



OPEN Morphological resemblance to injections elicits fear, disgust, and reduced conservation intent toward insects

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Insects are among the least preferred animals on this planet. Despite their crucial role in ecosystem functioning, understanding the reasons for negative public attitudes is essential for improving support for their conservation. We investigated whether morphological structures superficially resembling stingers (e.g., harmless ovipositors) influence Slovak students' fear of being stung, willingness to protect (WTP) insects, perceived attractiveness, and feelings of disgust. Students ($N=654$, 412 female, age range: 10–19 years) reported almost the same level of fear toward insects with sting-like structures as toward stinging insects (honeybees and wasps). Fear of being stung and disgust negatively predicted WTP, whereas attractiveness had a positive effect. Fear of being stung appears to be deeply rooted in human psychology, as it is correlated with the fear of injections. Mediation analysis further revealed that fear of injections indirectly reduced WTP by decreasing attractiveness and increasing disgust. Females show greater WTP than males. Overall, our results suggest that fear of being stung, elicited by insect morphology, is a significant psychological factor that should be considered when designing conservation strategies.

Keywords Threat perception, Environmental education, Fear of invertebrates

Bugs, although making up the majority of the world's species, are widely considered inferior, insignificant, disgusting, harmful, and deservedly killed. Changing this perception is essential¹.

Human attitudes toward animal species perceived as ugly, frightening, or disgusting pose a significant challenge to conservation efforts^{1–4}. Many ecologically important species—including snakes, bats, the aye-aye (*Daubentonia madagascariensis*), and numerous invertebrates—are subject to widespread persecution and neglect, despite their ecological importance and frequent harmlessness^{5–9}. To understand the deep-seated nature of these aversions, an evolutionary perspective is informative. This view suggests that human aesthetic preferences are shaped by natural selection, where beautiful objects are associated with survival and reproductive success, and ugly or frightening objects with potential threats¹⁰. Thus, innate emotional responses can be seen as adaptive reactions. However, these preferences are often imprecise and superficial^{11,12}, giving rise to biases that may no longer be adaptive in modern contexts¹. This evolutionary mismatch is particularly evident in the case of insects and arachnids, which are among the strongest triggers of extreme fear (phobias) and are consistently ranked among the most disliked and feared taxonomic groups globally^{1,3,13,14}.

However, insects are crucial for ecosystem functioning and provide irreplaceable services, such as pollination and seed dispersal¹⁵. Simultaneously, insect populations are experiencing rapid global decline^{16–18}. This dual reality makes it essential to foster greater public tolerance and support for insects^{13,19–21}. Unfortunately, promoting public involvement in insect conservation remains difficult: invertebrates are often neglected²², while conservation priorities tend to favor phylogenetically closer, larger, and more attractive animals^{14,23–32}. Furthermore, negative experiences with invertebrates also influence attitudes toward them. For instance, those who experienced bee stings reported greater fear of bees^{33,34} and were more willing to kill them³⁵. Therefore, a better understanding of the evolved psychological mechanisms underlying negative attitudes toward insects is crucial for improving conservation outcomes.

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The low popularity of insects can be largely explained by two prominent emotions: disgust and fear^{1,4,13,36–38}. Disgust is a universal emotional response marked by strong feelings of aversion toward cues associated with pathogens such as rotten food, bodily waste, or unhygienic environments^{39–41}. Disgust response is intrinsically linked to judgments of ugliness, as both function to alert an individual to potential pathogen threats and motivate avoidance⁴². Because many insects act as disease vectors⁴³, negative perceptions of insects are strongly shaped by disgust, which functions as an adaptive protective mechanism to reduce the risk of pathogen transmission^{36,38,44–48}. It can therefore be predicted that disgust will be associated with low perceived attractiveness in insects.

Fear is another fundamental emotional response to perceived threats or dangers. It initiates physiological and behavioural reactions that prepare an individual for the fight-or-flight response⁴⁹. Although the actual risk of mortality from stings is low, humans frequently encounter bees and wasps (Hymenoptera), and these interactions are readily associated with fear⁵⁰. Venom elicits rapid physiological responses, primarily through the activation of pain receptors that detect harmful stimuli. This results in immediate pain sensations and triggers protective reflexes⁵¹. Consequently, insect species capable of stinging are strongly associated with aversion and fear^{4,37,44,50,52–57}.

