Animal Conservation

Animal Conservation. Print ISSN 1367-9430

# Does colour matter? The influence of animal warning coloration on human emotions and willingness to protect them

P. Prokop[1,2] & J. Fančovičová[1]

1 Department of Biology, Faculty of Education, Trnava University, Trnava, Slovakia
2 Department of Animal Ecology, Institute of Zoology, Bratislava, Slovakia

**Keywords**
animals; aposematism; colour; conservation; emotions.

**Correspondence**
Pavol Prokop, Department of Biology, Faculty of Education, Trnava University, Priemyselná 4, PO Box 9, 91843 Trnava, Slovakia. Tel/Fax: +421 33 55 14618
Email: pavol.prokop@savba.sk

Editor: Iain Gordon
Associate Editor: Vincenzo Penteriani

Received 21 May 2012; accepted 22 November 2012

doi:10.1111/acv.12014

## Abstract

The perceived popularity of animals plays a crucial role in their support by the general public and consequently in the success of conservation efforts. We experimentally investigated with Slovak schoolchildren the role of animal coloration and basic human emotions in the willingness to protect animals. Both unaltered and experimentally manipulated pictures of aposematic animals increased perceived danger. Spiders and snakes were perceived as more dangerous/disgusting than other taxa, particularly birds and mammals. Children showed significantly a stronger willingness to protect aposematic animals over inconspicuous, cryptic animals. Perceived disgust and danger of animals negatively correlated with a willingness to protect them with females showing greater fear of animals than males. Our results suggest that the use of aposematic animals in conservation programs may increase their popularity and public support.

## Introduction

The degradation of natural resources by pollution, habitat devastation and climate change leads to global and progressive biodiversity loss (Hamber, Henderson & Speight, 2011), which is not currently mitigated despite increased efforts by responsible world leaders (Butchart *et al*., 2010). The most common entity used by conservation groups is species (Kaltenborn *et al*., 2006; Clucas, McHugh & Caro, 2008; Kissui, 2008; Ballouard, Brischoux & Bonnet, 2011). However, attitudes and priorities regarding managing wildlife by the general public which are required for successful animal conservation (Dickman, 2010) may be different from those of professional managers (Kellert, 2000; Mech, 2001; Ericsson *et al*., 2004; Gratwicke *et al*., 2008). Negative views of some animals, which are fabled with misleading myths and superstitions (Prokop, Fančovičová & Kubiatko, 2009*a*; Prokop, Özel & Usak, 2009*b*; Ceríaco *et al*., 2011), have resulted in direct persecution, which in combination with habitat destruction has led to the near extinction of several animal species (Breitenmoser, 1998; Kaczensky, 1999; Brito, Rebelo & Crespo, 2001; Fita, Neto & Schiavetti, 2010; Ceríaco, 2012). Surveys thus play an increasingly prominent role in wildlife management (Decker, Brown & Siemer, 2001; Kaltenborn *et al*., 2006; Drury, Homewood & Randall, 2011).

Negative perceptions of certain animals are the results of evolutionary, cultural and/or individual pressures (Vygotsky, 1978). Phylogenetically similar species are preferred, for example, over phylogenetically distant species (Herzog & Burghardt, 1988) and visual exposure to harmful animals such as snakes or parasites which pose a threat to humans is accompanied by elevated fear and/or disgust (Öhman & Mineka, 2003), particularly in females (Prokop *et al*. 2009*a,b*; Prokop, Fančovičová & Fedor, 2010*a*; Prokop, Usak & Fančovičová, 2010*b*; Prokop, Usak & Fančovičová, 2010*c*). Religiosity or traditional practices (Goodman & Hobbs, 1994; Frembgen, 1996; Ceríaco *et al*., 2011) and social factors, such as property relationships or economic value (Serpell, 2004), are typical examples of cultural factors that influence the perception of animals. Individual differences involve emotional and cognitive processes that are related, but work differently (Zajonc, 1980). Emotional response comes first but cognitive processes come later, when the defence response is under way (Zajonc, 1980; Öhman, Flykt & Lundqvist, 2000). Fear, for example, is an important determinant of attitudes towards large carnivore predators (Bjerke, Kaltenborn & Thrane, 2001; Prokop & Fančovičová, 2010). As a result, preferences for animals also vary between species (Czech, Krausman & Borkhataria, 1998; Czech & Krausman, 2001; Bjerke, Østdahl & Kleiven, 2003; Prokop & Tunnicliffe, 2010; Schlegel & Rupf, 2010;

Ballouard *et al.*, 2011), which suggests that certain species are preferred over others. Flagship species (Clucas *et al.*, 2008; Schlegel & Rupf, 2010; Barua *et al.*, 2012), exotic animals (Ballouard *et al.*, 2011) and animals with a higher perceived aesthetic value (Kellert, 1996; Knight, 2008; Veríssimo *et al.*, 2009) are preferred over local animal species and/or over animals with a lower perceived aesthetic value. These preferences probably explain the extremely poor level of knowledge regarding local biodiversity (Balmford *et al.*, 2002; Lindemann-Matthies, 2006; Ballouard *et al.*, 2011) and the negative attitudes towards certain unpopular animals such as invertebrates (Kellert, 1993; Prokop & Tunnicliffe, 2010; Barua *et al.*, 2012). Further consequences of preferences of certain flagship species are translated to a higher willingness to protect popular animals over unpopular animals (Martín-López, Montes & Benayas, 2007; Knight, 2008) and exotic animals over local animals (Ballouard *et al.*, 2011). Such a disconnection is probably responsible for paradoxical attitudes and behaviour, such as the abuses of pesticides in people's gardens who would otherwise consider themselves concerned by the decline of tigers in the wild (Ballouard *et al.*, 2011).

