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Arachnids: between fear and financial support for environmental education projects

Aracnídeos: entre perder o medo e apoiar financeiramente projetos de educação ambiental

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ABSTRACT

Arachnids contribute to socioenvironmental development by acting as bioindicators of environmental quality and providing essential ecosystem services, highlighting the need for public awareness to conserve these potentially umbrella species. This study evaluated the willingness to pay for informal education programs about arachnids in the central Brazilian savanna using the contingent valuation method (CVM). For this purpose, a preliminary analysis was conducted with 407 residents of a Brazilian municipality with a small population and significant number of arachnid stings. The respondents' profiles (gender, age, and education level), knowledge, perceptions of arachnids, and willingness to pay were sampled. Quantification, average/total willingness to pay, and Pearson's correlation were estimated using R software. Most respondents were women (75.43%), had a high school education and aged between 35 and 65 years. We observed that most respondents had some level of knowledge about the morphology, ecological characteristics, and importance of arachnids, especially for the environment. However, the results also indicate that older people, men, and those with lower education levels have a greater willingness to pay for educational events about Cerrado arachnids (IEPAs). Only a portion of the respondents were willing to pay for informal education programs in favor of arachnid awareness and conservation. The total willingness to pay was US$ 4,441.28, preferably managed by the state's public education institution. We concluded that there is significant and necessary potential for environmental education actions to promote the conservation of arachnid megadiversity.

Keywords: Environmental perception; Contingent valuation; Neotropical fauna; Arachnida; Conservation.

RESUMO

Os aracnídeos contribuem para o desenvolvimento socioambiental ao atuar como bioindicadores da qualidade ambiental e fornecer serviços ecossistêmicos essenciais. Evidenciando a necessidade da sensibilização popular para a conservação dessas espécies potencialmente guarda-chuva. Objetiva-se avaliar a disposição a pagar por programas de educação não formal sobre aracnídeos na savana central brasileira, usando o Método de Valoração Contingente (MVC). Para isso, foi realizada uma análise preliminar com 407 residentes de um município brasileiro com pequena população e acentuados acidentes com espécies de aracnídeos. Foram coletados o perfil (gênero, idade e nível de escolaridade), conhecimento, percepção dos aracnídeos e disposição para pagar dos respondentes. A quantificação, disposição média/total a pagar e a Correlação de Pearson foi realizada no software R. A maior parte dos entrevistados eram mulheres (75,43%), com ensino médio completo e idade entre 35 e 65 anos. Observamos que a maioria apresentava algum nível de conhecimento das características morfológicas, ecológicas e da importância dos aracnídeos, sobretudo para o meio ambiente. Contudo, os resultados também indicam que pessoas mais velhas, homens e com menor escolaridade têm maior disposição a pagar por eventos educativos sobre aracnídeos do Cerrado (PENA). Apenas uma parte dos entrevistados estava disposta a pagar por programas de educação não formal em favor da conscientização e preservação dos aracnídeos. A disposição total para pagar foi de US$ 4.441,28, preferencialmente gerida pela instituição pública de ensino do Estado. Conclui-se que há um potencial significativo e necessário para ações de educação ambiental para promover a conservação da megadiversidade dos aracnídeos.

Palavras-chave: Percepção ambiental; Valoração contingente; Fauna neotropical; Arachnida; Conservação.

INTRODUCTION

The threats and loss of global biodiversity reflect the insufficiency of current efforts to conserve natural resources (HARIRAM *et al.*, 2023; YANG *et al.*, 2023). Advances in the science-policy interface associated with environmental changes over the past two decades have contributed irregularly to long-term social awareness and sensitization (BALVANERA *et al.*, 2014), resulting in a decline in participation in environmental education initiatives related to biodiversity and ecosystem services, which are directly linked to human well-being (MCNEELY, 2010; LIU *et al.*, 2022). In other words, the willingness to participate in environmental initiatives is a key factor for the proper promotion of socioenvironmental development (ZHANG *et al.*, 2022).

The strategy of using so-called umbrella species plays a crucial role in conservation, awareness, and public mobilization (PÉREZ-ESPONA, 2021; GUPTA *et al.*, 2023; YANG *et al.*, 2023). Charismatic and highly visible species, such as *Panthera tigris*, *Ursus arctos*, *Tyto alba*, *Canis lupus*, and *Loxodonta africana*, ensure not only their protection but also that of other cooccurring species in their natural ecosystems (WANG *et al.*, 2023). By focusing on this pragmatic strategy, we can overcome the economic and cultural restrictions seen as insufficient and inadequate for the conservation of threatened areas (ROYNE *et al.*, 2011).

