančovičová, 2010; Prokop et al., 2010). In this study, we examined specific sets of behaviors that protect humans against pathogens.

Human behavior plays a pivotal role in the epidemiology of parasitic zoonoses (Macpherson, 2005). These behaviors include owning animals, movement of people, nutritional habits, personal hygiene, and contact with potentially contagious objects (Macpherson, 2005; Prokop & Fančovičová, 2010). According to the coevolutionary arms race model (Dawkins & Krebs, 1979), behaviors that eliminate disease transmission should be favored in humans by natural selection. It has been shown, for example, that infected birds and damselflies exhibit the longest dispersal distances probably because dispersal reduces the risk of infection (Møller, Martin-Vivaldi, & Soler, 2004; Suhonen, Honkavaara, & Rantala, 2010). Historically, diseases tend to have been transmitted by zoonoses (Pearce-Duvet 2006; Wolfe, Dunavan, & Diamond, 2007), although some research found that having pets provides health benefits to owners (Anderson, Reid, & Jennings, 1992; Serpell, 1991). Other work found the opposite, that having pets causes individuals to have poorer health (Budge, Spicer, Jones, & George, 1998; Paul & Serpell, 1996).

We hypothesize that humans who perceive themselves as more vulnerable to diseases have more highly activated behavioral immune systems, which would in turn be associated with stronger parasite-avoidance behaviors compared to people who perceive themselves at low risk of disease *(Hypothesis 1)*.

Because associations between humans and domestic animals have existed for a long time (there is fossil evidence for an association between *Homo erectus* and a wolf-like canine over half a million years ago; Messent & Serpell, 1981), we hypothesize that human behavioral immune systems would have adapted to allow a relationship with pets without emotional fear or disgust. Thus, we hypothesized that owning an animal would be inversely associated with an individual's perceived vulnerability to disease *(Hypothesis 2)*.

In line with the coevolutionary arms race model (Dawkins & Krebs, 1979), we hypothesize that close contact with contagious animals is associated with stronger parasite-avoidance responses compared to irregular contact with animals *(Hypothesis 3)*.

Finally, we hypothesize that parasite-avoidance behaviors is stronger in females, because of their evolutionary role in protecting the next generation (e.g., Curtis et al., 2004; Fessler & Navarrete, 2003) *(Hypothesis 4)*.

Materials and Methods

Participants

A total of 285 volunteers (119 males and 166 females) with a mean age of 14.7 (SE = 0.11) years (range = 11–19 years) attending seven schools participated in the study. All these schools are typical of state schools in Slovakia. Questionnaires were administered once by a classroom teacher. Participants were asked for personal information in the questionnaire: (1) their age, (2) sex, (3) whether they had animals (pets as well as farm animals), and if yes (4) what animal species they possessed. Most of the participants (69%) reported having at least one animal species at home (mean = 1.37, SE = 0.08, range = 1–7, N = 285). The types of animal kept were categorized into 15 animal taxonomies. Most of these animals could be considered as pets (dogs and cats were cited as 58% of all animal species) and a few as farm animals. Only 1% of animal owners reported having only farm animals, most participants reported having only pets (74%) or both pets and farm animals (25%). Removing children who had only farm animals did not influence our results, so the numbers of pets and farm animals were pooled together using validated methods (Prokop, Özel, & Uşak, 2009; Prokop, Prokop, & Tunnicliffe, 2008; Prokop & Tunnicliffe, 2010). One female participant was removed from analyses, because her questionnaires were not completed.

Research Instruments

Perceived Vulnerability to Disease

The Perceived Vulnerability to Disease Scale (PVDS) (Duncan, Schaller, & Park, 2009) was used to assess the participants' self-perceived vulnerability to disease. This scale consists of 15 items; one subscale assesses beliefs about one's own susceptibility to infectious diseases (Perceived Infectability [PI]; 7 items with Cronbach's α = .70); the second subscale assesses emotional discomfort in contexts that suggest an especially high potential for pathogen transmission (Germ Aversion [GA]; 8 items with Cronbach's α = .56). Items were rated on a 5-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Negatively worded items were scored in reverse order.