We hypothesize that the fear of insect stings reflects a broader psychological preparedness to perceive sharp, penetrating objects as threats. This mechanism is central to fear of injection, a common condition driven by the association of such objects with injury, pain, and pathogen introduction^{58,59}. Critically, fear of injection itself is influenced by disgust and contamination concerns⁶⁰, which are also core components of negative responses to insects^{1,38}. Therefore, we propose that fear of injection provides a possible framework for understanding certain insect aversions. Specifically, we posit that this fear generalizes to non-threatening morphological cues on insects that superficially resemble needles or stingers, such as elongated ovipositors or cerci, triggering aversive responses even in the absence of a genuine threat.

In this study, we investigated how the perceived fear of being stung influences a broader fear of insects and willingness to protect them. We further examined the roles of perceived insect disgust and attractiveness in shaping these attitudes toward insects. In addition, we explored the hypothesis that fear of insect stings may reflect a broader psychological vulnerability to threat perception, potentially sharing underlying mechanisms with other object-specific fears, such as fear of injections⁵⁹. Our research specifically focused on non-stinging appendages, such as ovipositors and cerci, which superficially resemble stingers but serve distinct biological functions. We hypothesized that the mere presence of these appendages contributes to negative evaluations of insects⁵⁴. Specifically, we predicted that (1) fear of being stung would be positively correlated with fear of injections and negatively associated with willingness to protect them. While a negative correlation between disgust and WTP and a positive correlation between attractiveness and WTP are well-documented for vertebrates, we attempted to confirm these relationships in invertebrates, which are disproportionately affected by negative human perceptions. We therefore hypothesized that (2) perceived disgust would be a significant negative predictor of willingness to protect insects, and perceived attractiveness would be a significant positive predictor. (3) Females would report higher levels of fear and disgust toward insects, consistent with established gender differences in these domains^{3,30,61–63}. Finally, we focused on the entire high school cohort of children and adolescents aged 10–19 years, as attitudes toward the natural environment are largely formed during this critical developmental period⁶⁴ and can have lasting effects on perceptions and behaviors in adulthood.

Methods

Participants

The participants were 654 Slovak students (412 females) aged 10–19 years ($M = 14.4$, $SE = 0.08$). This conventional sample was recruited through upper secondary and high school teachers known to the researchers who invited their students to participate. Recruitment primarily relied on advertisements distributed by classroom teachers, which described the study as an investigation of human attitudes toward animals. The upper limit of 19 was not chosen to contradict Kellert's categories, but rather to be inclusive of the entire high school student population, which includes students up to age 19. This provided a practical and coherent sampling frame for our school-age cohort. Participation was entirely voluntary, and no financial or other incentives were offered.

Photographs as visual stimuli

We prepared colourful visual stimuli of insects with cues resembling injections (hereafter “harmful,” $N = 10$) and insects lacking these cues (hereafter “harmless,” $N = 10$) (Table 1, Supplementary Table 1). In addition, two well-known stinging insects, *Vespula germanica* and *Apis mellifera*, were included as reference stimuli for the fear of being stung. All images were sourced from Google Images. To standardize the stimuli and eliminate potential confounding background elements, the background was removed from all images using the Photoroom application (<https://www.photoroom.com>). Participants rated each depicted insect for self-perceived fear of being stung, attractiveness, willingness to protect (WTP), and disgust of the depicted insect using 5-point Likert scales (1 = not at all, 5 = very much). Higher scores indicate greater fear, attractiveness, WTP, and disgust.

Measuring fear of injection

We adopted items from the Fear of Injection Scale⁶⁵ and slightly modified them to assess the participants' fear of injections. Specifically, the scale included five items for the Direct Fear domain (e.g., “Needle size frightens me”), five items for the Physiological Response domain (e.g., “I feel nauseous when I am receiving an injection”), and five items for the Indirect Fear domain (e.g., “Listening to someone talking about injections”). Items were rated on a 5-point Likert scale (1 = not at all, 5 = very much), with high internal consistency (Cronbach's $\alpha = 0.94$). Although the original Fear of Injection Scale by Hako et al.⁶⁵ was developed and validated for an adult population aged 18–25 years, we applied the scale to participants aged 10–19 years without modification. The scale items are straightforward and easily understood by adolescents, which is supported by the excellent internal consistency


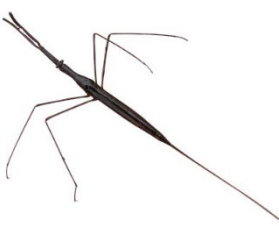
Harmless species	Harmful species
 <p><i>Hydrometra stagnorum</i></p>	 <p><i>Ranatra linearis</i></p>

Table 1. Examples of putatively harmful and harmless species.

in our sample. This indicates the scale is reliable and appropriate for use in high school-aged participants. For transparency, we have included the full scale in the Appendix A. Average scores across all items were used in the statistical analyses, with higher values indicating greater fear of injection.

