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Beauty Bias? Exploring the Influence of Attractiveness on Conservation Intentions for Plants and Their Pollinators

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Abstract: Plants are an essential component of ecosystems; however, their significance is frequently underestimated, resulting in less effective conservation efforts. One approach to address plant blindness (PB) or plant awareness disparity (PAD) is to establish connections between plants and animals, as animals inherently attract more human attention. In this study, we employed an online questionnaire to manipulate visual materials featuring plant flowers alone, plant flowers accompanied by pollinators, and pollinators in isolation. We assessed participants' willingness to protect (WTP) and the perceived attractiveness of both plants and their pollinators. Our findings revealed that pollinators presented alone received higher WTP scores than plants. Moreover, the visual association between pollinators and plants enhanced WTP plants. Conversely, plants were consistently perceived as more attractive than pollinators, irrespective of whether the flowers were displayed alone or alongside pollinators. The perceived attractiveness of both plants and pollinators was significantly correlated with WTP. Notably, colourful pollinators such as *Selasphorus rufus*, *Vestiaria coccinea*, and *Danaus plexippus* positively influenced WTP plants, while the remaining five species (predominantly invertebrates) did not exhibit a similar effect. We propose that establishing a connection between visually appealing pollinators and plants can help mitigate PB/PAD. These pollinators should be utilised as umbrella species to enhance human attention and interest in pollination processes and plant biology.

Keywords: plant awareness disparity; plant blindness; attitudes toward plants; willingness to protect plants

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1. Introduction

Citizens play a crucial role in environmental conservation, natural resource management, and environmental protection [1]. Public participation in citizen science projects has proven effective in local monitoring efforts, particularly in tracking invasive species and informing control strategies [2,3]. Environmental education is fundamental in empowering citizens, with evidence linking awareness campaigns to behavioural shifts toward sustainable practices [4,5]. For instance, urban green initiatives, such as citizen-led tree-planting programs, contribute to improved ecosystem services and climate resilience in cities [6,7]. Moreover, collaborative governance models that include citizens in decision-making processes often lead to more equitable and effective environmental policies [8–10]. Thus, fostering citizen engagement in nature protection is not only a practical necessity but also a moral imperative for ensuring the sustainability of natural systems.

Living organisms, however, do not receive equal support from citizens when it comes to conservation. Citizens tend to prioritise animal conservation over plant conservation, as animals often evoke stronger emotional connections and are perceived as more charismatic [11]. This bias can lead to a "plant blindness" (PB) effect [12] or plant awareness disparity (PAD) [13]. Plant blindness, defined by Wandersee and Schussler [12] as "the inability to see or notice the plants in one's own environment" (p. 82), can result in significant issues, including a failure to recognise the ecological and societal importance of plants [14]. To address the ableist connotations of this term, Parsley [13] proposed plant awareness disparity, which emphasises that equating disability with negative traits is problematic. Parsley et al. [15] identified four dimensions of plant awareness disparity: attention, attitude, knowledge, and relative interest. Building on this, Pany et al. [16] introduced the concept of plant awareness (PA), which shifts the focus from a deficit-oriented view to a more positive perspective aimed at enhancing plant awareness. They suggested that both plant blindness and plant awareness disparity can be seen as manifestations of a lack of plant awareness, and they similarly categorised dimensions of plant awareness into attention, knowledge, attitudes, and the recognition of plants as living organisms.

People often greatly undervalue the ecological importance of plants [17,18], despite their foundational role in ecosystems. Consequently, conservation efforts frequently focus disproportionately on fauna, potentially neglecting critical threats to plant biodiversity and ecosystem services [19]. This bias extends to scientific research, where studies in major conservation journals prioritise animals over plants [20] and even botanists bias their research toward blue-coloured plants, irrespective of their conservation status [21]. To effectively address the urgent threats facing plant biodiversity, it is essential to raise public interest and awareness about plants, ensuring that conservation efforts include all living organisms.

The aesthetic appeal of living organisms plays a significant role in conservation efforts. Research indicates that both plants [22,23] and animals [24,25] perceived as beautiful elicit greater public interest and a higher willingness to support conservation initiatives. For example, the high aesthetic preferences for animals in zoos correlate strongly with their presence in conservation programs and visitors' willingness to provide financial support for their conservation, suggesting that beauty enhances the perceived value of species and influences conservation priorities [26,27]. Conversely, negative emotions such as fear and disgust can adversely affect conservation efforts for less aesthetically appealing species [28]. Research on the associations between aesthetic appeal and willingness to protect species is far more comprehensive for animals than for plants, calling for further investigation into the role of aesthetics in plant conservation efforts.

Attention bias toward animals stems from innate human preferences for moving stimuli, which animals provide [29–31], as well as a lack of direct interaction with plants in modern lifestyles [19,32–34]. Humans are better at detecting animals than plants when shown images in quick succession [35–37]. Research with university students showed better recall of animal names than plant names, even when the names were equally familiar and nameable [38]. Children in Sanders et al.'s [18] study frequently overlooked plants depicted in visual images, while animals received significantly more attention. Even when plants were mentioned, they were often cited simply as sources of food for animals, supporting the idea that plants are generally valued less than animals, which are perceived as superior in ecological importance. However, certain plant characteristics, such as flowers with vivid colours and/or pleasing scents, significantly enhance human attention and positive attitudes toward plants [23,39,40]. Stressed plants also seem to attract human attention; people were able to recognise water-stressed plants with wilted leaves presented with non-stressed plants with a similar accuracy to abused animals presented with non-abused animals [41]. Fostering human interest and curiosity in plants appears to be an effective strategy for reducing PAD/PA/PB [42], especially considering that the objects that attract the most attention within the visual field are those associated with positive attitudes [43].

