Exploring teachers' experiences with insects as catalysts for science teaching in Brazilian early childhood education

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Abstract: Insects have significant potential as educational resources in early childhood education, but are underutilized in this stage of education. Thus, this study aimed to evaluate the relationships and experiences of early childhood education teachers with insects and how they influence the use of insects during classes. We hypothesized that teachers' experiences and knowledge about insects affect the quantity and diversity of insect-related activities during classes. We applied online questionnaires to assess teachers' knowledge and relationships with insects and their use in the classroom. Three hundred and sixteen teachers from across the country answered the questionnaire. Most teachers reported positive experiences with insects. Experiences influenced insect activities during classes, and positive ones related to greater number and diversity of activities. Thus, teachers' experiences are crucial factors in determining the use of insects during classes. It is necessary to demystify these animals and provide positive experiences so that teachers feel comfortable exploring these animals in the classroom.

Keywords entomology, science education, teacher training, early childhood education teachers.

Título: Explorando experiências de professores com insetos como catalisadores para o ensino de ciências na educação infantil brasileira

Resumo: Insetos têm potencial significativo como recursos educacionais na educação infantil, entretanto, eles são pedagogicamente subutilizados nessa etapa da educação. Assim, esse estudo objetivou avaliar as relações e experiências de professores da educação infantil com insetos e como elas influenciam o uso de insetos durante as aulas. Hipotetizamos que as experiências e conhecimentos dos professores sobre insetos afetam a quantidade e diversidade de atividades relacionadas com insetos em sala de aula. Nós aplicamos um questionário *online* para avaliar os conhecimentos e relações de professores da Educação Infantil com insetos e seus usos em sala de aula. Trezentos e dezesseis professores de todo o país responderam ao questionário. A maioria dos professores reportou ter tido experiências positivas com insetos. As experiências influenciaram atividades sobre insetos durante as aulas, e as positivas se relacionaram ao maior número e diversidade de atividades. É necessário desmistificar esses animais e

promover experiências positivas para que os professores se sintam confortáveis ao explorar esses animais em sala de aula.

Palavras-chave entomologia, educação científica, formação de professores, professores de educação infantil.

Introduction

Insects constitute the most diverse animal group on the planet, occurring in practically every ecosystem (Gullan and Cranston, 2014). These animals play a crucial role in various ecological processes, serving as key components in nutrient cycling, plant pollination, and biological control of agricultural pests (Schowalter, 2006). This significance has not gone unnoticed throughout human history, as insects are present in a plethora of world cultures, interacting with humans in distinct ways (Duffus et al., 2021): in folklore (Hogue, 2009), traditional medicine (Rajkhowa and Deka, 2016), or even as food source (Bernard and Womeni, 2017).

They exhibit a wide range of forms, sizes, colours, and behaviours, arousing awe and curiosity in people, especially children. Additionally, various natural processes can be observed in insect populations (Matthews et al., 1997), such as ecological interactions within and between species, and other population dynamics. Due to this fact, they are excellent pedagogical resources, providing a more concrete and meaningful learning experience.

In Early Childhood Education (ECE), which targets children aged 0 to 5 years and 11 months, the use of concrete and meaningful learning is more frequent, as this age group requires contextualized and tangible learning processes, posing a significant challenge for teachers. The challenge arises because a large portion of educational materials designed for this audience focuses solely on play, without contextualizing the content, and teaching practices are often limited to caregiving (Tosta and Souza, 2020).

In this sense, insects are commonly employed in ECE through activities such as painting, collage, and storytelling, particularly focusing on charismatic and colourful ones like butterflies (Nobre and Terán, 2018), bees (Santos et al., 2021), and ladybugs (Lopes et al., 2018). However, most often, only ludic distorted representations of insects are used, neglecting the use of real insects (Korasaki et al., 2021), which creates a distance between the child and the actual organism. Consequently, insects end up being underutilized in ECE.

In the context of using insects in ECE, it is observed that the personal relationships and experiences of the teacher can directly influence how they will explore all the pedagogical potentialities of nature and, consequently, insects (Nóvoa, 1999; Tardif, 2014). This is because, in addition to the lack of educational resources that focus on insects as a theme, elementary school teachers generally have limited scientific knowledge about these animals (Modro et al., 2009). Furthermore, people commonly associate insects with negative aspects such as disgust, fear, and diseases, driven by personal experiences or popular knowledge (Costa-Neto and Pacheco,

2004). Therefore, understanding the relationships of ECE teachers with insects becomes essential to comprehend the strengths and weaknesses of using these animals as themes and/or pedagogical resources during classes.