Independent researchers have determined that the perceived aesthetic of animals plays an important role in public support for animal conservation, along with other factors, particularly the population size, ecological importance, endemism commonness, or various cultural and historical traits (Kellert, 1996; Czech *et al.*, 1998; Knight, 2008; Veríssimo *et al.*, 2009; Zmihorski *et al.*, in press). To date, however, the role of animal coloration and morphology in conservation support has not been untangled. It is possible that the role of colour in animals plays a non-trivial role in the willingness to protect them, because our closest relatives, non-human primates, exhibit the most widespread variation in dermal and pelage coloration among mammals, suggesting that colour plays an important role in their communication (Caro, 2005). Evidence suggests that the red and black colours are associated with aggression, dominance (Hill & Barton, 2005; Little & Hill, 2007) and physical attractiveness (Elliot & Niesta, 2008; Roberts, Owen & Havlicek, 2010) in humans. Physiological measurements indicated that the red colour is more arousing than other colours (Wilson, 1966). Non-human animals possess a variety of colours that needed to be recognized by our ancestors due to the need to protect themselves against predators or find appropriate food. Therefore, we inherited an innate tendency to react emotionally to some animals (Öhman, 2007; Jacobs, 2009).

Certain animals have aposematic, warning coloration by which they advertise defensive mechanisms to predators while others are inconspicuous and cryptic (Poulton, 1890; Ruxton, Sherratt & Speed, 2004). Differences in animal coloration are particularly important as conspicuous coloration both promotes unlearnt avoidance and enhances avoidance learning in potential predators (e.g. Roper, 1990; Rowe & Guilford, 1996; Ruxton *et al.*, 2004). Although experimental data are scarce, humans seem to perceive warning coloration as more highly conspicuous similarly than (confusing) natural predators (Bohlin *et al.*, 2012). Aposematically coloured species of milkweed snakes (Marešová, Landová & Frynta, 2009), brightly coloured butterflies (Barua *et al.*, 2012) and penguins with a warm colour (Stokes, 2007) are perceived as more beautiful than other species and the perceived aesthetic of animals is positively associated with a willingness to protect them (Knight, 2008). As far as we are aware, however, no study has experimentally investigated the role of animal coloration in the human willingness to protect animals. Moreover, the nature of the flagship species was investigated based on their diet, taxonomic order, body size and International Union for the Conservation of Nature status (Clucas *et al.*, 2008), but not according to their coloration.

The aim of this study is threefold. First, we examine how the human emotions of fear and disgust and the willingness to protect animals vary during visual exposure to both unaltered and experimentally manipulated aposematic and cryptic animals. Second, we investigated whether the emotions of disgust and fear influence the human willingness to protect animals. Third, we investigated whether the human emotions of fear and disgust and the willingness to protect animals vary with respect to animal species. Finally, in light of the fact that females are more disgust and fear sensitive than males (e.g. Curtis, Aunger & Rabie, 2004; Prokop *et al.*, 2010*a*,*b*,*c*) and report greater environmental concern and greater pro-environmental behaviour (reviewed by Zelezny, Chua & Aldrich, 2000), we investigated whether there are gender differences in willingness to protect animals.

## Methods

### Participants

The sample of participants (118 males and 150 females) consisted of 10–20-year-olds attending five randomly selected primary and secondary schools in Western Slovakia. The mean age of the participants was 15.26 years (SE = 0.18). We have chosen 10–20-year-old participants for our research because students in this age group appear to be the most appropriate targets to foster ethical and ecological understanding of the role of animals in nature (Kellert, 1985). It appears that the level of sensitivity for the environment in an adult is formed during the teenage years (Sivek, 2002). The parents of the participants were asked for permission to perform the research with their children 1 month prior to the beginning of the study. We collected information about age, sex and grade of the participants in this study. Participants were then randomly divided into two groups: A and B.

### Measuring of disgust, fear and perceived danger

We presented colour pictures in lecture halls to groups of students. Each picture contained one animal (spider, insect, frog, reptile, bird and mammal) and was presented individually. Six pictures were aposematic animals and six were cryptic animals. Each group of participants was presented with a different species of animals. Each picture was presented for 1 min. Over this time, the participants rated perceived fear (How dangerous would you consider this animal?) and disgust (How disgusting would you consider this animal?), and the willingness to protect the animal (Do you think that this species should be protected by laws?) each on a 5-point scale (e.g. 1 = not at all, 5 = extremely disgusting; 1 = not necessary to protect, 5 = extremely important its protection). The ratings of fear, disgust and willingness to protect the animals were generally reliable (Cronbach's alphas > 0.7). A Cronbach's alpha coefficient lower than 0.70 is a possible cause for concern, signifying that the construct associated with that value might not be reliable (Nunnaly, 1978). If not stated otherwise, we calculated individual scores for each subscale by summing up the responses to the constituent items.

### Experimental manipulation of animal colour

The six aposematic and six cryptic animals (spider, insect, frog, reptile, bird and mammal) were presented in group A and different species of six aposematic and six cryptic animals were presented in group B (24 animal species in total, see Appendix S1). All participants evaluated danger, fear and willingness to protect animals on 12 pictures (6 aposematic and 6 cryptic) which resulted in 12 observations per participant on each dependent variable.

The six aposematic and six cryptic animals that were presented in group A were experimentally manipulated by Adobe Photoshop in such a way that the aposematic animals were changed to cryptic and the cryptic to aposematic and presented in group B. The six aposematic and six cryptic animals that were originally presented in group B were experimentally manipulated in the same way and presented in group A (Appendix S1). This allowed us to compare the responses of the participants to the same species which were presented to one group as originally aposematic and to another group of participants as cryptic and vice versa. This means that we did not expect any differences in the ratings of the original, untreated species between group A and group B of participants, but we predicted that the untreated species in group A will be perceived differently than the same, but experimentally manipulated species in group B and vice versa. The participants rated perceived disgust, fear and willingness to protect the animals in the same way as described above. We adjusted all the picture sizes to a standard body length. The pictures had a similar contrast and brightness. The order of presentation of all the pictures with respect to the colour of the animals and the experimental manipulation was random and was performed in one session. The participants were then debriefed and dismissed. We chose predominantly species that do not occur in Slovakia to avoid previous experiences and familiarity of participants with the presented animals.

