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Knowledge and Perceptions of Bat Guano Among Diverse Demographics in Malaysia

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ABSTRACT

Bat guano, or bat faeces, plays a crucial role in cave ecosystems, serving as a source of energy and impacting habitat dynamics. Its utilisation had been beneficial worldwide since centuries ago. However, a lack of awareness on bat guano's role in the ecosystem particularly in Malaysia can be identified. Hence, the study delves into the perceptions and knowledge of the local Malaysian community regarding bat guano. A virtual survey was conducted through platforms like WhatsApp, Facebook, and LinkedIn. Analysis of the chi-square test using SPSS Version 37 Software was done to show the correlation between respondents' demographics, guano knowledge, its importance, and their willingness to use it. Among 103 respondents, mostly aged 18 to 25, 64.08% were aware of bat guano, but few had used guano-derived products. Positive perceptions were linked to the age group ($p = 0.002$), indicating younger individuals were more receptive. Challenges to broader acceptance included cleanliness and safety concerns heightened by the ongoing COVID-19 pandemic. Despite efforts to provide information and change perceptions, 78.64% remained undecided about using bat guano in their daily lives due to persistent misconceptions. Public awareness and education are crucial for promoting its benefits, necessitating collaboration among researchers, educators, and government entities.

Keywords: bat awareness, bat droppings, benefits, community, ecosystem

INTRODUCTION

Bat guano, the excrement deposited by bats, is predominantly found on cave floors and plays a crucial role in the cave ecosystem (Ferreira & Martins, 1999; Sakoui *et al*., 2020). It serves as a primary energy source in caves, significantly influencing their dynamics and structural habitat (Fenolio *et al*., 2006). Guano supports a complex food web involving bacteria, fungi, protozoa, nematodes, arthropods, and other invertebrates (Harris, 1970). The composition of bat guano varies based on environmental factors, age, and the diet of bats (Ferreira & Martins, 1999; Karagoz, 2014).

Historically, the utilisation of bats guano in previous centuries had been recorded in various studies. A few examples of records were written by Buchannan (1800) where harvesting of guano from *Chaerephon plicatus*, the cave-dwelling Asian wrinkle-lipped bat, had been occurring for decades in Cambodia (Sothearen *et al*., 2014). Bat guano was also used to produce gunpowder due to its high phosphorus content (Ghanem & Voigt, 2012; Linn & Myint, 2018). It has also been utilised in radiocarbon dating to record environmental changes, revealing a savanna ecosystem in Borneo during the Pleistocene epoch (Wurster *et al*., 2019). In Western countries, guano has been used non-invasively to identify bats, particularly after the rise of white-nose syndrome (Kanuch *et al*., 2007; Puechmaille *et al*., 2007). In Malaysia, bat guano has been found in various locations in Borneo, with significant deposits in Racer Cave -part of Mulu National Park, and in Niah Cave located in Niah National Park, highlighting its mineral diversity through degradation processes (McFarlane & Lundberg, 2018).

In the field of mycology, guano obtained from Madai Cave, Sabah were found to contain 32 species of fungi such as *Penicillium* spp., *Aspergillus* spp., and *Purpureocillium lilnacium* as well as several pathogenic yeasts and

microbes used in developing biological control agents for harmful plants nematodes and other harmful plant microbes (Wasti *et al*., 2021).

Studying guano morphology is crucial for understanding the dietary habits of bats and developing effective conservation strategies. By analysing guano, researchers can gain insights into bat habitats and diet partitioning. Additionally, assessing prey availability helps determine the potential for bats to coexist with other species, thereby reducing competition with other predators in the area such as other bat species, nocturnal birds and some herpetofaunas (Ware *et al*., 2020). Dietary specialisation is one of the key factors contributing to extinction risk in bats. Through guano analysis, researchers can identify the dietary preferences of bat species and implement targeted conservation strategies to maintain a balanced prey-predator relationship (Ware *et al*., 2020).

However, community discussions about the utilisation of bats guano revealed mixed perceptions. Addressing public perceptions of bat guano is vital for successful conservation efforts. Studies from various regions showed that local communities often viewed bat guano negatively. For instance, in Fort Collins, Colorado, 76% of surveyed participants had negative views on bat guano, with only 7% expressing positive thoughts (Sexton & Stewart, 2007). Similarly, in Mexico, coffee farmers considered bat guano usage detrimental to disease-resistant agroecosystems, and 59% had limited knowledge about it (Torres-Jiménez *et al*., 2020).

