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ORIGINAL PAPER

Perceptions of undergraduate students on ladybugs and social wasps in ecosystems

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Abstract
Beneficial insects play a vital role in agricultural food production by providing essential ecosystem services. While bees and butterflies are widely recognized as key pollinators, the roles of other beneficial insects, such as ladybugs and social wasps, remain underappreciated. In Cambodia, little is known about students' perceptions of these insects and their ecological functions. To address this gap, we conducted an online survey to assess how Cambodian undergraduate students perceive ladybugs and social wasps. Our findings revealed that students rated ladybugs and social wasps as moderately beneficial compared to other study animals. Bees and butterflies were regarded as the most beneficial insects, whereas ants and spiders were considered the least beneficial. Ladybugs were more accepted in shared habitats than social wasps, as students expressed more positive emotions toward ladybugs. This preference is likely due to ladybugs' ecological contributions and appealing appearance. Despite demonstrating a good understanding of social wasps' ecological roles, students were less willing to share habitats with them, primarily due to fear. These results suggest that enhancing public education, promoting citizen science, and increasing media exposure about beneficial insects could improve perceptions and support conservation efforts for these ecologically important species.

Keywords Perspective · University students · Predators · Biophilia · Biophobia · Beneficial insects

Introduction

Each species within an ecosystem plays a vital role, whether its contribution is immediately apparent or subtle. Insects, incredibly diverse and deeply integrated into Earth's ecosystems, play vital roles ranging from pollination and decomposition to acting as disease vectors (Verma et al. 2023). The ecosystem services provided by insects, such as pollination, biological control, organic matter recycling, carbon sequestration, and water filtration, contribute significantly to achieving the Sustainable Development Goals (Dangles and Casas 2019). The society increasingly recognizes the essential roles of honey bees in food security and environmental conservation (Hall and Martins 2020), while the other taxa supporting agriculture remain underappreciated and relatively understudied (Noriega et al. 2018; Schmack et al. 2024).

Ladybugs (Coccinellidae), also known as ladybirds or lady beetles, are widely valued in their roles as natural predators of pests like aphids in both natural and agricultural ecosystems, highlighting their important roles in sustainable pest management (Bros et al. 2024; Haelewaters and Yaakop 2024). Farmers acknowledged ladybugs as a key contributor to biological control, considering them as more significant than other arachnids and insects in cider apple orchards (Martínez-Sastre et al. 2020). Similarly, social wasps (Vespidae), such as yellowjackets, paper wasps, and hornets, play important roles in agricultural pest control (Schmack et al. 2021), pollination, seed dispersal, and organic matter decomposition (Brock et al. 2021). Despite their essential contributions to ecosystem and agriculture,

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people tend to dislike and undervalue their presence (Baker et al. 2020; Schmack et al. 2024). Similar to other organisms, groups of beneficial insects including ladybugs and social wasps are declining due to climate change, habitat loss and fragmentation, pesticides and chemical pollution (Hailay Gebremariam 2024).

Ladybugs, as highly mobile arthropods, do not perceive the urban landscape as a barrier to movement. They are distributed in community gardens regardless of size, food availability, and habitats (Liere et al. 2019). Similar to ladybugs, wasp communities are resilient to urbanization, but declines in species richness. These suggested the potential disruptions, threatening the vital services of hymenopteran parasitoids in highly modified urban remnants (Christie and Hochuli 2009). Wasps are often noticed as unimportant and annoying regardless their ecosystem services (Baker et al. 2020; Schmack et al. 2024), while ladybugs are regarded as key biological control agents (Martínez-Sastre et al. 2020). It seems that people's perceptions and feelings can influence conservation behavior toward both charismatic species like ladybugs and uncharismatic ones like wasps.

People's perceptions of the roles of insects may vary depending on their prior knowledge and experience, leading them to either value or devalue these roles. The UK public dislikes wasps compared to bees and has limited awareness of wasps' ecosystem services (Sumner et al. 2018). Japanese gardeners are more inclined to see insects as beneficial and display favorable emotions toward ladybugs, honeybees, and butterflies compared to non-gardeners (Vanderstock et al. 2022). Schmack et al. (2024) found that urban gardeners have negative views of wasps due to misunderstandings about their ecological roles and a fear of these insects. These studies mentioned primarily focus on specific groups (e.g., the UK public, Japanese gardeners, German urban gardeners). Expanding these studies to different regions and groups of people is necessary to determine if similar perceptions of wasps and other insects are widely shared. In this study, we conducted an online survey at universities in Phnom Penh, Cambodia, to investigate student perceptions of social wasps and ladybugs, as well as the ecosystem services they provide. We hypothesized that (i) undergraduate students perceive social wasps and their ecosystem functions as less beneficial to ecosystem compared to other insects and spiders; (ii) they tend to favor ladybugs and dislike wasps; (iii) undergraduate students with greater knowledge of wasps/ladybugs have more positive feelings toward them and are more willing to share their gardens with wasps than those with less knowledge.