We used the Perceived Infectability subscale to assess interpersonal differences in perceived vulnerability to infectious diseases. Only this subscale contains items that explicitly measure perceived vulnerability to diseases. In contrast, the Germ Aversion subscale assesses some behaviors and emotional avoidance of some pathogen-relevant stimuli. Thus, the Germ Aversion subscale reports pathogen avoidance behaviors rather than perceived vulnerability to diseases. We found no correlation between the PI and GA subscales (Pearson $r = .08$, $p = .21$, N = 284).

Avoidance of Parasitic Diseases

Because Duncan et al.'s (2009) Germ Aversion scale is restricted to items related to disease transmission from other humans, we self-constructed a new 5-point Likert-style Parasite Avoidance Scale (PAS; 28 items with Cronbach's α = .71). The items on the PAS followed Macpherson's (2005) review on the role of human behavior and transmission of parasitic diseases. Negatively worded items were scored in reverse order. The Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy (.67) and Barlett's test of sphericity ($\chi^2 = 1164.6$, $df = 378$, $p < .001$) yielded insignificant results (minimal recommended value of KMO test is .6; see Kaiser, 1974), which allowed us to submit data to principal components analysis (PCA with Varimax rotation). PCA resulted in 10 independent components (PC1–PC10) explaining 60% of the results variance with 18 values > 1.0. Because researchers disagree about the minimum loading that warrants item retention (Sharma, 1996; Tabachnick & Fidell, 2001), we used a liberal assignment criterion of at least 0.40 following similar research works (e.g., McKibbin et al., 2009; Thompson & Mintzes, 2002). Exclusion of components that were represented by ≤ 2 items and exclusion of one component that was conceptually very heterogeneous (Tybur et al., 2009) resulted in five independent components with 15 items explaining 49% of the results variance. The full version of the final PAS, including the excluded items, is available from the corresponding author upon request.

Animal owners were asked to rate (on a 5-point Likert scale) four additional items focused on practices relevant to animal ownership that potentially could be associated with parasite transmission ("I allow my dog/cat to lick me," "I allow my dog/cat to sleep in my bed") and parasite avoidance ("I worm my dog/cat regularly," "I frequently get rid of my dog/cats feces").

We calculated individual's scores for each factor by averaging responses to the constituent items. High mean scores for PVDS meant that participants perceived themselves as highly vulnerable to infectious diseases. In contrast, high PAS meant that participants avoided transmission of parasitic diseases.

Description of PAS

Descriptive statistics for PAS components are shown in Table 1. All dimensions showed only modest reliability, which was probably caused by the low number of items in each dimension. All dimensions were focused on behavioral avoidance of parasitic diseases in different contexts. Following Macpherson (2005), parasitic diseases should be transmitted via corpses or feces, or by disease-relevant animals, thus the Feces/Corpses and Animal disgust dimensions measured avoidance of such stimuli (example questions: "It would bother me a great deal to touch the dead body of a mouse," "If I was to find a cockroach in my room I would be unable to sleep"). The Swimming/Toilet and Handwashing dimension measures aversion of or preference to swimming in public pools, using public toilets, washing hands, and washing foods (vegetables and fruits). These behaviors also underlie parasite transmission (example questions: "I enjoy swimming in swimming pools" (reverse scored), "I always wash vegetables prior to consumption"). The traveling dimension measures human desire to travel to areas that are high risk in terms of disease transmission such as countries with tropical forests (example question: "I would like to go on an expedition to a tropical forest" [reverse scored]).