Umbrella species are commonly cited among mammals and birds due to their greater perception of their environmental importance, charisma, and beauty (WITTEMYER *et al.*, 2013; GALLEGOS-FERNANDEZ *et al.*, 2023). However, despite being less frequently mentioned as possible umbrella species, arachnids (Arachnida) have significant potential for ensuring complex ecological interactions with other species (BALLESTEROS *et al.*, 2022). Additionally, they assist in the bioindication of environmental quality and maintenance of ecosystem services such as controlling populations of other arthropods, decomposing organic matter, and producing bioproducts (SPILLER *et al.*, 2018; COSTA *et al.*, 2021).

However, the frequent aversion of people to the appearance of arachnids and their lack of sympathy for them make it difficult to recognize and adopt them as umbrella species (BATT, 2009). Negative perceptions and affrid increase with the occurrence of accidents and evenonation caused by few species, which affects the general public's understanding of the ecological roles of arachnids (AGNARSSON, 2023; HERZIG *et al.*, 2023). This aversion can be mitigated through environmental education, proper

regulation, and the creation of specific conservation policies for these groups (KUNTNER, 2022).

Contingent valuation methods are crucial for obtaining solid information for public and environmental policies (CUCCIA, 2020). They help measure people's interest and willingness to pay for natural resources, ecosystem services, environmental preservation, conservation (WHITEHEAD *et al.*, 2023), and knowledge (an aspect that does not have a direct market price). Thus, this Contingent Valuation Research (*CVM*) aims to assess the willingness to pay for knowledge and improvement of popular knowledge about arachnids in the central Brazilian savanna. Additionally, this study aimed to identify factors that may influence this willingness, providing valuable insights for formulating conservation and environmental education strategies in the region.

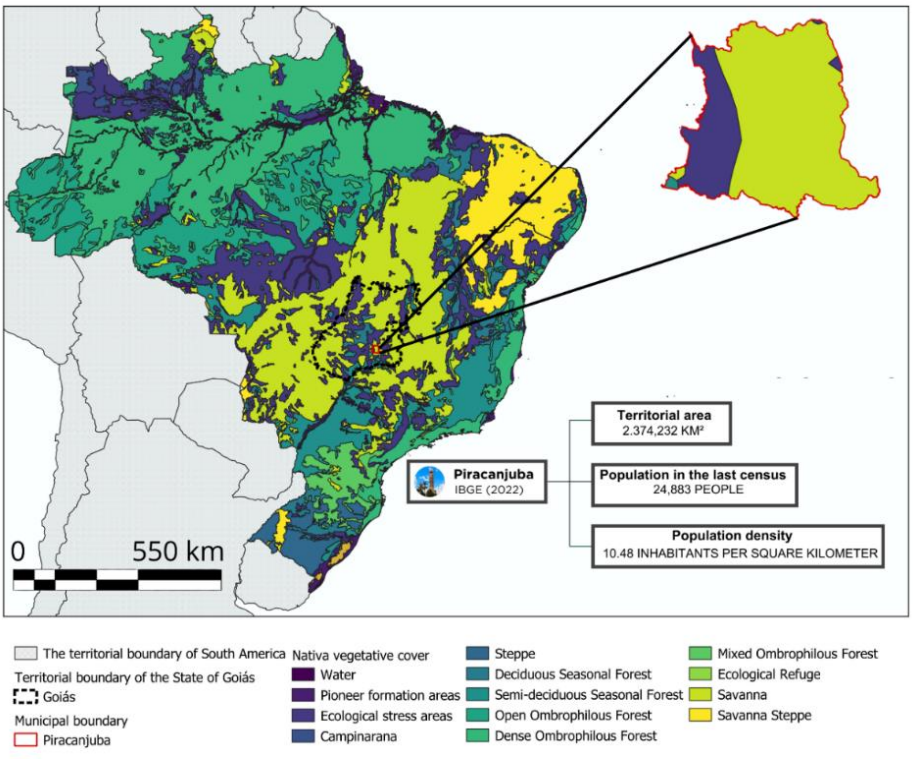
Therefore, we carried out this study as a preview to estimate how people in a small town in the interior of Brazil would react to the possibility of contributing financially to a nonformal education program involving preserving arachnids, with the expectation of extrapolating the results to larger cities. To do this, we wanted to answer the following questions: Do people recognize arachnids easily? How do they describe the basic characteristics of arachnids? What do people know about the ecological roles played by arachnids? Would they be willing to participate in nonformal educational courses? Would they be willing to contribute financially to an educational program?