Procedure

Participant recruitment and data collection were conducted in a school environment. The online survey was open to participants for approximately eight weeks, from April to June 2025, and took no more than 10 min to complete. Prior to the study, informed consent forms were distributed to the parents of all potential participants. The research was conducted during regular school hours within classroom settings. All sessions were supervised both by the classroom teacher. Participants were asked their demographic information (school type, age, gender), followed by the series of insect images. For each image, they provided their ratings on all four dependent variables (fear of being stung, attractiveness, WTP, and disgust) simultaneously before proceeding to the next insect (Appendix B). Following the completion of all insect image evaluations, participants were directed to a separate section of the survey to complete the Fear of Injection Scale (Appendix B). Participants first provided informed consent and then rated their fear of animals based on the pictures presented.

Statistical analyses

All statistical analyses were conducted using four separate models, one for each dependent variable: self-perceived fear of being stung, insect attractiveness, WTP for insects, and disgust. Generalized Linear Mixed Models (GLMMs) were used to assess the effects of the following predictors: categorical variables included participant gender (male or female) and type of insect (harmful, harmless, and stinging), while continuous predictors included scores from the Fear of Injection scale. Age was excluded from the models because its effect was not significant, likely due to the narrow age range. The participant ID and school type were included as random effects. Simple correlations (Spearman's rho) between all variables are available in Appendix C.

Depending on the dependent variable, additional continuous predictors were included: fear of being stung (beta distribution with logit link), insect attractiveness, and disgust; WTP (Gaussian distribution), fear of being stung, and insect attractiveness; insect attractiveness (beta distribution with logit link), fear of being stung, and disgust; and disgust (beta distribution with logit link), fear of being stung, and insect attractiveness. Continuous predictors were mean-centered to reduce multicollinearity and improve the variance inflation factor (VIF) values, preserving the interpretability of the coefficients^{66,67}.

Bonferroni-corrected post hoc tests were used to explore the differences among categorical variables (e.g., males vs. females). Effect sizes were calculated using Cohen's d, with thresholds of 0.2, 0.5, and 0.8, indicating small, medium, and large effects, respectively⁶⁸.

To examine the indirect pathways through which fear of injection influences WTP, a mediation analysis was conducted following Hayes⁶⁹. The model tested whether insect attractiveness and disgust mediated the relationship between fear of injection (predictor) and WTP (outcome). The analysis estimated (1) the direct effect of fear of injection on WTP, controlling for mediators; (2) the indirect effects via each mediator (a-path \times b-path); and (3) the total effect combining direct and indirect pathways. The significance of indirect effects was assessed using bootstrap confidence intervals with 5,000 resamples. Continuous variables were mean-centered prior to the analysis to reduce multicollinearity and improve interpretability, consistent with the main analyses. All statistical analyses were performed using Jamovi software⁷⁰.

Results

Fear of being stung

Fear of injection was significantly associated with self-reported fear of being stung (Table 2, Supplementary Table 2). Insects with cues resembling injections (perceived as harmful) received significantly higher fear-of-being-stung scores than insects lacking these cues (perceived as harmless) (Fig. 1). The fear of being stung by truly stinging insects was significantly higher than oft for both harmless and harmful insects. However, the median values for harmful (median = 3.8) and stinging insects (median = 4.0) were very similar; although the difference was statistically significant, the effect size was negligible (Cohen's d = 0.058). In contrast, the differences between

	X ²	df	P
Gender	11.83	1	<0.001
Type of insect (harmless, harmful, stinging)	154.97	2	<0.001
Attractiveness	2.85	1	0.092
Disgust	57.71	1	<0.001
Fear of injection	4.61	1	0.032

Table 2. Results of the generalized linear mixed model (GLMM) predicting fear of being stung scores.