### Statistical analyses

A comparison of ratings of disgust, perceived danger and willingness to protect the untreated animals was performed with an analysis of covariance (ANCOVA). Treatment (groups A and B) and gender (male and female) were defined as categorical variables. The age of the participants was treated as covariate. The mean score of the aposematic animals or the mean score of the cryptic animals was defined as dependent variable. Pairwise comparisons between the means were performed with a paired *t*-test and by a Tukey post hoc test.

A comparison of ratings of disgust, perceived danger and willingness to protect the treated animals was performed with a series of paired *t*-tests. The mean scores of the untreated aposematic species presented in group A were compared with the mean scores of the same species experimentally changed to cryptic in group B and vice versa. The same procedure was applied to untreated cryptic species in both groups. Each domain (disgust, perceived danger and willingness to protect) was compared separately (see Figs 3 and 4).

An analysis of differences in perceived disgust, danger and willingness to protect the untreated six animal groups listed in Fig. 2 was performed with a repeated measures analysis of variance (ANOVA). The mean scores for each domain (disgust, perceived danger and willingness to protect) and for each untreated animal group (spiders, insects, amphibian, reptiles, birds and mammals) were calculated regardless of animal colour. Gender and treatment were defined as categorical predictors. This analysis allowed examining whether there are differences in participants' perception of various groups of animals.

To examine whether emotions (disgust, perceived danger) are associated with the willingness to protect animals, the correlation between the mean scores of perceived disgust, danger and willingness to protect the untreated six animal groups was consequently calculated. We used partial correlation coefficients (partial *r*) that allowed for controlling for the effects of treatment, gender and age. All statistical tests are two tailed and calculated with Statistica (StatSoft, Inc., 2001; Version 6, StatSoft, Inc., Tulsa, OK, USA).

## Results

### Disgust of untreated aposematic and cryptic animals

ANCOVA revealed that females expressed a higher disgust for both cryptic and aposematic animals than males (Fig. 1) and that the effect of the treatment was significant (Table 1). The cryptic animals in group A were perceived as more disgusting than the aposematic animals, although the reverse was true for group B. An analysis of means revealed that there were no differences in the disgust of aposematic and cryptic animals (paired *t*-test, $t = 0.16$, d.f. = 267, $P = 0.87$).

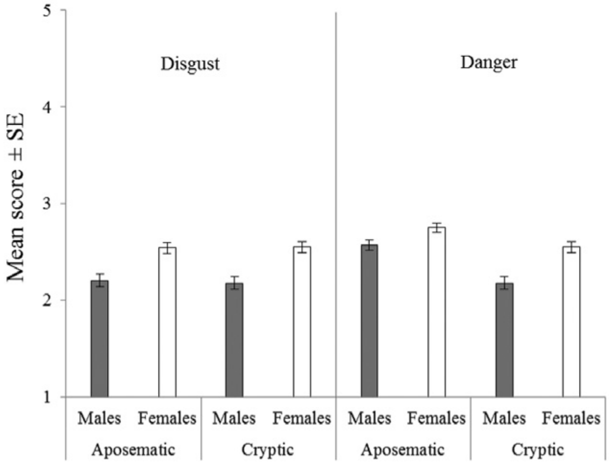


**Figure 1** Gender differences in relation to perceived disgust and danger for animals.

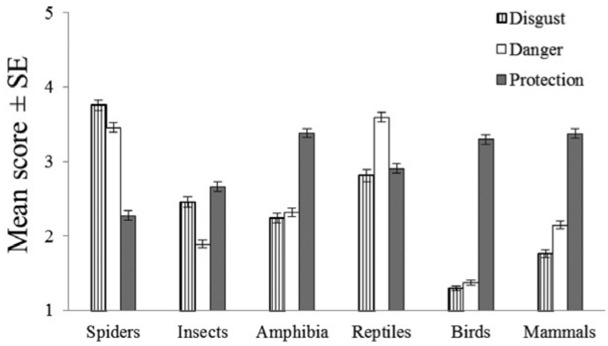


**Figure 2** Differences in the participants' disgust, danger and willingness to protect six groups of animals.

## The perceived danger of untreated aposematic and cryptic animals

Similarly as in the previous case, ANCOVA revealed that females showed a higher perceived danger in relation to both cryptic and aposematic animals than males (Fig. 1) and that the effect of the treatment was significant (Table 2). Interaction between Treatment × Gender suggests that there were no significant gender differences in perceived danger from animals in group A, but females rated animals as significantly more dangerous than males in group B (Tukey post hoc test, $P = 0.53$ and $P < 0.001$, respectively). Aposematic animals were perceived as more dangerous than cryptic animals (paired $t$-test, $t = 10.56$, d.f. = 267, $P < 0.001$). Significant effects of the other variables (Table 2) suggest that older participants rated aposematic animals as more dangerous than younger participants, but no similar trend was observed in ratings of cryptic animals. Further, the perceived danger of aposematic and cryptic animals was rated very similarly in group A, with group B perceiving aposematic animals as more dangerous and with gender differences being the most exaggerated (females scored higher) in terms of perception of the danger of