Researchers have made several important attempts, which would be helpful in mitigating at least some of the four components of PAD [42–44]. For instance, integrating authentic plant-based research to undergraduate student's curriculum strongly influenced attitudes and knowledge domains of PAD [45]. Engagement in hands-on activities, such as gardening [46,47], and teacher-guided physical contact and dialogues about exceptional or medicinal plants [48] fostered a more intimate connection with plants. The Pet Plant Project, where students grew and monitored an unknown plant from seed, also resulted in the enhanced appreciation of plants in most students [49]. Integrating plant awareness into educational frameworks is essential for fostering a deeper connection with nature, ultimately contributing to the achievement of sustainability goals [17,50].

Brkovic et al. [42] emphasised that fostering a stronger attachment between people and plants should not rely predominantly on assessing knowledge about plants; it should also involve examining behavioural intentions, which serve as proxies for actual behaviours. The willingness to protect living organisms is a widely recognised behavioural intention that reflects an individual's commitment to environmental stewardship and biodiversity conservation [51].

Previous research has shown that both people's memory [37] and their interest in plants [52] increased when plants were presented alongside animals. However, concerning the latter, the visual presence of most animals that serve as pollinators largely did not enhance plant attractiveness or the willingness to protect (WTP) plants [52]. This finding may be attributed to the fact that most pollinators are insects, which are generally less popular among people than vertebrates [53–55]. However, the perceived attractiveness of pollinators has not yet been considered. This issue is crucial, given that perceived attractiveness supports WTP living organisms [24,25,27,28,51,56,57]. In this study, we investigated how the perceived attractiveness of pollinators influences the willingness to protect plants and pollinators by experimentally manipulating the presence of pollinators near flowers using visual materials.

2. Materials and Methods

2.1. Participants and Procedure

The research, conducted online between November 2023 and January 2024 using an online questionnaire, involved participants recruited through the university's website in Trnava, Slovakia. A total of 251 volunteer respondents participated, with a majority being women (N = 206, 82%). The ages of the respondents ranged from 11 to 54 years, with a mean age of 25 years (SE = 0.51). Median age was 23. The percentage representation of age cohorts was as follows: 28% (age category 11–20, 76% female), 52% (age category 21–30, 84% female), 14% (age category 31–40, 89% female), and 6% (age category 41–54, 80% female). Our goal was to gather data from participants across diverse age groups. To achieve this, the questionnaire was distributed via the university's webpage and through social networks, inviting all potential participants regardless of age, sex, or education level to complete it. To reach younger participants, the questionnaire was also sent to six science teachers at various primary and secondary schools, who were asked to share it with their students. Importantly, the respondents were not informed about the research hypotheses.

2.2. Description of Research Tool

The research tool utilised was an online questionnaire created using the Google Forms application. This questionnaire was divided into two main sections. The first section served as an introduction, familiarizing participants with our intention to collect data on human preferences for living organisms. Participants began by providing informed consent and answering basic demographic questions, such as sex and age. The second section focused on gathering data regarding the attractiveness of and willingness to protect various organisms: plants presented alone, pollinators presented alone, and plants in the presence of pollinators. This section included 24 photos sourced from Google, with sixteen of these images previously used in different research [52]. The photos were displayed in random order to minimise bias. The photos were randomised during the development of the questionnaire. However, Google Forms does not provide a built-in feature for randomizing question order during administration. Therefore, the randomised order was fixed at the time of questionnaire creation and remained consistent for all participants who accessed the survey. This means that while each participant viewed the images in a predetermined random order, there was no further randomisation applied during their individual sessions. Below each image, participants were asked two questions related to attractiveness and willingness to protect (WTP) the depicted plants and pollinators. The syntax of each question was crafted to be clear and concise, minimizing ambiguity. Therefore, we utilised straightforward language and avoided jargon to ensure comprehension across diverse demographic groups. Prior to administering the questionnaire, we asked a sample of six science teachers to assess the clarity and relevance of the questions as well as their ability to capture the intended constructs of attractiveness and WTP. Feedback from teachers was analysed to refine the questions further. To assess self-perceived attractiveness, participants responded to the following questions: "How do you like the plant in the picture?" and "How do you like the animal in the picture?" WTP was evaluated through the following questions: "Do you think this plant should be protected by law?" and "Do you think this animal should be protected by law?" Respondents rated their answers using a five-point Likert scale: for attractiveness ratings, options ranged from "I don't like it at all" to "I like it extremely"; for WTP ratings, options ranged from "definitely not" to "definitely yes".

2.3. Selection of Images for the Questionnaire

In assessing the attractiveness and willingness to protect plants presented alone and in the presence of pollinators, we selected eight plants, eight pollinators, and eight images depicting pollinators alongside plants. The pollinators included both vertebrates and invertebrates, with a complete list of species provided in Table 1. We predominantly used non-native species for two reasons: first, to avoid any confounding effects related to familiarity with the species; second, because Slovakia lacks vertebrate pollinators, such as bats or birds. Our study aimed to use an unrestricted list of potential pollinators, not limited to insects alone. When choosing the photos, we ensured that the pollinator was positioned similarly and at the correct angle in images where it appeared with a specific plant. However, we found that the backgrounds in some photos were distracting and did not match those of the images featuring plants with pollinators. To address this issue, we used free software from Photoroom (https://www.photoroom.com) accessed on 2 October 2023 to remove the distracting backgrounds. In the modified images, we retained only the branches on which the animals were standing. These edited images were then incorporated into the questionnaire.