Conversely, in Balla and Guidimouni, Niger, 96.7% of horticulturists used bat guano to enhance plant growth. Guano extraction was also prevalent in nearby Magarawa Village, where workers, aware of the risks, often wore protective clothing (Harouna *et al*., 2021). In Southeast Asia, 26% of caves in the Philippines were used for guano collection (Tanalgo *et al*., 2016). In Thailand, significant guano mining activities occurred in Lopburi and Chiang Rai, managed by local Buddhist temples, providing income for villagers (Suwannarong *et al*., 2020).

Despite numerous studies on bat guano worldwide, a survey at Kuala Gandah Interpretive Centre (Krau Wildlife Reserve) is one of two surveys that touched on bats guano knowledge in Malaysia (Kingston *et al*., 2006). The survey, which was an effort from the Malaysian Bat Conservation Research Unit (MBRCU) was determined to establish an environmental education programme for bats. The survey found that only 3.4% of visitors were aware of its agricultural benefits. The second survey on the public perception of bats guano in Peninsular Malaysia had found that a major participants of the survey acknowledge the utility of bats guano as organic fertiliser. However, the participants agree that bat droppings have a pungent odour and is not comfortable living with bats in proximity (Lim & Wilson, 2019).

This perceptions and low awareness level underscores a significant educational gap on bats guano utilisation, this may be due to the unfavourable public opinion on the matter. Appreciation of guano as a sustainable source of fertiliser and research values would indicate a better management in guano mining. Tanalgo *et al*. (2016) mentioned that the threats of bats declination in Thailand were contributed by the destruction of cave habitats from the lack of protocol and regulation for guano mining in the area becomes a big threat to the population. Management in guano extraction activities is of the utmost importance to hinder the destruction of geological cave features and bat roosts' damages (Tanalgo *et al*., 2016). Hence, the objective of this virtual study is to assess the level of awareness and knowledge about bat guano among various demographic groups in Malaysia, including differences based on age, gender, education level, and geographic location, to inform targeted educational and conservation efforts.

MATERIALS AND METHODS

A social survey was conducted where 17 questions was published through social media platforms such as Facebook, LinkedIn, WhatsApp, and Instagram. The questionnaire was distributed randomly, and it was available for a two-month period, from February to April 2023. Utilising a virtual form provided numerous advantages, including convenience, scalability, and efficient data management and analysis. Respondents could participate at their own pace and convenience, removing geographical constraints and enabling broader participation. A pre-survey trial was not in place

as the study's goal is to gather as much data as possible within the available timeframe, prioritising broad participation over preliminary testing. To accommodate a wider audience, the questionnaire was offered in both Malay and English.

The information sheet included the purpose of the study, participants' right to withdraw, ensuring confidentiality and anonymity, and information on data storage. An informed consent that confirmed their voluntary participation in the study was included at the beginning of the questionnaire. The participants were informed that no identifiable data would be published.

The survey was adapted from questionnaire done by Lim and Wilson (2019), where it covers demographics, familiarity, perception, and knowledge, as well as responses to bats. Certain questions were modified to align with the objectives of this study. The survey aimed to assess general perceptions and knowledge of bat guano based on respondents' educational levels and demographic characteristics. Demographic variables included gender, age group, place of residence, level of education, and occupation. The questionnaire was divided into four sections: respondents' demographics (Questions 1 to 5), general knowledge of bat guano (Questions 6 to 13), understanding of its importance (Questions 14 and 15), and willingness to use bat guano after learning about its benefits (Questions 16 and 17).

Some questions required elaboration on choice through open-ended questions (Table 1). The questions provide flexibility to discuss aspects of the answers that might not have been considered. Other than that, it gives an understanding of the respondents' experiences in their own words. Most of the questions provided are closed-ended questions to ensure efficiency in respondents answer time, and the compilation of data. It also provides consistency in uniform data, to be easily compared across respondents. Scores from true or false questions gauged knowledge levels. A Likert scale was not utilised in the survey questions to ensure a simplified question structure and to ease the response for participants with varying education levels. Survey results were compiled in Excel and imported into SPSS Version 37 for analysis. Statistical analysis using a chi-square test through SPSS was done to test the significance of each demographic character against the knowledge and utilisation of bat guano by the respondents, followed by linear regression to assess knowledge scores. Analysis of the chi-square test was used to determine the correlation between the demographic characters and the yes or no variables.