Table 1. Descriptive statistics of Parasite Avoidance Scale (PAS) (N = 285 participants)

	Items (n)	Mean	SE	α	Average inter-item correlation
Feces/corpses	3	3.84	.06	.64	.37
Swimming/toilet	3	2.55	.06	.61	.35
Hand-washing	3	4.39	.04	.62	.36
Traveling	3	2.31	.05	.62	.36
Animal disgust	3	3.17	.06	.56	.30

Results

Hypothesis 1: Perceived vulnerability to diseases positively correlates with antiparasite behaviors.

The Perceived Infectability (PI) score was defined as a dependent variable, and mean scores of Germ Aversion (GA), age, sex, and mean scores of five PAS as listed in Table 1 were defined as predictors in the multiple regression model (forward stepwise method). As shown in Table 2, multiple regression resulted in marginally significant results (R^2 = .03, $F(4, 279) = 2.21$ $p < .06$). Hypothesis 1 was therefore supported. Interestingly, participants with a greater desire to travel to high-risk places perceived themselves as more vulnerable to diseases than participants with a low desire for traveling. Avoidance of disease-transmitting animals was higher in individuals with high PI scores. Participants with high PI scores tended to avoid swimming in swimming pools and/or visiting public toilets, but this association was not significant. However, participants who reported infrequent handwashing or washing vegetables tended to perceive themselves as less vulnerable to diseases. Other variables were removed from the model (Table 2).

Table 2. Linear multiple regression (forward stepwise method) on Perceived infectability (PI) score. Age, gender, feces/corpses and germ aversion (GA) predictors were excluded from the model

	β	SE of β	$t(279)$	p
Animal disgust	.11	.06	1.85	.06
Traveling	–.12	.06	–1.98	.04
Hand-washing	–.09	.06	–1.45	.15
Swimming/toilette	.07	.06	1.14	.25

Hypothesis 2: Owning an animal will be inversely associated with an individual's perceived vulnerability to disease.

To test this prediction, owning animals (total number of reported animals) was defined as a dependent variable, and PI was defined as an independent variable. Because previous analysis showed some associations between PI and engaging in antiparasite behavior, we included sex, age, and mean scores of GA and five PAS subscales as further independent variables into the multiple regression model (forward stepwise method). The model was statistically significant ($R^2 = .14$, $F(7, 276) = 6.60$ $p < .001$). As shown in Table 3, the more animal species the participants had, the lower the PI score, which means that having animals is associated with low perceived vulnerability to disease. Hypothesis 2 was therefore supported. However, having more animals at home was significantly associated with lower avoidance of disease-transmitting animals, disgust of feces/corpses, higher avoidance of public pools and/or toilets, and less frequent handwashing. A gender effect was seen but can be explained by the higher mean number of animal species at home reported by females.

Table 3. Linear multiple regression (forward stepwise method) on total number of reported animals at home. Age and germ aversion (GA) predictors were excluded from the model

	β	SE of β	$t(279)$	p
Hand-washing	–.22	.06	–2.26	.02
Feces/corpses	–.12	.06	–2.08	.04
Swimming/toilette	.17	.06	2.91	.004
Perceived infectability	–.12	.06	–2.19	.03
Animal disgust	–.19	.07	–2.66	.008
Gender	.17	.07	2.50	.012
Traveling	–.08	.06	–1.34	.18

Hypothesis 3: Close contact with contagion carrying animals will be associated with stronger antiparasite responses.

Dog and/or cat owners ($N = 171$, one nonresponder) were further examined using partial correlations (controlled for the effect of gender and age) and ANOVAs for their associations between parasite-avoidance behavior and possible parasite-transmitting behavior with relevance to owning an animal at home. It was found that worming animals (mean = 4.32 ± .11) and regular exclusion of their feces (mean = 3.38 ± .11) gave higher mean scores than allowing pets to be in the bed (mean = 2.07 ± .11), or allowing pets to lick (mean = 2.75 ± .11) ($F(3, 675) = 78.45$, $p < .001$). This means that parasite-avoidance behaviors are stronger among this group than practices that would be associated with parasite transmission supporting Hypothesis 3. Gender differences in these behaviors were not significant. Further correlations showed that allowing pets to lick positively correlated either with worming and/or exclusion of feces (partial $r = 0.17$ and 0.16, both $p < .05$). This also supports Hypothesis 3. Allowing pets to stay in the bed showed the same positive trends, but results were not statistically significant.

