Does visiting The Bug Farm change perceptions on invertebrates, nature recovery, and insect-based food, through education?

By Sabaha Hussein

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7. **Appendix:**

1.0 Summary:

Invertebrates are underrepresented and undervalued, and are subject to widespread negative attitudes, resulting in inadequate conservation support and funding. This study aimed to assess the impact of informal environmental education on public perceptions of invertebrates.

A Likert-style questionnaire was used to measure changes in visitors' perceptions of invertebrates, nature recovery, and insect-based foods across six exhibits at Dr Beynon's Bug Farm in the UK, including The Tropical Zoo, The Nature Recovery Centre (conservation-focused interpretation), and Grub Kitchen (insect-based food experience). Participants completed a pre-visit survey assessing baseline perceptions and follow-up sections after visiting each exhibit, in which the same statements were repeated in exhibit-specific contexts. Open-ended questions were included to provide contextual insight. Paired Wilcoxon signed-rank tests with Holm–Bonferroni correction were used to assess change.

All exhibits produced significant perceptual shifts; however, effects were domain-specific rather than consistent across all exhibits. Interactive exhibits were most strongly associated with behavioural change, including increased tactile comfort and willingness to consume insect-based foods. The Nature Recovery Centre generated the largest emotional shift, while the Bug Farm Trail (trail promoting conservation actions) produced the strongest increase in perceived personal agency. Environmental importance showed limited movement, likely reflecting high baseline agreement. Exhibit visit order did not significantly influence outcomes.

A 10-week follow-up indicated that most respondents reported some degree of behavioural change, suggesting that perceptual shifts extended beyond the immediate visit. These findings highlight the importance of diverse exhibit formats in informal environmental education, as different psychological barriers respond to different modes of engagement.

2. Introduction:

2.1 Importance of invertebrates

Invertebrates comprise approximately 95% of all animal species, with around 66% belonging to the class *Insecta* (ZHANG, 2011). Despite this dominance, they remain among the most disliked taxonomic groups globally (Lockwood, 2013; Prokop et al., 2010), and are disproportionately underrepresented and endangered (IUCN, 2025; Lister & Garcia, 2018; Eisenhauer et al., 2019).Yet they provide fundamental ecosystem services, including pollination, soil aeration, and decomposition (Costanza et al., 1997), all of which are essential to global ecosystem functioning. Costanza et al. (1997) estimated that global ecosystem services are valued at approximately US$33 trillion per year, a substantial proportion of which is directly or indirectly attributable to invertebrates. Despite this, they receive only 8% of conservation funding (Cardoso et al., 2011).

Although invertebrates are essential for human and ecological survival, persistent negative attitudes, particularly toward insects, and their frequent portrayal as pests or health threats, make it challenging to justify their conservation **(Mammola et al., 2022;** Martín-López et al., 2007) and to mobilise support for pro-conservation actions (Soga et al., 2023; Cardoso et al., 2011). Public preference consistently favours familiar, charismatic, and aesthetically appealing species, while those perceived as “unattractive” or fear-inducing receive less support and funding (Collado et al., 2022; Gunnthorsdottir, 2001; Knight, 2008). However, public engagement is fundamental to reducing current extinction rates (Ladle et al., 2008), and increasing awareness may strengthen support for invertebrate conservation (Soga & Gaston, 2021;Meuser et al., 2009)

2.2 Psychological and media barriers

Disgust sensitivity appears to be shaped through childhood socialisation and health education (Bixler & Floyd, 1999). Attitudes formed primarily based on affect (emotion) rather than cognition may be more responsive to emotional appeals than to fact-based arguments (Edwards, 1990). Disgust toward particular objects may be learned, innate, or an interaction between the two (Bixler & Floyd, 1999). It has been proposed that disgust and fear serve distinct evolutionary functions: disgust as a mechanism for pathogen avoidance, and fear as a response to physical threat (Al-Shawaf et al., 2017).

Popular media frequently capitalises on these responses. Programmes such as ‘Fear Factor’ and ‘I'm a Celebrity...Get Me Out of Here!’ frame insect encounters as fear-based challenges, potentially reinforcing negative attitudes (Looy & Wood, 2006; Bixler & Floyd, 1999). Films (Berenbaum & Leskosky, 2009) and online content that spread misinformation further amplifies these perceptions, particularly within an era of rapid digital information exchange (Mammola et al., 2022).

2.3 Entomophagy and behavioural change

Aversion toward insects also limits their uptake as a human food source. Entomophagy (the consumption of insects) offers an environmentally sustainable, nutritious, and potentially ethical means of meeting the demands of a growing global population (Gahukar, 2011;Yen, 2009). In many regions, insects already contribute substantially to food security and are valued as both human and animal feed (Bodenheimer, 1951; DeFoliart, 1992; Gahukar, 2011; Yen, 2009). However, insect consumption is often perceived as unusual or unacceptable in Western and other developed countries (Yen, 2009), with negative perceptions are among the primary barriers to wider adoption (Hamerman, 2016; Lensvelt & Steenbekkers, 2014).

Changing perceptions of invertebrates and the behaviours associated with them is therefore critical. Public attitudes influence funding priorities, ethical considerations surrounding invertebrate welfare, and support for invertebrate-based research (Drinkwater et al., 2019). Increasing awareness and improving perceptions may help strengthen both conservation and sustainable food initiatives.

Many studies emphasise the importance of positive childhood experiences with nature and invertebrates through field trips (Bixler & Floyd, 1999; Bixler et al., 1994**),** classroom pets (Fisher & Lorenz-Reaves, 2018), and other early-exposure opportunities. However, less attention has been paid to whether perceptions can be meaningfully shifted in adulthood.

2.4 Study aims

This study aimed to identify which exhibits or sessions in an informal education setting are associated with the greatest shifts in visitors’ perceptions of invertebrates, nature recovery, and insect-based foods. It also examined whether changes in visitor perceptions following a

visit were associated with reported behavioural intentions, particularly regarding insects. The findings aim to inform future educational outreach by identifying approaches most strongly linked to positive perceptual and behavioural change.

3.0 Methods:

3.1 Study site and background:

Dr Beynon's Bug Farm (hereafter, The Bug Farm) is a visitor attraction in St Davids, Wales (Figure 3.1) that integrates sustainable food and farming practices, applied research, and nature recovery (Figure 3.2). The site comprises multiple indoor and outdoor exhibits, visitor facilities, and managed habitats, all of which visitors can move freely through.

Six exhibits were selected for this study to reflect the range of educational outreach offered at The Bug Farm. These included The Museum and The Nature Recovery Centre, both of which present information on invertebrates, with the former covering edible insects and the latter nature recovery. The Up-Close Handling session and Grub Kitchen incorporate direct interaction, allowing visitors to hold and consume insects, respectively. The Tropical Zoo provides the opportunity to view a diverse range of invertebrates, with optional staff interaction.

For this study, the term "bug" follows The Bug Farm's definition and is used to describe any invertebrate, defined as an animal without a backbone.

Figure 3.1| Red marker indicating the location of Dr Beynon's Bug Farm in St Davids, Wales.