In Brazil, the curricular assumptions for ECE are nationally guided by the National Curricular Reference for Early Childhood Education (RCNEI) (Ministério da Educação e do Desporto, 1998) and the Common National Curricular Base (BNCC) (Ministério da Educação, 2018). However, it is the responsibility of local government education departments, schools, and teachers to adapt and implement this curriculum. Often, the curriculum is constructed at the local level without teacher participation, depriving them of the opportunity to discuss it, resulting in a superficial, traditionally oriented, and content-driven curriculum (Alves and Fialho, 2019). This movement contradicts the idea that the teacher identity requires autonomous exercise and a sense of control over their work (Nóvoa, 1996; Tardif and Lessard, 2005). Such conceptions are also linked to a technicist initial training that is reflected in pedagogical practice, leading teachers to reproduce content without reflection (Gomes, 2018; Sokolowski, 2013).

The personal experiences and knowledge of educators emerge as a central aspect of the construction of the teacher-curriculum relationship in ECE, as it can strongly drive the adult-child relationship and, consequently, teaching practices (Pena, 2017). Thus, teachers tend to imprint their worldviews and personal experiences on the determination of adopted methodologies, as well as the content addressed in the classroom. In this context, teacher knowledge should be analyzed from a plural and temporal perspective, acknowledging that these are acquired gradually throughout their life history and professional career (Tardif, 2014). In this sense, teachers' personal knowledge is directly related to teaching and learning processes, as it can influence the methodologies and content presented to students. In other words, children learn from what is offered to them, and the personal interactions and motivations of teachers can determine the content learned by students. Therefore, both the knowledge of teaching and that derived from Education and Didactics should enable teachers to understand teaching as a social reality, fostering their ability to investigate their own reality in the continuous reflection and construction of their identity and teaching practice (Pimenta, 1996).

Considering this reality, a question arises: What factors influence Brazilian teachers in determining the content to be taught in Early Childhood Education, especially related to insects? Therefore, this research aims to assess the relationships and experiences between ECE teachers and insects and how these relationships can influence the use of these animals in the classroom. To do so, we test the hypothesis that teachers' experiences with insects and their knowledge about these animals affect the quantity and diversity of insect-related activities used in the classroom. We predict that (i) Good experiences with insects will lead the teachers to use them more times and in more diverse ways in the classroom, and (ii) The knowledge level will also increase the number and types of activities about insects applied by the teachers. Additionally, we discuss the factors that, in the teachers' view, limit the use of insects in ECE.

Methodology

Data sampling

We applied an online questionnaire via Google Forms® to collect responses from ECE teachers regarding questions regarding their experiences and interactions with insects. The choice of the virtual form is justified by its ease of application, broad geographical reach, and cost-effectiveness (Carlomagno, 2018). We included 23 questions, comprising eight multiple-choice and 15 open-ended questions. However, the total number of questions answered could vary depending on the participant's responses. For instance, if a teacher indicated not having had experiences with insects, they would be directed to another section of the questionnaire, skipping questions related to experiences with insects. The same approach was taken concerning the use or non-use of insects in the classroom.

The questionnaire was divided into six sections. The first section focused on characterizing the demographic profile of the participants in the research. We collected data related to age, gender, ethnic-racial identification, and academic background. In the second section, we addressed teaching, gathering information about the city and state where the teacher works, the duration of their teaching experience, and whether they work in a public or private institution. The third section explored the personal relationships and experiences of teachers with insects. The fourth section explored the teacher's ability to visually classify an animal as an insect. In the fifth section, we asked teachers about the importance of insects, and what importance they attributed to them. Finally, in the sixth section, we assessed how teachers use insects in the classroom and identified factors that may limit this utilization.

After receiving approval from the Research Ethics Committee of the State University of Minas Gerais under Protocol Number 5.553.583, the questionnaire was made available online for responses from August 1st to August 31st, 2022. The link was disseminated nationwide through the authors' social media, institutional emails from municipal education departments, and messaging apps. The technique employed was the "virtual snowball," where teachers were requested to share the questionnaire with their colleagues, thereby expanding its reach (Costa, 2018).

Data analysis

To establish the demographic profile of the participants, we calculated the mean age overall and by gender. For data related to ethnic/racial identification, academic background, and teaching experience, we calculated their frequency of occurrence, expressed as a percentage.

To analyze the relationship between participants' feelings, defined as feelings, sensations, and emotions expressed in words (see Cezar and Jucá-Vasconcelos, 2016) and the word "insect," we employed adaptations of the Free Association Technique. This technique accesses participants' spontaneous first thoughts about a given topic, ensuring greater accuracy and precision in their responses (Laplanche and Pontalis, 2001). For ease of

analysis, we categorized feelings into Positive (words related to positive feelings/sensations about insects or caused by them, such as admiration, joy, etc.), Negative (words related to negative feelings/sensations about insects or caused by them, such as fear, disgust, etc.), Neutral (when expressions did not convey positive or negative sensations about insects, typically involving vague words or descriptions of animal characteristics such as small, flying, nature, etc.), and Indeterminate (when the word used for describing the sensation did not definitively indicate whether it was positive or negative, such as attention, concern, etc.). We calculated the frequency of reported feelings and created a word cloud using the Word Cloud tool (wordcloud.com), in which the size of the word corresponds to the frequency of citations.