MATERIALS AND METHODS

The research conducted using the Contingent Valuation Method (CVM) was carried out in Piracanjuba (Figure 1), which is located in the Meia Ponte microregion and Southern Goiás mesoregion (SOUZA *et al.*, 2023). The area covers 2,374.232 km², with a total population of 24,883 inhabitants and a population density of 10.48 inhabitants/km² (IBGE, 2024). The municipality features typical Cerrado Central vegetation (Figure 1). The interior of the state of Goiás is often affected by a high incidence of scorpion stings. For this reason, it is common for part of the population to be afraid of arachnids. Located in the interior of Goiás, the city of Piracanjuba has a population of approximately 24,000 inhabitants, making it a good model for the development of educational actions (IEPAs) to raise awareness about arachnids and the role of the population in their conservation. The city was therefore chosen as a model for studies into the population's perception of arachnids and the viability of educational actions supported financially by the population.

Data collection was randomly conducted through questionnaires answered by 407 individuals in personal and individual interviews, either in person or via Google Forms (to accommodate the peculiarities and accessibility of the population), from March 30 to May 29, 2024. We chose to exclude questionnaires answered by individuals from other locations outside the selected municipality from the sample group. Additionally, individuals aged 18 years and older were used as the selection criterion for interviewees, and only fully completed questionnaires were considered. The questionnaires comprised 22 objective questions, divided to gather information on the interviewee's profile, their knowledge of arachnid diversity, and their willingness to pay. Additionally, information about the anonymity and confidentiality of the responses was included in the questionnaire. Additionally, this pilot test aimed to verify the effectiveness of implementing solid and replicable environmental education measures for other Brazilian municipalities. The initial project sought to understand the public's willingness to pay and the feasibility of adopting informal education programs about arachnids, the influence of demographic factors (gender, age, and education level), and the impacts of perceptions and aversions on the conservation of these species.

Figure 1. Territorial demarcation of the municipality of Piracanjuba in the Brazilian Federation and State of Goiás.



Source: Authors' elaboration

The minimum sample size was determined with a 95% confidence interval and a 5% margin of error, as established by the following equation:

$$n = \frac{\frac{t^2 pq}{d^2}}{1 + \frac{1}{N}\left[\frac{t^2 pq}{d^2} - 1\right]}$$

where *n* refers to the sample size, *N* to the total population size, *t* to the confidence interval, *p* to the probability of success, *q* to the probability of failure, and *d* to the estimated forecast (SANTOS *et al.*, 2012; WANG; CHOW, 2014; COSTA *et al.*, 2018).

The tabulation and quantification of attributes for qualitative and quantitative data verification were conducted in Excel. The total willingness to pay (WTP) and average willingness to pay (AWTP) of the interviewees from the population residing in the area were estimated as indicated by the following equation:

$$DAPm\left(\frac{ni*X}{N}\right) \text{ e } DAP = DMP\ x\ N$$

where "*ni*" refers to the number of interviewees willing to pay, "*X*" to the average monetary value associated with the number of interviewees willing to pay, "*DMP*" to the average willingness to pay, and "*N*" to the total number of the sample (SANTOS *et al.*, 2012; SILVA; SCHERER, 2021). Subsequently, we applied Pearson's correlation coefficient using the independent variables (gender, age, and education level of the respondents) to measure the correlation with the dependent variable (willingness to pay for lectures or courses on Cerrado arachnids).

RESULTS

Among the 407 interviewees, 75.43% were female, and the remaining 24.57% identified as male, nonbinary, or preferred not to disclose (Figure 2). Additionally, the majority of respondents (63.11%) were aged 35 to 65 years or older, with 62.41% having incomplete or complete higher education or postgraduate degrees (Figure 2).

Regarding the respondents' knowledge of the term "arachnid", 81.33% claimed to have heard of arachnids, which are characterized by the presence of four pairs of legs, such as spiders, scorpions, and ticks (Figure 3E). On the other hand, 18.67% erroneously associated the term with animals such as bees, flies, and wasps or even with associations

between fungi and plant roots, indicating a lack of knowledge on the subject (Figure 3E). Thus, we sought to understand which variables associated with morphological and dietary characteristics could reflect different levels of understanding and familiarity with these animals in daily life.