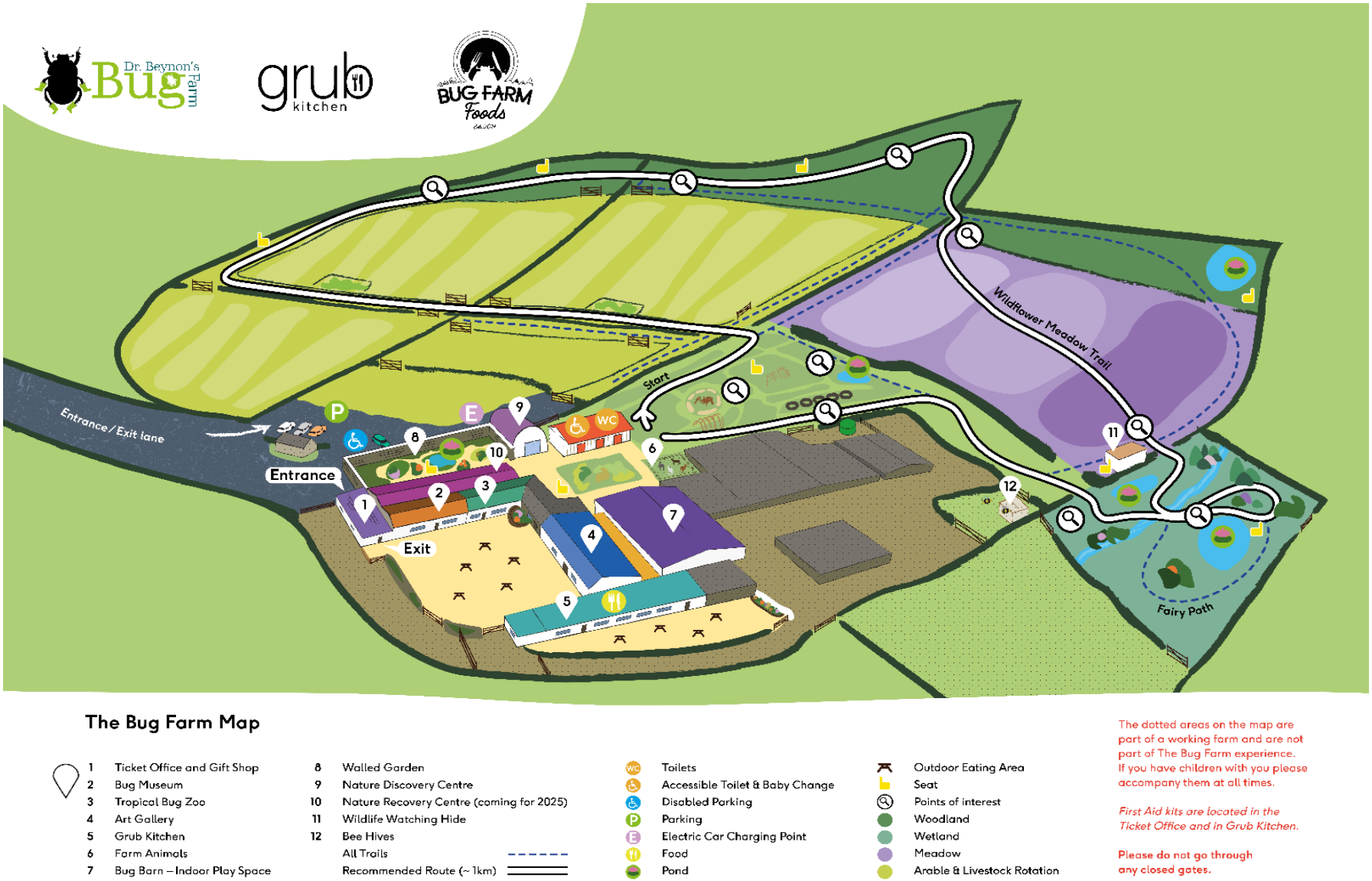

Figure 3.2. Front page of a flyer containing the map of Dr Beynon's Bug Farm, showing the layout of visitor facilities, habitats, and recommended visitor routes (Dr Beynon's Bug Farm, 2024**,** internal document, February 2).

Questionnaire design:

A 5-point Likert-style paper-and-pencil questionnaire was used to collect visitor perceptions before the visit and after each subsequent exhibit. Response categories ranged from 1 *(strongly agree)* to 5 *(strongly disagree)*, including the option of 3 *(neutral)*. This format was chosen to enable rapid data collection without imposing on the visitors' day. The question wording was designed to be clear and simple, accessible across a wide range of ages and reading abilities.

Each questionnaire began with a general pre-visit section comprising eight statements assessing attitudes towards invertebrates, nature recovery, and eating insects. These statements were then repeated for each relevant exhibit or session (hereafter referred to as 'exhibits'). The statements were:

1. *I feel positively about bugs*.
2. *I feel comfortable touching bugs*.
3. *I think bugs are important for the environment*.
4. *I know what I personally can do to help nature*.
5. *I would eat insects*.
6. *I think insects can taste good*.
7. *Eating insects can be good for the environment*.
8. *I would choose to buy and eat insect-based food at home*.

The six exhibits evaluated were the Museum, Tropical Zoo, Nature Recovery Centre, Bug Farm Trail, Up-Close Handling Session, and Grub Kitchen. The questionnaire structure reflected key components of the visitor experience, including indoor exhibits, outdoor habitats, and food-based engagement.

The questionnaire concluded with post-visit reflection statements, largely mirroring the pre-visit items, alongside open-ended questions to collect qualitative data on which aspects of the visit had the greatest impact and how visitors felt about invertebrates (Appendix 3.1). Example statements included: *"I feel more positively about bugs after today"* and *"I learnt something new today"*.

Following a small pilot study, the Museum section was introduced, and exhibit order numbering was made more prominent to improve clarity and navigation for respondents (Appendix 3.1).

Data collection process:

Data collection took place over a two-week period from 19th July to 2nd August 2025, across eight open days at The Bug Farm.

Questionnaires were distributed at the Museum exhibit, where visitors were signposted upon arrival. The Museum is located adjacent to the Ticket Office and was typically the first exhibit participants visited (Figure 3.2).

Upon entering the Museum, visitors were invited to participate in the dissertation research. Those who agreed were verbally briefed on the study and procedures; this information was also outlined in the questionnaire information sheet (Appendix 3.1).

Participants were instructed to complete the relevant sections of the questionnaire immediately after visiting each exhibit or experience included in the study.

At the end of the questionnaire, participants were invited to provide contact details for a two-month post-visit follow-up relating to their response to the open-ended question, "*What positive steps for nature will you take after this visit (if any)?*" Participation in the follow-up was optional and incentivised via entry into a prize draw for a Bug Farm hamper assembled by the researcher. The questionnaire responses were digitised continuously throughout the data collection period.

Posters were posted at exhibit exits as visual cues and reminders for visitors to complete the appropriate section of the questionnaire (see Appendix 3.2 for an example).

Post-visit behaviour follow-up:

Ten weeks after their visit, participants who had consented to follow-up contact were sent an email outlining a brief background to the study, restating the open-ended question *"What positive steps for nature will you take after this visit (if any)?",* and reminding them of their original response. Recipients were asked to describe any progress made towards this action

or to report any additional positive steps taken that were inspired by their visit to The Bug Farm. The incentive to enter a Bug Farm goody bag prize draw was reiterated. The full email format is provided in Appendix 3.3.

Due to a low response rate, a reminder email containing the same content was subsequently sent, with the subject line and opening text revised to clarify that it was a resend.

Open-ended responses describing post-visit behavioural actions were thematically coded into categories representing the degree of behaviour change, ranging from *"achieved intended action"* to *"no action taken"*.

Ethical considerations:

A full ethical review was conducted and approved by the ethics committee of Swansea University (No. 2 2025 13534 13371) before data collection (Appendix 3.4).

Questionnaires were GDPR-compliant. They were completed anonymously; no personal details apart from an email address (e.g., name, address) were collected from respondents to minimise social desirability bias and protect participants' privacy. These were accessible only to the researcher and Dr Beynon. Informed consent and the right to withdraw were clearly communicated during the initial briefing and within the questionnaire materials (Appendix 3.1).

Statistical analyses:

All analyses were performed using RStudio Statistical Software (v4.3.1; R Core Team, 2023). Data manipulation was conducted using the packages *dplyr* (Wickham et al., 2023), *tidyr* (Wickham et al., 2024), *forcats* (Wickham, 2025), and *stringr* (Wickham, 2023). Figures were produced using *ggplot2* (Wickham, 2016) and *scales* (Wickham et al., 2025). The full reproducible analysis code is provided in Appendix 3.5.

Because the response data were ordinal and paired, nonparametric paired Wilcoxon signed-rank tests were used throughout. Holm–Bonferroni corrections were applied to account for multiple comparisons. Statistical significance was assessed at $\alpha = 0.05$. Analyses were conducted for the six selected Bug Farm exhibits to compare visitors' pre-visit baseline

responses with post-exhibit perceptions of invertebrates, nature recovery, and insect-based food. Only paired responses were included in analyses.

Baseline (pre-visit) perceptions served as the reference point for all subsequent exhibit-specific responses. Effect sizes were calculated to quantify the magnitude of observed changes. Median changes were interpreted alongside the tests to distinguish between reinforcement of existing attitudes and substantive shifts in perception.

A secondary analysis examined whether the magnitude of change differed by visit order to account for potential carryover effects arising from cumulative exposure across the site. The visit order was collapsed into three categories (visited first, visited second, visited later) to ensure adequate sample sizes within each group. Where visit order information was missing or ambiguous (e.g. multiple exhibits assigned the same position), order data were coded as missing and excluded from order-specific analyses.

For post-visit reflective statements on the exhibits, one-sample Wilcoxon signed-rank tests were used to assess whether median responses differed from the neutral midpoint of the Likert scale, indicating an overall shift in visitor perceptions.

For post-visit answers identifying the most memorable experience, if two or more answers were listed, the first exhibit mentioned was recorded for analysis. Responses that did not clearly reference a specific exhibit were excluded.

4. Results:

4.1. Descriptive statistics:

Sample Characteristics

Of the 116 participants who completed the questionnaire, 67 (58%) provided an email address for follow-up contact. Of these, 15 (22%) responded to the initial follow-up email. Following a reminder email, the total number of responses increased to 29 (43%).

Table 4.1. Age groups surveyed (n = 114) across the eight open days at The Bug Farm, in descending order of magnitude.

Age Groups	Individuals (n)	Percentage (%)
25-34	23	20.2
65+	23	20.2
35-44	17	14.9
55-64	16	14.0
45-54	13	11.4
Under 18	12	10.5
18-24	10	8.8

Of the 114 who answered, 64 (56.1%) identified as female, 49 (43.0%) as male, and 1 (0.9%) person selected 'Other'. Twenty-one participants (18.4%) had visited The Bug Farm previously, whilst 93 (81.6%) were first-time visitors.

4.2. Changes in visitor perceptions before and after visiting the exhibits and sessions:

Museum

There was strong evidence of a positive educational impact associated with the Museum visit, with significantly more positive feelings towards insects observed after the visit (n = 106; W = 276; r = 0.61; p_{adj} = 0.003). Similarly, willingness to choose insect-based foods increased significantly following the Museum visit (n = 104; W = 546; r = 0.64; $p_{adj} < 0.001$) (Figure 4.1).

Median responses remained unchanged for these questions (1 and 3, respectively), indicating that attitudes were already generally positive prior to entry and that observed changes reflect

shifts in response distributions rather than central tendency. In contrast, there was no evidence of a change in perceptions of the environmental importance of insects (n = 104; W = 8.5; r = 0.17; p_{adj} = 0.752), with the median remaining unchanged at 1.