Hypothesis 4: Antiparasite behaviors will be stronger in females, because of their evolutionary role in protecting the next generation.

The most pronounced differences in PAS, favoring higher female scores, were found in Animal disgust, Feces/Corpses and then Swimming/Toilet responses (ANCOVA controlled for the effect of age and the total number of animals at home, $F(6, 275) = 21.36$, $p < .001$). Travelling and Handwashing and GA dimensions showed no differences with respect to gender (all ps > .14). In summary, females avoid disease-transmitting animals, corpses, feces, and using public pools more so than males. This finding supports Hypothesis 4.

Table 4. Partial correlations (controlled for effect of age, gender, and owning animals) between PAS subscales and germ aversion (GA). Numbers in **bold** denote significant relationships ($p < .05$)

	Traveling	Hand-washing	Swimming/toilette	Animal disgust	GA
Feces/corpses	.01	–.01	.09	**.20**	**.20**
Traveling		**–.12**	**.21**	.01	–.05
Hand-washing			.07	**.12**	**.26**
Swimming/toilette				**.17**	**.31**
Animal disgust					**.30**

Relationships Between PAS and GA

To test whether GA and PAS are related, we performed additional correlations. GA correlated moderately with all PAS dimensions except for traveling (Table 4). Participants who avoided swimming in public pools and participants with high disgust toward disease-transmitting animals had higher germ aversion (GA) scores did than other participants. Participants with an increased desire for traveling tended to avoid swimming pools, but reported handwashing less frequently than others.

Discussion

This study supports the theory of an activated behavioral immune system and associated parasite-avoidance behavior in humans who feel more vulnerable to diseases. Four hypotheses were explicitly tested:

1. *Perceived vulnerability to diseases positively correlates with parasite-avoidance behaviors.* There was a significant association between perceived vulnerability to disease and parasite-avoidance behaviors, although there were some behaviors that did not fit this trend. Some behavior seemed to occur in opposition to an individual's perceived vulnerability to disease. Disgust toward animals that can transmit diseases and avoidance of public swimming pools or public toilets tended to be higher in participants with a higher Perceived Infectability Score (although this trend was not always significant). Contrary to our hypotheses, participants who perceived themselves as more vulnerable to diseases reported washing their hands or food less frequently than participants who felt less vulnerable to disease. Similarly, participants with a high desire to travel to potentially risky areas felt more vulnerable to diseases than did other participants. These results could be explained as a byproduct of the correlation previously noted between pathogen disgust and neuroticism (Tybur et al., 2009), though this explanation seems unlikely since frequency of handwashing would be expected to be high in people who feel themselves more vulnerable to diseases (Porzig-Drummond, Stevenson, Case, & Oaten, 2009; Prokop & Fančovičová, 2010; Prokop et al., 2010). A high desire to travel could be explained by a higher potential dispersal of immunologically compromised individuals and would support evidence from experiments carried out with animals (Møller et al., 2004; Suhonen et al., 2010). Or, perhaps people with poor health tend to search for places that provide health benefits (e.g., sea, spa, etc.). Another possible explanation for these results could be the common assumption that antiparasite responses are weak relative to antipredator responses, which is based on the observation that parasitic infections are usually less immediately fatal than a predator attack (Anderson & May, 1982; Dobson & Hudson, 1986). Yet, this is unlikely as well, as it would predict no correlation between antiparasite behavior and perceived infectability. We propose that the evolutionary arms race model between parasites and their hosts (Dawkins & Krebs, 1979) is most likely responsible for these results. Direct contact with disease-relevant animals may be more costly than, say, handwashing, so that natural selection favors avoiding disease-transmitting animals that often pose a threat of infection with a lethal disease (e.g., plague is transmitted by rodents, cockroaches, and ectoparasites). In contrast, handwashing with soap and clear water does not have a long evolutionary history (Curtis, 2007), so that selective forces for this are not as strong as for avoidance of disease-transmitting animals.