Concerning teachers' experiences with insects, we utilized adaptations of Content Analysis (Bardin, 2011). A thorough reading of each response was conducted to identify trends and patterns. These techniques were also applied to analyze the description of the most successful activity involving insects from each teacher's personal experience, the perceived importance of insects according to teachers, and the factors limiting teachers from using insects in the classroom. From these analyses, we could also quantify data that was subsequently used in inferential analyses.

Initially, we sought to verify if the types of feelings described by the respondents were associated with their personal experiences with insects. To do this, we applied a Chi-Square with Yates correction test using the 'chisq.test' function from the 'base' package (R Core Team, 2021) to a matrix of the absolute frequency of feelings occurrence by type of experience (Supplementary Table 1). The same test was used to assess if specific types of experiences were linked to specific insect taxa, applied to a matrix of absolute frequency of insect taxa occurrence by type of experience (Supplementary Tabel 2). In this case, we excluded those taxa that were only once mentioned by respondents. Based on these results, we used the 'corrplot' function from the 'corrplot package' to obtain a Pearson correlation matrix of Pearson residuals with each category of feeing-experience combination, to identify the relationships that most contributed to the observed differences.

To understand if the knowledge about insects (measured as the ability to correctly classify animals as insects) is linked to teachers' experiences, we constructed Generalized Linear Models (GLMs) with a quasipoisson distribution. In these models, the number of correct classifications was used as the response variable, and the type of experience was used as the predictor variable.

We also examined the effects of teachers' personal experiences on the development of activities involving insects. These analyses were conducted in two ways. Initially, we used a GLM with a binomial distribution to test whether knowledge about insects and personal experiences influenced the probability of implementing activities involving insects. For this, we used a binary variable indicating whether teachers implemented activities (assigning the number 1 when the respondent mentioned conducting

activities involving insects and 0 when the respondent mentioned not conducting such activities) as the response variable. The predictor variables included the number of correct insect classifications by each teacher (indicating the teacher's knowledge about insects) and the types of reported experiences (positive, negative, or neutral).

To assess whether the number of different activities conducted could be predicted by knowledge about insects and personal experiences, we employed GLM with a quasipoisson distribution. This analysis considered only the responses of teachers who mentioned conducting activities. In this model, the total number of different activities reported by each teacher was used as the response variable, with the number of correct insect classifications by each teacher (indicating knowledge about insects) and the types of reported experiences included as predictor variables.

In addition to the total number of activities, considering that each teacher has a different set of regularly applied activities, we also aimed to determine if the variety of activities conducted was influenced by knowledge about insects and the type of reported experience. For this purpose, we constructed a matrix of activity implementation by each teacher.

This matrix considered all possible activities mentioned by all interviewed teachers, assigning a value of 1 if a teacher used a specific activity and 0 if not (Supplementary Table 3). From this matrix, we generated a similarity matrix among teachers using the 'vegdist' function from the ‘vegan package’ (Oksanen et al., 2022). In this analysis, we used the Jaccard distance, as it is the most appropriate for presence-absence data regarding activity implementation. Subsequently, we conducted a Permutational Multivariate Analysis of Variance (PERMANOVA) using the 'adonis2' function from the 'vegan' package. The similarity matrix served as the response variable, with the number of correct insect classifications by each teacher serving as a proxy for knowledge about insects. The types of reported experiences (positive, negative, or neutral) were included as predictor variables.

To assess differences between pairs of personal experience categories, we utilized the 'pairwiseAdonis' function from the 'pairwiseAdonis' package (Arbizu, 2017). The similarity matrix was used as the response variable, with the type of reported experience (positive, negative, or neutral) as the predictor variable. Whenever necessary, models were simplified using a 'stepwise' approach, where non-significant variables were removed from the model.

Results

During the questionnaire application, we had 327 accesses, but 11 individuals declined to participate in the survey, resulting in a total of 316 participants. Based on the obtained data, we were able to outline the average demographic profile of the participants. The majority of participants were women (96%, n = 302) who identified as either white (45.8%, n = 145) or mixed-race (41.46%, n = 131). The average age was 41.8 (± 9.54) years. Most held a degree in Pedagogy (50%), and had specialization in

education-related areas (59%, n = 186). Participants were from all regions of the country, with the majority residing in the Southeast region of Brazil (65.5%, n = 210) and working in public (89%, n = 280) municipal (88.53%, n = 248) schools, with ten or more years of experience as early childhood education teachers (43%, n = 135).

When asked about the word "insect," teachers most frequently associated it with negative feelings (34.6%, n = 37) compared to neutral feelings (30%, n = 32), positive feelings (27%, n = 29), and undefined feelings (8.4%, n = 9). However, interestingly, the word with the highest frequency of mentions was "curiosity", with 52 citations, indicating a dichotomous relationship between teachers and these animals. This suggests that while insects evoke negative feelings, they also spark curiosity in a significant portion of participating teachers (Figure 1).