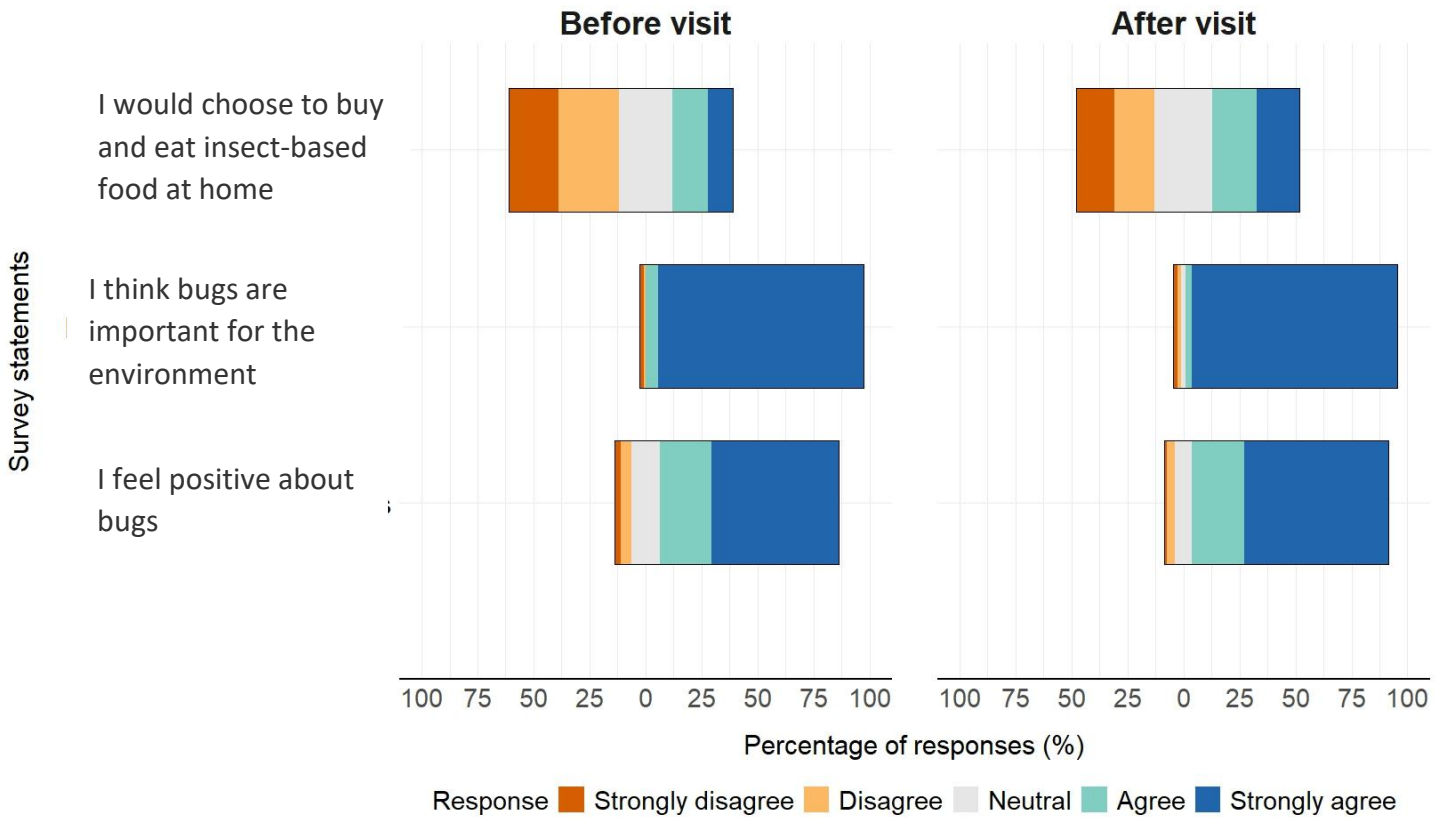

Figure 4.1. Comparison of visitors' perceptions before The Bug Farm visit and after the Museum visit. Responses were recorded on a five-point Likert scale from strongly disagree to strongly agree, with neutral responses centred.

Tropical Zoo

There was strong evidence of an increase in positive feelings towards insects following the visit (n = 105; W = 409; r = 0.66; $p_{adj} < 0.001$). Although the median response remained unchanged at 1, the distribution shifted markedly towards stronger agreement, indicating a meaningful improvement in sentiment, as shown in Figure 4.2.

In contrast, perceptions of the environmental importance of insects showed no evidence of change following the intervention (n = 104; W = 15.5; r ≈ 0.10; $p_{adj} = 0.860$).

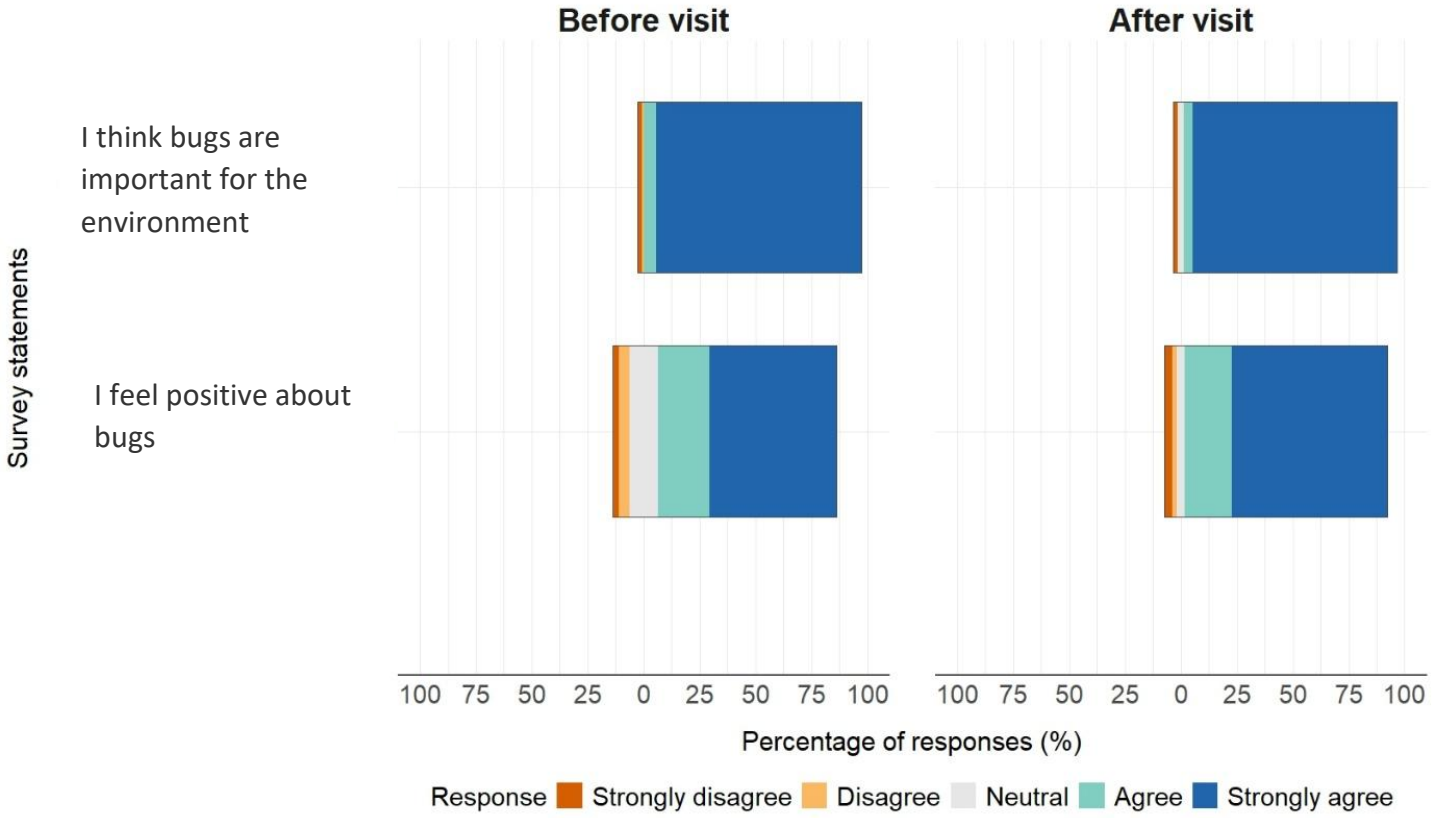

Figure 4.2. Comparison of visitor perceptions before The Bug Farm visit and after the Tropical Zoo visit. Responses were recorded on a five-point Likert scale from strongly disagree to strongly agree, with neutral responses centred.

Nature Recovery Centre

There was strong evidence of a positive impact on visitors' feelings towards insects following the visit (n = 83; W = 408; r = 0.76; $p_{adj} < 0.001$). Similarly, visitors reported significantly greater confidence in helping nature after the visit (n = 83; W = 888; r = 0.62; $p_{adj} < 0.001$) (Figure 4.3).

For both statements, median responses remained at 1; however, response distributions shifted towards stronger agreement, indicating an overall strengthening of already positive attitudes. In contrast, there was no evidence of a change in perceptions of the environmental importance of insects (n = 82; W = 15; r = 0.17; $p_{adj} = 0.752$).