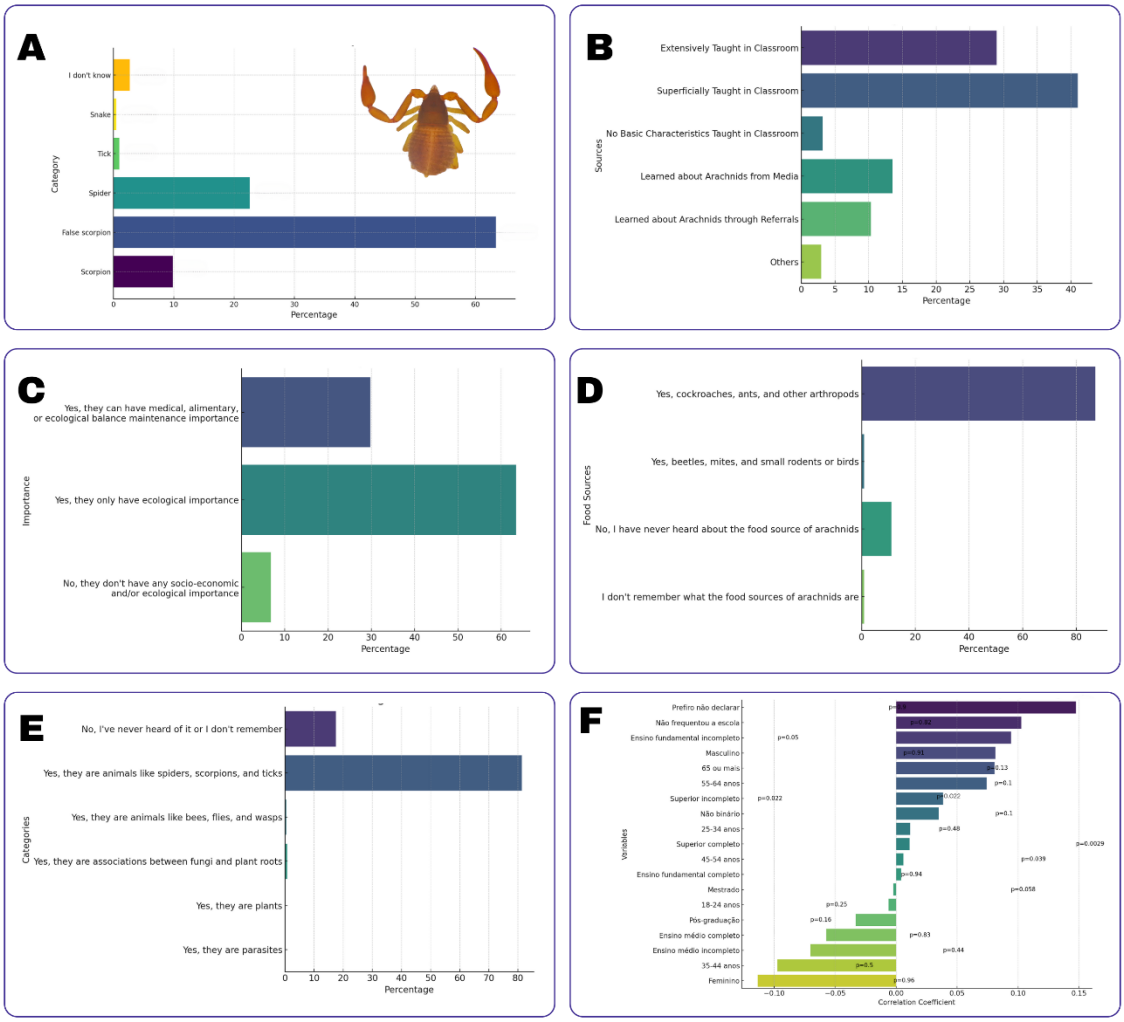
Figure 2. Heatmap of willingness to pay and investment preferences percentages for educational events on cerrado arachnids. * (SIEXT) Centro de inovação empreededorismo tecnologia e sustentabilidade da Universidade Estadual de Goiás; (PROIN) Programa de incubadora da Universidade Estadual de Goiás; (RENAC) Programa de Pós-graduação em Recursos Naturais do Cerrado; (SME) Secretária de Educação Municipal.