Figure 1 - Feelings expressed in words when teachers encounter the word 'INSECT.' The larger the word, the higher the frequency of mentions. Green represents positive feelings, red represents negative feelings, blue represents neutral feelings, and black represents undefined feelings.

The majority of participating teachers (68.35%, n = 216) reported having experiences with insects, with 46.3% (n = 100) describing these experiences as positive, 38.4% (n = 83) as negative, and 15.3% (n = 33) as neutral (i.e., not eliciting either positive or negative feelings). In total, 36 insects across 13 orders were mentioned (Supplementary Table 3), along with 12 non-insect animals. The most frequently mentioned insects were bees (15%, n = 57), butterflies (13%, n = 49), ants (12%, n = 46), cockroaches (11%, n = 40), mosquitoes (10%, n = 37), ladybugs (8%, n = 29), and beetles (6%, n = 22), respectively. The most frequently mentioned non-insect animal was the spider (54%, n = 20). The types of experiences were not evenly distributed among the mentioned insect taxa (χ^2 = 139.52, d.f. = 40, p = 0.0004), allowing the identification of three groups: i)

predominantly positive experiences with butterflies and ladybugs; ii) predominantly negative experiences represented by cockroaches and mosquitoes; and iii) neutral experiences with beetles (Figure 2).

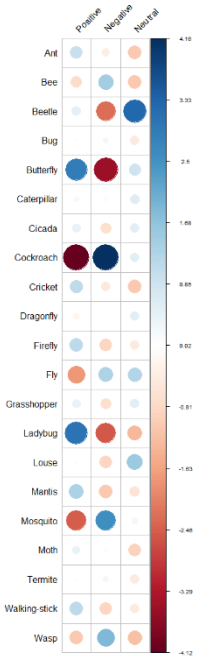

Figure 2 - Correlation plot of Pearson Chi-Square residuals for each insect taxon category against experience type (χ^2 = 139.52, d.f. = 40, p = 0.0004). Positive residuals are shown in blue, indicating a positive association between the corresponding insect taxon and experience type, while negative residuals are shown in red, indicating a negative association. The size of the circle represents the strength of the correlation, with larger circles indicating stronger associations.

The reported feelings are directly related to the type of experiences individuals had with insects. Differences in feelings are notably linked to negative experiences, which were significantly more negatively associated with positive experiences and positively associated with negative experiences than would be expected by chance (χ^2 = 91.86, d. f. = 6, p = 0.0004, Fig. 3).

Furthermore, our analysis revealed that insect knowledge - assessed by the ability to correctly classify images - does not significantly correlate with individual experiences (d. f. = 2, F = 2.5716, p = 0.078). This finding suggests that, on average, individuals with varying types of experiences have a similar number of correct classifications (see Supplementary Figure 1).

In terms of the perceived importance of insects, 97% of teachers view these animals as significantly important. Their significance is attributed to their role in the food chain (36%), their contribution to ecosystem balance and functioning (23%), and their involvement in pollination processes (17%).

Our results futher indicate that the type of personal experience with insects plays a crucial role in determining whether teachers engage in

activities involving insects (Table 1). Teachers with positive experiences are approximately four times more likely to include insect-related activities compared to those with negative experiences. Similarly, teachers with neutral experiences are about twice as likely to conduct such activities compared to those with negative experiences (Table 2, Figure 4).

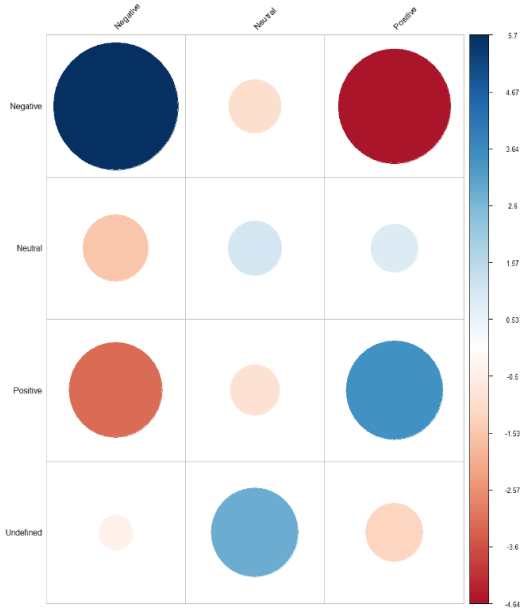

Figure 3 - Correlation plot among Pearson Chi-Square residuals for each category of feelings against experience type (χ^2 = 91.86, d. f. = 6, p = 0.0004). Positive residuals are shown in blue, indicating a positive association between the type of feelings and experience type, while negative residuals are shown in red, indicating a negative association. The size of the circle represents the strength of the correlation, with larger circles indicate stronger associations.