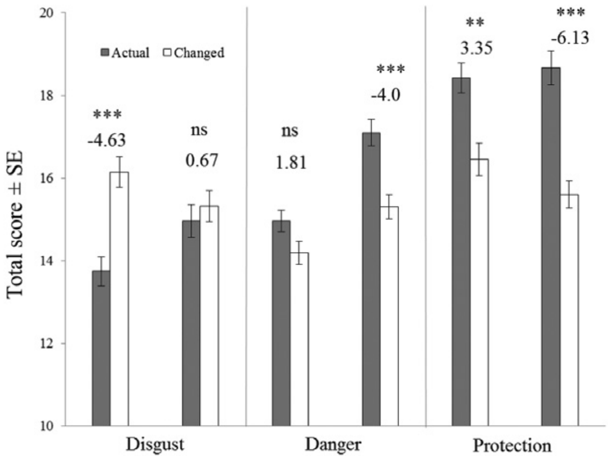


**Figure 3** A comparison of the perception of actual unmanipulated aposematic animals with the same, but manipulated animals changed to cryptic. First pair of bars within each domain represents original unmanipulated animals presented in group A and manipulated animals presented in group B. Second pair of bars within each domain represents original unmanipulated animals presented in group B and manipulated animals presented in group A. Numbers above bars are $t$-values with d.f. = 133. The asterisks denote significant differences based on paired $t$-tests (** $P < 0.01$, *** $P < 0.001$, ns = not statistically significant).

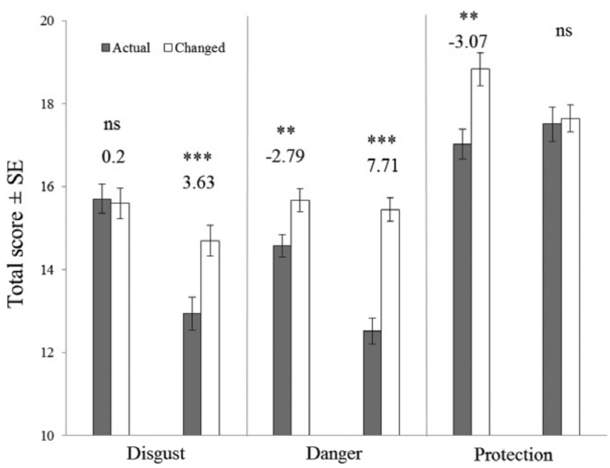


**Figure 4** A comparison of the perception of actual unmanipulated cryptic animals with the same, but manipulated animals changed to aposematic. First pair of bars within each domain represents original unmanipulated animals presented in group A and manipulated animals presented in group B. Second pair of bars within each domain represents original unmanipulated animals presented in group B and manipulated animals presented in group A. Numbers above bars are $t$-values with d.f. = 133. The asterisks denote significant differences based on paired $t$-tests (** $P < 0.01$, *** $P < 0.001$, ns = not statistically significant).

**Table 1** Results of ANCOVA on perceived disgust for aposematic and cryptic animals

| | SS | d.f. | MS | *F* | *P* |
|---|---|---|---|---|---|
| Aposematic animals | | | | | |
| Intercept | 43.57 | 1 | 43.57 | 87.75 | < 0.0001 |
| Age | 0.34 | 1 | 0.34 | 0.69 | 0.41 |
| Treatment | 2.25 | 1 | 2.25 | 4.53 | 0.03 |
| Gender | 7.43 | 1 | 7.43 | 14.97 | < 0.0001 |
| Treatment × Gender | 1.18 | 1 | 1.18 | 2.38 | 0.12 |
| Error | 130.60 | 263.00 | 0.50 | | |
| Cryptic animals | | | | | |
| Intercept | 50.21 | 1.00 | 50.21 | 114.23 | < 0.0001 |
| Age | 0.00 | 1.00 | 0.00 | 0.01 | 0.92 |
| Treatment | 14.20 | 1.00 | 14.20 | 32.31 | < 0.0001 |
| Gender | 9.27 | 1.00 | 9.27 | 21.08 | < 0.0001 |
| Treatment × Gender | 0.03 | 1.00 | 0.03 | 0.06 | 0.81 |
| Error | 115.61 | 263.00 | 0.44 | | |

ANCOVA, analysis of covariance; d.f., degrees of freedom; MS, mean squares; SS, sum of squares.

**Table 2** Results of ANCOVA on perceived danger for aposematic and cryptic animals

| | SS | d.f. | MS | *F* | *P* |
|---|---|---|---|---|---|
| Aposematic animals | | | | | |
| Intercept | 44.85 | 1 | 44.85 | 150.54 | < 0.0001 |
| Age | 1.89 | 1 | 1.89 | 6.36 | 0.01 |
| Treatment | 7.19 | 1 | 7.19 | 24.12 | < 0.0001 |
| Gender | 2.17 | 1 | 2.17 | 7.28 | 0.01 |
| Treatment × Gender | 2.03 | 1 | 2.03 | 6.80 | 0.01 |
| Error | 78.36 | 263 | 0.30 | | |
| Cryptic animals | | | | | |
| Intercept | 49.56 | 1 | 49.56 | 216.49 | < 0.0001 |
| Age | 0.08 | 1 | 0.08 | 0.34 | 0.56 |
| Treatment | 7.90 | 1 | 7.90 | 34.52 | < 0.0001 |
| Gender | 7.64 | 1 | 7.64 | 33.38 | < 0.0001 |
| Treatment × Gender | 0.12 | 1 | 0.12 | 0.51 | 0.47 |
| Error | 60.21 | 263 | 0.23 | | |

ANCOVA, analysis of covariance; d.f., degrees of freedom; MS, mean squares; SS, sum of squares.

cryptic animals, although less pronounced in the perception of aposematic animals (Fig. 1).

## Protection of animals

ANCOVA did not indicate any significant effects of the examined predictors on the protection of animals (Table 3). However, an examination of means revealed that the participants were more willing to protect aposematic animals than cryptic animals (paired *t*-test, $t = 5.84$, d.f. = 267, $P < 0.0001$).