Source: Authors' elaboration

Most respondents (73.79%) demonstrated the ability to correctly recognize and identify the main distinctive characteristics of arachnids, noting that they have venom (some species) and a body divided into two parts, the cephalothorax and the abdomen (Figure 4A). A significant portion (16.18%) acknowledged that while the main food source consists of other insects and animals, some arachnids have the ability to feed on plant resources (Figure 4A). Furthermore, a minority (10.03%) correctly noted that some arachnid species are parasites, mentioning examples of species that interact with animals

or plants (Figure 4A), indicating an understanding of the behavioral diversity of these animals.

Figure 3. Percentage distribution of prior knowledge about arachnids of the Brazilian savanna (Cerrado). (A) Question number 12, "What creatures is this?" (B) question number 10 "Where did you learn about arachnids?" (C) question number 14 "Do you think arachnids have any importance to nature or to people?" (D) question number 11 "Can you name at least one type of food used by arachnids (Check more than one option if necessary)? (E) question number 7 "Can you tell me if you have heard of the term arachnid? (F) Correlations between the independent (age, gender and education) and dependent (DAP) variables.



Source: Authors' elaboration

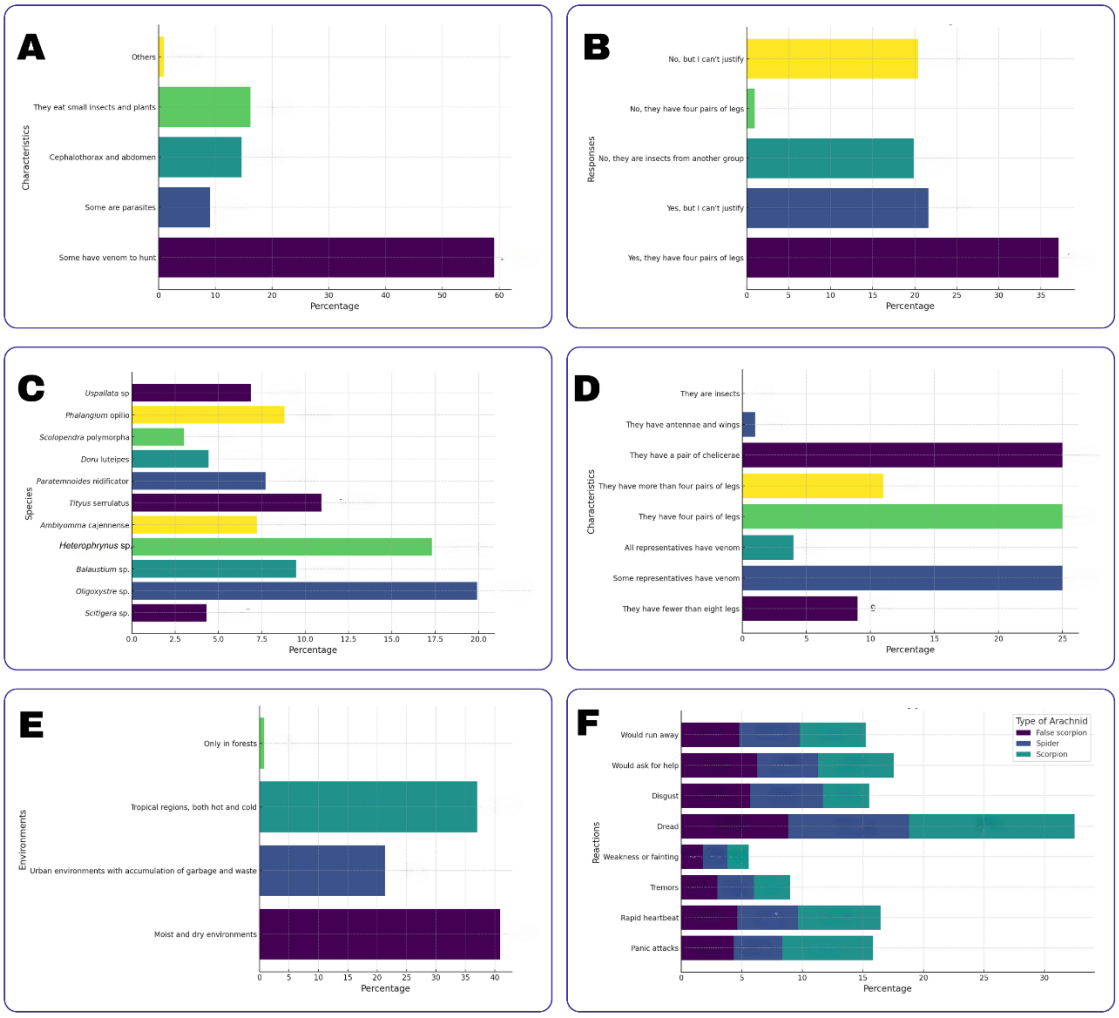
Among the interviewees, 54% were able to correctly identify the main morphological and physiological characteristics associated with arachnids or species from the same class as spiders (Figure 4D). However, 46% also erroneously considered