Source of variation	Estimate	Standard Error	z value	p-value
Intercept	0.266	0.2215	1.204	0.2287
Neutral Experience	1.045	0.4800	2.178	**<0.05**
Positive Experience	1.468	0.3571	4.111	**<0.01**

Table 1 - Coefficients from the generalized linear model testing the probability of conducting insect-related activities based on different types of teacher experience with insects. Bold p-values indicate statistically significant results (α = 0.05).

Among teachers who conducted activities involving insects, our data indicate that only the type of experience significantly influenced the number of different activities implemented. Teachers with positive experiences engaged a greater variety of activities compared to those with neutral or negative experiences. In contrast, the number of different activities carried out by teachers with neutral experiences was similar to that of teachers with negative experiences (Table 3, Fig 5).

Experience Type	Odds Ratio	CI 2.5%	CI 97.5%
Negative	1.30	0.85	2.02
Neutral	2.84	1.15	7.77
Positive	4.34	2.20	0.95

Table 2 - Odds ratio for realization of activities with insects in relation to the experience type of each teacher.

Figure 4 - Odds ratio for conducting insect-related activities based on each category of personal experiences with insects reported by teachers. The dashed line represents zero, and the whiskers, the confidence interval. If the confidence interval crosses the zero line, there is no difference between this odd ratio and a zero chance of applying activities using insects.

Comparison	Estimate	Std. Error	z-value	p-value
Neutral x Negative	-0.057	0.104	-0.545	0.846
Positive x Negative	0.18	0.074	2.498	**0.032**
Positive x Neutral	0.24	0.094	2.563	**0.027**

Table 3 - Pairwise comparisons of the number of different activities implemented by teachers, based on their types of experiences with insects. Bold p-values indicate statistically significant differences ($\alpha = 0.05$).

Despite having a low explanatory power, the type of experience was a determinant factor for the set of activity types implemented by the teachers (Table 4, Fig 6). These sets were different between individuals with positive and negative experiences, as well as between those with positive and neutral experiences. No differences were observed in the types of activities between individuals with neutral and negative experiences (Table 5).

When asked about the most effective type of insect-related activity, teachers mentioned various activities/methodologies, with the three most common being the observation of live or dead insects (72 mentions), followed by outdoor research/investigation (45 mentions), and the use of songs related to insects (31 mentions).

Regarding the factors limiting the use of insects in early childhood education, teachers identified several factors, which, upon evaluation, revealed two main categories: teachers' negative feelings towards insects

(170 mentions) and the lack of knowledge and access to insects (167 mentions).

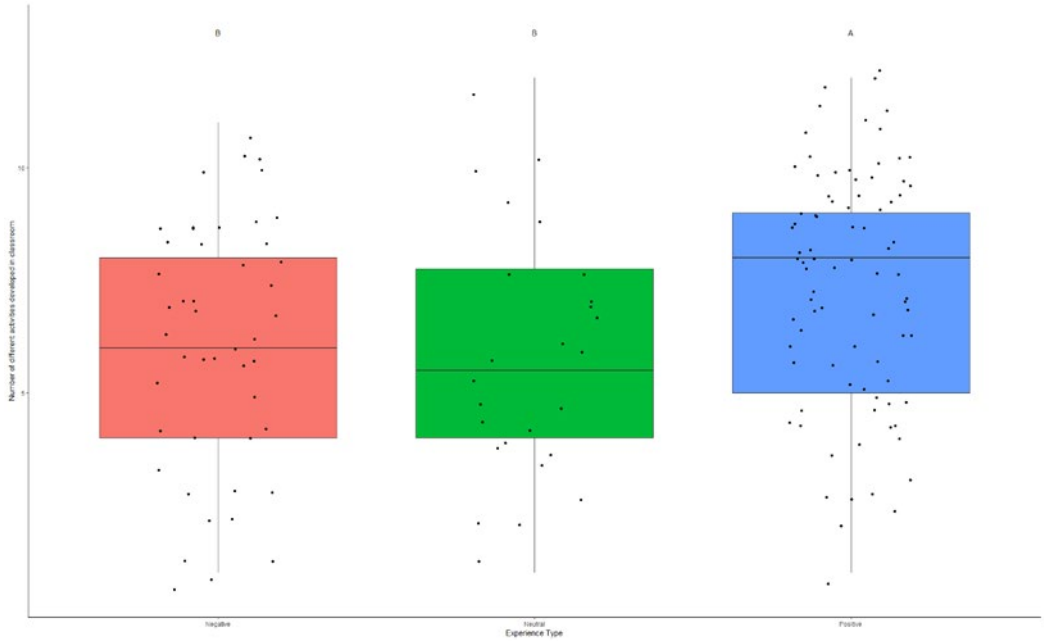

Figure 5 - Mean number of activities developed by teachers, categorized by their experience types with insects. The boxes represent 50% of the data, gray horizontal lines indicate the median, whiskers represent the standard errors and each black dot represents an individual observation (teacher response). Boxes with different letters denote statistically significant differences.