Table 1. List of questions of the social survey conducted through Microsoft Forms.

Section Number	Question Number	Question
1 Demographic	1	Gender
	2	Age
	3	Place of residence
	4	Level of education
	5	Occupation
2 Knowledge and Experience	6	Are you familiar with the term bat guano before?
	7	If your previous answer was yes, where did you first hear about bat guano before?*
	8	What was your perception of bat guano before?
	9	Why do you have that perception?*
	10	Have you encountered bat guano anywhere before?
	11	If your previous answer was yes, where did you encounter the bat guano before?
	12	Have you utilised bat guano derived product before in any matters?
	13	If your previous answer was yes, how long have you been using bat guano derived product before?
3 Knowledge of Bats Guano Importance	14	Do you understand the importance of bat guano before?
	15	According to your knowledge, which do you think is the importance of bat guano?
4 Final Personal Thoughts	16	After reading the information, do you wish to use bat guano in your life?
	17	If your previous answer was no, what is the reason?*

*Open-ended questions

RESULTS

Demographic

A total of 103 respondents was obtained from 29 males, 72 females, 1 undisclosed (prefer not to say). The age group of respondents (Question 2) were described in Figure 1. The answers comprised of 65 respondents in the age group of 18 to 25 years old (63.11%), 22 respondents from 26 to 35 years old (21.36%), 6 respondents from 36 to 45 years old (5.83%), 5 respondents from 46 to 55 years old (4.85%), and the others were from above 55 years old (4.85%). The localities of respondents (Question 3) were dispersed around the states of Malaysia with the highest number of respondents from Sarawak at 40.78% (42 respondents) while the lowest number was 1 respondent (0.97%) from Kelantan, Melaka, Pahang and Perak (Figure 2). The results show 99% of the respondents had obtained or currently pursuing their tertiary education ranging from diploma or matriculation (11 respondents – 10.67%), Bachelor's degree (73 respondents – 70.87%), Master's degree (16 respondents – 15.53%) and Doctorate degree (2 respondents – 1.94%), while only 1 respondent obtained primary and secondary education (0.97%).

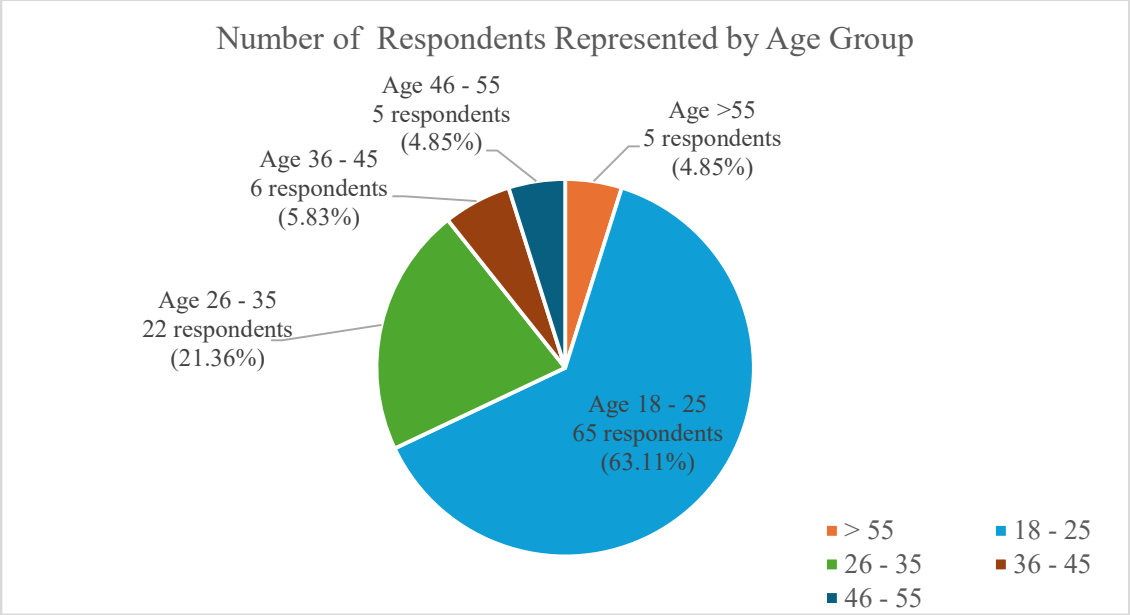

Figure 1. The pie chart on the age groups of 103 respondents in the survey**.** The biggest age group of the respondents is from the age of 18 to 25 at 63.11%, while the lowest is the age group 46 to 55 years old and above 55 years old at 5 respondents, respectively.