Table 1. List of plants and pollinators used in the questionnaire. Native species are marked with "n".

	Species Name	Tree/Shrub/Herbaceous	Described by
Plants alone	Hybrid Fuchsia (*Fuchsia hybrida*)	Shrub	Ch. Plumier, 1696–1697
	Gray's Lobelia (*Lobelia grayana*)	Shrub	E. Wimm., 1948
	Durian nyekak (*Durio kutejensis*)	Tree	G. de Orta, 1563
	Candlestick Banksia (*Banksia attenuata*)	Tree	R. Brown, 1810
	Common yarrow (*Achillea millefolium*) ^{n}	Herbaceous	C. Linné, 1753
	Wall hawkweed (*Hieracium murorum*) ^{n}	Herbaceous	J. Loudon, 1829
	Purple coneflower (*Echinacea purpurea*)	Herbaceous	C. Moench, 1794
	Wood cranesbill (*Geranium sylvaticum*) ^{n}	Herbaceous	W. Withering, 1796
		Invertebrate/Vertebrate	
Pollinators alone	Rufous hummingbird (*Selasphorus rufus*)	Vertebrate	J. F. Gmenil, 1788
	Scarlet honeycreeper (*Vestiaria coccinea*)	Vertebrate	G. Forster, 1780
	Cave nectar bat (*Eonycteris spelaea*)	Vertebrate	G. E. Dobson, 1871
	Honey possum (*Tarsipes rostratus*)	Vertebrate	P. Gervais & J. Verreaux, 1842
	Bee-eating beetle (*Trichodes apiarius*) ^{n}	Invertebrate	C. Linné, 1758
	Summer butterbur blacket (*Cheilosia canicularis*) ^{n}	Invertebrate	G. W. F. Panzer, 1801
	Monarch butterfly (*Danaus plexippus*)	Invertebrate	C. Linné, 1758
	Honey bee (*Apis mellifera*) ^{n}	Invertebrate	C. Linné, 1758
Plants with Pollinators	Hybrid Fuchsia/Rufous hummingbird	-	-
	Gray's Lobelia/Scarlet honeycreeper	-	-
	Durian nyekak/Cave nectar bat	-	-
	Candlestick Banksia/Honey possum	-	-
	Common yarrow/Bee-eating beetle	-	-
	Wall hawkweed/Summer butterbur blacket	-	-
	Purple coneflower/Monarch butterfly	-	-
	Wood cranesbill/Honey bee	-	-

2.4. Statistical Analyses

Two Generalised Linear Mixed Models (GLMMs) were employed. In the first GLMM examining the influence of Species display arrangement (SDA) (plant alone, pollinator alone, plant presented together with pollinator), sex and participant age on WTP plants and pollinators, the WTP was defined as an ordinal dependent variable. Categorical predictors were the effect of SDA and sex. Scores of attractiveness (plant alone, plant with a pollinator, and pollinator) and age were defined as continuous predictors. We defined attractiveness and age as continuous predictors due to their significant role in influencing conservation attitudes. Research indicates that the aesthetic appeal of living organisms elicits greater public interest and greater willingness to support conservation initiatives [23,25]. Additionally, Fančovičová et al. [23] reported a negative correlation between the age of the participants and their willingness to protect the plants, suggesting that age may influence WTP. ID of participant (N = 251) was treated as the random effect. Simple correlations (Pearson) between plant attractiveness presented alone and WTP plants presented alone and between pollinator attractiveness presented alone and WTP pollinators presented alone were examined with summed attractiveness and WTP data per each participant. These data achieved normality after Box–Cox transformation. The optimal lambda values obtained for our variables are as follows: Attractiveness of pollinators: λ = 0.85; Attractiveness of plants: λ = 1.79; WTP pollinators: λ = 1.34; WTP plants: λ = 0.76. The application of these transformations significantly improved the normality of the data distributions, as assessed by Shapiro–Wilk test. A subsample of attractiveness and willingness to protect (WTP), treated as ordinal dependent variables, was analysed using an additional GLMM. In this model, herbaceous plants were compared to trees (pooled with shrubs) as a categorical predictor, with participant ID included as a random effect. In the second GLMM, we examined the influence of SDA (plant alone, pollinator alone, plant presented together with pollinator), sex, and participant age on perceived attractiveness of plants and pollinators (ordinal dependent variable). WTP was not included in this model because attractiveness is assumed to influence WTP but not vice versa. ID of participant (N = 251) was treated as the random effect. Differences between SDA were performed with Bonferroni post-hoc test. Differences in WTP and perceived attractiveness between species were performed with series of GLMMs (WTP plant, plant attractiveness, WTP pollinators, pollinator attractiveness), where WTP or attractiveness were defined as ordinal dependent variables, species (plant or pollinator) was defined as categorical predictor, and ID of participant was treated as the random effect. Participant age and sex were not included in these analyses, because previously described analyses showed that their influence on WTP/attractiveness is small. Data from pictures showing both pollinators and plants together were not included in these analyses. All statistical tests were performed with the jamovi project (2024) [58].

3. Results

3.1. Factors Influencing WTP Plants and Pollinators

WTP plants and pollinators was significantly influenced by the SDA (Table 2, Figure 1). Participants demonstrated a greater willingness to protect pollinators than plants, regardless of whether the plants were presented alone or alongside a pollinator. Plants presented alone received the lowest WTP scores. The attractiveness of both plants and pollinators, defined as a continuous predictor, was significantly correlated with WTP for both groups (estimate = 1.08). Notably, a significant interaction between variables indicated that female participants exhibited a higher WTP pollinators than male participants. However, the effects of age (estimate = -0.01) and sex were not significant (Table 2).