## Do animal species influence emotions and the willingness to protect them?

The repeated measures ANOVA with the mean scores of six animal groups indicated that spiders and snakes were

**Table 3** Results of ANCOVA on willingness to protect aposematic and cryptic animals

| | SS | d.f. | MS | *F* | *P* |
|---|---|---|---|---|---|
| Aposematic animals | | | | | |
| Intercept | 4035.44 | 1 | 4035.44 | 200.57 | < 0.0001 |
| Age | 59.21 | 1 | 59.21 | 2.94 | 0.09 |
| Treatment | 5.33 | 1 | 5.33 | 0.26 | 0.61 |
| Gender | 31.45 | 1 | 31.45 | 1.56 | 0.21 |
| Treatment × Gender | 0.70 | 1 | 0.70 | 0.03 | 0.85 |
| Error | 5291.42 | 263 | 20.12 | | |
| Cryptic animals | | | | | |
| Intercept | 2543.27 | 1 | 2543.27 | 129.98 | < 0.0001 |
| Age | 2.97 | 1 | 2.97 | 0.15 | 0.70 |
| Treatment | 8.71 | 1 | 8.71 | 0.45 | 0.51 |
| Gender | 18.42 | 1 | 18.42 | 0.94 | 0.33 |
| Treatment × Gender | 70.03 | 1 | 70.03 | 3.58 | 0.06 |
| Error | 5146.05 | 263 | 19.57 | | |

ANCOVA, analysis of covariance; d.f., degrees of freedom; MS, mean squares; SS, sum of squares.

perceived as the most and birds the least disgusting and dangerous ($F_{5,1315} = 282.4$ and 371.3, both $P < 0.001$, respectively; Fig. 2). Participants were less willing to protect spiders, insects and reptiles in comparison with mammals and birds ($F_{5,1315} = 70.7$, $P < 0.0001$). The effect of treatment was not significant for any of measured domain (perceived disgust, danger and willingness to protect, all $P > 0.1$) and females expressed a higher disgust and danger for animals than males ($F_{1,263} = 8.55$ and 9.45, both $P < 0.01$, respectively). Females showed a similar willingness to protect animals than males ($F_{1,263} = 1.19$, $P = 0.27$). The partial correlations on the total mean score of perceived disgust, danger and willingness to protect all animals revealed that perceived disgust and danger correlated significantly (partial $r = 0.59$, $P < 0.001$), although the willingness to protect animals was inversely related to the emotion of disgust and fear (partial $r = -0.44$ and $-0.20$, $P < 0.001$ and $P = 0.001$, respectively).

## Perception of experimentally manipulated animals

### Aposematic animals treated as cryptic

As shown in Fig. 3, although not all differences in the perception of aposematic and their manipulated cryptic animals were significant, trends based on mean scores were the same. Actual aposematic animals tended to be perceived as less disgusting and more dangerous than when they were experimentally manipulated and coloured as cryptic animals. The willingness to protect unmanipulated aposematic animals was significantly stronger than the willingness to protect the same animals that were presented as cryptic.

### Cryptic animals treated as aposematic

There were no consistent trends in perception of disgust of unmanipulated cryptic animals and their experimental presentation as aposematic (Fig. 4). However, experimentally manipulated aposematic animals were perceived as significantly more dangerous than cryptic, unmanipulated animals. The willingness to protect experimentally treated aposematic animals tended to be higher (the trends were the same, albeit not significant in one case) with the willingness to protect unmanipulated cryptic animals.

## Discussion

This study experimentally investigated the effects of animal coloration on human emotions of disgust and fear and on the willingness to protect them. Visual exposure to harmful animals triggers basic emotions such as disgust and fear (Öhman & Mineka, 2003; Knight, 2008; Prokop *et al.*, 2010*a*,*b*,*c*) which is negatively associated with their support (Bjerke *et al.*, 2001; Knight, 2008; Prokop & Fančovičová, 2010, 2012). As far as we are aware, however, there is no study that has experimentally investigated how animal coloration influences human emotions.

We determined that visual exposure to both experimentally altered and unaltered aposematic animals enhances perceived fear, but not the disgust, towards these animals. This suggests that humans decode the warning signals of animals correctly, just as their natural predators (see Ruxton *et al.*, 2004) and that colours play a prominent role in human interactions with other animals (Caro, 2005). A higher perceived fear on the part of the participants who rated animals with aposematic colours also adds to the literature on the role of warning colours by humans, particularly red and black, which are known to be associated with aggression, dominance and attractiveness (Hill & Barton, 2005; Little & Hill, 2007; Elliot & Niesta, 2008; Roberts *et al.*, 2010). The participants showed a greater willingness to protect aposematic animals as compared with cryptic animals. This finding both adds to the current knowledge of the nature flagship species (Clucas *et al.*, 2008; Schlegel & Rupf, 2010; Ballouard *et al.*, 2011; Barua *et al.*, 2012) and provides practical implication for conservationists. In particular, it should be investigated how animal coloration influences the popularity of flagship species among the general public as the success of the use of conspicuously coloured animals in conservationist programs requires public support (Czech *et al.*, 1998; Kleiman *et al.*, 2000; Martín-López *et al.*, 2007). If cryptic animals need to be presented, it is possible that manipulation of background coloration which influences their conspicuousness will increase their popularity and, consequently, conservation efforts. For example, men who viewed a woman on a red, relative to a white, background perceived her as more attractive (Elliot & Niesta, 2008). More experiments on background coloration are required.