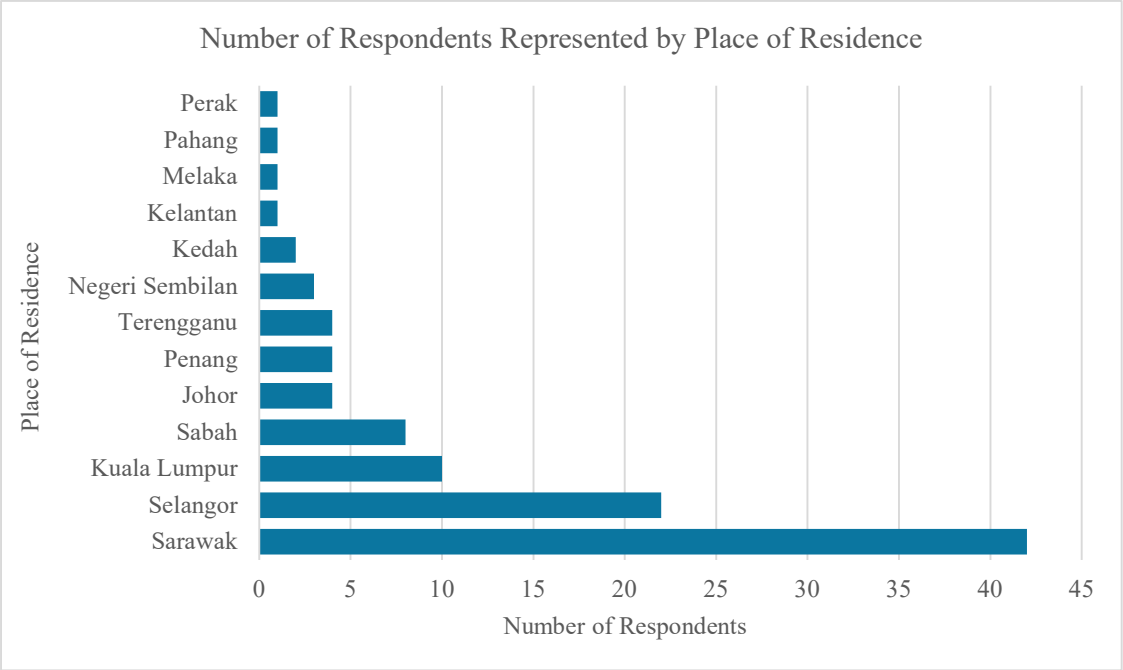

Figure 2. The bar chart on the place of residence of 103 respondents in the survey**.** The highest place of residence of the respondents in the survey is from Sarawak at 42 respondents, while the lowest number was 1 respondent each, from Kelantan, Melaka, Pahang and Perak

Knowledge and Experience

Through the questionnaire, it was found that 64.08% of the respondents were familiar with bats guano (66 respondents), while 37 respondents (35.92%) answered 'no' to the question (Question 6). The chart was presented in Figure 3. Among all of the respondents, the term bats' guano was mostly discovered through word of mouth (42 respondents), scientific readings (34 respondents) and social media (33 respondents) (Question 7). Additionally, 52 of the 66 respondents (78.79%) perceived bat guano in a positive way (Question 8). Few of the respondents' negative view of bats' guano was said due to the unhealthy nature of the bats' guano and the high number of microbes in it (Question 9).

Respondents' experiences in encountering bat guano (Question 10) are varied, with 60.19% (62 respondents) having come across bat guano and 41 respondents (39.81%) having never encountered bat guano before. Most of the respondents said to had encountered bats guano in the cave (51 respondents) while a few had seen it in urban buildings (26 respondents), and only 5 respondents had encountered bat guano or bat guano-derived products in stores (Question 11). Utilisation of bat guano among the respondents is weighted on one response, where 96.12% (99 respondents) have never used bat guano at all (Question 12), three of the respondents used bat guano in less than a year and only one respondent had used bats guano derived product for one to five years (Question 13). The results of the chi square test are shown in Table 2. Through the data, a significant correlation ($p<0.05$) was only found in the relation between the age group and the positive perception of bat guano, while others were not significant.