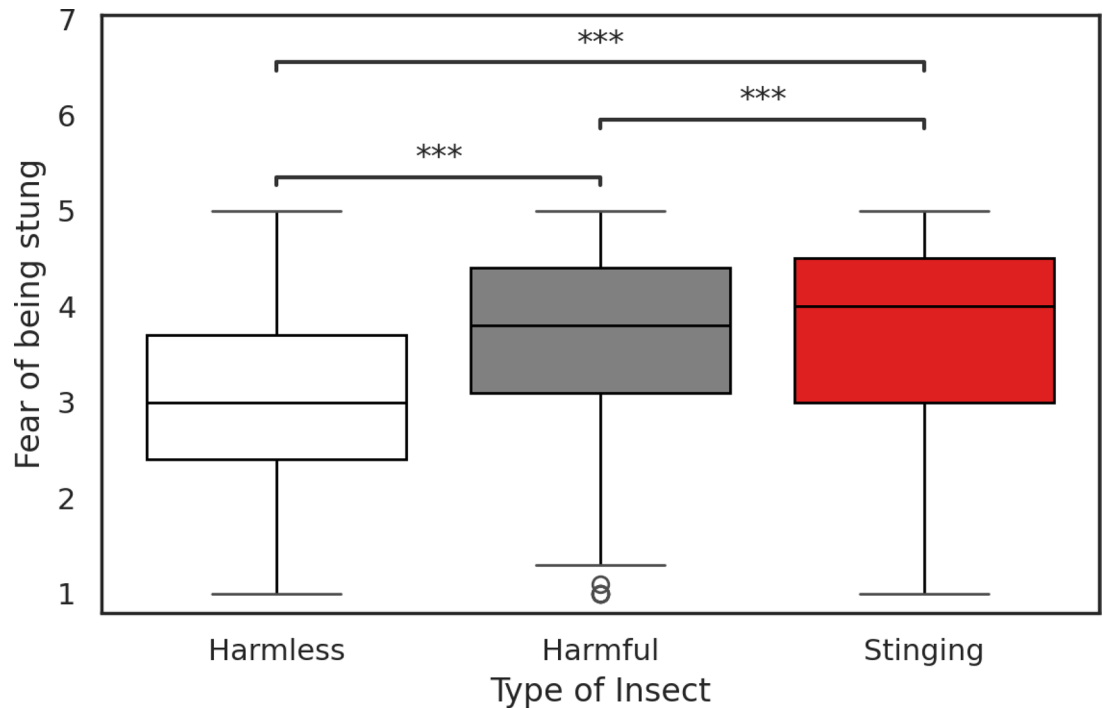


Fig. 1. Differences in fear of being stung with respect to type of insect. The box shows the interquartile range (IQR), the horizontal line is the median, whiskers extend to $1.5 \times$ IQR beyond the 1st and 3rd quartiles, and points beyond whiskers represent outliers. Asterisks indicate a significant difference ($***P < 0.001$).

harmless insects (median = 3.0) and both harmful (Cohen's $d = 0.700$) and stinging insects (Cohen's $d = 0.560$) reflected medium effect sizes.

Females reported significantly greater fear of being stung than males, and this effect was consistent across all the insect categories. Additionally, greater perceived disgust was positively associated with fear of being stung, whereas perceived attractiveness was negatively associated with it.

Willingness to protect insects

Type of insect did not influence the WTP (Fig. 2). Being female was associated with higher WTP regardless of the type of insect, indicating a main effect of gender without moderation by type of insect. Fear of being stung exhibited Simpson's paradox: while the mixed model coefficient initially suggested that higher fear increased WTP, analyses excluding fear of injection revealed the expected pattern, showing that greater fear of being stung decreased WTP. Excluding fear of being stung did not affect the significance of fear of injection; however, when fear of being stung was removed, fear of injection remained non-significant. Perceived disgust was negatively associated with WTP, whereas perceived attractiveness was positively associated with WTP (Table 3, Supplementary Table 3).

Insect attractiveness

Stinging insects were perceived as significantly more attractive than both harmful and harmless insects (Fig. 3). Perceived disgust negatively influenced insect attractiveness, whereas all other predictors were not significant (Table 4; Fig. 3, Supplementary Table 4). Excluding either fear variable did not alter the results.

Disgust of insects

Consistent with the previous model, attractive insects were perceived as significantly less disgusting than less attractive insects, confirming the strong bidirectional relationship between these two variables (Table 5,