In summary, our explanation suggests that the lack of antiparasite behaviors can be delayed by natural selection (highly perceived vulnerability to disease in people who do not wash hands or who travel to risky regions), as these forces do not reduce host fitness enough to select for antiparasite defenses.

2. *Owning an animal is inversely associated with an individual's perceived vulnerability to disease.*

3. *Close contact with contagion animals is associated with stronger antiparasite responses.* Our results fully supported the above hypotheses. The more animal species the participant reported owning, the lower the perceived vulnerability to disease. These results support previous works showing positive effects of keeping animals on participants' health (Anderson & May, 1992; Serpell, 1991; see also Budge et al., 1998). Because PVDS assesses beliefs about one's own susceptibility to infectious diseases (emotions), proximate mechanisms explaining how owning animals could influence perceived vulnerability to disease should include psychological as well as somatic factors. In agreement with Paul and Serpell (1996), having animals may positively contribute to physical activities (e.g., walking with dogs), social interaction (visiting friends), as well as to increasing self-esteem and empathy (Poresky & Hendrix, 1990) and positive attitudes (Prokop & Tunnicliffe, 2010). However, another possibility is that the social background of animal

owners differs from non animal owners. For example, a previous study on a large sample of participants (~1,500) showed that animal owners in Slovakia had better educated parents than nonowners (Prokop et al., 2008). Education level can be associated with higher income, so that participants with more animals could stem from affluent backgrounds, their improved lifestyles accounting for a lower vulnerability to disease (we do not have additional data about the parents' incomes, so we cannot support or reject this hypothesis). Another explanation for the association between owning animals and health benefits may be that people who happen to have a high perceived vulnerability to diseases tend not to own animals. As correlative works are traditionally limited with a lack of strong statements about causal relationships (e.g., Goetz & Shackelford, 2009), we cannot unambiguously reject this possibility. However, previous research showed that virtually all children want to have a pet (Kidd & Kidd, 1985), though having pets seems to depend more on the parents' decisions (Prokop et al., 2008). This suggests that there is no effect of PVDS on children's decisions to have a pet, which indirectly rejects this alternative explanation. Furthermore, recent research showed that physical contact with disgust elicitors like dead bodies or unpopular animals significantly reduces disgust sensitivity (Randler, Hummel, & Prokop, 2011; Rozin, 2008). Our results also show that having animals at home is inversely associated with animal disgust (Table 3), which suggests that having animals at home and handling them regularly reduces disgust sensitivity. Further experimental research on keeping pets at home examining the family background of pet owners and nonowners is required.

Importantly, animal ownership was associated with stronger parasite-avoidance practices such as removal of animal feces or worming of animals than parasite-transmitting behaviors. This result provides relatively clear examples of how the coevolutionary arms races works when humans are pathogen hosts. Human coexistence with animals has resulted in a number of shared parasite species (reviewed by Macpherson, 2005), but the cost of increased parasite transmission caused selection for effective antiparasite behaviors like avoiding and removal of animal feces from your environment. Contemporary humans adopted more sophisticated techniques like worming, which also effectively eliminates pathogen prevalence. Further research should be focused on antiparasite practices in traditional societies, like hunter-gatherers from Africa or South America.