Methods

We employed online survey in this study to gather the information undergraduate students' perceptions on social wasps and ladybugs. An online survey is widely recognized as an effective method for assessing the public's attitudes toward specific wildlife species (Schmack et al. 2024; Sumner et al. 2018; Vlasák-Drücker et al. 2022). We adopted our online questionnaire from a recent study (Schmack et al. 2024) and created online survey in English and translated it into Khmer (Cambodian language). The survey was hosted on Google Forms, and insect photos were included to provide clearer context for the questions (e.g., we used an image of each animal alongside the relevant question). We included other insect groups and spiders in our survey to prevent leading questions. Before distributing the questionnaire, the Khmer translated version was pre-tested with a small group of six students to ensure the questions were clear and easy to understand. After final revisions, the questionnaire was distributed with undergraduate students through the researchers' networks (e.g., by providing a link via Telegram). To encourage more responses, we also printed QR codes linking to the survey and the researchers walked around campus, inviting students to voluntarily complete the questionnaire. Respondents took approximately 10–15 min to complete the entire survey, and the online survey was conducted from October to December 2024. Before completing the online survey, participants were first asked to indicate their agreement to take part in the insect survey by selecting one of the following options: (1) Yes, I voluntarily agree to participate in this research survey under the conditions of confidentiality, (2) No, I do not agree to participate. Only participants who selected "agree" in the first question were included in the analysis for this study. Since each participant provided consent in the online survey, ethical approval was not required for this study.

To assess whether students view different groups of insects and their ecosystem services, we asked respondents to rate insect groups (butterflies, wasps, ladybugs, ants, bees) and spiders on a scale from 1 to 6, with 1 representing the least beneficial and 6 the most beneficial (Supplementary 1). Students were allowed to select the same number to multiple insect groups. We also asked them to explain their choices in an open-ended response. One researcher independently coded these qualitative answers, identifying key phrases and cross-checking the codes (Supplementary 2). The coding process revealed six reasons for selecting the most beneficial taxa (pollination, honey, function in ecosystem, cool insects, benefits to human, and nothing) and eight reasons for choosing the least beneficial (no function, harm to human, I don't know, damage crops, sting, pests, fear, and predators). To directly compare the reasons behind

undergraduate students' choices for the least and the beneficial taxa, we created a subset of open-ended responses and coded those. The percentage was calculated from the proportions of answers from different respondents, and each respondent could have more than one answer in their opened-ended responses.

To evaluate students' knowledge on ladybugs and social wasps, we asked three simple questions about their ecology (Supplementary 1). Each correct answer earned + 1 point, incorrect answers received 0 points, and the response "wasps/ladybugs have no function" was penalized with − 1 point. Points were summed for each respondent, resulting in individual ladybug/wasp knowledge scores ranging from − 1 to 3. Because the data did not follow a normal distribution, we used non-parametric methods for analysis. The Wilcoxon signed rank test was employed to compare students' knowledge levels about ladybugs and wasps. A significant difference in variance is identified based on the p-value ($p < 0.05$).

To assess students' willingness (attitude) to share their gardens with wasps, we asked them to indicate how strongly they agreed or disagreed with the statement, "If I could, I would keep wasps out of my garden" (Supplementary 1). To make the statement easier to understand, it was reversed to a positive form, and the answers were also reversed to maintain the same rating scale. In this scale, "strongly disagree" was assigned a score of 4, "disagree" was assigned 3, "agree" was assigned 2, and "strongly agree" was assigned 1. We asked two questions about their attitudes toward ladybugs and wasps. We averaged the ratings from both questions to calculate the mean attitude toward these two insects. The Wilcoxon signed rank test was also used in this matter to compare the different variances. To quantitatively examine the relationship between undergraduate students' knowledge and attitudes toward ladybugs and wasps, we employed Spearman's rank correlation as the data did not follow a normal distribution.

To qualitatively assess students' emotions toward ladybugs and wasps, we asked the question, "What do you feel when you see or hear a ladybug/wasp?" (Supplementary 1). Respondents could choose only one emotion from the following categories: curiosity, fascination, affection, fear, anger, disgust, panic, and neutral. We calculated the percentage of each category to compare students' emotions toward ladybugs and wasps. We analyzed the percentage distribution of responses to assess the varying emotions expressed toward ladybugs and wasps. To facilitate the comparison of positive and negative emotions, we classified the responses into three categories: positive (curiosity, fascination, affection), negative (fear, anger, disgust, panic), and neutral (nothing). To examine the relationship between undergraduate students' attitudes and emotions toward ladybugs and wasps, we employed the Kruskal-Wallis rank sum test, as the data were non-normally distributed.

All analyses were conducted by using R statistical software (R Core Team, 2024).

Table 1 Percentage of undergraduate students by demographic characteristics (gender, level of study, field of study, and place of birth). Each percentage represents the proportion of students within each category or subcategory relative to the total sample

No	Category		Percentage (%)
1	Gender	Male	19.2
		Female	79.8
		Others	1.0
2	Level of study	First year	2.5
		Second year	16.3
		Third year	49.8
		Fourth	31.5
3	Field of study	Biology	35.5
		Geology	19.2
		Math	18.7
		Tourism	11.8
		Others	7.9
		Chemistry	4.4
		Environmental Science	2.5
4	Place of birth	Phnom Penh (Capital city)	6.9
		Province	93.1

Results

The data was collected from 208 Cambodian undergraduate students. However, five respondents were excluded due to the missing information or because they were not undergraduate students. As a result, 203 valid samples were used for analysis in this study. The demographics of respondents were summarized in Table 1. In brief, the students included in this study were predominantly female (79.8%), with 19.2% male and 1.0% identifying as other. The majority were third-year students (49.8%), while first-year students represented the smallest group (2.5%). Their majors ranged from Math (18.7%) to Biology (35.5%). Additionally, most students (93.1%) were born in provincial areas.