physical aspects of other arthropods (Figure 4D). When asked about the food resources of these animals, the majority of respondents (86.98%) recognized the main feeding sources of arachnids by mentioning examples such as cockroaches, ants, and other arthropods (Figure 3D). However, a significant number of respondents (13.02%) admitted to not knowing the food sources of arachnids or associated them with other unusual resources of this class (Figure 3D). This suggests an area with potential for greater dissemination and educational initiatives.

Following the presentation of a photo of a pseudoscorpion found in their municipality, the majority of interviewees (63.39%) were able to correctly identify the animal, while a smaller percentage (33.61%) associated the image with another arthropod with similar characteristics or associated it with snakes (Figure 3A). Eleven more photos were shown to indicate which ones were arachnids, resulting in approximately 81.33% accuracy in choosing the species, such as *Heterophrynus* sp. (17.31%), *Oligoxystre* sp. (19.92%), *Titys serrulatus* (10.95%), and *Amblyomma cajennense*, which are more familiar in the daily lives of the local population (Figure 4C). The species *Scolopendra polymorpha*, *Phalangium opilio*, and *Uspallata* sp. were identified incorrectly as arachnids by 18.67% of the interviewees (Figure 4C). We also observed that 58.72% of the respondents identified or considered ticks to be arachnids (the most abundant species in their daily lives) without being able to explain or justifying them based on the number of legs (Figure 4B). Among the respondents, the majority (77.89%) knew that arachnids can occur under different climatic conditions (Figure 4E). On the other hand, a minority of 22.11% associated the presence of arachnids with urban areas with garbage and waste and forested areas (Figure 4E). However, the options 'in urban areas with garbage and waste' and 'only in forests' were not counted among the valid responses, as their presence cannot be directly associated with the accumulation of garbage and waste or restricted to forest environments.

In terms of understanding the importance of arachnids, 63.39% consider them important for maintaining the environment by controlling other arthropods, such as insects (Figure 3C). Others (29.73%) also recognized that they may have medicinal or dietary importance (Figure 3C). However, a minority (6.88%) of these species have no socioeconomic or ecological importance (Figure 3C). This shows that the majority of the total respondents (93.12%) recognized and differentiated the aspects of arachnid importance for the environment and humans (Figure 3C).

Figure 4. Percentage distribution of prior knowledge about arachnids of the Brazilian savanna (Cerrado). (A) Question number 14: "Which characteristic(s) do you associate with arachnids (Check more than one option if necessary)? (B) Question 16: "Do you think ticks are arachnids, meaning they belong to the same group as spiders?" (C) question number 15 "Would you know which of the animals below are arachnids (Check more than one option if necessary)?" (D) question 8 "What characteristics do you associate with arachnids (Check more than one option if necessary)? (E) Question number 9: "Where can arachnids be found?" (F) question number 17, "What would you do if you found a pseudoscorpion such as the one in the image in your house (Check more than one option if necessary)?" 18) "What is your reaction when you see a spider (Check more than one option if necessary)?; and 19 "What is your reaction when you see a scorpion (Check more than one option if necessary)?"



Source: Authors' elaboration

When asked about the sources through which they learned about arachnids, we observed a variation in popular knowledge sources (formal education, media, and

personal interactions). Most respondents (72.97%) said they learned about them in basic education, courses, and degrees, while 13.51% and 10.32% learned through media and/or conversations with friends and family, respectively (Figure 3B).