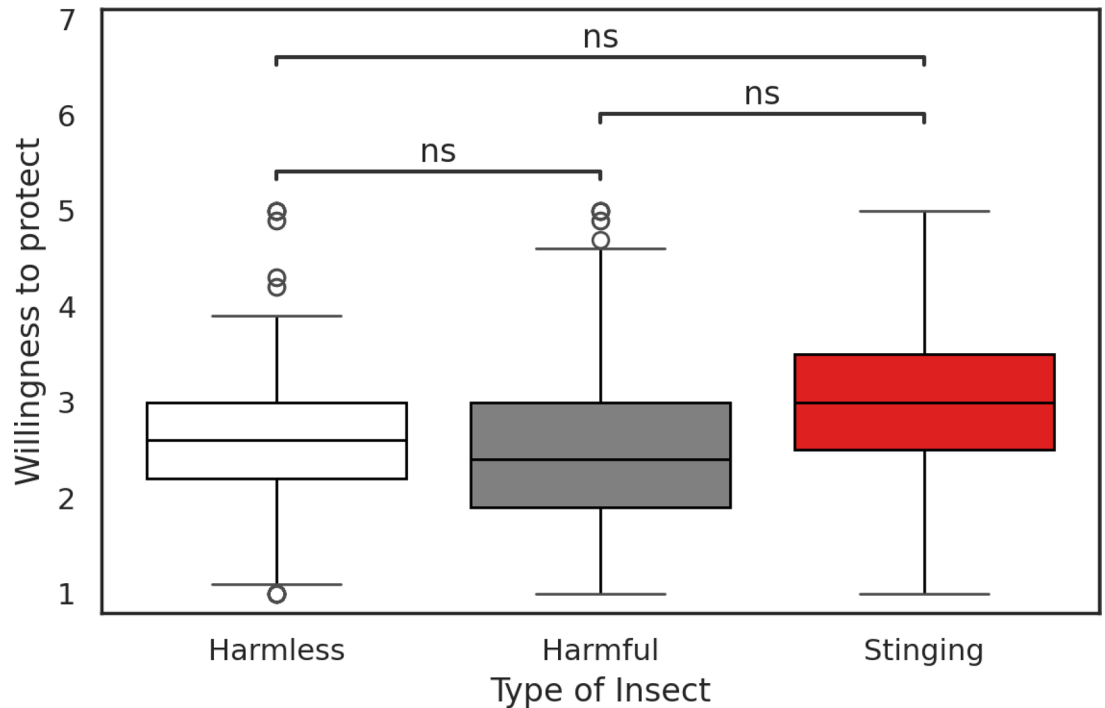


Fig. 2. Differences in WTP for insects with respect to type of insect. ns = not significantly different. For designations, see Fig. 1.

	F	df	df (res.)	P
Gender	38.483	1	1062	<0.001
Fear of being stung	23.959	1	1954	<0.001
Disgust	34.095	1	1846	<0.001
Fear of injection	1.461	1	1717	0.227
Attractiveness	117.853	1	1949	<0.001
Type of insect (harmless, harmful, stinging)	0.884	2	1952	0.413

Table 3. Results of the generalized linear mixed model (GLMM) predicting willingness to protect (WTP) scores.

Supplementary Table 5). Stinging insects were rated as less disgusting than both harmful and harmless insects (Fig. 4). A greater fear of being stung was associated with higher perceived disgust. Excluding either fear variable did not significantly alter the results of the study. Gender differences were not significant predictors of insect disgust.

Mediation effects of fear of injection on WTP

Because fear of injection was positively correlated with both fear of being stung and disgust, and these two variables negatively influenced WTP, we conducted mediation analyses to clarify these relationships (Fig. 5).

Mediation analysis revealed two significant pathways through which fear of injection influenced WTP. In the attractiveness pathway, fear of injection negatively predicted perceived attractiveness ($\beta = -0.094$, $P < 0.001$), which in turn positively predicted WTP ($\beta = 0.344$, $P < 0.001$), yielding an indirect effect of $\beta = -0.032$. In the disgust pathway, fear of injection positively predicted disgust ($\beta = 0.107$, $P < 0.001$), which negatively predicted WTP ($\beta = -0.167$, $P < 0.001$), resulting in an indirect effect of $\beta = -0.018$.

The total indirect effect was $\beta = -0.050$, with a direct effect of $\beta = -0.025$, resulting in a total effect of $\beta = -0.053$. These results indicate that the fear of injection reduces WTP primarily by decreasing perceived attractiveness and increasing disgust, with both pathways contributing to a significant negative mediation between fear of injection and WTP.