Students perceive ladybugs and social wasps as moderately beneficial compared to bees and butterflies

Our results showed that students ranked bees (61.9%) as the most beneficial, followed by butterflies (17.0%); while ladybugs (9.2%) were ranked as the third and social wasps (4.8%) as the fourth beneficial insects amount them (Fig. 1). It further indicated that students perceived spiders (30%) as the least beneficial insects, and followed by ants (24.7%).

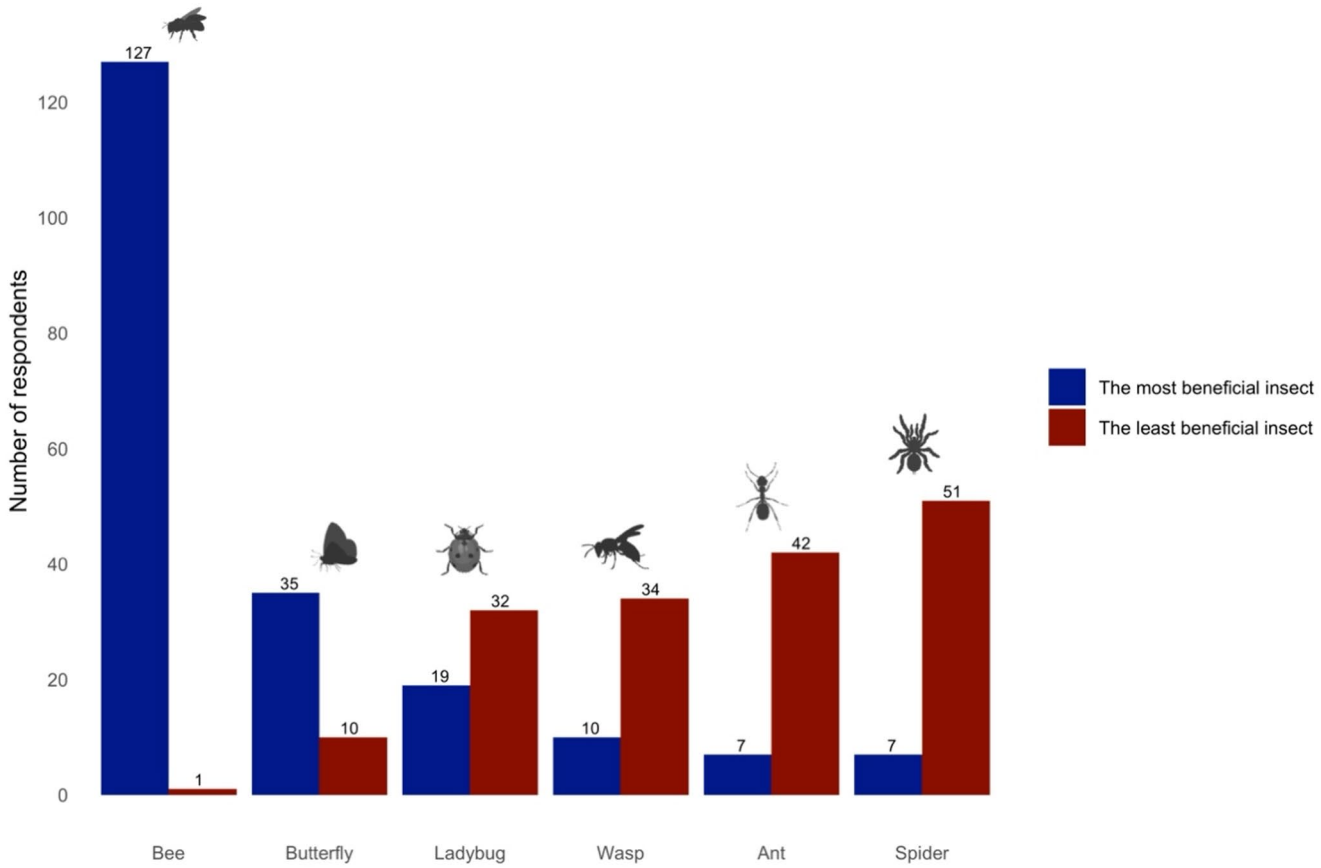

Fig. 1 Rating scale of respondents for the most beneficial (rating 6) and the least beneficial insect (rating 1). The dark-blue color represents the most beneficial insects and the dark-red represents the least beneficial insects. The number above each bar represents the number of respondents choosing each animal group

Respondents identified six reasons for selecting a taxon as the most beneficial for this study with the majority of pollination (43.9%), honey (29.3%), and function in ecosystem (17.9%) (Fig. 2a). The most common reasons for being the least beneficial animals were no functions (27.9%), and harm to human (22.4%) (Fig. 2b).

Students show greater knowledge of social wasps but prefer coexisting with ladybugs

Undergraduate students' knowledge about ladybugs varied significantly across departments (Kruskal-Wallis, chi-squared = 31.923, $p < 0.05$). Specifically, students from the department of Biology demonstrated significantly higher knowledge compared to students in Math ($p = 0.0009$), Tourism ($p = 0.002$), and Others ($p = 0.002$). In contrast, no significant differences were found in knowledge about social wasps between departments (Kruskal-Wallis, chi-squared = 9.6261, $p = 0.14$).

Overall, respondents demonstrated significantly different levels of knowledge between ladybugs (0.70 ± 0.1) and wasps (1.41 ± 0.1) (Wilcoxon test, V = 3710.5, $p = 0.004$; Fig. 3a). Attitudes toward ladybugs (2.72 ± 0.06) and social wasps (2.04 ± 0.06) also differed significantly (Wilcoxon test, V = 1780, $p < 0.05$; Fig. 3b). There was no correlation between knowledge and attitudes toward wasps, but this result was not statistically significant ($r = 0.09$, $p = 0.16$; Fig. 3c). In contrast, our findings revealed a statistically significant but weak positive correlation between knowledge and attitudes toward ladybugs ($r = 0.16$, $p = 0.02$; Fig. 3d).