Although there is a great deal of work that investigates which factors influence conservation attitudes in general (Kellert, 1996; Czech *et al.*, 1998; Brackney & McAndrew, 2001; Knight, 2008; Veríssimo *et al.*, 2009), or the attitudes of children towards the natural world in particular (e.g. Caro, Pelkey & Grigione, 1994; Eagles & Demare, 1999; Rosalino & Rosalino, 2012), the role of human emotions in support of animal conservation has been largely neglected (Knight, 2008). Current research has determined that more disgust sensitive people avoid disabled, obese or old people (Park, Faulkner & Schaller, 2003; Park, Schaller & Crandall, 2007; Duncan & Schaller, 2009), which suggests that basic human emotions play a more important role in social interactions than previously expected. Here we demonstrated that the emotions of disgust and fear significantly and negatively influence the human willingness to protect animals. This supports the previous work demonstrating that the emotions of fear (Bjerke *et al.*, 2001; Knight, 2008; Prokop & Fančovičová, 2010), disgust (Prokop & Fančovičová, 2012), and beliefs in myths and superstitions (Brito *et al.*, 2001; Prokop *et al.*, 2009*a*; Fita *et al.*, 2010; Ceríaco, 2012) are negatively associated with their support that needs to be taken into account when planning conservation programs. For example, physical contact on the part of children with unpopular animals reduces both disgust and fear as was recently demonstrated by Randler, Hummel & Prokop (2012) and Ballouard *et al.* (2012). Effective educational programs are therefore one of the promising opportunities as to how to improve the emotional perception of animals in children.

Finally, we discovered that spiders, insects and snakes were perceived as more disgusting/dangerous than birds and mammals (Fig. 2). These results reflect generally higher support for birds and mammals among both conservationists (Clark & May, 2002) and the general public (Czech *et al.*, 1998) in all probability, as these may be privileged species because they are more positively socially constructed than reptiles, amphibians and invertebrates (Czech & Krausman, 2001). However, the present study demonstrates that the popularity of generally unpopular animals can be at least partly improved by presenting species with conspicuous, aposematic coloration, in which particular colours and their combinations that contribute to the perceived aesthetic of animals (Stokes, 2007; Knight, 2008; Marešová *et al.*, 2009; Barua *et al.*, 2012) remain to be studied. Animals were generally perceived as more dangerous/disgusting by females than by males. These results corroborate previous research works supporting the low popularity of certain animals over others (e.g. Bjerke *et al.*, 2003; Schlegel & Rupf, 2010) and gender differences in terms of perception of animals (Prokop *et al.*, 2009*a*,*b*, 2010*a*,*b*; Prokop & Tunnicliffe, 2010). It additionally supports the reliability of the collected data. Similarly as in the study by Knight (2008), increased concerns about animal protection among females have not been supported (Zelezny *et al.*, 2000).

It might be questioned whether the results of this study are applicable to adults who have a stronger impact on nature conservation than children. Previous research indicated that the participants in this age group were able to distinguish dangerous animals from harmless animals according to their visual appearance (Prokop *et al.*, 2010*b*), similarly as adults (Lobue & Deloache, 2011), thus we suggest that a replication of this experiment with adults would yield similar results. Additional research is undoubtedly needed before definite conclusions can be made.

To conclude, both animal coloration and human emotions seem to play important roles in the human willingness to protect animals. Humans are more willing to protect aposematic animals which could be explained by the greater attention caused by high conspicuousness, perceived beauty, as well as by deeper details concerning underlying mechanisms in the brain between the emotions and warning colours which remain to be studied. Disgust and fear of animals are more important predictors of willingness to protect animals as thought previously. Presentation of aposematic animals in conservation programs focused on protection of particular species may increase their popularity and public support. Ontogeny of perception of warning colours by humans and effects of background coloration on perception of animals are challenges for future research.

## Acknowledgements

We are grateful to the editor, Javier Balbontín and Luis Ceríaco for insightful comments on earlier versions of this paper. Peter Nižnánsky helped with the experimental manipulation of animals. David Livingstone improved the English.

## References

Ballouard, J.M., Brischoux, F. & Bonnet, X. (2011). Children prioritize virtual exotic biodiversity over local biodiversity. *PLoS ONE* **6**, e23152.

Ballouard, J.M., Provost, G., Barré, D. & Bonnet, X. (2012). Influence of a field trip on schoolchildren's attitude toward unpopular organisms: an experience with snakes. *J. Herpetol.* **46**, 423–428.

Balmford, A., Clegg, L., Coulson, T. & Taylor, J. (2002). Why conservationists should heed Pokémon. *Science* **295**, 2367.

Barua, M., Gurdak, D.J., Ahmed, R.A. & Tamuly, J. (2012). Selecting flagships for invertebrate conservation. *Biodivers. Conserv.* **21**, 1457–1476.

Bjerke, T., Kaltenborn, B.P. & Thrane, C. (2001). Sociodemographic correlates of fear-related attitudes toward the wolf (*Canis lupus lupus*). A survey in southeastern Norway. *Fauna Norv.* **21**, 25–33.

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

Bohlin, T., Gamberale-Stille, G., Merilaita, S., Exnerová, A., Štys, P. & Tullberg, B. (2012). The detectability of the colour pattern in the aposematic firebug, *Pyrrhocoris apterus*: an image-based experiment with human 'predators'. *Biol. J. Linn. Soc.* **105**, 806–816.

Brackney, M. & McAndrew, F.T. (2001). Ecological world views and receptivity to different types of arguments for preserving endangered species. *J. Environ. Educ.* **33**, 17–20.

Breitenmoser, U. (1998). Large predators in the Alps: the fall and rise of man's competitors. *Biol. Conserv.* **83**, 279–289.

Brito, J.C., Rebelo, A. & Crespo, E.G. (2001). Viper killings for superstitious reasons in Portugal. *Bol. Asoc. Herpetol. Esp.* **12**, 101–104.

Butchart, S.H.M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J.P.W., Almond, R.E.A., Baillie, J.E.M., Bomhard, B., Brown, C., Bruno, J., Kent, E., Carpenter, K.E., Carr, G.M., Chanson, J., Chenery, A.M., Csirke, J., Davidson, N.C., Dentener, F., Foster, M., Galli, A., Galloway, J.N., Genovesi, P., Gregory, R.D., Hockings, M., Kapos, V., Lamarque, J.-F., Leverington, F., Loh, J., McGeoch, M.A., McRae, L., Minasyan, A., Hernández Morcillo, M., Oldfield, T.E.E., Pauly, D., Quader, S., Revenga, C., Sauer, J.R., Skolnik, B., Spear, D., Stanwell-Smith, D., Stuart, S.N., Symes, A., Tierney, M., Tyrrell, T.D., Vié, J.-C. & Watson, R. (2010). Global biodiversity: indicators of recent declines. *Science* **328**, 1164–1168.