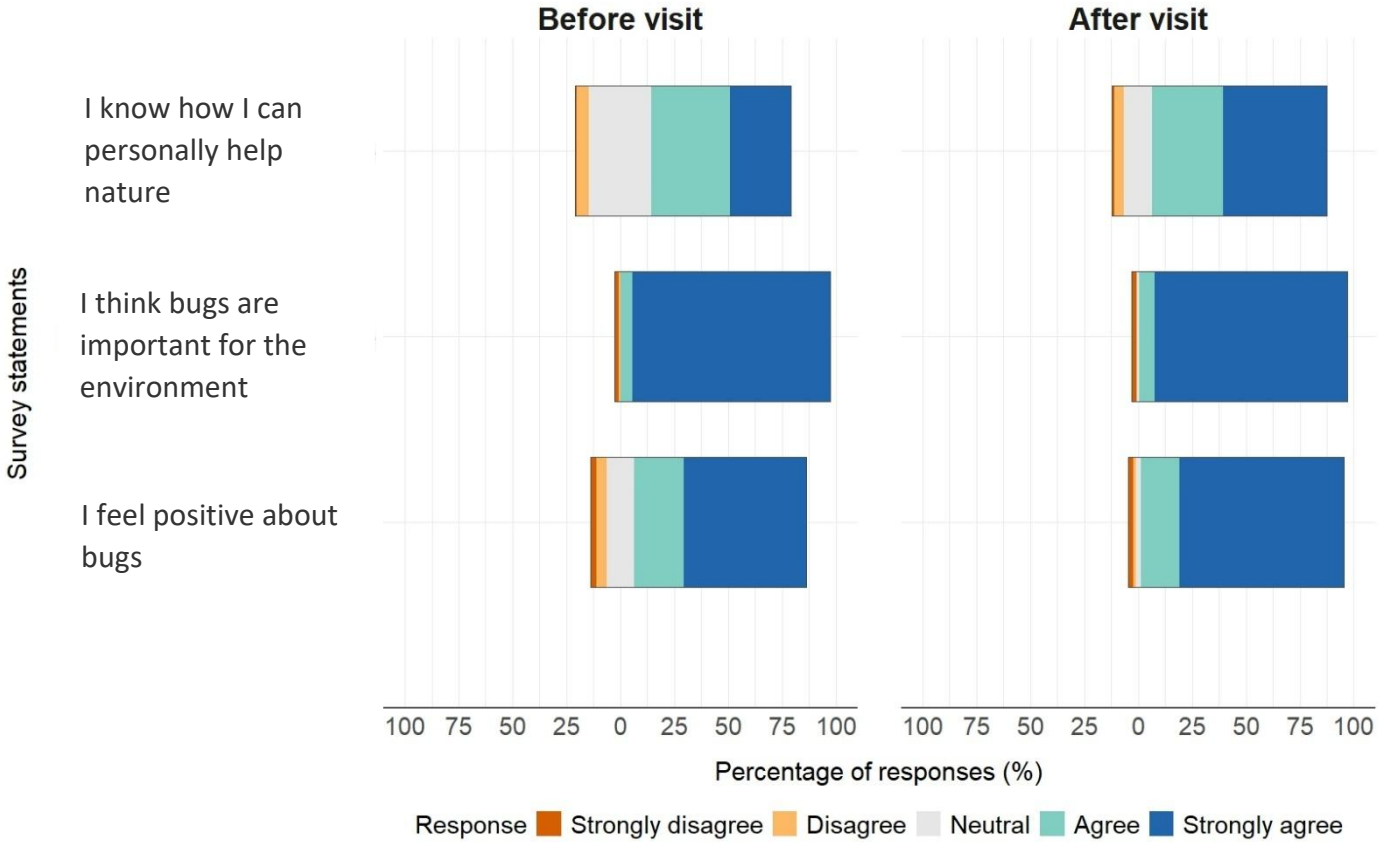

Figure 4.3. Comparison of visitor perceptions before The Bug Farm visit and after the Nature Recovery Centre visit. Responses were recorded on a five-point Likert scale from strongly disagree to strongly agree, with neutral responses centred.

The Bug Farm Trail

There was strong evidence of a positive impact on visitors' feelings towards insects following the visit (n = 88; W = 407; r = 0.66; $p_{adj} < 0.001$). Similarly, visitors reported significantly greater confidence in helping nature after the visit (n = 85; W = 820; r = 0.71; $p_{adj} < 0.001$) (Figure 4.4).

For both statements, median responses remained at 1; however, response distributions shifted towards stronger agreement, indicating an overall strengthening of already positive attitudes. In contrast, there was no evidence of a change in perceptions of the environmental importance of insects (n = 87; W = 10; r = 0.04; $p_{adj} = 1$).

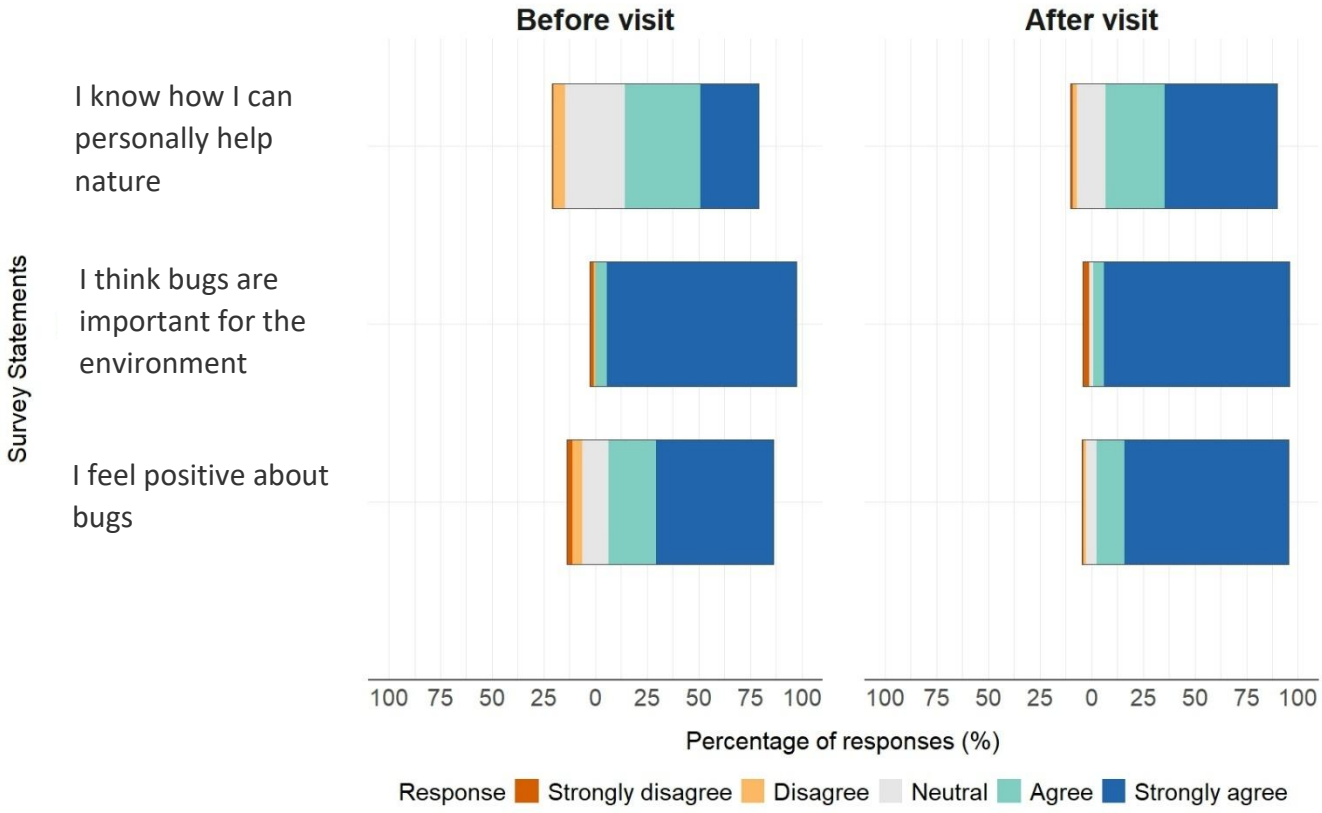

Figure 4.4. Comparison of visitor perceptions before The Bug Farm visit and after The Bug Farm Trail visit. Responses were recorded on a five-point Likert scale from strongly disagree to strongly agree, with neutral responses centred. Only paired responses are shown.

Up-Close Handling session

There is strong evidence that visitors feel more positive towards insects after the session (n = 77; W = 234; r = 0.61; p_{adj} = 0.003). Similarly, there's strong evidence that visitors were more comfortable touching insects after the session (n = 77; W = 738; r = 0.70; p_{adj} < 0.001) (Figure 4.5). Although the median paired difference was 0, substantial improvements among a subset of participants produced a strong overall shift in the distribution of positive responses.

There was no evidence of a change in perceptions of the environmental importance of insects following the session (n = 76; W = 2.5; r = 0.46; p_{adj} = 0.424).