Simple correlations showed that there was a significant positive correlation between the attractiveness of plants and the WTP plants (r = 0.58, $p < 0.001$) as well as between the attractiveness of pollinators and the WTP pollinators (r = 0.65, $p < 0.001$).

Table 2. GLMM on willingness to protect (WTP) plants and pollinators.

	X^2	df	*p*
Attractiveness	1553.895	1.00	< 0.001
Age	0.864	1.00	0.353
SDA	121.458	2.00	< 0.001
Sex	1.612	1.00	0.204
SDA × Sex	9.378	2.00	0.009

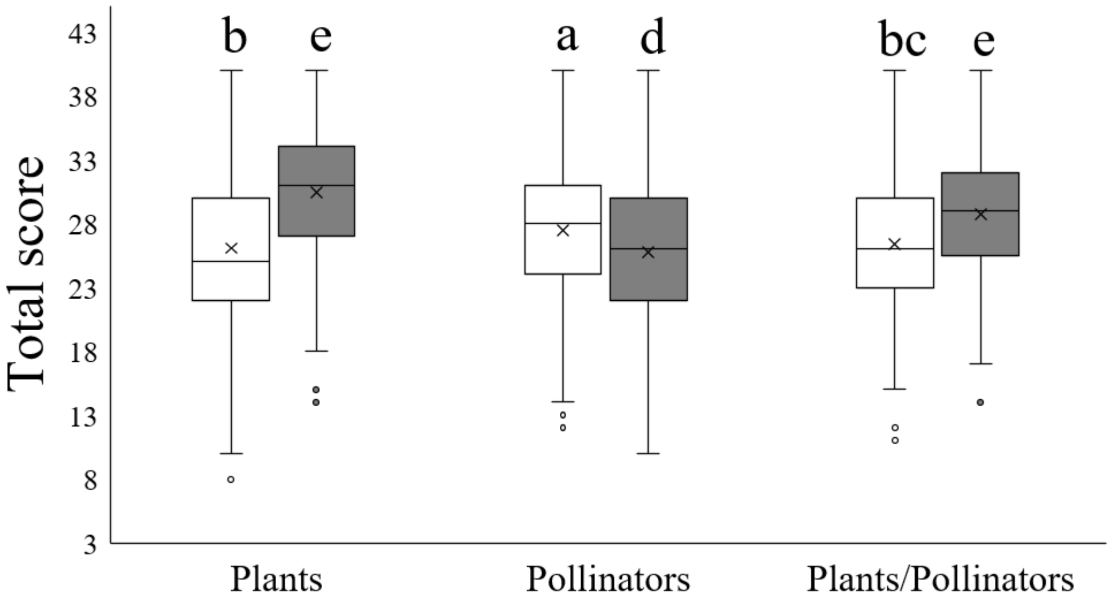

Figure 1. Differences in WTP (open boxes) and perceived attractiveness (grey boxes) with respect to SDA. Box plots represent medians (line), means (asterisk), 1st and 3rd quartile, and minimum and maximum values. Dots are outliers. The letters denote significant differences (WTP: a vs. b, $p < 0.001$, a vs. bc, $p < 0.001$, b vs. bc, $p = 0.04$; attractiveness: d vs. e, $p < 0.001$, e vs. e, $p = 0.93$).

3.2. Factors Influencing Perceived Attractiveness of Plants and Pollinators

The effect of SDA significantly influenced the perceived attractiveness of plants and pollinators (Table 3). Pollinators were perceived as least attractive compared with plants. Plants were similarly attractive regardless of whether presented alone or with pollinators (Figure 1).

Table 3. GLMM on perceived attractiveness of plants and pollinators.

	χ^2	df	p
SDA	50.706	2.00	< 0.001
Sex	0.049	1.00	0.826
Age	0.283	1.00	0.595

3.3. Differences in WTP and Attractiveness Between Plants

Differences in WTP plants and their attractiveness were significant (GLMM, $\chi^2 = 203$ and 484, df = 7, both $p < 0.001$, respectively). All species received lower WTP scores than perceived attractiveness scores (Figure 2). Fuchsia received the highest WTP/attractiveness scores, while banksia was perceived as the least attractive.