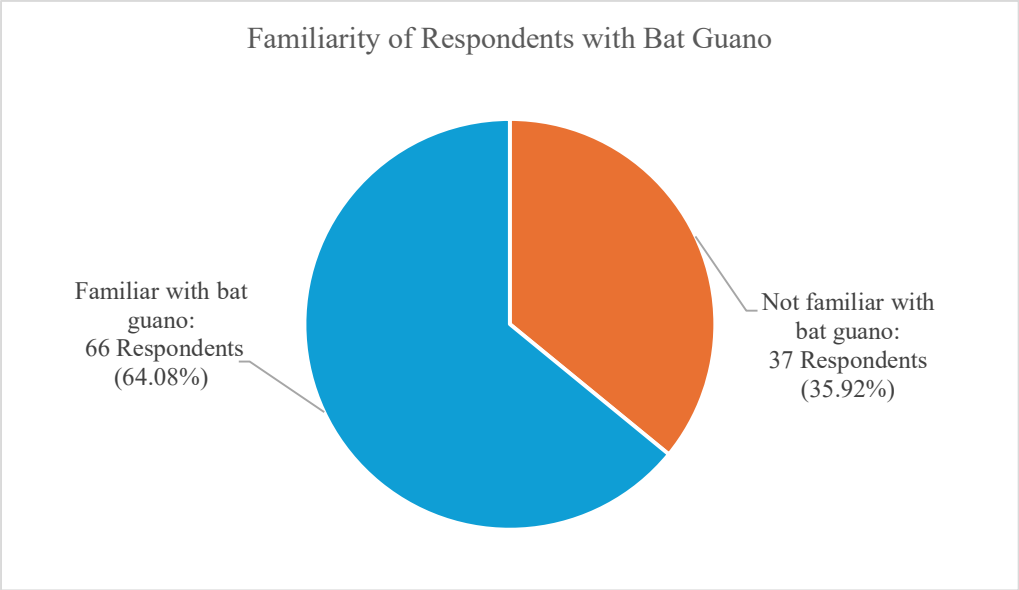

Figure 3. The pie chart on the familiarity with bat guano for 103 respondents in the survey**.** 66 respondents or 64.08% were found to be familiar with bat guano while the others (37 respondents – 35.92%) are not familiar with bat guano.

Table 2. p values of demographic characters against key knowledge of bats guano by the respondents. Analysis of the chi-square test shows the correlation between the demographics characters and the yes or no variables.

	Gender	Age Group	Level of Education	Place of Residence
Familiarity with the term bats guano	0.346 ± 0.03	0.532 ± 0.17	0.493 ± 0.19	0.398 ± 0.14
Positive perception of bat guano	0.707 ± 0.23	0.002 ± 0.28*	0.254 ± 0.33	0.341 ± 0.03
Had encountered bats guano previously	0.357 ± 0.22	0.838 ± 0.10	0.599 ± 0.04	0.406 ± 0.13
Experience in using bat guano-derived products	0.075 ± 0.21	0.902 ± 0.32	0.874 ± 0.32	0.804 ± 0.04
Understand the importance of bat guano	0.643 ± 0.14	0.976 ± 0.03	0.229 ± 0.29	0.455 ± 0.09

Notes: All values are p value ± standard error of P.
*p<0.05 The Association between the two variables is statistically significant.

Knowledge of Bats Guano Importance

In the true or false section of the knowledge on the importance of bat guano (Question 15), eight questions were asked about the importance of bats guano which are (a) as plants fertilisers; (b) in carbon dating; (c) as ecosystem stabiliser; (d) as animal's habitat; (e) in the field of research; (f) in traditional medicine; (g) as aesthetical value; and (h) as a product of biomass. The result established that a major number of respondents knew the importance of bats guano as plant fertiliser (99 participants – 96.1%) and in the field of research (98 participants – 95.1%). As expected, a few of the respondents are unaware of the aesthetic value of bats guano (32 participants – 31.1%) and the utilisation of bats guano in carbon dating (36 participants – 35%).