Finally, we sought to understand the different perceptions, fears, and behaviors of the respondents regarding arachnids. These insights are related to awareness, conservation, management, and accident prevention implications. Thus, the results show differences in terms of reactions and perceptions among the three specimens (spider, pseudoscorpion, and scorpion). Most respondents considered scorpion species to provoke extreme reactions, such as panic attacks, dread, aversion, and a desire to kill the animal (Figure 4F). On the other hand, although also arachnids, spiders and pseudoscorpions demonstrate less intense reactions at dread and panic levels, favoring their survival in greater quantities (Figure 4F). In other words, we can see that the results reflect the diversity of perceptions and actions that the respondents perform, indicating a potential interest in conserving and understanding pseudoscorpions and some spiders.

Regarding willingness to pay, 36.89% (Figure 2) of respondents reported that they would pay some amount to obtain more information, whether to understand biodiversity, contribute to species conservation, or understand the benefits of these animals as food and medicinal sources. We obtained an average willingness to pay of U$2.08 per educational event (Figure 2). Regarding investment management, respondents (55.88%) preferred it to be managed by a public university, while a significant portion (44.12%) preferred it to be administered by the Municipal Education Secretariat or local health surveillance (Figure 2). These results highlight the importance of dissemination initiatives and environmental education about the Cerrado arachnid fauna, which can contribute to greater appreciation and protection of the environment where these animals are found.

The Pearson correlation results suggest that older people, specifically males, have a greater willingness to pay (WTP) for lectures or courses on Cerrado arachnids (Figure 3F). This positive correlation is associated with people aged 55 to 64 years (0.074) and 65 years or older (0.081). On the other hand, the correlation between genders is positive for men (0.081) and negative for women (-0.114), suggesting a lower willingness to pay. Regarding education level, lower education levels, such as people who did not attend school (0.103) and those with incomplete elementary education (0.094), had a positive correlation. Postgraduates (-0.033) and masters (-0.002) show negative or almost null correlations. In summary, this relationship between WTP and education level varies depending on the educational category.

By analyzing the means of different value ranges (Figure 2), we obtained an average WTP (DAPm) of approximately U$10.91 per educational event (lecture and courses) for the Cerrado arachnids. Additionally, the data showed an estimated WTP (DTP) of approximately U$4,441.28 per year. The results provide an overview of the interest in understanding the biodiversity and socioenvironmental potential of arachnid species. These estimates also reflect significant economic potential for conducting educational events and raising awareness about these animals in the region.

DISCUSSION

The data allow us to observe that factors other than gender, age group, and education level may significantly influence willingness to pay for educational events. The theory of planned behavior suggests that human behavioral interactions with consumption are strongly influenced by the social environment and individual consumer characteristics (HULTMAN *et al.*, 2015; DIALLO *et al.*, 2021). The simultaneous action of these external and internal influences affects the formation of opinions and accentuates trends in reactions that lead to consumption and the availability of time to achieve specific goals (REN *et al.*, 2020; FERREIRA *et al.*, 2022). In the current context, only part of the population's willingness to pay for Cerrado arachnids can be explained by this study. These estimates do not indicate a low potential for adopting conservation measures for environmental resources in the municipality. There is visible concern, curiosity, and awareness among the population about the need for educational events, especially if they are offered for free by the government.

Overall, the potential positive impact on the municipality's economic and socioenvironmental development highlights the importance of investing in educational initiatives. However, it should be noted that there is variation between the hypothetical and real markets (LIST; SHOGREN, 1998). The hypothetical DAPm may have different values depending on the payment method, financial probability, quality, and type of offer (YU *et al.*, 2014).

The perception gained from the collected information allows us to conclude that people interviewed can identify characteristics and representatives of arachnids. Unlike other works associated with popular knowledge of arachnid species, residents of the sampled municipality were able to recognize fewer conventional species. For example, we can mention pseudoscorpions (*P. nidificator*), whip spiders (*Heterophrynus* sp.), and

mites (*Balaustium* sp.). These species are often recognized in arachnid environmental education and are more common in people's daily lives, such as spiders, scorpions, and ticks (MODRO *et al.*, 2011; JUNIOR; OLIVEIRA-NETO, 2018; RIBEIRO-NETO *et al.*, 2020). It is believed that the level of education of the interviewees, where the majority have at least incomplete higher education, may influence part of this observed prior knowledge. However, confusion and misconceptions associated with classes with characteristics similar to those of arachnids are still perceived.