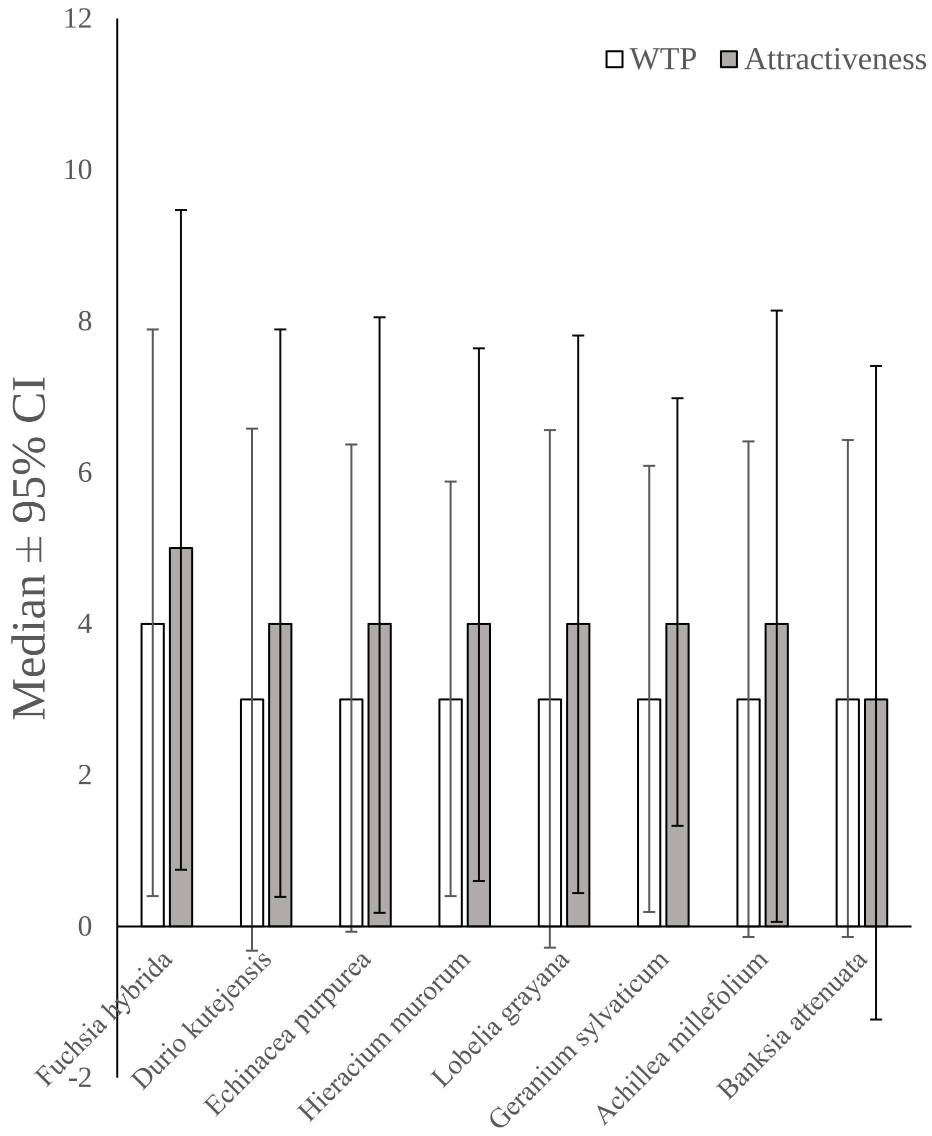

Figure 2. Descriptive statistics of plants' WTP and attractiveness scores.

3.4. Differences in WTP and Attractiveness Between Pollinators

Differences in WTP pollinators and their attractiveness were significant (GLMM, $\chi^2 = 580$ and 553, df = 7, both $p < 0.001$, respectively). In contrast to plants, WTP scores were never smaller than the perceived attractiveness scores. *C. canicularis*, *T. rostratus*, and *T. apiarius* received lower WTP/attractiveness scores than other species (Figure 3). Additional GLMMs with the invertebrate/vertebrate pollinator defined as a categorical predictor instead of the pollinator species showed that plants presented with vertebrate pollinators received significantly higher WTP and attractiveness scores than plants with invertebrate pollinators ($\chi^2 = 20$ and 15.7, df = 1, both $p < 0.001$, respectively).

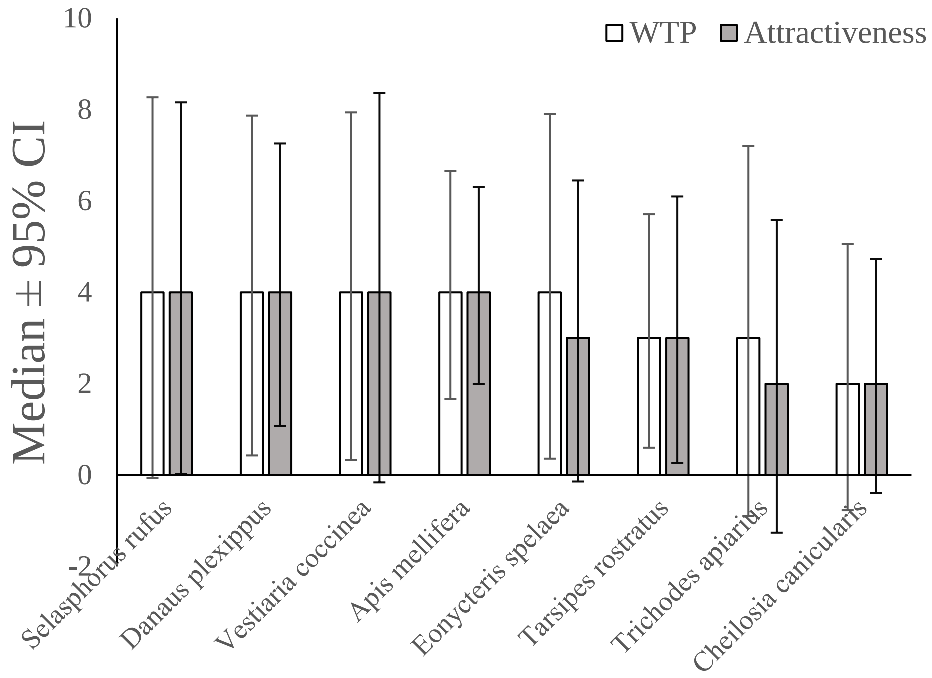

Figure 3. Descriptive statistics of pollinators' WTP and attractiveness scores.