Discussion

We investigated the role of insect appendages resembling stings in shaping insect fear. Consistent with our hypotheses, the presence of such appendages contributed to the perceived fear of being stung. We also demonstrated that the fear of being stung indirectly influenced the willingness to protect (WTP) insects through

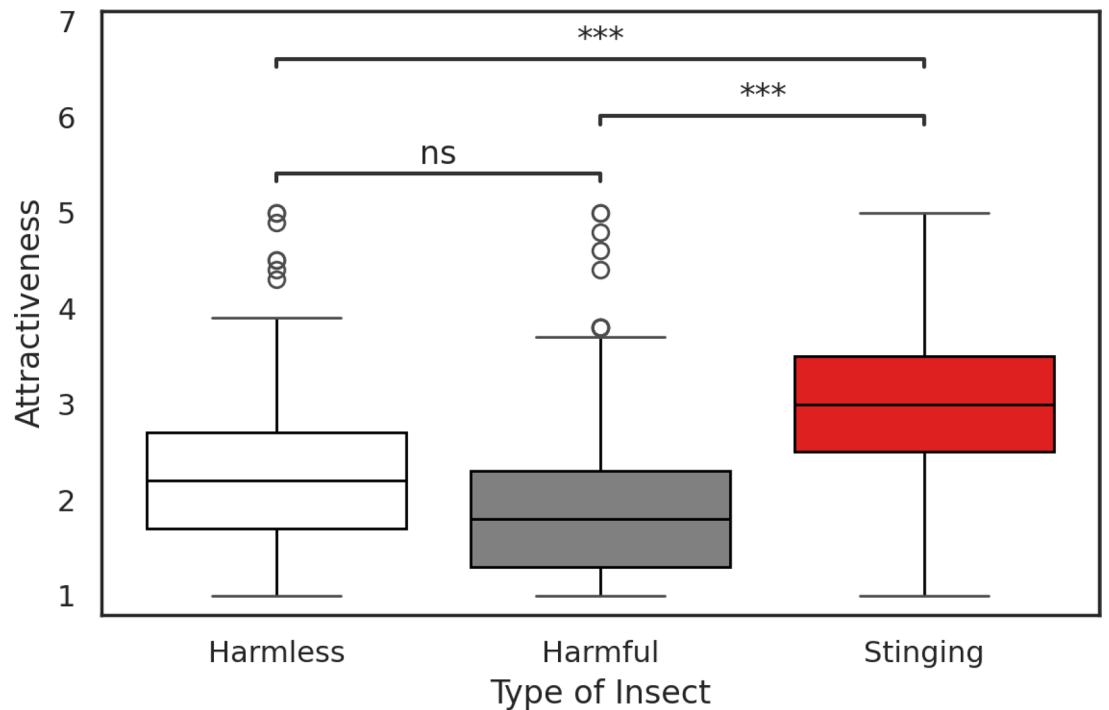


Fig. 3. Differences in insect attractiveness with respect to type of insect. Asterisks indicate a significant difference ($***P < 0.001$). ns = not significantly different. For designations, see.

	X ²	df	P
Gender	1.422	1	0.233
Type of insect (harmless, harmful, stinging)	32.726	2	<0.001
Disgust	160.218	1	<0.001
Fear of injection	0.798	1	0.372
Fear of being stung	2.33	1	0.127

Table 4. Results of the generalized linear mixed model (GLMM) predicting insect attractiveness scores.

	X ²	df	P
Gender	2.042	1	0.153
Type of insect (harmless, harmful, stinging)	12.372	2	0.002
Fear of being stung	36.065	1	<0.001
Attractiveness	140.564	1	<0.001
Fear of injection	0.131	1	0.718

Table 5. Results of the generalized linear mixed model (GLMM) predicting insect disgust scores.

perceived insect attractiveness and disgust. Additionally, being female was associated with greater fear of being stung and higher WTP.

Although dislike and neglect of insects are predominantly linked to disgust and disease avoidance^{36,38,47}, the mechanisms underlying fear of insects are less well understood⁵⁰. Our findings suggest that appendages resembling stingers contribute to the negative perception of insects. The evidence for this conclusion is threefold. First, insect species lacking visible sting-like appendages in the photographs received lower ratings of fear of being stung. This supports the speculation of Shipley and Bixler⁵⁴ that the dislike of ichneumon wasps, which possess a long but harmless ovipositor, may result from a mistaken belief that it is a stinger. Similarly, local respondents in Northeast India perceived the White Dragontail (*Lamproptera curius*), a butterfly with elongated hindwing “tails,” as harmful, poisonous, and frightening¹⁹. Second, the differences in fear of being stung between stinging and harmful-looking but harmless insects were negligible, whereas both these groups differed substantially from