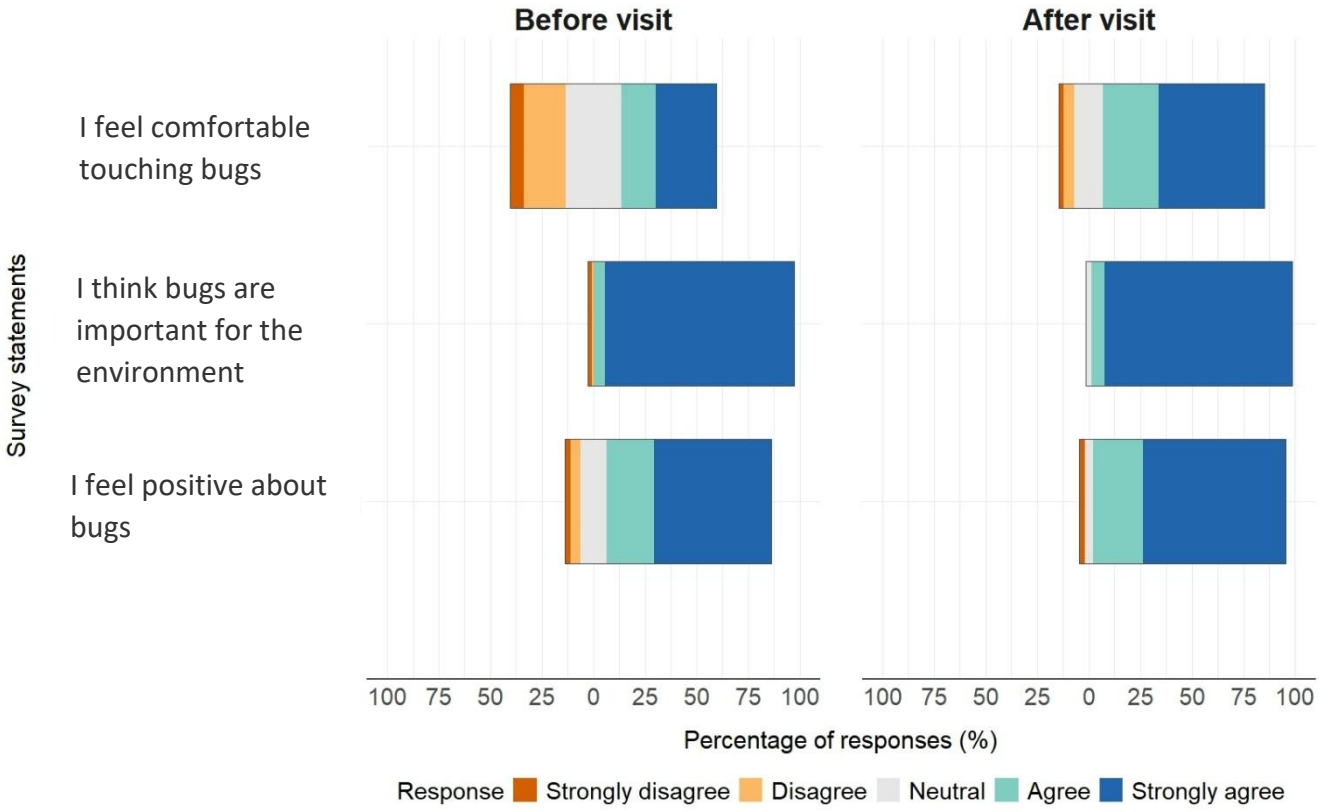

Figure 4.5. Comparison of visitor perceptions before The Bug Farm visit and after the Up-close Handling session. Responses were recorded on a five-point Likert scale from strongly disagree to strongly agree, with neutral responses centred.

Grub Kitchen

The number of paired responses varied across questions because one item was introduced later in the data collection period. There was strong evidence that visitors felt more positive towards insects following the visit (n = 83; W = 342; r = 0.71; $p_{adj} < 0.001$ (Figure 4.6).

Among the subset of respondents who answered the statement about whether insects taste good (n = 25), there was also strong evidence of a positive shift following the visit (W = 114; r = 0.80; $p_{adj} = 0.001$). For this statement, the median response decreased from 3 to 2, indicating a shift in central tendency towards stronger agreement.

Willingness to eat insects also increased following the visit (n = 82; W = 1250; r = 0.59; $p_{adj} = 0.001$), as did willingness to choose insect-based food options (n = 83; W = 792; r = 0.59; $p_{adj} = 0.001$). Median responses for eating insects shifted from 3 to 2, indicating a shift in central tendency towards stronger agreement. In contrast, the median response for choosing insect-based foods remained at 3, suggesting that the observed changes for this statement reflect shifts in the response distribution rather than shifts in central tendency.

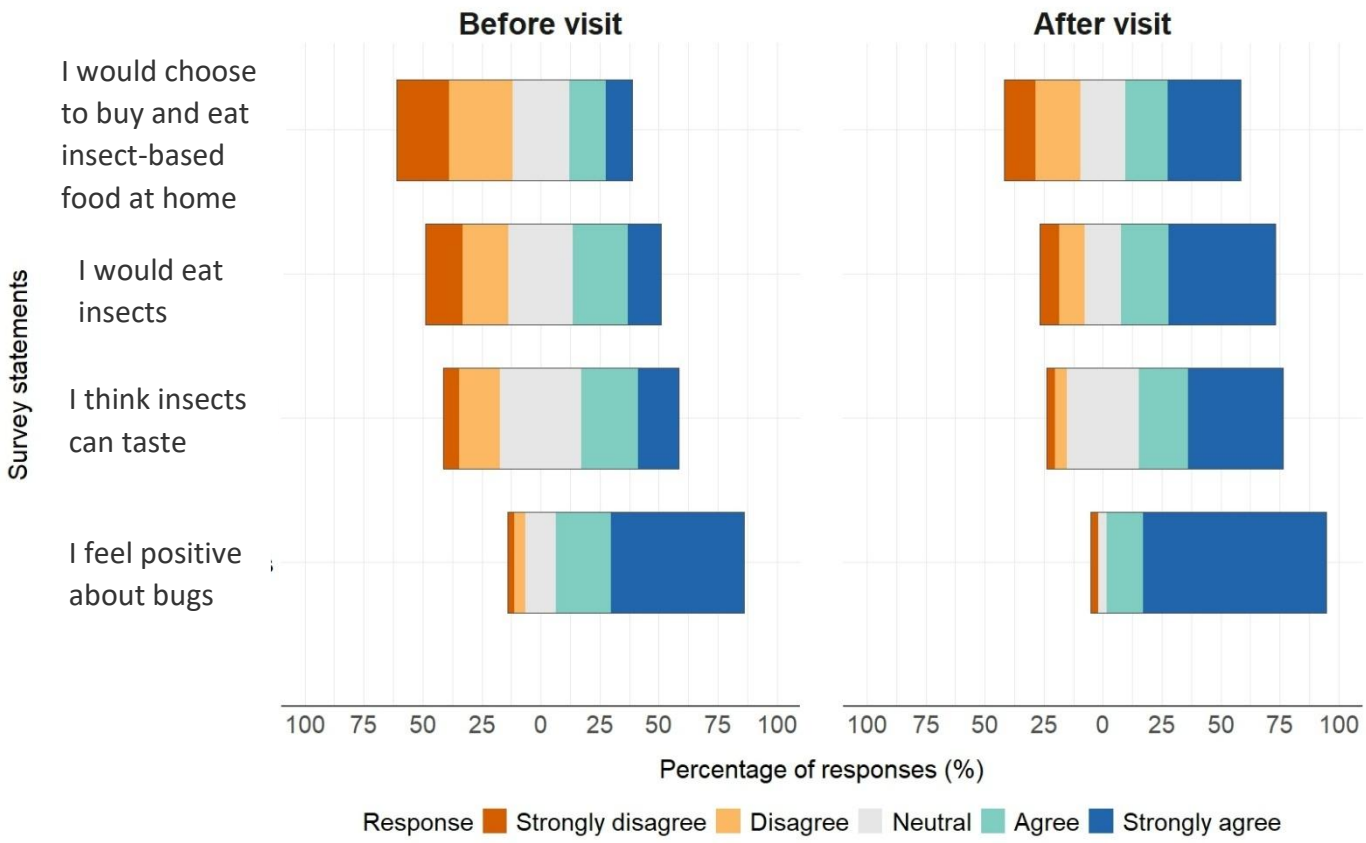

Figure 4.6. Comparison of visitor perceptions before The Bug Farm visit and after the Grub Kitchen visit. Sample sizes vary across questions because one item was added later in the

data collection period. Responses were recorded on a five-point Likert scale from strongly disagree to strongly agree, with neutral responses centred.

4.3. Visit order as a potential moderator of perception change:

Across most sections and visit orders, median change scores were zero, indicating stable perceptions relative to baseline. Although some variability (IQR > 0) was observed in a subset of respondents in Grub Kitchen and the Nature Recovery Centre when visited later, indicating continued perception shifts (Table 4.1).

Table 4.1. Median change in perception scores (after − baseline) by visit order and section. A median of 0 indicates no net shift from baseline for most respondents. Δ means the difference between values.

Exhibit / Session	Order visited	n	Median Δ	IQR Δ
Bug Farm Trail	Visited first	6	0	0
Bug Farm Trail	Visited later	149	0	0
Grub Kitchen	Visited first	12	0	0
Grub Kitchen	Visited second	28	0	1
Grub Kitchen	Visited later	106	0	1
Museum	Visited first	149	0	0
Museum	Visited second	30	0	0
Museum	Visited later	27	0	0
Nature Recovery Centre	Visited later	135	0	1
Tropical Zoo	Visited first	2	0	0
Tropical Zoo	Visited second	88	0	0
Tropical Zoo	Visited later	48	0	0
Up-close Handling	Visited first	36	0	0
Up-close Handling	Visited second	21	0	0
Up-close Handling	Visited later	90	0	0

4.4. Post-visit perceptions relative to a neutral response:

Responses indicated that all post-questionnaire statements differed significantly from the neutral midpoint of the Likert scale, with a consistent skew towards agreement (Figure 4.8). Strong effects were observed for *positive feelings*, *environmental importance*, *learnt something*, and *do something*, all of which showed median response changes from 3 to 1 and had very large effect sizes (n = 106; W = 198—291; r = 0.76–0.81; $p_{adj} < 0.001$), indicating strong and consistent positive evaluations of the day.

Responses relating to *helping nature* and *eating insects* showed slightly weaker, though still significant, changes from neutrality. Median responses for these statements changed from 3 to 2, with a very large effect size for *helping nature* (n = 106; W = 158; r = 0.80; $p_{adj} < 0.001$) and a moderate effect size for *eating insects* (n = 106; W = 1232; r = 0.36; $p_{adj} < 0.001$), suggesting that, although participants broadly agreed with these statements, attitudes toward consuming insects were more variable.