3.5. Differences in WTP and Attractiveness Between Plants Presented with Pollinators

Differences in WTP and the attractiveness of plants presented with pollinators were significant (GLMM, $\chi^2 = 257$ and 336, df = 7, both $p < 0.001$, respectively). Plants associated with two of four vertebrates (fuchsia with *S. rufus*, durian with *E. spelaea*) received higher WTP scores than plants with remaining vertebrates (*L. grayana* with *Vestiaria coccinea* and *B. attenuata* with *T. rostratus*) and plants associated with invertebrates (Figure 4). An additional GLMM analysis was conducted using invertebrate versus vertebrate pollinators as a categorical predictor instead of individual pollinator species. The results showed that plants associated with vertebrate pollinators received significantly higher WTP scores ($\chi^2 = 90$, df = 1, $p < 0.001$). However, the attractiveness scores were not affected by the animal class ($\chi^2 = 0.253$, df = 1, $p = 0.61$).

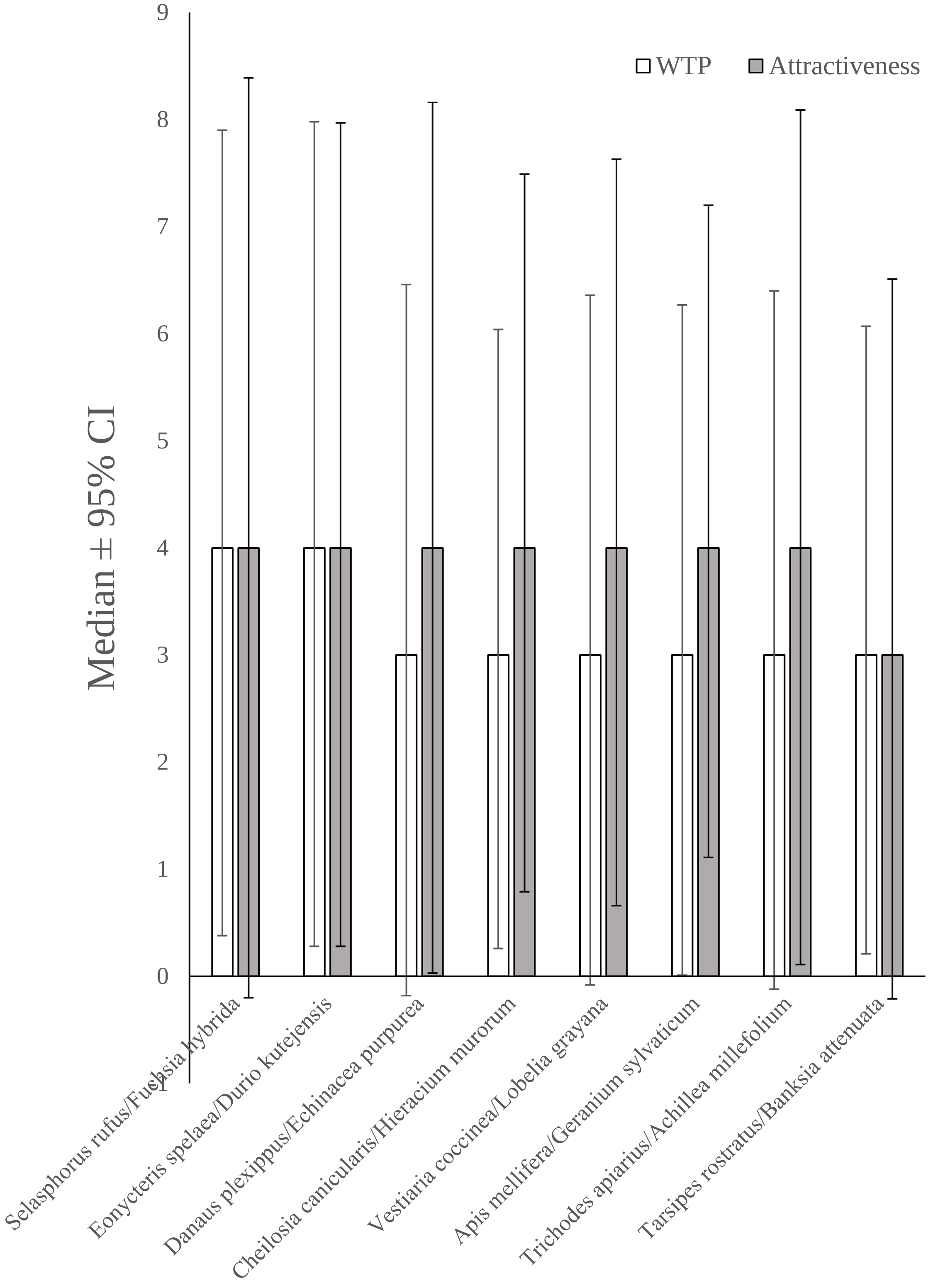

Figure 4. Descriptive statistics of WTP and attractiveness scores of plants presented with pollinators.

3.6. Differences in WTP and Attractiveness Between Herbaceous Plants and Trees

Herbaceous plants were perceived as more attractive (median = 4, 95% CI [3.90, 4.01]) than trees (median = 4, 95% CI [3.58, 3.73]) (GLMM, $\chi^2 = 29.7$, df = 1, $p < 0.001$). In contrast, WTP herbaceous plants was significantly lower (median = 3, 95% CI [3.06, 3.20]) compared to the WTP trees (median = 3, 95% CI [3.32, 3.46]) (GLMM, $\chi^2 = 40.1$, df = 1, $p < 0.001$).

4. Discussion

We demonstrated that the WTP plants and animals differs, with pollinators significantly influencing the WTP plants, but not their attractiveness. Additionally, there were notable differences in WTP and perceived attractiveness between various plant and pollinator species.