Source of Variation	d. f.	Sum of Squares	R^2	F	p-value
Type of Experience	2	0.7486	0.02	2.2067	**0.007**
Residual	155	26.2933	0.97		
Total	157	27.0419	1.00		

Table 4 - PERMANOVA results for the comparison of diferences among the set of different activities used by the teachers based on experience types as predictors. Bold p-values indicate significant statistical results ($\alpha = 0.05$).

Comparison	d. f.	Sum of Squares	R^2	F	p-value
Negative x Neutral	1	0.1539	0.01	0.76	0.61
Negative x Positive	1	0.4824	0.02	2.98	**0.009**
Neutral x Positive	1	0.3907	0.02	2.47	**0.023**

Table 5 - Results of the pairwise PERMANOVAS among types of experience in relation to the set of different activities Applied by each teacher. Bold p-values indicate significant statistical results ($\alpha = 0.05$).

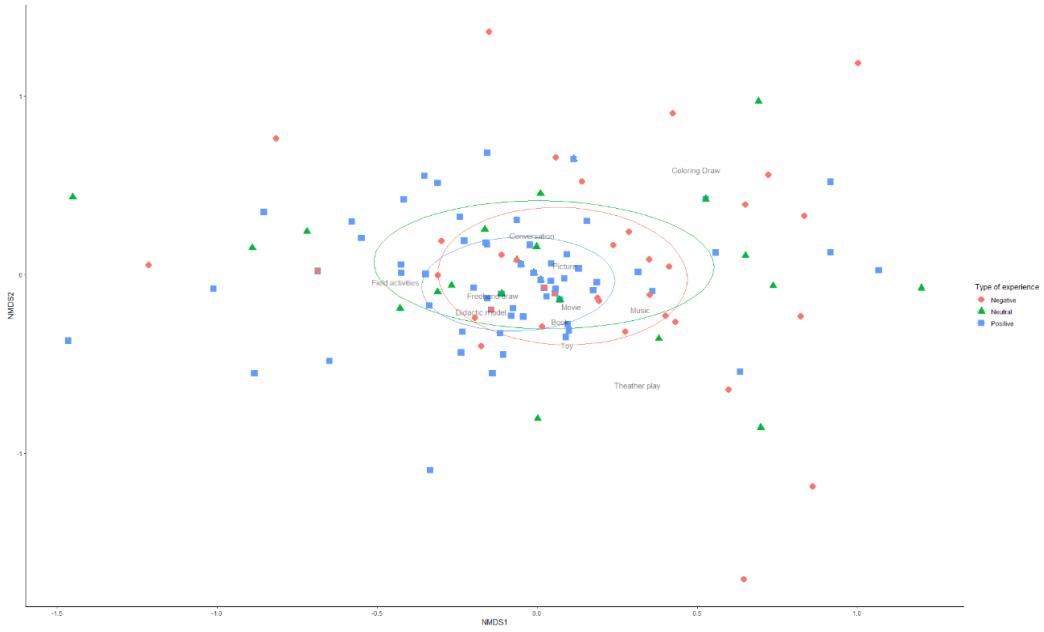

Figure 6 - NMDS based on the sets of activities applied by teachers in each experience type category (red = negative, green = neutral, blue = positive).

Discussion

Our data support our hypothesis that teachers' experiences are a significant motivating factor for the implementation of insect-related activities in the classroom. Both the number and types of activities were strongly influenced by teachers' experiences, proving this variable to be more pivotal than teachers' knowledge of insects.

In our research, the majority of participants were female, a pattern consistent with various studies on early childhood education in Brazil (Souza and Melo, 2018, Coelho et al., 2023, Ramos et al., 2023). This pattern harkens back to the historical and cultural processes of early childhood education, which have long been associated with caregiving roles traditionally attributed to women (Kuhlman-Jr, 2000). Despite advancements in early childhood education concepts, there is still some resistance to men participation in these spaces (Monteiro and Altmann, 2014). Thus, our data reflect the reality of Brazilian early childhood education, as indicated in the 2022 census, where 96.3% of educators in this educational stage identified as women (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira, 2023).

Regarding teachers' sentiments associated with the word "insect," our data revealed a dichotomy. While these animals sparked curiosity in some teachers, reports of disgust and fear were also common. This pattern is evident in other ethnoentomological studies, which indicate that the construction of the ethnozoological domain "insect" is directly related to the feelings and sensations these animals evoke in people (Costa-Neto and Pacheco, 2004; Santos et al., 2015). Despite a tendency to associate the word "insect" with negative feelings (Alencar et al., 2012), these organisms also evoke admiration in many cases (Albuquerque et al., 2022).

Most teachers reported having had experiences with insects. This result is linked to the presence of insects in urban and peri-urban environments, known as urban or synanthropic insects (Robinson, 2005). Therefore, the occurrence of these beings in close proximity, or even inside homes, leads to numerous encounters and interactions between these animals and humans. This diversity of interactions is reflected in the dichotomy of reported experiences, with nearly equal numbers of reports of positive and negative experiences.