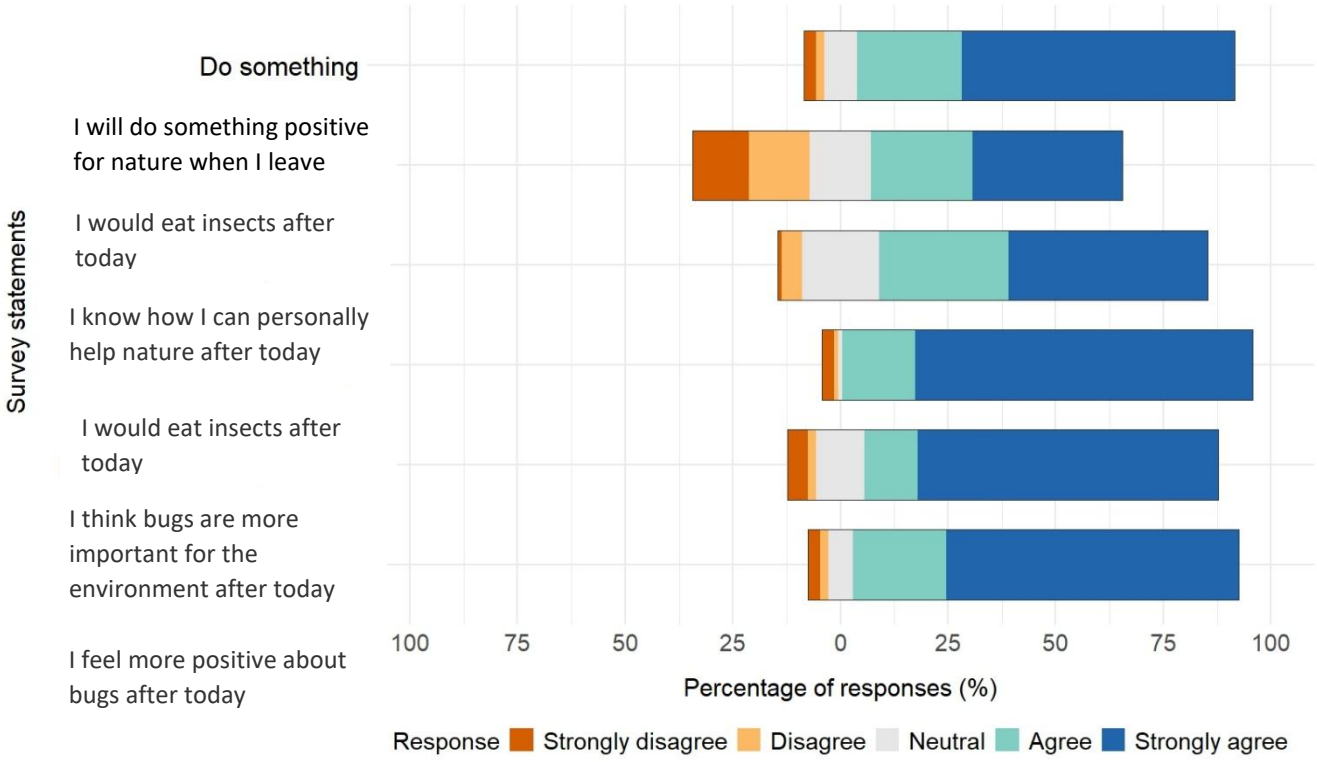

Figure 4.8. Responses reflect visitors' perceptions at the end of their visit and are shown relative to a neutral midpoint. Responses were recorded on a five-point Likert scale from strongly disagree to strongly agree, with neutral responses centred.

4.5. Post-visit comments on the most memorable experience:

The top three most-mentioned exhibits were the Up-close Handling session (n = 41; 36.3%), the Tropical Zoo (n = 24; 21.2%), and The Bug Farm Trail (n = 16; 14.2%). The three least mentioned were Grub Kitchen (n = 4; 3.5%), the Museum (n = 3; 2.7%) and the Nature Recovery Centre (n = 2; 1.8%). 113 visitors answered this question.

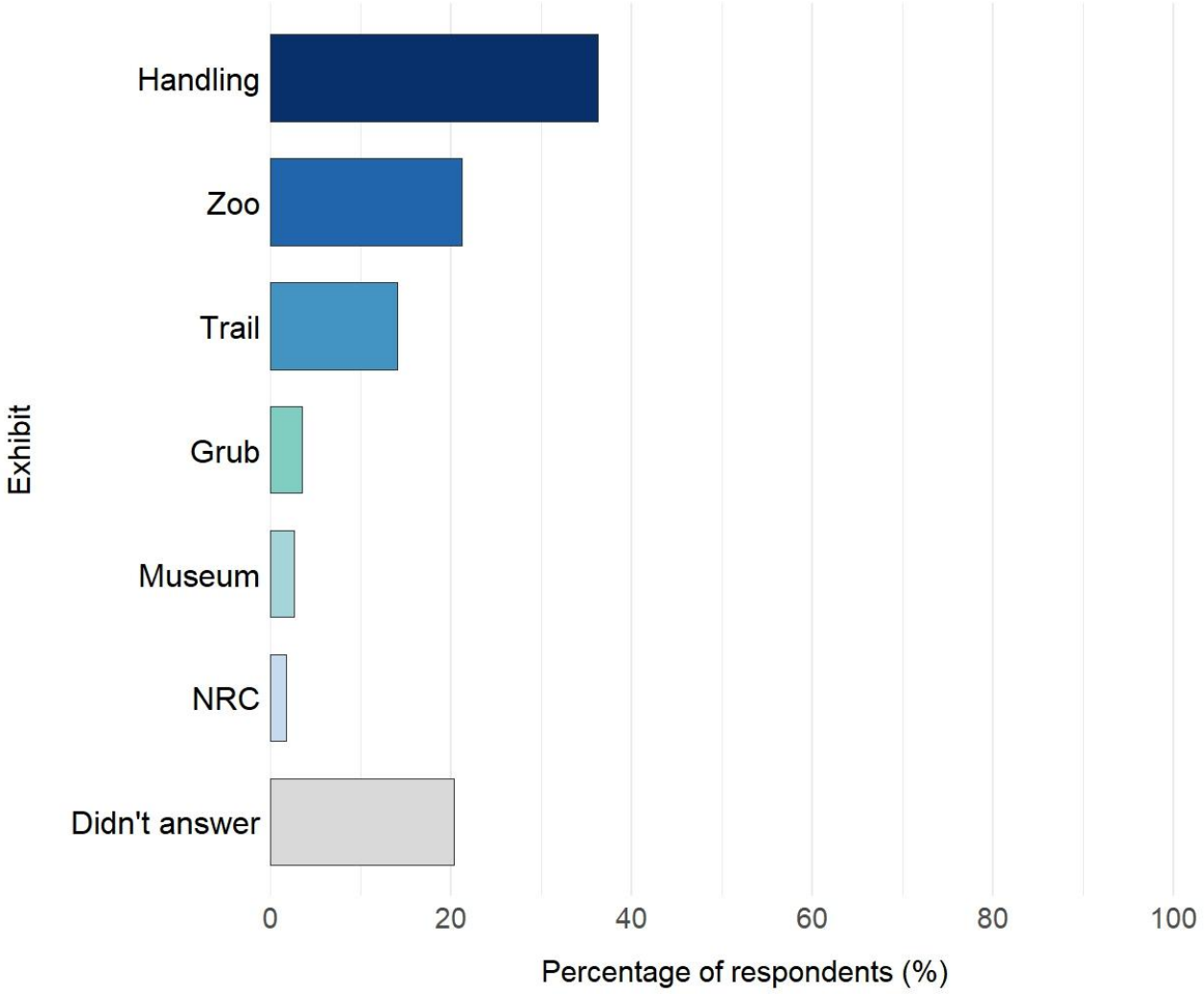

Figure 4.9. Distribution of answers for the question *"Was there a specific part of your visit that you found especially memorable?"* in the reflection section following a visit to The Bug Farm.

4.6. Self-reported behaviour change following the visit

Most respondents reported achieving (n = 11; 39.3%) or partially achieving (n = 9; 32.1%) the action they identified, indicating evidence of post-visit behaviour change. Some respondents expressed intention but had not yet acted (n = 6; 21.4%), and a minority had taken no action (n = 2; 7.1%).