Students feel more positive about ladybugs and more negative about social wasps

Negative emotions toward social wasps were primarily driven by fear (77.3%), while positive emotions toward ladybugs were attributed to fascination (31%), curiosity (30%), and affection (12.2%) (Fig. 4). Respondents expressed the highest positive emotions toward ladybugs (79.5%), followed by bees (44.8%), with wasps receiving the lowest percentage (15.2%) (Fig. 5). The results also clearly indicated that respondents felt the most negative

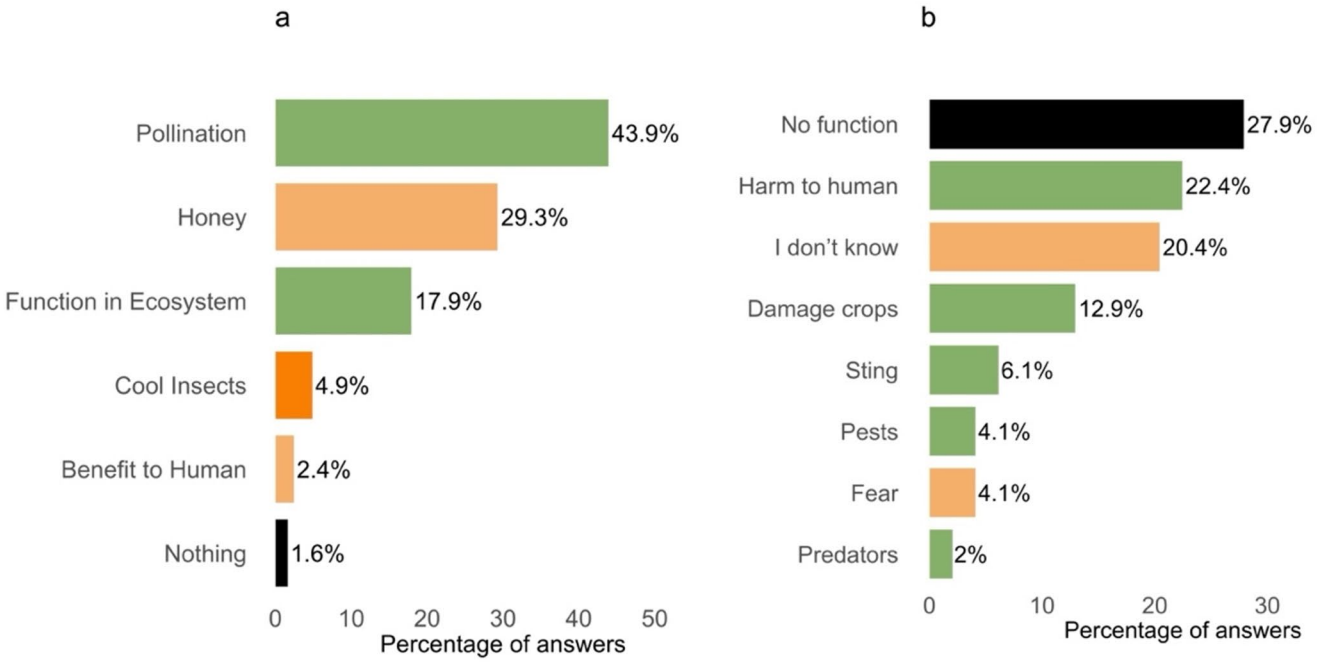

Fig. 2 Respondents' reasons for selecting taxa as the most and least beneficial groups: (a) Reasons for the most beneficial, (b) Reasons for the least beneficial group. Percentages beside each bar indicate the proportion of respondents for each answer