A multiple linear regression analysis in the study examined the relationship between demographic factors (gender, age, place of residence, and level of education) and knowledge of bat guano. The model explained 8.5% of the variance in bat guano knowledge ($R^2 = 0.085$), with an adjusted R^2 of 4.7%, indicating a relatively low explanatory power. Despite this, the overall model was tested for statistical significance. Table 3 presents the regression coefficients for each independent variable. The results indicate that age was the only significant predictor of bat guano knowledge ($p = 0.008$),

suggesting that the age group influenced, the knowledge on bat guano. Gender (p = 0.483), place of residence (p = 0.163), and level of education (p = 0.950) were not statistically significant predictors, indicating that these demographic factors do not have a strong influence on bat guano knowledge in this sample.

Table 3. Analysis of multiple linear regression between the demographics characters and knowledge score of bats guano utilisation

	Coefficient (B)	Std. Error	t-value	Sig. (p value)
(Constant)	5.783	1.191	4.856	<0.001
Gender	0.227	0.322	0.705	0.483
Age	-0.403	0.150	-2.690	0.008
Place of residence	-0.052	0.037	-1.406	0.163
Level of Education	0.015	0.245	0.063	0.950

Final Personal Thoughts

In the final section of the questionnaire, a short passage about bats guano was described as follows.

"Guano" (from the Spanish Quecha: *wanu*) is the accumulation of bats, seabirds and seals' excrement (Ferreira, 2019). Bat guano specifically refers to the excrement of bats. Cave roosts are the main provider of guano (Ghanem and Voigt, 2012). Guano fertiliser is a suitable fertiliser as it has high phosphorus and nitrogen levels (Tuttle and Moreno, 2005). A diverse number of invertebrates inhabit the guano in caves (Ferreira and Martin, 1998). Research on guano can also determine records of environmental changes in the cave in the past (Wurster *et al*., 2019). Hence, there are multiple values of bats guano that should be inserted into the education syllabus of Malaysia to change the community's perception."

Upon the information, respondents were asked whether they choose to use bats guano in their daily life (Question 16), the results were described in Figure 4. Only 33.01% (34) of the respondent would choose to use bats guano, while eight chose the contrary (7.7%), 61 respondents (59.22%) were undecided. A mixture of age groups was identified in refusing utilisation of bat guano, where two respondents from four age groups (18 – 25, 26 – 35, 36 – 45, and >55) each, answered 'no' to the question.

Question 17 noted that few of the respondents that are unsure in using bats guano is due to the doubtfulness in bats' guano cleanliness and safety while another respondent from the same group answered that bats guano is hard to come by. Respondents that refuse to use bat guano also mentioned on the cleanliness and safety of bat guano, while some respondents from the group admitted on not using any fertilisers in their day-to-day life. One respondent that refused to use bats guano voiced out on the lack of understanding on bats guano importance which shows the vitality on exposure and education regarding the matter.