4. *Antiparasite behaviors will be stronger in females, because of their evolutionary role in protecting the next generation*. In support of our hypothesis, females scored higher in three of the five antiparasite scales. Higher pathogen disgust has been consistently found in females than in males (e.g., Curtis et al., 2004; Tybur et al., 2009). Interestingly, there were no gender differences in our PI or GA scales (although the GA scale showed marginally significant tendencies favoring females), which contrasts the findings of previous research (Duncan et al., 2009). However, gender differences in PVDS were not significant in subsequent research of Duncan and Schaller (2009), indicating that male and female responses on PVDS can vary greatly. The Travelling and Handwashing dimensions also failed to show any differences with respect to gender. In line with previous explanations, we propose that there are relatively lower selective forces befalling individuals who do not wash their hands or foods regularly or who desire to travel to risky regions. It therefore seems that females show stronger antiparasite responses when the risk of being infected by disease is higher.

Conclusion

This study revealed that there is a significant association between an individual's perceived vulnerability to disease and their level of parasite-avoidance behavior. As far as we know, previous studies investigated associations between vulnerability to disease and individuals levels of "disgust" toward items, but this is the first study to examine the broader relationships between perceived disease vulnerability and a wide range of behaviors responsible for disease transmission. Our results suggest that parasite-avoidance behaviors are not unidirectional and can be easily predicted in contexts where benefits from the behaviors greatly exceed the costs of implementing the behavior. Having animals is associated with an increased reporting of lower perceived vulnerability to disease. Females show more pronounced parasite-avoidance responses than males especially in contexts threatened by high cost/benefit differences. Further research should measure human's parasite-avoiding behaviors in various pathogen prevalence conditions and examine the proximate causes of health benefits from having pets. Finally, the Parasite Avoidance Scale should be extended to investigate a broader range of parasite-avoidance tactics.

Acknowledgment

We thank John Young for improving the English of the manuscript as well as two anonymous referees and Samuel D. Gosling, who provided helpful comments on an earlier draft of this paper. This work was partly supported by project VEGA no. 1/0124/11.

References

Anderson, R. M., & May, R. M. (1982). *The population biology of infectious disease.* Berlin: Springer-Verlag.

Anderson, W. P., Reid, C. M., & Jennings, G. L. (1992). Pet ownership and risk factors for cardiovascular disease. *Medical Journal of Australia, 157,* 298–301.

Budge, R. C., Spicer, J., Jones, B., & George, R. S. (1998). Health correlates of compatibility and attachment in human-companion animal relationships. *Society and Animals, 6,* 219–234.

Curtis, V. (2007). A natural history of hygiene. *Canadian Journal of Infectious Diseases, Medicine and Microbiology, 18,* 11–14.

Curtis, V., Aunger, R., & Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease. *Biology Letters, 272,* 131–133.

Curtis, V., & Biran, A. (2001). Dirt, disgust, and disease: Is hygiene in our genes? *Perspectives in Biology and Medicine, 44,* 17–31.

Dawkins, R., & Krebs, J. R. (1979). Arms races between and within species. *Proceedings of the Royal Society of London, Ser. B, 205,* 489–511.

Dobson, A. P., & Hudson, P. J. (1986). Parasites, disease and the structure of ecological communities. *Trends in Ecology and Evolution 1,* 11–15.

Duncan, L. A., & Schaller, M. (2009). Prejudicial attitudes toward older adults may be exaggerated when people feel vulnerable to infectious disease: Evidence and implications. *Analyses of Social Issues and Public Policy, 9,* 97–115.

Duncan, L. A., Schaller, M., & Park, J. H. (2009). Perceived vulnerability to disease: Development and validation of a 15-item self-report instrument. *Personality and Individual Differences, 47,* 541–546.

Faulkner, J., Schaller, M., Park, J. H., & Duncan, L. A. (2004). Evolved disease-avoidance processes and contemporary xenophobic attitudes. *Group Processes and Intergroup Relations, 7,* 333–353.

Fessler, D., & Navarrete, C. (2003). Domain specific variation in disgust sensitivity across the menstrual cycle: Evidence in favor of an evolutionary account of sexual disgust. *Evolution and Human Behavior, 24,* 406–417.