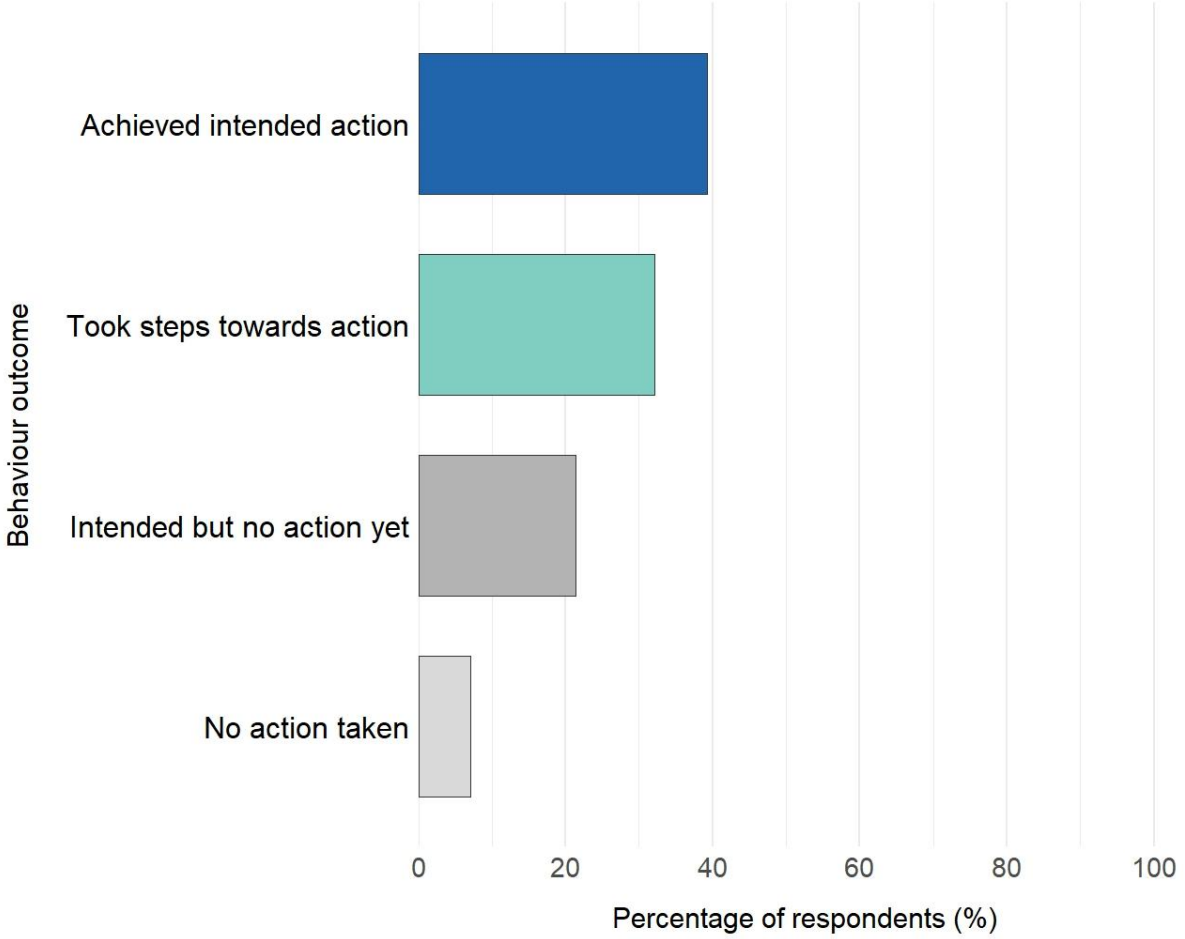

Figure 4.10. Distribution of self-reported behaviour change following a visit to The Bug Farm.

5.0 Discussion:

5.1 Overview of key findings

This study aimed to assess how different exhibits at The Bug Farm influenced visitor perceptions of invertebrates, nature recovery, and insect-based food. Overall, the findings suggest that all exhibits had a significant positive impact on visitor perceptions. When comparing exhibits, clear differences emerged in both the magnitude and domain of perceptual change. Interactive experiences were generally associated with the strongest behavioural shifts, whereas more observational exhibits produced smaller, though still significant, changes. Most post-visit respondents also indicated a behavioural shift after leaving The Bug Farm.

5.2 Comparing exhibits

The Handling session and Grub Kitchen were linked to the largest behavioural shifts, particularly in tactile comfort and willingness to consume insect-based foods. Both experiences involve direct sensory engagement, suggesting that embodied exposure in a positive environment may reduce disgust and food neophobia (Straube et al., 2006**;** Hardy, 1988)**.** In contrast, the Nature Recovery Centre (NRC) was associated with the most substantial emotional shift, indicating that ecological framing and contextualisation may be especially effective in enhancing affective responses toward invertebrates. The Bug Farm Trail produced the largest increase in perceived personal agency, likely reflecting its emphasis on practical actions and visible conservation messaging. Although the Tropical Zoo and Museum were highly significant across several statements, their overall effect sizes were smaller. These exhibits may primarily reinforce knowledge and familiarity rather than directly challenging affective or behavioural barriers.

Notably, the Handling session was most frequently identified as the most memorable experience, followed by the Zoo (Figure 4.9), suggesting that emotional importance and reported enjoyment do not always align directly with the magnitude of statistical change.

Overall, the environmental importance statement showed limited movement across exhibits. This likely reflects high baseline agreement and potential self-selection among visitors, resulting in ceiling effects that constrained measurable change. Apart from this statement,

shifts were generally consistent across domains, reinforcing the conclusion that exhibit format influences the type, rather than simply the extent, of perceptual change.

These findings suggest that effective informal environmental education may require a diversity of exhibit formats, as different psychological barriers, disgust, perceived efficacy (Bandura, 1977), and perceived ecological importance appear to respond to different types of engagement.

5.3 Comparisons across domains:

Emotional shift

The statement about feeling positive about bugs was included across all exhibit sections, and each exhibit produced a significant positive shift in this domain. This suggests that The Bug Farm experience consistently enhances visitors' emotional responses toward invertebrates.

This may reflect The Bug Farm's explicit aim to portray invertebrates in a positive and accessible way, highlighting the ecological and societal benefits they provide. Across exhibits, invertebrate science is communicated in an engaging manner, often through interactive elements such as The Museum bug-hunting activity and The Bug Farm Trail quiz sheet. In the Zoo and Handling sessions, staff enthusiastically answer questions and share detailed insights into insect life histories, helping to draw visitors into the invertebrate world rather than positioning insects as something alien or threatening. The NRC portrays invertebrates in the broader ecological context.

This contrasts with common media portrayals of invertebrates. For example, Mammola et al. (2022) found that 47% of reviewed spider-related articles contained factual errors, and 43% were rated as sensationalistic by experts. Such portrayals may reinforce fear-based narratives. Biophobia has also been reported as higher among individuals living in urbanised environments, where regular exposure to insects in natural settings is reduced (Fukano & Soga, 2021; Soga et al., 2020). In this context, even short, positive encounters with invertebrates may help counterbalance prior negative framing (Vanderstock et al., 2022).

These emotional shifts are important because affective states play a central role in conservation outcomes. Public attitudes toward species influence funding, policy attention, and perceived conservation priority, with more "attractive" or charismatic species often receiving greater protection (Collado et al., 2022;Colléony et al., 2017; Martín-López et al.,

2007). Arthropods are also disproportionately underrepresented in conservation listings and assessments (Costanza et al., 1997), despite their ecological importance. Enhancing positive emotions toward insects may therefore indirectly contribute to broader support for conservation.

Direct contact and immersive experiences may be particularly influential in reducing affective barriers such as disgust, which has been widely identified as a limiting factor in support for invertebrate conservation (Bixler & Floyd, 1999). Handling insects within a controlled, positive environment may accelerate attitude change through embodied experience and familiarity (Hardy, 1988). Furthermore, children's levels of biophobia have been shown to decrease with greater knowledge of invertebrates and more frequent nature experiences (Soga et al., 2020). Exhibits such as The Bug Farm Trail and Handling session address both exposure and knowledge simultaneously, which may help explain the consistent positive emotional shifts observed.

Behavioural Intentions:

Exposure to insects for eating and handling in a safe, positive environment may have contributed to the observed shifts in behavioural intentions. Although response distributions shifted, median scores were often unchanged. This likely reflects ceiling effects, as pre-visit medians were typically already at 1 (strongly agree), limiting the potential range for further improvement.

However, distributional changes still suggest movement within categories. In the post-visit reflection section, some items showed median shifts of up to two levels. For example, intentions regarding insect-based food shifted from neutral to agree, indicating meaningful change despite constrained scale range.

Food neophobia often generates strong reactions to the idea of consuming insects, shaped by negative cultural associations and media portrayals (Looy & Wood, 2006). Programmes such as 'I'm a Celebrity…Get Me Out of Here!' frequently frames insect consumption as a fear-based challenge, reinforcing disgust narratives rather than normalising entomophagy. In contrast, The Bug Farm presents insects in a family-friendly, positively framed environment, encouraging hands-on engagement and the tasting of insect-based foods. This approach aligns with Bixler & Floyd (1999), who argued that environmental education should prioritise

"lessening the tendency of individuals to view these creatures as repulsive while simultaneously fostering a positive interest in them," thereby addressing the affective barriers created by disgust. These findings suggest that direct exposure and positive framing may reduce psychological barriers and shift willingness, even where initial attitudes appear resistant. This pattern is reflected in visitor feedback, with one participant noting: *"The meet the bugs definitely helped me be more open to handling bugs, and the bug bolognese/burger made me more comfortable about the idea of eating insects."*

However, interpretation of these behavioural intention shifts should be considered alongside minor structural limitations in the questionnaire design. One pre-visit statement regarding eating insects was not mirrored in later sections, rendering it unsuitable for paired analysis. Additionally, the item assessing whether insects could taste good was introduced later in the data collection period and was completed by a smaller subset of participants (n = 25 paired responses), reducing statistical power for that outcome.

Stability of Environmental Importance:

The statement relating to environmental importance did not show a statistically significant shift. Pre-visit scores were already high, with most participants selecting 'Strongly agree'. This ceiling effect limited the potential for measurable change.

The lack of movement may indicate that visitors arrive with pre-existing pro-environmental values. Rather than creating environmental concern, The Bug Farm may therefore reinforce or validate attitudes that are already present. This pattern is consistent with a self-selection effect, whereby individuals who choose to visit are already positively disposed toward nature and conservation.

Secondary analysis on order effects:

The order in which exhibits were visited was examined as a potential moderator of perception change. It was anticipated that exhibits encountered earlier in the visit might produce larger shifts, particularly given the high baseline scores and potential ceiling effects. However, positive changes were observed across visit positions, and differences in the magnitude of change were generally small and inconsistent between sections.