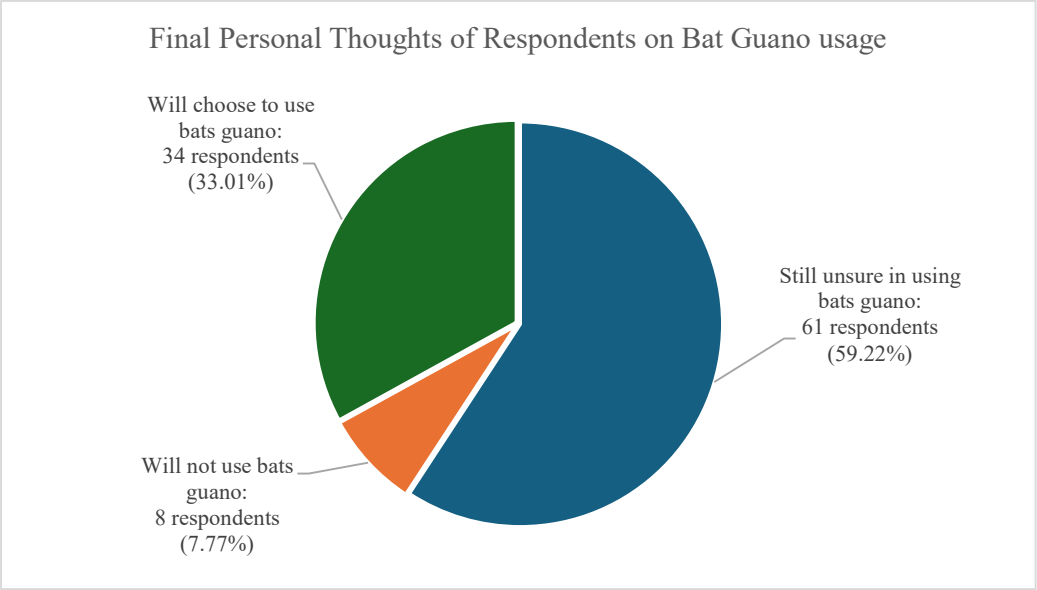

Figure 4. The pie chart on the final personal thoughts of bat guano for 103 respondents in the survey**.** Among the respondents, 61 respondents are still unsure about using bat guano, while 8 respondents refuse to use bat guano in their day-to-day life. 34 respondents expressed willingness to use bat guano.

DISCUSSION

The demographic data revealed a significant concentration of respondents from Sarawak. Despite the survey being distributed across multiple social media platforms and through secondary networks, most responses were collected through the primary researcher's network, which predominantly includes university students aged 18-25 years. This demographic skew reflects the researcher's connections and may impact the generalisability of the results to a broader Malaysian population.

Mixed perceptions of bat guano were discovered through the questionnaire, where 64.1% of the respondents are aware of the presence of bats guano. This is similar to the finding reported by Torres-Jimenez *et al*. (2020) on the perception of bat guano among coffee farmers in Mexico with 59% of the interviewees having little to no knowledge of bat guano benefits to the local community. This is due to the negative perception of the community towards bats as well as feeling fearful of bats (chiroptophobia). The negative perception of the community towards bats is rooted from fearing their appearance, the stigma of bats as a vector of human diseases and viewing bats as 'bloodsuckers' (Torres-Jimenez *et al*., 2020).

Establishing the channels of information platforms can be the first step in bats' guano introduction and awareness for bat conservation goals. Since word of mouth achieved the highest scoring in introducing bat guano to the survey's participants, an outreach programme through talks and showcase is one of the possible methods in widening the positive viewpoints of bat guano in the community. Responses to the questionnaires vary in terms of the countenance of bat guano and experience in handling bat guano. A major portion of the respondents had never used bat guano-derived products which might be due to the lack of market awareness of bat guano as fertiliser where the study by Kingston *et al*. (2006) recorded that only 3.4% of the survey participants knew about the utilisation of bats guano as fertiliser.

In the current survey, one of the respondents claims the denial of using bat guano products is due to the scarcity of bat guano supplies in stores. Although there are no scientific publications or records to support the claim, through online surfing, the market for bats guano in Malaysia were investigated. The market for bat's guano as organic fertilisers in Malaysia comprises of local producers and international brands, where Pok Asia Marketing which is a local company based in Kelantan, supplies 100% natural and pure bat guano organic fertiliser. Other than that, the company Serbajadi also

offers the Natural Pure Guano fertiliser in their range of products. 'Bat guano fertiliser mix' by international companies 'Down to Earth' and Plagron has also penetrated the Malaysian market. Since the availability of bats guano in local agriculture market is not widespread, the current existing companies that promotes the usage of bats guano as fertiliser in Malaysia is a good model to be expanded nationwide.

The number of respondents who acknowledge the usage of bat guano as plant growth fertiliser and its value in research is high at 96.1% and 95.1%, respectively. This shows a hopeful path for the conservation work of bats guano and bats generally. The data is also reflected in the survey done by Lim and Wilson (2019) where 72.9% of 340 respondents agreed with the utility of bats droppings as organic fertilisers. The increment of percentage between the current survey and the survey done by Lim and Wilson (2019) might be due to the influence of educational level of the participants. Where only 86% of the respondents in the previous study in comparison to 99% of the current study had received or is receiving tertiary education.