The engagement of people in environmental issues has been steadily increasing, especially through the media, aiming to mitigate environmental impacts and climate change (RAASCH *et al.*, 2021). This involvement has raised societal concerns about economic relationships and the environment (SILVA; LIMA, 2004). However, it does not provide a broad awareness of the characteristics, behaviors, and importance of the species present in the biome where they are located. In support of these ideas, there is low in-depth knowledge of arachnids, which are often influenced by the media and the lack of dissemination of scientific topics in accessible language. For example, we can mention spider and scorpion species that are used to raise awareness among the population about health hazards and preventive measures (SANTANA *et al.*, 2023). This can result in misunderstandings, fears, phobias, and inappropriate reactions that can affect the well-being, development, and survival of these animals (JUNIOR; OLIVEIRA-NETO, 2018; SANTANA *et al.*, 2023). Situations of threat, fear, and aversion can increase impulsive expressions of defense, fight, and aggression (BRANDÃO *et al.*, 2003).

These changes, which are directed toward the conservation of arachnids, pose significant threats to diversity (PINHEIRO *et al.*, 2016). Furthermore, the lack of accurate information about richness (Linnean deficit), abundance (Prestonian deficit), distribution (Wallacean deficit), and ecological relationships (Hutchinsonian deficit) further exacerbates the inefficiency of arachnid conservation efforts (BRANCO; CARDOSO, 2020). Understanding the factors that influence willingness to pay for raising awareness of socioenvironmental importance is crucial for changing the popular perception of arachnids. We observe that although some respondents recognize the limitations of their knowledge about the diversity and ecology of species, they are willing to pay to aid in their conservation. We note that most respondents consider arachnids to be important only for ecological maintenance. Our analyses show that willingness to pay could increase if actions were implemented to help identify nutritional and medicinal benefits. In other words, the willingness to pay for courses and lectures on Cerrado arachnids becomes

more attractive when it goes beyond the theoretical context to achieve social and economic benefits (DUFFUS *et al.*, 2023). Thus, it is believed that raising awareness about the need to conserve this local diversity can yield more substantial results.

Even though some respondents considered it the responsibility of the public sector to provide courses and lectures on Cerrado arachnids, if the population were to contribute, we would have a WTP of U$4,441.28 per year. We consider this estimated value to be favorable for carrying out the IEPA. Therefore, we estimate that a 15-hour course for an audience of 50 young people and adults taught by a professional with a degree in biological sciences would cost approximately U$600.00 in Brazil. Thus, considering the estimated value of U$4,441.28 per year, it would be possible to offer an educational course seven times a year. In this way, an education program would reach an estimated 350 people a year. Thus, according to our results, if in a city with a population of approximately 25,000, approximately 144 people are willing to make a financial contribution of U$2.08/year toward an educational programme to raise awareness and conserve arachnids of the Cerrado biome, a total of 350 people/year could be reached, giving a ratio of five people reached directly for every two people willing to support financially.

CONCLUSION

In conclusion, our results reveal an average willingness to pay (WTP) of U$2.08 per individual and a total willingness to pay (TWP) of U$4,441.28. This indicates that the majority of the population recognizes the urgency of improving knowledge about Cerrado arachnids. Despite acknowledging the importance and limitations of their knowledge, many are unwilling to pay for its enhancement. They believe that the responsibility for these environmental education initiatives should solely rest with the government, as municipalities receive funding for such activities. Additionally, they acknowledge the existence of gaps that need to be filled for this knowledge to bring environmental, economic, and social benefits. Thus, our study demonstrates that the region has significant economic and socioenvironmental potential for educational initiatives related to arachnids.

It is understood that the majority of the interviewees have a perception of the main characteristics present in arachnid species, although there are confusions and misconceptions associated with other orders and classes of arthropods. The results also indicate that *insights* associated with perceptions and inadequate reactions to arachnids

are related to a lack of in-depth information about the behavior and ecology of these animals. It became evident that they had mostly general knowledge acquired from school, higher education courses, and popular wisdom.

Furthermore, for this study, factors beyond gender, age, and educational level should be considered when planning educational (IEPA) and awareness strategies. The preference for investment management by the public university suggests that the local population recognizes the importance of the institution in conducting awareness and environmental education initiatives. Therefore, given that the study was conducted in a megadiverse and cryptic region and that the results showed a high valuation of arachnids by the population, it justifies strengthening conservation and environmental education initiatives in the region and the Brazilian Cerrado as a whole.

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