Across most exhibits and visit orders, median change scores were zero (Table 3.1), indicating relative stability in perceptions compared to baseline. Nonetheless, a small number of exhibit–order combinations, such as those in Grub Kitchen and The NRC, showed greater variability, suggesting that some respondents continued to shift positively even when exhibits were visited later in the sequence. Overall, this indicates that exhibit impact was not strongly dependent on visit order, and that exhibits retained the capacity to influence perceptions even when experienced later in the visit.

However, interpretation of these patterns should consider potential measurement constraints. The Likert-scale format may have been influenced by acquiescence or central-tendency bias, potentially inflating agreement levels and contributing to the stability of the median. Additionally, the reverse-coded scale (1 = strongly agree; 5 = strongly disagree) may have increased the risk of response error where participants did not consult the key carefully, introducing minor inconsistency in reported change.

Post-visit graphs:

Post-visit responses highlighted the Up-Close Handling session as the most memorable experience of the day. This suggests that direct, tactile interaction is sufficiently novel and engaging to leave a lasting impression. Memorability may play an important role in sustaining attitude change beyond the immediate visit, particularly where emotional engagement is involved.

Interestingly, the Nature Recovery Centre and Grub Kitchen were among the least frequently selected as most memorable exhibits, despite producing some of the largest perceptual shifts (Figure 4.9, 4.6, 4.3). The Nature Recovery Centre generated the greatest positive change in attitudes toward invertebrates, while Grub Kitchen was associated with one of the largest shifts in willingness to consume insect-based foods. This suggests that exhibits that challenge existing perceptions may not necessarily be perceived as the most memorable, yet may be more effective at driving attitudinal change. Behavioural shifts may therefore occur in experiences that challenge visitors slightly, rather than in those that are preferred or enjoyable. This difference between memorability and magnitude of perceptual shift also suggests that different exhibits may operate through distinct mechanisms - some creating emotional attachment, others prompting behavioural reconsideration.

The importance of childhood exposure to nature-based experiences is well documented, with early encounters often linked to later conservation interest and career pathways (Tanner, 1980). Notably, in the two-month follow-up emails, some parents reported that their children expressed aspirations to become an "entomologist", with one specifying an "entomologist of moths." While anecdotal, these responses suggest that immersive experiences may contribute to identity formation and longer-term engagement with invertebrates.

Interpretation of longer-term behavioural outcomes should, however, be approached with caution. As the study relied primarily on self-reported attitudes and behavioural intentions, the two-month follow-up may reflect a subset of more environmentally engaged participants, given that it depended on voluntary re-engagement. Additionally, although several respondents reported planned pro-environmental actions, not all had yet been implemented, in some cases due to seasonal constraints. This suggests that behavioural change may be either overestimated due to self-selection or underestimated due to timing, highlighting the need for longer-term longitudinal research to determine whether stated intentions translate into sustained action.

5.4 Future research

Due to time and scope constraints, several potentially informative analyses were not undertaken. Data from school groups who visited The Bug Farm as part of organised trips, including structured talks, handling sessions, insect tasting, and guided exploration of the Museum and Zoo, were not analysed separately. Examining these cohorts could provide valuable insight into whether age group and peer environment moderate changes in perception. For example, do structured focus sessions amplify emotional or behavioural shifts? Does peer context influence how positively students report feeling about insects?

Further subgroup analyses would also be informative. Although willingness to consume insect-based food showed notable positive shifts overall, the reflection item *'I would choose and buy insect-based food at home'* retained the largest proportion of 'strongly disagree' responses. Comparing visitors who attended Grub Kitchen with those who did not may clarify whether direct exposure is necessary for behavioural movement. Additionally, linking exhibit experience to recorded purchases could offer a more tangible indicator of behavioural change beyond stated intention.

Finally, incorporating a more randomly selected sample of the public would help determine whether the observed reinforcement-of-values effect persists in less environmentally engaged populations. A longer longitudinal design could further assess whether reported intentions translate into sustained behavioural change over time.

Conclusion:

1. Interactive experiences were associated with the strongest behavioural shifts, whereas more observational exhibits produced smaller, though still significant, changes.
2. Impact was domain-specific, indicating that exhibit format influences the type of perception change (emotional, behavioural, personal agency-related), rather than just its magnitude.
3. Emotional impact and reported enjoyment do not consistently align with statistical effect size. Exhibits perceived as most memorable were not always those associated with greatest attitudinal shift.
4. Behavioural shifts may therefore occur in experiences that challenge visitors slightly, rather than those that are simply preferred or most enjoyable.
5. Limited movement in perceptions on environmental concern likely reflects high-baseline pro-environmental values across visitors, suggesting The Bug Farm may reinforce existing attitudes rather than create environmental concern.
6. The importance of diverse exhibit formats in informal environmental education is highlighted, as different psychological barriers respond differently depending on the mode of engagement.

Appendix:

Appendix 3.1: Visitor Questionnaire:

Visitor Questionnaire

This survey is part of a dissertation project being undertaken at Swansea University's Department of Biosciences, investigating how different exhibits at The Bug Farm may affect visitors' opinions.

You will be asked the same short questions after each exhibit you visit, and your responses will help identify which exhibits are most impactful.

Participation is entirely **voluntary**, and all responses will remain **anonymous**. If you choose to provide your contact information, it will be stored securely and only used for a follow-up in two months and to enter you into a prize draw (more information at the end).
You may withdraw your consent at any time.

The findings will be used for academic purposes and to support ongoing improvements to educational experiences at The Bug Farm.

Estimated total time taken: 10 minutes

By continuing, you confirm you are over 16 or have parental/guardian/teacher permission and you consent to take part in this research.

Please complete each **relevant section after** visiting it. **Indicate the order** in which you visited the exhibitions by **circling the number** next to each section title. If you did not visit a section, please **circle 'N/A'.**

Which of the following age groups do you belong to?

Age (if under 18)…… 18-24 25-34 35-44 45-54 55-64 65 or over

Please state your sex:

Male Female Other Prefer not to say

Have you visited The Bug Farm before? Yes No

Section 1: Upon entry into the Bug Farm

Please mark: 1 – Strongly Agree, 2 – Agree , 3 – Neutral, 4 – Disagree, 5 – Strongly Disagree

	1	2	3	4	5
I feel positively about bugs					
I feel comfortable touching bugs					
I think bugs are important for the environment					
I know what I can personally do to help nature					
I would eat insects					
I think eating insects can be good for the environment					
I would buy and eat insect-based food at home					

Section 2: The Museum N/A 1st 2nd 3rd 4th 5th 6th

	1	2	3	4	5
I feel positively about bugs					
I think bugs are important for the environment					
I would buy and eat insect-based food at home					

Section 3: The Tropical Bug Zoo N/A 1st 2nd 3rd 4th 5th 6th

	1	2	3	4	5
I feel positively about bugs					
I think bugs are important for the environment					

Section 4: The Nature Recovery Centre N/A 1st 2nd 3rd 4th 5th 6th

	1	2	3	4	5
I feel positively about bugs					
I think bugs are important for the environment					

I know what I can personally do to help nature					

Section 5: Up-Close Meet the Bugs N/A 1st 2nd 3rd 4th 5th 6th

Please mark: 1 – Strongly Agree, 2 – Agree , 3 – Neutral, 4 – Disagree, 5 – Strongly Disagree

	1	2	3	4	5
I feel positively about bugs					
I feel comfortable touching bugs					
I think bugs are important for the environment					

Section 6: Bug Farm Trail N/A 1st 2nd 3rd 4th 5th 6th

	1	2	3	4	5
I feel positively about bugs					
I think bugs are important for the environment					
I know what I can personally do to help nature					

Section 7: Grub Kitchen N/A 1st 2nd 3rd 4th 5th 6th

Have you purposefully eaten insects before today? Yes No

	1	2	3	4	5
I feel positively about bugs					
I would eat insects					
Insects can taste good					
I would buy and eat insect-based food at home					

Please turn over for the "Before you leave" section.

Section 8: Before you leave

Please mark: 1 – Strongly Agree, 2 – Agree , 3 – Neutral, 4 – Disagree, 5 – Strongly Disagree

	1	2	3	4	5
I feel more positively about bugs after today					
I would eat insects after today					
I think bugs are more important for the environment after today					
I know what I can personally do to help nature after today					
I learnt something new today					
I will do something positive for nature when I leave					

What positive action for nature do you plan to do (if anything)?

If you're happy to be contacted in two months' time for a follow-up, please leave your email address below.
As a thank you, you'll be automatically entered into a prize draw to win a Bug Farm goodies hamper and a free entry ticket!

Please note down below item(s), if you bought anything in the shop.

Was there a specific part of your visit that you found especially memorable?

Would you visit again? Yes No

Please leave any additional comments below:

Data collection and storage is managed by The Bug Farm and follows The Bug Farm's Privacy Policy. We will not share personal details with anyone at any time.

Appendix 3.2: Questionnaire Reminder Poster:

Appendix 3.3: Post-visit Follow-up Email:

Subject: The Bug Farm Dissertation Follow-Up & Prize Draw 🌿

Dear Participant,

I hope this email finds you well.

As part of my dissertation follow-up, I'm getting back in touch regarding the question:

> **"What positive action for nature do you plan to do (if anything)?"**

At the time of your visit, you shared the following:

> **[Visitor answer here]**

Please reply to this email and let me know if you have made any progress in this area, or if your visit to The Bug Farm has inspired you to take any additional positive steps for nature since then.

Once you reply, you'll be entered into a **prize draw** to win a **Bug Farm goody bag**, including a **season family ticket, books, edible insects**, and more!

Thank you so much for taking the time to participate in my dissertation research - your contribution is greatly appreciated.

I will contact the prize draw winner in **early November**.

Best of luck, and I look forward to hearing from you!

Best wishes,

Sabaha Hussein

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