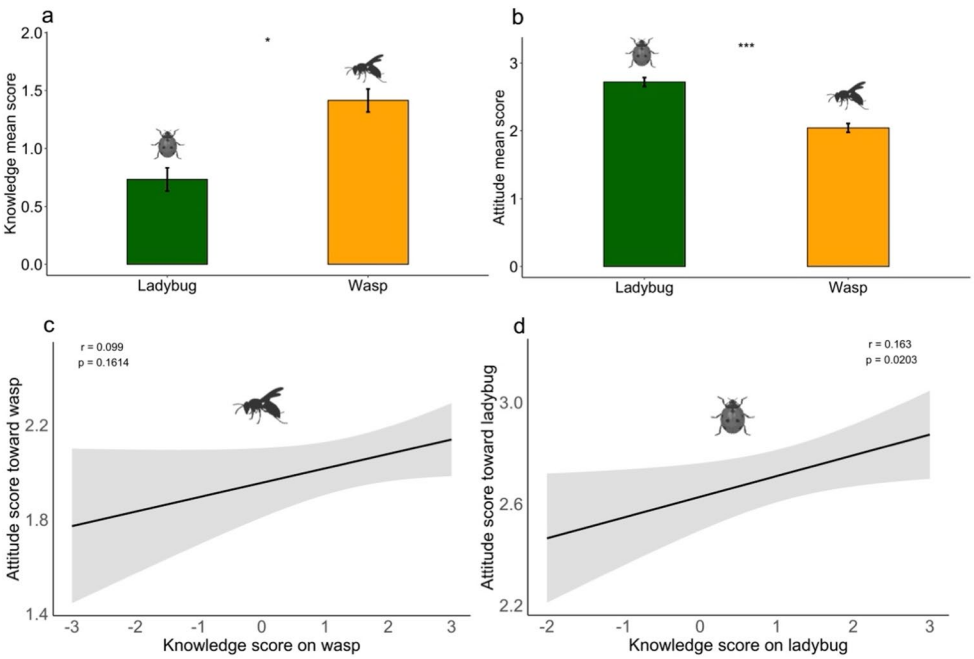

Fig. 3 Respondents' knowledge and attitudes, and correlations between these factors for ladybugs and social wasps: (a) Knowledge comparison between ladybugs and social wasps, (b) Attitude comparison between ladybugs and social wasps, (c) Correlation between knowledge and attitude for social wasps, (d) Correlation between knowledge and attitude for ladybugs. The number in the bracket in the text represents (mean ± se). * indicates significant difference ($p < 0.05$), *** indicates highly significant difference ($p < 0.0001$)

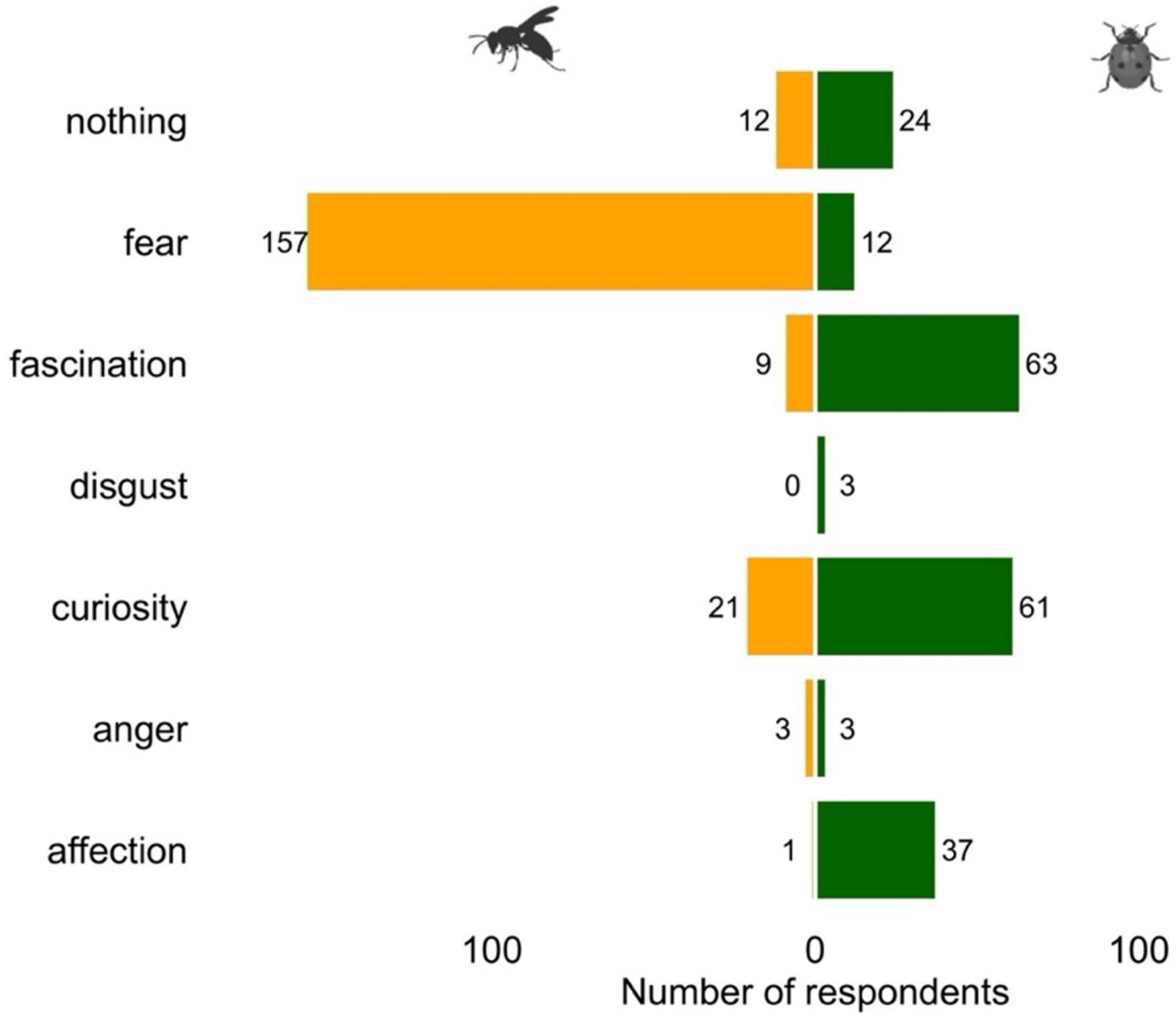

Fig. 4 Seven emotions toward ladybugs and social wasps. Numbers beside each bar represent the respondents who selected each emotion

emotions toward social wasps (78.8%), fewer toward bees (44.8%), and the least toward ladybugs (8.8%).

We found that respondents exhibited a stronger preference for ladybugs associated with positive emotions (Kruskal-Wallis, Chi-squared = 17.077, $p < 0.05$; Fig. 6a). In contrast, respondents showed a relatively lower preference for wasps with negative emotions (Kruskal-Wallis, Chi-squared = 1.8375, $p = 0.4$) (Fig. 6b). Respondents answered various positive and negative comments on different animal groups (Fig. 7).