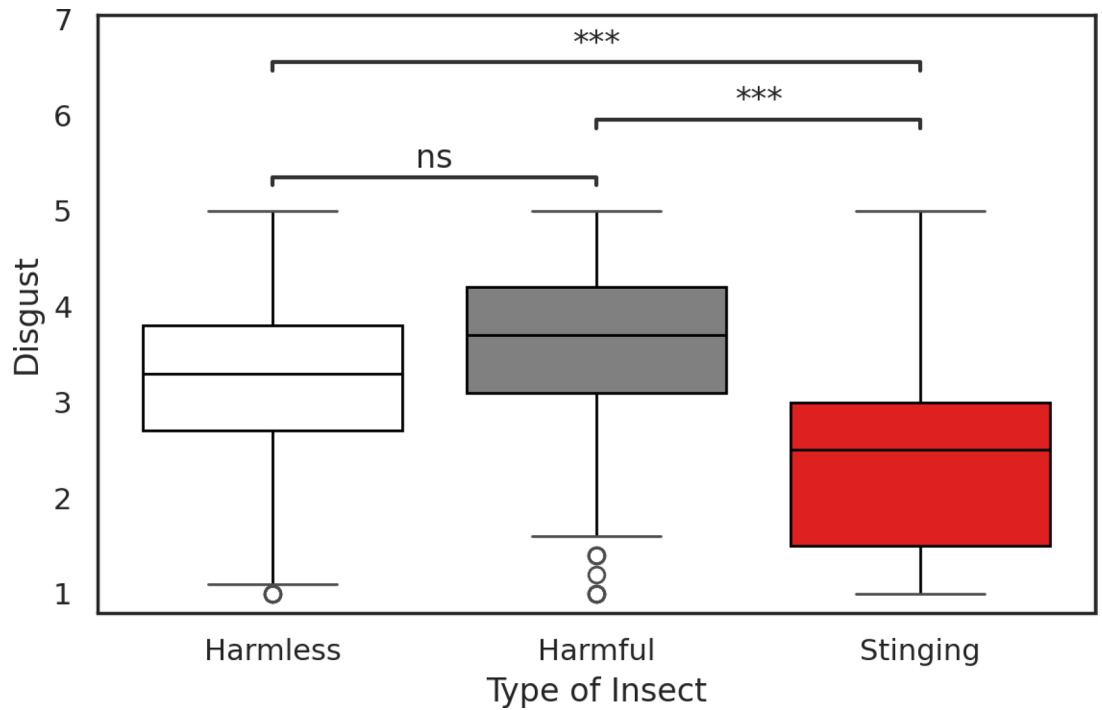


Fig. 4. Differences in insect disgust with respect to type of insect. Asterisks indicate a significant difference ($***p < 0.001$). ns = not significantly different. For designations, see Fig. 1.

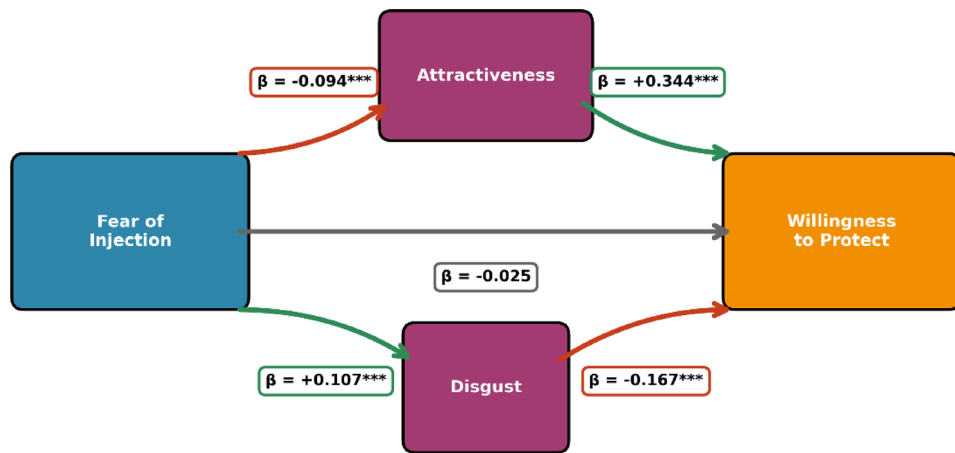


Fig. 5. Mediation model showing pathways from fear of injection to willingness to protect through attractiveness and disgust. Asterisks indicate a significant relationship ($***P < 0.001$).

harmless insects lacking visible appendages. Third, fear of injection was positively correlated with fear of being stung by insects, providing additional evidence for the proposed mechanism underlying this fear.