Caro, T. (2005). The adaptive significance of coloration in mammals. *Bioscience* **55**, 125–136.

Caro, T.M., Pelkey, N. & Grigione, M. (1994). Effects of conservation biology education on attitudes toward nature. *Conserv. Biol.* **8**, 846–852.

Ceríaco, L.M.P. (2012). Human attitudes towards herpetofauna: the influence of folklore and negative values on the conservation of amphibians and reptiles in Portugal. *J. Ethnobiol. Ethnomedicine* **8**, 8.

Ceríaco, L.M.P., Marques, M.P., Madeira, N.C., Vila-Viçosa, C.M. & Mendes, P. (2011). Folklore and traditional ecological knowledge of geckos in Southern Portugal: implications for conservation and science. *J. Ethnobiol. Ethnomedicine* **7**, 26.

Clark, J.A. & May, R.M. (2002). Taxonomic bias in conservation research. *Science* **297**, 191–192.

Clucas, B., McHugh, K. & Caro, T. (2008). Flagship species on covers of US conservation and nature magazines. *Biodivers. Conserv.* **17**, 1517–1528.

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

Czech, B. & Krausman, P.R. (2001). *The endangered species act. History, conservation biology, and public policy*. Baltimore: The Johns Hopkins University Press.

Czech, B., Krausman, P.R. & Borkhataria, R. (1998). Social construction, political power, and the allocation of benefits to endangered species. *Conserv. Biol.* **12**, 1103–1112.

Decker, J.D., Brown, T.L. & Siemer, W.F. (2001). Wildlife management as a process. In *Human dimensions of wildlife management in North America*: 77–90. Decker, J.D., Brown, T.L. & Siemer, W.F. (Eds). Bethesda: The Wildlife Society.

Dickman, A.J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Anim. Conserv.* **13**, 458–466.

Drury, R., Homewood, K. & Randall, S. (2011). Less is more: the potential of qualitative approaches in conservation research. *Anim. Conserv.* **14**, 18–24.

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

Eagles, P.F. & Demare, R. (1999). Factors influencing children's environmental attitudes. *J. Environ. Educ.* **30**, 33–37.

Elliot, A.J. & Niesta, D. (2008). Romantic red: red enhances men's attraction to women. *J. Pers. Soc. Psychol.* **95**, 1150–1164.

Ericsson, G., Heberlein, T.A., Karlsson, J., Bjärvall, A. & Lundvall, A. (2004). Support for hunting as a means of wolf *Canis lupus* population control in Sweden. *Wildl. Biol.* **10**, 269–276.

Fita, D.S., Neto, E.M.C. & Schiavetti, A. (2010). 'Offensive' snakes: cultural beliefs and practices related to snakebites in a Brazilian rural settlement. *J. Ethnobiol. Ethnomedicine* **6**, 13.

Frembgen, J.W. (1996). The folklore of geckos: ethnographic data from south and west Asia. *Asian Folkl. Stud.* **55**, 135–143.

Goodman, S.M. & Hobbs, J. (1994). The distribution and ethnozoology of reptiles of the northern portion of the Egyptian eastern desert. *J. Ethnobiol.* **14**, 75–100.

Gratwicke, B., Mills, J., Dutton, A., Gabriel, G., Long, B., Seidensticker, J., Wright, B., You, W. & Zhang, L. (2008). Attitudes toward consumption and conservation of tigers in China. *PLoS ONE* **3**, e2544.

Hamber, C., Henderson, P.A. & Speight, M.R. (2011). Extinction rates, extinction-prone habitats, and indicator groups in Britain and at larger scales. *Biol. Conserv.* **144**, 713–721.

Herzog, H. & Burghardt, G.M. (1988). Attitudes toward animals: origins and diversity. *Anthrozoös* **1**, 214–222.

Hill, R.A. & Barton, R.A. (2005). Red enhances human performance in contests. *Nature* **435**, 293.

Jacobs, M.H. (2009). Why do we like or dislike animals? *Hum. Dimens. Wildl.* **14**, 1–11.

Kaczensky, P. (1999). Large carnivore predation on livestock in Europe. *Ursus* **11**, 59–72.

Kaltenborn, B.P., Bjerke, T., Nyahongo, J.W. & Williams, D.R. (2006). Animal preferences and acceptability of wildlife management actions around Serengeti National Park, Tanzania. *Biodivers. Conserv.* **15**, 4633–4649.

Kellert, S.R. (1985). Attitudes towards animals: age-related development among children. *J. Environ. Educ.* **16**, 29–39.

Kellert, S.R. (1993). Values and perceptions of invertebrates. *Conserv. Biol.* **7**, 845–855.

Kellert, S.R. (1996). *The value of life: biological diversity and human society*. Washington, DC: Island Press.

Kellert, S.R. (2000). *The public and the wolf in Minnesota, 1999*. Minnesota: International Wolf Center, Brooklyn Center, 412 pp.

Kissui, B.M. (2008). Livestock predation by lions, leopards, spotted hyenas, and their vulnerability to retaliatory killing in the Maasai Steppe, Tanzania. *Anim. Conserv.* **11**, 422–432.

Kleiman, D.G., Reading, R.P., Miller, B.J., Clark, T.W., Scott, J.M., Robinson, J., Wallace, R.L., Cabin, R.J. & Felleman, F. (2000). Improving the evaluation of conservation programs. *Conserv. Biol.* **14**, 356–365.