Our primary research question was whether the presence of pollinators on flowers influences the willingness to protect plants, given that animals are generally perceived as more attractive than plants [29,30]. Additionally, we aimed to determine whether pollinators' presence affects plants' perceived attractiveness, as perceived attractiveness is known to support the WTP living organisms [24,25]. Our findings indicate that the presence of pollinators on flowers significantly contributes to WTP plants; however, this effect appears to be limited to a few specific species of pollinators. Pollinators received higher WTP scores than plants presented alone or when plants were shown alongside pollinators. Paradoxically, despite the attractiveness scores of plants being higher than those of pollinators, participants exhibited lower WTP plants than pollinators.

Contrary to our expectations, pollinators did not enhance the perceived attractiveness of plants. Research showed that the perceived attractiveness and WTP are correlated [24,25,52,56,57]. However, the correlations between attractiveness and WTP, when assessed separately for plants and pollinators, suggest that attractiveness is more closely associated with WTP in the case of pollinators than in plants. Pollinators attract greater attention from participants, supporting the superiority of animals over plants [19,29,30]. These findings reinforce that human visual attention has evolved to prioritise animate stimuli due to ancestral survival needs, such as predator avoidance and prey detection. In contrast, inanimate stimuli—referring to motionless objects such as plants—are not prioritised by humans [59].

Herbaceous plants were rated higher for attractiveness but received lower WTP scores compared to trees and shrubs. Some researchers suggest that trees possess characteristics that make them easier to identify, leading to greater public familiarity with them than with herbs [60]. While it is possible that better knowledge motivates people to prioritise the protection of trees over herbs, it is unclear whether participants could discern whether they were viewing a tree or herb based on images predominantly showing flowers. If they could, we propose that admiration—an unconscious response to large objects, including trees—may underlie the higher WTP scores for trees [61].

Although the overall influence of pollinators on plants was found to be significant, only a limited number of pollinator species should be considered. Comparisons of the median WTP scores for plants with and without pollinators revealed that three vertebrate pollinators (*S. rufus*, *V. coccinea*, *E. spelaea*) and one invertebrate pollinator (*D. plexippus*) positively contributed to the WTP plants. Notably, in independent research, *V. coccinea* and *E. spelaea* also positively influenced the WTP plants [52], suggesting that their impact on WTP is not incidental. Vertebrates, being phylogenetically closer to humans, are generally perceived as more appealing than invertebrates [62], which may explain why vertebrate pollinators enhanced WTP scores for plants more than their invertebrate counterparts. These findings highlight the need to focus on specific pollinator species when assessing their impact on plant conservation efforts. Conservation strategies can be tailored to enhance public engagement and support for plant protection initiatives by understanding which pollinators significantly influence WTP.

The mean attractiveness scores of plants were generally high; however, their WTP scores consistently remained lower. To enhance the WTP plants through visual cues of pollinator–plant interactions, it is essential to improve the perceived attractiveness of pollinators. Our data indicated that certain species were perceived as less attractive—specifically, some insects (*C. canicularis*, *T. apiarius*) and small mammals (*T. rostratus*). It would be misguided to exclude these species from environmental education activities; instead, we should utilise more attractive species as umbrella species to enhance the appeal of other pollinators. It is evident that highly colourful species such as *S. rufus*, *V. coccinea*, and *D. plexippus* naturally attract human attention. However, if relatively dull species like *A. mellifera* are also found to be attractive to humans, this suggests that factors beyond mere colouration contribute to their appeal [63]. To effectively increase the understanding of pollination processes and plant signalling, which ultimately enhances pollination success, educational programmes must incorporate physical experiences and a deeper exploration of these concepts. Doing so can foster a greater appreciation for pollinators and plants, thereby improving conservation efforts.

Most research indicates a tendency for greater appreciation of plant sciences among females [64]. However, several studies have found no significant differences between genders in areas such as factual knowledge about plants [47,64,65], interest in plants [30,66], and attitudes toward plants [67]. Similarly, the present study did not reveal robust differences between males and females in the aesthetic appreciation of plants, except for a higher WTP pollinators among females. This finding is surprising, considering that females generally show a lower preference for less popular animals compared to males [30]. Research suggests that females are often more inclined to protect nature, demonstrating higher levels of environmental concern and pro-environmental behaviours. For instance, studies have shown that women exhibit stronger pro-environmental attitudes and intentions than men [68]. This tendency may stem from traditional socialisation processes that encourage caregiving and nurturing roles among females, fostering a deeper connection to nature and environmental stewardship [69].

The results of our research are primarily useful for the development of biology curricula, specifically in creating illustrations for textbooks and workbooks that depict the reproductive organs of plants. Lower secondary school students (ages 10–11) in Slovakia are expected to understand the biology and functions of plant reproductive organs. They should be able to identify basic flowering plant species found in various ecosystems, such as meadows and forests, and comprehend the role of pollinators in maintaining plant diversity. These topics are further explored in the sixth grade, where students learn about the dependency of entomophilous plants on their pollinators and the significance of pollinators in agricultural plant production. They also study the detailed structure of plant flowers, and the processes involved in pollination. In grades 8 and 9, students delve into anthropogenic impacts on biodiversity and biological balance, examining organisms that thrive in urban environments and the co-evolutionary processes between plants and their pollinators. Consequently, lower secondary school biology explicitly requires an understanding of animal–plant interactions, which necessitates visual materials that depict these fascinating biological processes. However, it remains unclear whether existing visual materials in biology textbooks adequately represent the relationship between pollinators and plants. Research indicates that photographs of plants are less numerous and diverse than those of animals [70]. Therefore, integrating images of both plants and their pollinators can help bridge the gap between the often-overlooked importance of plants and the frequently emphasised role of animals. To enhance educational programs at various levels—primary, secondary, and even tertiary education—we recommend incorporating visually engaging materials that illustrate these associations. For instance, primary school curricula could include activities that allow children to explore local ecosystems, observe pollinators in action, and understand their vital role in plant reproduction. This experiential learning approach fosters a deeper appreciation for biodiversity from an early age. At the secondary level, educators could implement project-based learning methodologies where students investigate local plant–pollinator interactions through field studies or citizen science projects. Such hands-on experiences not only enrich students' understanding but also encourage critical thinking about ecological relationships. Moreover, integrating findings from previous research on effective visual learning strategies can further support these recommendations. Studies have shown that visually appealing materials enhance student engagement and retention of information [71]. By aligning our educational resources with these insights, we can create a more comprehensive biology curriculum that emphasises the interconnectedness of life forms.