The positive correlation between fear of injections and fear of insect stings may reflect a shared sensitivity to general anxiety and fear of pain or injury⁵⁹. Both fears involve anticipating bodily harm from sharp objects (needles or stings) and elicit similar anxiety responses. Individuals with higher trait anxiety, defined as a behavioral tendency to perceive a wide range of harmless situations as threatening and respond with anxiety, are particularly susceptible to both fears due to a generalized sensitivity to perceived threats and anticipation of negative outcomes^{58,59}. Moreover, prior traumatic experiences with needles may further amplify the fear of insects, especially for species perceived as morphologically harmful. This expectation is supported by findings that individuals with prior bee sting experiences report a greater fear of bees^{33,34}. These interconnections warrant further investigation to clarify their underlying mechanisms.

Interestingly, there were no differences in WTP among the harmless, harmful, and stinging insects. One possible explanation for this pattern is the ambivalent perception of stinging insects, particularly bees, where the fear of being stung is offset by the perceived ecological benefits these species provide^{37,54,55}. Furthermore,

stinging insects were perceived as significantly more attractive and less disgusting than harmful or harmless insects, likely because of their conspicuous aposematic coloration²⁶ and the tendency for perceived beauty to outweigh negative associations with insects^{71–73}.

Importantly, both fear of being stung and disgust toward insects negatively and significantly influenced the WTP. The former finding suggests that insect morphology should be considered in conservation efforts. For example, plants with spines have a lower WTP than those without spines⁷⁴. This indicates that angular shapes associated with anger and aggression, and potentially resembling dangerous objects that influenced human survival throughout evolutionary history, such as teeth, claws, or horns⁷⁵ can negatively affect people's willingness to support conservation. This finding aligns with previous research demonstrating associations between disgust and unfavorable attitudes toward insects^{36,38,47}.

The inclusion of children and adolescents in our research warrants specific consideration, as childhood and adolescence are formative periods for the development of attitudes toward nature and animals^{64,76}. Research shows that fear of needles is most pronounced in children and typically decreases with age⁵⁸ and that negative early experiences with insects can shape lifelong attitudes⁷⁷. Therefore, a high sensitivity to needle-related fear could be a critical factor in the early formation of entomophobia and subsequent avoidance by insects. In addition, children are susceptible to adopting negative attitudes toward animals from parents⁷⁸ and the media, which often depict unrealistic portrayals that exacerbate fears and perpetuate a vicious cycle of biophobia⁷⁹. Consequently, early interventions in biology education may be critical in fostering positive attitudes in children towards living organisms.

The fear of being stung appears to be deeply rooted in human psychology. Although fear of injection—a correlate of fear of being stung—did not directly influence WTP for insects, it exhibited two important indirect effects: increased disgust and reduced perceived attractiveness of insects. This finding supports the notion that perceiving something as ugly or unpleasant may serve an adaptive function by helping humans avoid potential threats that could cause pain or injury^{10,42}. Collectively, these results provide indirect evidence that fear and disgust of invertebrates are correlated^{4,26,44}.

Regarding gender differences, females demonstrated a higher WTP for insects than males. This may seem counterintuitive, given that females are generally more fearful and sensitive to disgust than males⁶². However, females consistently exhibit greater willingness to support animal conservation^{30,63,71}, likely reflecting higher empathy and care toward animals^{80,81}, more positive animal welfare attitudes⁸², and more supportive attitudes toward conservation initiatives⁸³.

Our findings demonstrate that WTP for insects is influenced not only by the fear of being stung but also by broader, underlying vulnerabilities to threat perception, which can be triggered by specific morphological features, such as sting-like appendages. The indirect effect of fear of injections on perceived disgust and attractiveness further highlights the role of insect morphology in conservation strategies. Consequently, when selecting flagship species for campaigns targeting schools, tourists, or the general public, morphological traits—including the presence of sting-like appendages, large body size, and bright coloration—should be carefully considered to avoid inadvertently activating deep-seated threat perceptions.

Data availability

Data is provided within supplementary information files.

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Author contributions

P.P. designed the study, J.F. and ST performed the experiment, P.P. wrote the manuscript. P.P. performed statistical analyses, P.P. visualized the results, J.F. obtained funding for publication.

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Competing interests

The authors declare no competing interests.

Ethics declarations

This study was approved by the Institutional Review Board of Trnava University (Licence no. KEIV 02/2025). All methods were performed in accordance with the relevant guidelines and regulations, including the

Declaration of Helsinki. Informed consent was obtained from all participants involved in the study.

Additional information

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