Among the mentioned insects, three groups are associated with the type of experience. The group with predominantly positive experiences was associated with butterflies and ladybugs. These insects have great visual appeal, showcasing vibrant colors. Additionally, they are culturally linked to beauty and transformation in the case of butterflies (Volkova, 2016) and good luck in the case of ladybugs (Hogue, 2009). Moreover, these insects are harmless, leading to more experiences classified as positive.

Cockroaches and mosquitoes were associated with predominantly negative experiences. Cockroaches are commonly linked to dirt and diseases, eliciting fear and disgust in most people (Costa-Neto and Gouw, 2006; Costa-Neto and Magalhães, 2007). As for mosquitoes, being hematophagous insects, they commonly generate negative experiences, as their bites cause itching and discomfort, along with the risk of transmitting diseases such as dengue (Alves et al., 2019).

The group of neutral experiences was associated with other beetles (excluding ladybugs). However, the term "beetle" is very generic, encompassing a wide diversity of insect species (Costa-Neto and Rodrigues, 2006). The Order Coleoptera, which includes beetles and ladybugs, is the most diverse on the planet, containing animals of various sizes, shapes and colors (Gullan and Cranston, 2014). The most common and abundant beetles in urban areas are often brown or black and not visually striking (Frizzas et al., 2020). Moreover, most beetles do not pose risks to humans through bites or stings, which may explain the neutral experiences reported by the teachers.

Analyzing the importance attributed to insects, it is notable that most teachers believe these organisms are positively significant. This result contrasts with the feelings of repulsion expressed by some teachers. In other words, even though insects may evoke negative emotions psychologically, the participants rationalize and acknowledge their importance for nature. These findings align with studies by Modro et al. (2009) and Passos et al. (2011), where the majority of teachers also assigned positive importance to insects. Additionally, the three most cited functions by teachers were related to ecological aspects, suggesting that educators have an interest in the topic, possibly seeking information beyond textbooks. This is noteworthy as studies by Cardoso et al. (2008) and Lage et al. (2012) indicate that textbooks often provide limited exploration of the ecological functions of insects.

Regarding the use of insects in the classroom, our results indicated that knowledge about insects was not a determining factor in the diversity of

activities implemented. Personal experiences played a more significant role in the number and diversity of teaching practices involving insects. The construction of a teacher's knowledge and its application in a professional context can be analytically broken down into components of pedagogical knowledge (content knowledge, curriculum knowledge, student knowledge, pedagogical content knowledge and pedagogical knowledge) (Fernandez, 2014). Among these core skills for a teacher, pedagogical content knowledge (Shulman, 1986) stands out, emphasizing the ability to adapt subjects to the students' understanding at a specific academic level. A central aspect of this content is the teacher's conception of the purposes for teaching the topic (Grossman, 1990).

Our findings underscore the potential for fostering biophilia — our affinity and interest for the natural world, and all that lives (Fromm, 1973) — as a core principle in educational public policies and practices. By showing how positive teacher experiences with insects enhance their use as pedagogical tools, this research highlights the importance of nurturing meaningful connections between teachers and the natural environment (Quinn et al., 2015; Cont et al., 2023). This affinity can be harnessed by designing curricula that incorporate real-life encounters with insects, encouraging students to appreciate the ecological significance and beauty of these organisms (Boileau and Russel, 2020). It is noteworthy that experiences play a significant role in determining what will be constructed in the classroom, as positive feelings of teachers are directly linked to their sense of self-efficacy (Brígido et al., 2011). Teaching about other arthropod groups, such as arachnids, for example, is also directly affected by teachers' feelings of fear and disgust (Wagler and Wagler, 2017). This is also true for insects in Spain, where negative emotions aroused are significantly associated with a lack of interest among educators (Prado et al., 2020).

Recognition these complex relationships between humans and insects is necessary to consider appropriate teaching and learning processes to address significant ecological challenges today, such as the pollinator crisis (Boileau and Russel, 2020) or the global decline of entomofauna (Sánchez-Bayo and Wyckhuys, 2021). In this regard, applying different teaching techniques can be crucial for achieving these objectives in teaching entomology in early childhood (Edwards et al., 2012).

Among the activities that teachers find most effective using insects are those involving outdoor activities and insect observation (alive or dead). Direct contact with real insects stimulates students' curiosity and interest in the lesson, substantially contributing to knowledge acquisition. This theme has been the subject of research that observed the relevance of contact with real insects at different stages of education (Raymundo and Alencar, 2022; Carvalho et al., 2022). Music was also mentioned as one of the most relevant activities for teaching about insects. This highlights the importance of playfulness in early childhood education (Moraes et al., 2021), and suggests that combining playfulness with concrete experiences can generate positive results in this phase (Korasaki et al., 2021).