Fincher, C. L., & Thornhill, R. (2008). Assortative sociality, limited dispersal, infectious disease and the genesis of the global pattern of religion diversity. *Proceedings of the Royal Society of London, Ser. B, 275,* 2587–2594.

Fincher, C. L., Thornhill, R., Murray, D. R., & Schaller, M. (2008). Pathogen prevalence predicts human cross-cultural variability in individualism/collectivism. *Proceedings of the Royal Society of London, Ser. B, 275,* 1279–1285.

Goetz, A. T., & Shackelford, T. K. (2009). Sexual coercion in intimate relationships: A comparative analysis of the effect of women's infidelity and men's dominance and control. *Archives of Sexual Behavior, 38,* 226–234.

Kaiser, H. (1974). An index of factorial simplicity. *Psychometrica, 39,* 31–36.

Kidd, A. H., & Kidd, R. M. (1985). Children's attitudes toward their pets. *Psychological Reports 57,* 15–31.

Macpherson, C. N. L. (2005). Human behavior and the epidemiology of parasitic zoonoses. *International Journal for Parasitology, 35,* 1319–1331.

McKibbin, W. F., Shackelford T. K., Goetz, A. T., Bates, V. M., Starratt, V. G., & Miner, E. J. (2009). Development and initial psychometric assessment of the rape avoidance inventory. *Personality and Individual Differences, 46,* 336–340.

Messent, P. R., & Serpell, J. A. (1981). An historical and biological view of the pet-owner bond. In B. Fogle (Ed.), *Interrelations between people and pets* (pp. 5–22). Springfield, IL: CC Thomas.

Møller, A. P., Martin-Vivaldi, M., & Soler, J. J. (2004). Parasitism, host immune defense and dispersal. *Journal of Evolutionary Biology, 17,* 603–612.

Navarrete, C. D., Fessler, D. M. T., & Eng, S. J. (2007). Elevated ethnocentrism in the first trimester of pregnancy. *Evolution and Human Behavior, 28,* 60–65.

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

Park, J. H., Faulkner, J., & Schaller, M. (2003). Evolved disease-avoidance processes and contemporary antisocial behavior: Prejudicial attitudes and avoidance of people with physical disabilities. *Journal of Nonverbal Behavior, 27,* 65–87.

Park, J. H., & Schaller, M. (2009). Parasites, minds, and cultures. *The Psychologist, 22,* 942–945.

Paul, E. S., & Serpell, J. A. (1996). Obtaining a new pet dog: Effects on middle childhood children and their families. *Applied Animal Behavior Science, 47,* 17–29.

Pearce-Duvet, J. M. C. (2006). The origin of human pathogens: Evaluating the role of agriculture and domestic animals in the evolution of human disease. *Biological Reviews, 81,* 369–382.

Poresky, R. H., & Hendrix, C. (1990). Differential effects of pet presence and pet bonding in young children. *Psychological Reports, 67,* 51–54.

Porzig-Drummond, R., Stevenson, R., Case,T., & Oaten, M. (2009). Can the emotion of disgust be harnessed to promote hand hygiene? Experimental and field-based tests. *Social Science and Medicine, 68,* 1006–1012.

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

Prokop, P., Fančovičová, J., & Fedor, P. (2010). Health is associated with antiparasite behavior and fear of disease-relevant animals in humans. *Ecological Psychology, 22,* 222–237.

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

Prokop, P., Prokop, M., & Tunnicliffe, S. D. (2008). Effects of keeping animals as pets on children's concepts of vertebrates and invertebrates. *International Journal of Science Education, 30,* 431–449.

Prokop, P., & Tunnicliffe, S. D. (2010). Effects of keeping pets on children's attitudes toward popular and unpopular animals. *Anthrozoös, 23,* 21–34.

Prokop, P., Uşak, M., & Fančovičová, J. (2010a). Health and the avoidance of macroparasites: A preliminary cross-cultural study. *Journal of Ethology, 28,* 345–351.