Discussion

This study examined undergraduate students' perceptions of insects and their ecosystem services, focusing on social wasps and ladybugs, by examining their knowledge, attitudes, and emotions through an online survey. The findings highlighted important implications for university education, particularly in shaping higher education program development and undergraduate curriculum design, with a focus on life sciences and entomology. Our study revealed that undergraduate students perceive the benefits of social wasps and ladybugs to be moderate compared to those of bees and butterflies. Ladybugs, often regarded as charismatic insects, are recognized for sharing habitats more readily than social wasps, which are viewed as less charismatic. Students

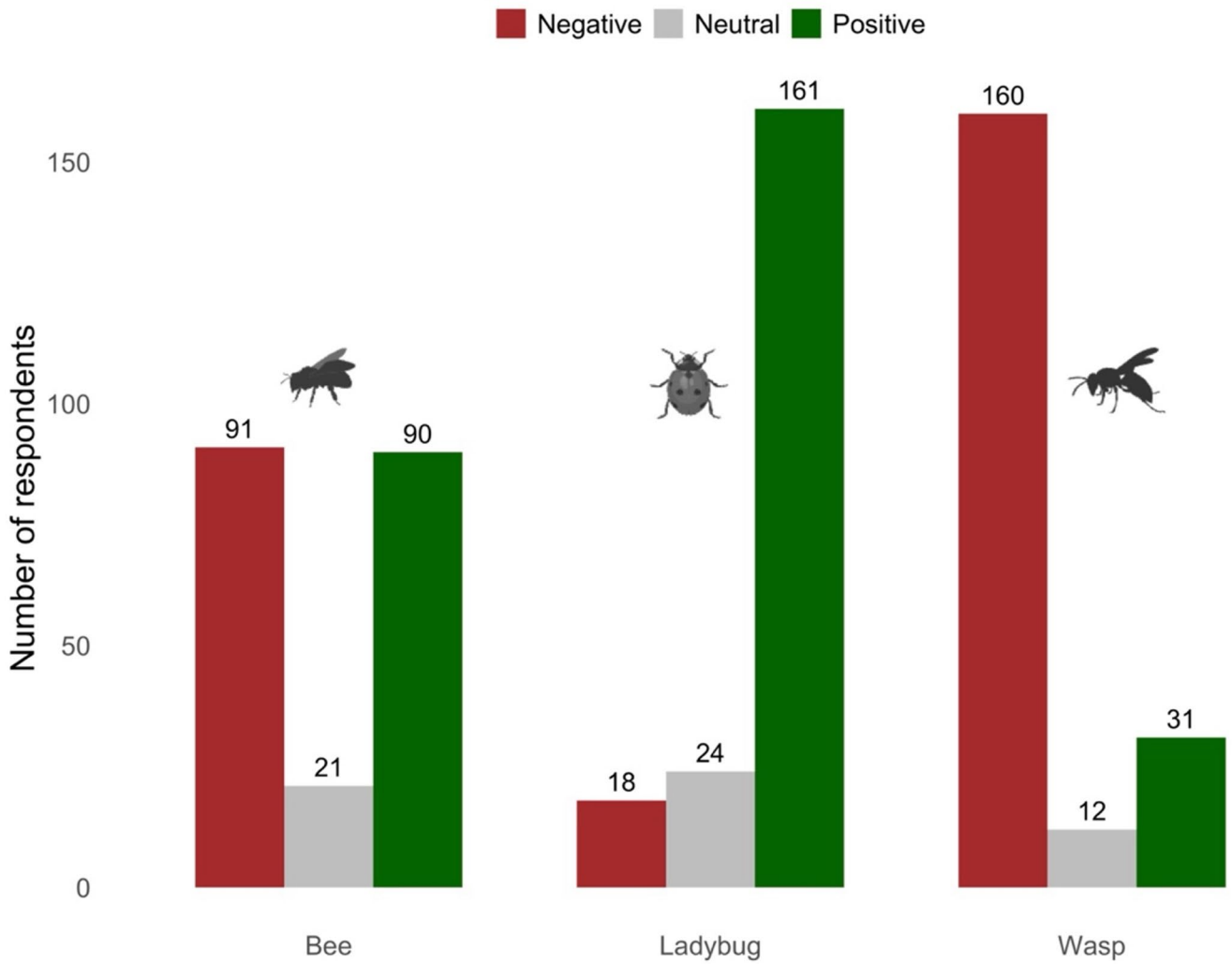

Fig. 5 Emotions (negative, neutral, and positive) toward bees, ladybugs, and social wasps. Numbers above each bar represent the respondents who selected each emotion