Knight, A.J. (2008). 'Bats, snakes and spiders, Oh my!' How aesthetic and negativistic attitudes, and other concepts predict support for species protection. *J. Environ. Psychol.* **28**, 94–103.

Lindemann-Matthies, P. (2006). Investigating nature on the way to school: responses to an educational programme by teachers and their pupils. *Int. J. Sci. Educ.* **28**, 895–918.

Little, A.C. & Hill, R.A. (2007). Social perception of red suggests special role in dominance signaling. *J. Evol. Psychol.* **1–4**, 161–168.

Lobue, V. & Deloache, J.S. (2011). What's so special about slithering serpents? Children and adults rapidly detect snakes based on their simple features. *Vis. Cogn.* **19**, 129–143.

Marešová, J., Landová, E. & Frynta, D. (2009). What makes some species of milk snakes more attractive to humans than others? *Theory Biosci.* **128**, 227–235.

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

Mech, L.D. (2001). Managing Minnesota's recovered wolves. *Wildl. Soc. Bull.* **29**, 70–77.

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

Öhman, A. (2007). Face the beast and fear the face: animal and social fears as prototypes for evolutionary analyses of emotion. *Psychophysiology* **23**, 123–145.

Öhman, A. & Mineka, S. (2003). The malicious serpent: snakes as a prototypical stimulus for an evolved module of fear. *Curr. Dir. Psychol. Sci.* **12**, 5–9.

Öhman, A., Flykt, A. & Lundqvist, D. (2000). Unconscious emotion: evolutionary perspectives, psychophysiological data, and neuropsychological mechanisms. In *The cognitive neuroscience of emotion*: 296–327. Lane, R. & Nadel, L. (Eds). New York: Oxford University Press.

Park, J.H., Faulkner, J. & Schaller, M. (2003). Evolved disease-avoidance processes and contemporary anti-social behavior: prejudicial attitudes and avoidance of people with physical disabilities. *J. Nonv. Behav.* **27**, 65–87.

Park, J.H., Schaller, M. & Crandall, C.S. (2007). Pathogen-avoidance mechanisms and the stigmatization of obese people. *Evol. Hum. Behav.* **28**, 410–414.

Poulton, E.B. (1890). *The colours of animals, their meaning and use. Especially considered in the case of insects*. London: Kegan Paul, Trench, Trübner.

Prokop, P. & Fančovičová, J. (2010). Perceived body condition is associated with fear of a large carnivore predator in humans. *Ann. Zool. Fenn.* **47**, 417–425.

Prokop, P. & Fančovičová, J. (2012). Tolerance of amphibians in Slovakian people: a comparison of pond owners and non-owners. *Anthrozoös* **25**, 277–288.

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

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

Prokop, P., Özel, M. & Usak, M. (2009b). Cross-cultural comparison of student attitudes toward snakes. *Soc. Anim.* **17**, 224–240.

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

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

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

Randler, C., Hummel, E. & Prokop, P. (2012). Practical work at school reduces disgust and fear of unpopular animals. *Soc. Anim.* **20**, 61–74.

Roberts, S.C., Owen, R.C. & Havlicek, J. (2010). Distinguishing between perceiver and wearer effects in clothing color-associated attributions. *Evol. Psychol.* **8**, 350–364.

Roper, T.J. (1990). Responses of domestic chicks to artificially coloured insect prey: effects of previous experience and background colour. *Anim. Behav.* **39**, 466–473.

Rosalino, L.M. & Rosalino, C. (2012). Nature conservation from a Junior High School perspective. *J. Nat. Conserv.* **20**, 153–161.

Rowe, C. & Guilford, T. (1996). Hidden colour aversion in domestic chicks triggered by pyrazine odours of insect warning displays. *Nature* **383**, 520–522.

Ruxton, G.D., Sherratt, T.N. & Speed, M.P. (2004). *Avoiding attack. The evolution of crypsis, warning signals and mimicry*. New York: Oxford University Press.

Schlegel, J. & Rupf, R. (2010). Attitudes towards potential animal flagship species in nature conservation: a survey among students of different educational institutions. *J. Nat. Conserv.* **18**, 278–290.

Serpell, J.A. (2004). Factors influencing human attitudes to animals and their welfare. *Anim. Welf.* **13**, 145–151.

Sivek, D.J. (2002). Environmental sensitivity among Wisconsin high school students. *Environ. Educ. Res.* **8**, 155–170.

StatSoft, Inc. (2001). *Statistica Data Analysis Software System, version 6*. Tulsa: StatSoft, Inc. Available at: http://www.statsoft.com.

Stokes, D.L. (2007). Things we like: human preferences among similar organisms and implications for conservation. *Hum. Ecol.* **35**, 361–369.

Veríssimo, D., Fraser, I., Groombridge, J.J., Bristol, R. & MacMillan, D.C. (2009). Birds as tourism flagship species: a case study of tropical islands. *Anim. Conserv.* **12**, 549–558.

Vygotsky, L. (1978). *Mind in society: the development of higher psychological processes*. Cambridge: Harvard University Press.

Wilson, G.D. (1966). Arousal properties of red versus green. *Percept. Mot. Skills* **23**, 942–949.

Zajonc, R.B. (1980). Feeling and thinking: preferences need no inferences. *Am. Psychol.* **35**, 151–175.

Zelezny, L.C., Chua, P.P. & Aldrich, C. (2000). Elaborating on gender differences in environmentalism. *J. Soc. Issues* **56**, 443–457.

Zmihorski, M., Dziarska-Palac, J., Sparks, T.H. & Tryjanowski, P. (in press). Ecological correlates of the popularity of birds and butterflies in Internet information resources. Oikos, doi: 10.1111/j.1600-0706.2012.20486.x.

## Supporting information

Additional Supporting Information may be found in the online version of this article:

**Appendix S1.** List of species used in PowerPoint presentation.