However, relations between demographic factors and knowledge of bat guano were found to be independent of one another except for age group and positive perceptions of bat guano. This contradicts the conclusion of surveys done by Lim and Wilson (2019) on the public perception and knowledge of the chiropterans' group, as the research done reported that most demographic factors can affect the communities' knowledge, perception and response to bats. The contradiction could be due to the lack of variability in other demographic factors such as gender, localities and education level that could affect coefficient value of the relations. A higher number of respondents should be sourced through other platforms such as face-to-face interviews, physical questionnaires and phone calls to ensure a wide range of demographic variability can be obtained for a more significant data.

Positive perceptions of bats guano were significantly contributed by the age group. Thornton and Quinn (2009), and Shafie *et al*. (2017) also reached a similar consensus in their study, where it is noted that there is a high association between the knowledge of current wildlife issues and age group. On the topic of bat guano, a major part of the younger age groups had a more positive take towards the usage of bat guano among the community. This might be due to the reliability of social media which is being used largely by the younger groups in information exchange and publications (Auxier & Anderson, 2021). This was supported by the significant correlation between the age group and the knowledge of bat guano's importance coefficients. When looking at the apprehension on the importance of bat guano, the lowest number of results were obtained for recognition of bat guano for aesthetic purposes. Although it is not commonly known and sought for, bat guano was once used as an art medium in the Caribbean and Bulgaria cave art due to its high availability in caves (Samson *et al*., 2017; Sassoni *et al*., 2020).

Finally, the doubt about the cleanliness and safety of bat guano will always be the driving force in the denial of bat guano. Bat guano emits a strong, unpleasant odour due to the high levels of ammonia from decomposed urine and faeces. This strong smell can be off-putting and creates a perception of uncleanliness. The accumulation of guano can also lead to an unsanitary environment, promoting the growth of bacteria, fungi, and other microorganisms, some of which can be harmful to humans (Wasti *et al*., 2021). The perceived filthiness and the health risks associated with these microorganisms contribute to the scepticism around bat guano.

Other than that, with the lingering pandemic of Covid-19 and its devastating casualties, usage of bats-derived products (such as bushmeat, in research and fertilisation) has proceeded with caution. A recent study by Tan *et al*. (2021) in Wind Cave Nature Reserve, Bau, Sarawak found a high diversity of alpha and beta coronaviruses which are unique to Borneo Island in almost half of the samples collected. This study which was done in the heights of Covid-19 pandemic was expected to add on the negative perception of the utilisation of bats guano in day-to-day activities. Considering the current issues influencing the bats and bats guano perception, the survey found that more than a quarter of the respondents would choose to use bat guano in their daily life at the end of the questionnaire which shows the willingness of Malaysian community in switching to an organic material in fertilisation as well as utilising bats guano efficiently.

The study on the health hazards of bat guano increased an urge for better management of health safety in bat guano collection (Jayasvasti & Jayasvasti, 2018). This can be done through training and management systems that can be empowered by the government (Jayasvasti & Jayasvasti, 2018). Further research and education on the utilisation of bat guano in Malaysia and the steps to handle them are of the utmost importance to ensure an improvisation of bat guano benefit in the eyes of Malaysian perspective. Strategic approaches to increasing acceptance and awareness of bats guano can be planned thoroughly using education and advocacy through platforms social media and scientific publications. Other than that, policies on the training and management system of bat guano utilisation should also be outlined in by Malaysian governments to safely manage the collection of guano and to control the disruption of the ecosystem in guano harvesting.

CONCLUSION

Bat guano utilisation has been proven throughout the centuries. From the usage of bat guano as gunpowder to its vast usage in the agriculture industry, tapping into the reservoir of bat guano can be beneficial to the economy. Despite that, the acceptance of bat guano in the Malaysian community is still lacking. The study highlights the mixed perceptions of bat guano among the Malaysian public, with significant awareness but persistent concerns regarding cleanliness, safety, and potential health risks. The significant demographic factor of age group affecting the perception of bats guano in the community suggests a growing acceptance of bat guano, influenced by higher education levels and social media exposure. However, factors such as fear of bats, stigma, and limited market awareness will continue to restrict acceptance and usage. Future research should explore changes in public perception over time, particularly in response to educational initiatives. Health risk assessments related to guano use, economic market studies, and ecological research on harvesting impacts are also essential. Furthermore, establishing standardised methods for guano collection and processing can improve quality control and consumer confidence. With comprehensive education, scientific advocacy, and government-backed safety measures, bat guano has the potential to become a widely accepted and valuable resource in both economic and environmental contexts.

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