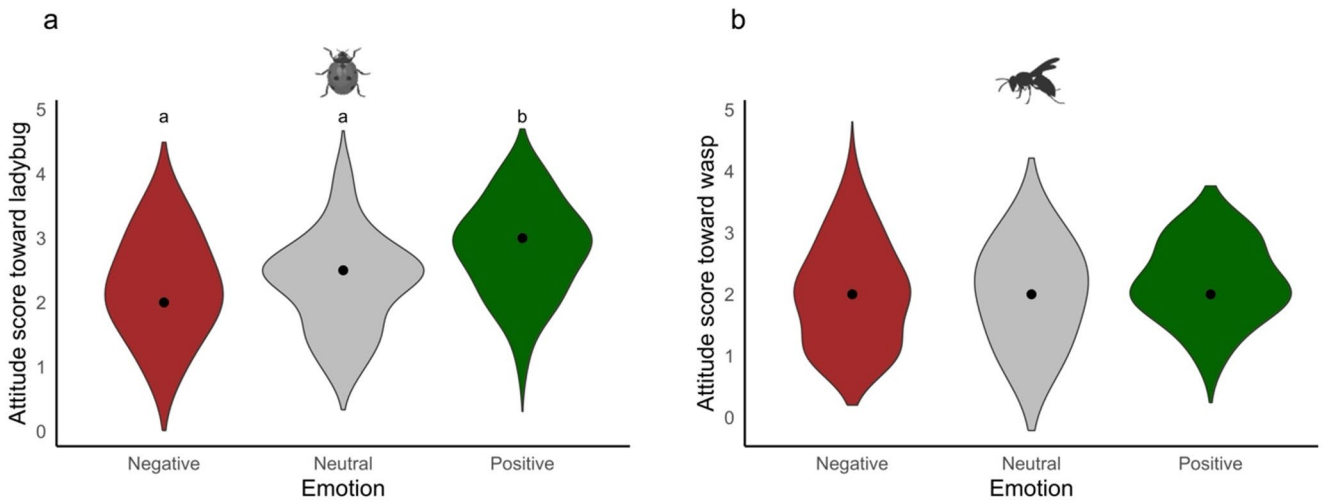

Fig. 6 Emotions (negative, neutral, and positive) associated with attitude toward ladybugs and social wasps. The different letter above violin represents the significant difference between emotions in relation to attitude score ($p < 0.05$)

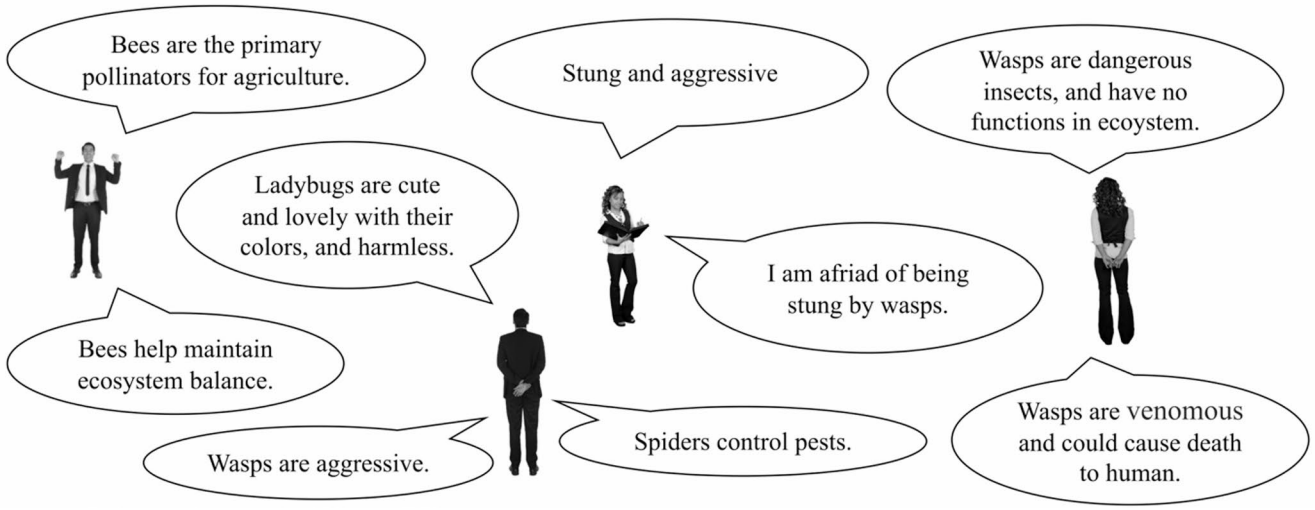

Fig. 7 Selected participant quotes highlighting positive and negative perceptions across different study animals

expressed more positive emotions toward ladybugs than social wasps, primarily due to their ecological roles and appealing appearance. Although undergraduate students demonstrated a better understanding of social wasps, their willingness to share habitats with them was notably lower compared to ladybugs, due to their fear of social wasps. Encouraging positive interactions and increasing awareness of the ecological role of social wasps as pest predators and pollinators can enhance their image and foster appreciation for these uncharismatic species, while promoting conservation efforts without suggesting their right to exist is dependent on their benefits to humans. These efforts could support life on land and contribute to enhancing ecosystem services in agriculture, helping to advance the goal of zero hunger through sustainable agricultural practices.

Our results indicated that undergraduate students regarded bees and butterflies as the beneficial insects because of their potential ecosystem services, such as pollination and honey production, which is consistent with a previous study (Vanderstock et al. 2022). Spiders and ants were considered the least beneficial animals, possibly due to misunderstandings of their ecological roles and appearance. Gardeners' responses reflected the public's dislikes to social wasps, highlighting the overlooked roles of predatory insects and misconceptions about the importance of "dangerous" and "ugly" insects and spiders (Schmack et al. 2024; Sumner et al. 2018; Vanderstock et al. 2022). For instance, two of undergraduate students mentioned that "wasps may be frightening, yet they are fascinating to study, especially their ecology, including nesting and foraging behaviors" and "wasps can be dangerous to humans when they sting, and they can also damage agricultural crops". These quotes highlighted the clear reasons behind the public's dislike of social wasps and their interests to explore more about these insects, while also emphasizing that misconceptions about their ecological roles still persist. While undergraduate students considered ladybugs and social wasps moderately beneficial among these six study animals, it is crucial to enhance public awareness of their biodiversity and the ecosystem services they provide. Thus, future research should be focused on the ecological potentials of social wasps and ladybugs in agroecosystems to demonstrate their ultimate benefits and improve their public perception.