Prokop, P., Uşak, M., & Fančovičová, J. (2010b). Risk of parasite transmission influences perceived vulnerability to disease and perceived danger of disease-relevant animals. *Behavioral Processes, 85,* 52–57.

Randler, C., Hummel, E., & Prokop, P. (2011). Practical work at school reduces disgust and fear of unpopular animals. *Society and Animals* (in press).

Ritz, T., Thons, M., Fahrenkrug, S., & Dahme, B. (2005). Airways, respiration, and respiratory sinus arrhythmia during picture viewing. *Psychophysiology, 42,* 568–578.

Rozin, P. (2008). Hedonic "adaptation": Specific habituation to disgust/death elicitors as a result of dissecting a cadaver. *Judgment and Decision Making, 3,* 191–194.

Rozin, P., Haidt, J., & McCauley, C. (2000). Disgust. In M. Lewis & J.M. Haviland (Eds.), *Handbook of emotions* (2nd ed., pp. 637–653). New York: Guilford.

Schaller, M. (2006). Parasites, behavioral defenses, and the social psychological mechanisms through which cultures are evoked. *Psychological Inquiry, 17,* 96–101.

Schaller, M., & Duncan, L.A. (2007). The behavioral immune system: Its evolution and social psychological implications. In J.P. Forgas, M.G. Haselton, & W. von Hippel (Eds.), *Evolution and the social mind* (pp. 293–307). New York: Psychology Press.

Schaller, M., Miller, G.E., Gervais, W.M., Yager, S., & Chen, E. (2010). Mere visual perception of others' disease symptoms facilitates a more aggressive immune response. *Psychological Science, 21,* 649–652.

Schaller, M., & Murray, D.R. (2008). Pathogens, personality and culture: Disease prevalence predicts worldwide variability in sociosexuality, extraversion, and openness to experience. *Journal of Personality and Social Psychology, 95,* 212–221.

Serpell, J.A. (1991). Beneficial effects of pet ownership on some aspects of human health and behavior. *Journal of the Royal Society of Medicine, 84,* 717–720.

Sharma, S. (1996). *Applied multivariate techniques*. Hoboken, NJ: Wiley.

Stark, R., Walter, B., Schienle, A., & Vaitl, D. (2005). Psychophysiological correlates of disgust and disgust sensitivity. *Journal of Psychophysiology, 19,* 50–60.

Stevenson, R.J., Case, T.I., & Oaten, M.J. (2009). Frequency and recency of infection and their relationship with disgust and contamination sensitivity. *Evolution & Human Behavior, 30,* 363–368.

Suhonen, J., Honkavaara, J., & Rantala, M.J. (2010). Activation of the immune system promotes insect dispersal in the wild. *Oecologia, 162,* 541–547.

Tabachnick, B.G., & Fidell, L.S. (2001). *Using multivariate statistics* (4th ed.). Boston, MD: Allyn & Bacon.

Thompson, T.L., & Mintzes, J.J. (2002). Cognitive structure and the affective domain: On knowing and feeling in biology. *International Journal of Science Education, 24,* 645–660.

Thornhill, R., Fincher, C.L., & Devaraj, A. (2009). Parasites, democratization, and the liberalization of values across contemporary countries. *Biological Reviews, 84,* 113–131.

Tybur, J.M., Lieberman, D., & Griskevicius, V. (2009). Microbes, mating, and morality: Individual differences in three functional domains of disgust. *Journal of Personality and Social Psychology, 97,* 103–122.

Wolfe, N.D., Dunavan, C.P., & Diamond, J. (2007). Origins of major human infectious diseases. *Nature, 447,* 279–283.

Accepted for publication: November 11, 2010

Pavol Prokop

Department of Biology
Trnava University
Priemyselna 4
91843 Trnava
Slovakia
Tel. +421 33 5514-618
Fax +421 33 5514-618
E-mail pavol.prokop@savba.sk