On the other hand, there are factors that limit the use of insects in the classroom, according to the participating teachers. These factors include their negative feelings about insects and the lack of knowledge, and access to these animals (Prado et al., 2020). Once again, negative experiences and the associated feelings, combined with culturally constructed knowledge about insects, prevent many teachers from being interested in these animals and using them as a theme or pedagogical resource. However, it is important to emphasize that some feelings of fear and repulsion towards insects result from a lack of knowledge and absence of positive experiences, as mentioned by some teachers' responses. The majority of participating teachers were graduates in Pedagogy, a course that presents deficits in teaching Natural Sciences (Ovigli and Bertucci, 2009; Pires and Malacarne, 2018) and consequently does not include entomology in its basic curriculum. Thus, their knowledge about insects is likely acquired during high school, primarily through textbooks. In this sense, studies show that insect content in textbooks is often rudimentary and highlights only the harms that insects can cause (Almeida et al., 2006; Gangwani and Landin, 2018) which may reinforce the culturally attributed negative stereotypes associated with these animals.

In this context, initial and continuing teacher education should be a focal point for popularizing the use of insects in education. Initiatives in this area have been carried out at various stages, including the initial training of pre-service teachers (Haefner et al., 2006) and continuing education for practicing teachers (Golick et al., 2010), as well as the provision of didactic models for teacher replication (Matos et al., 2009) and proposals for activities involving various insect taxa (Canedo-Júnior et al., 2021). However, initiatives like these are still in their early stages, especially those directed at Early Childhood Education teachers. In this regard, more initiatives should be developed, providing these teachers with materials that contribute in an accessible way to the acquisition of entomological knowledge, enabling them to dispel misconceptions about insects and feel comfortable working with these animals in the classroom.

The findings of this study significantly demonstrate how educational policies for incorporating environmental topics into Early Childhood Education in Brazil are deficient. Although public policy guidelines applicable to Early Childhood Education, such as the Educational Basis and Guidelines Law (LDB 9394/96) (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira, 2023), the National Curriculum Guidelines for Early Childhood Education (DCNEI) (Ministério da Educação, 2010), the National Common Core Curriculum (BNCC) (Ministério da Educação, 2018), and more explicitly, the National Curriculum Reference for Early Childhood Education (RCNEI) (Ministério da Educação e do Desporto, 1998), emphasize the need to include contact with nature in the curriculum, the reality of daycare centers and kindergartens is quite different (Tiriba, 2010).

As observed in the present study, the incorporation of a specific topic—such as insects—into the Early Childhood Education curriculum depends more on teachers' personal experiences than on the existence of

educational guidelines that propose such inclusion. Therefore, it is necessary to take a critical look at the curricula of teacher training programs for Early Childhood Education to ensure compliance with existing educational policies. Additionally, new educational policy guidelines should be developed in partnership with universities and research centers to facilitate teachers' access to scientific content, particularly concerning environmental literacy and biodiversity conservation. This would promote the dissemination of methodologies and teaching practices in natural sciences within an approach that prioritizes meaningful learning. By engaging more closely with scientific knowledge, teachers can have new and enriching experiences with nature, which may positively influence the inclusion of these topics in the classroom.

Furthermore, the data from this study can effectively contribute to raising teachers' awareness and understanding of the importance of addressing nature-related content, enabling children's engagement, exploration, and awareness while recognizing insects as valuable pedagogical resources that enhance these practices. Reflection in teaching is an essential element for teachers to restructure their knowledge, rethink their practices, and reconsider their own conceptions of knowledge and its inherent aspects. As argued by Freire (1987), praxis is fundamental in education.

Conclusions

In this study, we explored the conceptions of Brazilian teachers regarding the use of insects in Early Childhood Education. We confirmed the hypothesis that teachers' experiences with insects affect the implementation of entomology-related activities in the classroom. We also observed a certain dichotomy between teachers' feelings and experiences with insects, as these animals. While these animals elicit negative sentiments, they also evoke admiration and are considered positively important for nature.

We further investigated the factors that limit the use of insects in the classroom, as reported by teachers. Once again, we observed that negative feelings reduce interest in insects. Additionally, limited access to these animals and insufficient knowledge about them also hinder their utilization.

In light of these findings, this study highlights the importance of understanding the relationships between teachers and the content they teach in the classroom. We observed the need to popularize entomological knowledge in an accessible way to debunk misconceptions and facilitate positive experiences between teachers and insects. This, in turn, sparks the interest of teachers in working with insects in Early Childhood Education, contributing to enriching teaching and learning processes.

Additionally, educational systems, which often portray zoology (and therefore entomology) as distant and abstract subjects, especially in early childhood education (Azevedo et al., 2022), must update their approach, providing teachers with new and positive experiences that will undoubtedly reflect in classroom practices. Lastly, we hope that this study encourages professionals in Entomology and Education to produce educational materials

on the topic of insects specifically for basic education teachers, especially those in Early Childhood Education.

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