Undergraduate students had a better understanding of the diversity, diet, and roles of social wasps compared to ladybugs. While students with more knowledge of ladybugs displayed a more positive attitude toward them, this pattern was not seen with social wasps. Students showed greater knowledge of social wasps than ladybugs, likely because wasps can sting and often cause strong reactions, making them more memorable. Even occasional encounters with wasps tend to leave a lasting impression. In Cambodia, public concern about wasps primarily centers on the risk of stings or allergic reactions rather than their presence as a daily nuisance. In contrast, ladybugs are generally seen as harmless and less noticeable, leading to less attention and interest. Additionally, educational materials and media often emphasize caution around wasps, while ladybugs receive less focus, which may explain the difference in students' familiarity and understanding. Our findings, which showed that greater knowledge of social wasps does not reflect to a willingness to share habitat, align with a recent study suggesting that knowledge alone did not enhance people's willingness to donate for species conservation in Germany (Vlasák-Drücker et al. 2022). Schmack et al. (2024) demonstrated that urban gardeners who had a deeper understanding of the ecology and role of wasps showed more positive emotions toward them. This aligns with our findings, which

indicate that greater knowledge of ladybugs leads to more positive emotions and attitudes toward them. While knowledge about certain species can influence positive emotions and attitudes, it does not necessarily translate into a willingness to take more proactive actions, such as sharing habitat or donating for conservation efforts. The findings suggest that knowledge alone may not drive conservation behavior, and additional factors like emotional connection, culture, or practical experience could play essential roles in fostering active support for conservation efforts. As our study is limited to university students, we recommend expanding future research to include diverse populations, such as farmers and gardeners in Cambodia, to gain a broader understanding of their perceptions of these insects.

The most prominent positive emotions, such as fascination, curiosity, and affection, were observed toward ladybugs, while negative emotions, particularly fear, were directed toward social wasps. This suggests that people often value charismatic insects based on their appearance, rather than their ecological roles. One of undergraduate students answered that "wasps can sting and harm to human". Similarly, the primary reason for disfavor social wasps among Chinese public is the fear of being stung (Dai et al. 2021) and the associated negative emotions, such as annoyance and pain from stings (Schmack et al. 2024). It has been suggested that moral judgments are driven by intuition and emotion, with reasoning later used to justify them, so we form positive attitudes toward species based on emotion and then rationalize them (Haidt 2001). It is likely that people's emotional responses, particularly fear and affection, significantly shape their attitudes toward insects, often influencing them more than an understanding of the species' ecological roles, with these emotional reactions typically followed by rationalizations or justifications.

Although most comparable studies have been conducted in the temperate regions of Central Europe, our findings are likely to reveal important differences in how populations understand and perceive insects. Cambodia, like many tropical countries, possesses exceptionally high biodiversity and a long-standing cultural and practical engagement with insects spanning agriculture, daily life, and entomophagy. These ecological and socio-cultural contexts are likely to shape distinctive patterns of knowledge, perception, and familiarity with insects. Rather than constituting a limitation, this represents a significant strength of the study. By presenting empirical data from a tropical and previously underrepresented region, our study offers valuable comparative perspectives that advance the broader understanding of human–insect interactions on a global scale. Since there are no major taxonomic studies on wasps in Cambodia, it is difficult to determine how species-specific behaviors may influence human perceptions. Future research should prioritize taxonomic surveys, particularly in urban areas, to better understand the diversity of wasp species present in the country. We acknowledged that our study may be influenced by disciplinary bias, especially in the observed relationship between knowledge and attitudes toward insects. Due to their extensive exposure to entomological content, biology students are likely to hold more informed and favorable perspectives. Consequently, the current sample limits the generalizability of our findings to the wider Cambodian population. Future studies should include students from a wider range of disciplines or the publics and employ larger sample sizes to more comprehensively represent the overall Cambodian population. Rather, this current study should be regarded as a preliminary investigation into student perspectives within scientific fields, serving as a basis for future research encompassing more diverse and representative population groups.

Conclusion

In summary, this study highlights the importance of addressing students' perceptions and emotions towards insects in shaping university education, particularly in life sciences and entomology. It reveals that while undergraduate students acknowledge the ecological benefits of both social wasps and ladybugs, they tend to view ladybugs more favorably due to their charismatic appearance and less fear of them. The findings suggest that fostering a better understanding of social wasps' ecological roles as pest predators and pollinators could help improve their image and promote conservation efforts. This underscores the importance of valuing all species and life on land, regardless of their immediate benefits to humans. Additionally, educational initiatives, citizen science programs, accessible identification tools, and increased media exposure can enhance awareness of wasps and other underrepresented insects, thereby addressing biases in conservation priorities.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10841-025-00713-4.

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Author contributions SK initiated and designed the study and secured

funding. SK and TM developed the questionnaire and collected the data. SK conducted the data analysis and wrote the first draft of the manuscript. SK, SP, OU, TM, DM, and VN reviewed, edited, and revised the manuscript. All authors contributed to the revisions and approved the final version of the manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

Ethics statement All participating students were informed about the purpose of the study and asked for their voluntary participation. In the online survey, we asked participants to confirm their approval with options: Yes/No. Written/implied consent was obtained from each respondent and recorded in the questionnaire before they proceeded with the entire online survey, which served as a recorded agreement.

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