Given that our research was conducted in Slovakia, we recognise that applying our findings requires consideration of regional differences. For example, not all visually appealing pollinators are present or equally recognisable across all areas. Species such as the Rufous hummingbird and Scarlet honeycreeper are limited to specific geographic regions. Cultural differences may influence perceptions of beauty [72] and the importance of pollinators among different populations [73], potentially limiting the appeal of certain species in diverse regions. Less conspicuous species, like the Summer butterbur blacket, may be less familiar or understood compared to globally recognised pollinators such as the Monarch butterfly. Additionally, certain pollinators, like the Cave nectar bat, may face negative perceptions in some regions due to traditional myths or cultural beliefs [74]. Science educators should design activities that ensure charismatic species, such as birds or large butterflies, do not overshadow less visually appealing yet equally important pollinators, like beetles or flies. By striking this balance, educational programs can foster a more inclusive and accurate understanding of pollinator diversity and its ecological significance.

In our study, we opted to use certain exotic, unfamiliar species to mitigate familiarity bias among participants, which could influence their responses regarding the attractiveness and willingness to protect various organisms. We acknowledge that employing unfamiliar species may not elicit the same natural responses from participants as native species would. This discrepancy can affect the generalisability of our findings to real-world contexts, where participants primarily interact with native flora and fauna. Societal attitudes toward non-native species often exhibit bias, as reflected in differing preferences and willingness to protect (WTP), since emotional and cultural connections with native species may differ from those associated with non-native species [24,25]. However, species such as Hybrid Fuchsia and Purple Coneflower are frequently grown in gardens, which may help bridge the gap in eliciting natural responses despite their non-native status. Therefore, we encourage future research to explore participant responses to both native and non-native species to better understand how familiarity influences perceptions across different contexts.

Our study clearly shows that certain pollinators significantly enhance the WTP plants; others may not contribute positively to this perception. Visually appealing species, such as *S. rufus* and *D. plexippus*, or species with similar appearance, can be used as umbrella species in conservation messaging to attract public interest. By cultivating a deeper understanding of pollination processes and plant signalling through experiential learning [71], we can cultivate greater appreciation for both pollinators and plants among local communities. For example, community-driven citizen science projects that emphasise the beauty and ecological roles of these pollinators can enhance social cohesion and promote sustainable practices. Contextualisation of the role of plants and pollinators in ecological services in local ecosystems can enhance students' critical thinking about ecological relationships while promoting pro-environmental behaviours [75]. For example, by creating pollinator gardens with plants known to attract these species, we can empower communities to take active roles in conservation efforts. Although an individual's capacity to conserve pollinators may seem small, their actions in private spaces, such as gardens, allotments, and areas where they work or volunteer, can have a significant impact [76]. Furthermore, their perceptions influence the management of public spaces, which collectively cover vast areas with substantial potential to support pollinators. Furthermore, educating people about the benefits of reduced mowing, leaving certain areas unmown, and creating patches of bare ground for ground-nesting bees can further promote plant and pollinator diversity, ultimately benefiting both the ecosystem and local communities [77].

Limitation

The age range of our sample was notably broad, with a mean age of 25; however, it is important to recognise that the distribution is skewed towards younger participants. Specifically, the older age groups were underrepresented, with only 6% of the participants falling into the 41–54 age category. This limitation restricts our ability to generalise findings across all age cohorts and may result in a biased understanding of plant and animal knowledge among different demographic groups. Fančovičová et al. [23] reported a negative correlation between the WTP plants and the age of the participants, while this study did not show associations between age and the WTP plants. One possible reason for the failure to replicate previous results could be the skewed age distribution of the participants. Another possibility is that the plant species used in Fančovičová et al. [23] were very different from those in the present research. We propose that the latter explanation is more likely, since Prokop and Fančovičová [52], using identical species of plants, did not show correlations between WTP and age.

It is important to note that the sample in this study was biased, with a significant overrepresentation of female respondents (82% of total participants). Therefore, while the results suggest no strong differences related to gender, they should be interpreted with caution until further research includes a more balanced sample.

5. Conclusions

In conclusion, the willingness to protect plants, and ultimately, the issues of plant blindness and plant awareness disparity [12,13], can be partly improved by visually connecting plants with their pollinators. However, the attractiveness of pollinators, which appears to be crucial for enhancing the willingness to protect plants, varies significantly. Only certain species, particularly colourful vertebrates and butterflies, are effective candidates for this enhancement. Utilising attractive pollinators as umbrella species in botany education can increase student interest in botany and human awareness of insect pollinators. These insects are often overlooked yet play a vital role in the functioning of ecosystems on our planet. By initially focusing educational efforts on visually appealing pollinators, we can foster a greater appreciation for their ecological importance and encourage conservation efforts. This approach serves as a crucial first step, creating an opportunity to engage students and the public with less visually appealing yet equally vital species within ecosystems. This "umbrella effect" can help broaden awareness and support for the conservation of all organisms that contribute to ecological balance.

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