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Cover: The nine vultures of India, digital art made on Krita by Dupati Poojitha.

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ARTICLE

Communities attitudes and conservation strategies for flying foxes *Pteropus* spp. (Mammalia: Chiroptera: Pteropodidae): a case study from Sabah, Malaysia Borneo

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Abstract: Flying foxes (*Pteropus* spp.) are keystone pollinators and seed dispersers in tropical ecosystems, yet over half of these bat species are threatened with extinction, making their conservation a global priority. In Sabah, Malaysia, understanding local communities' attitudes toward flying foxes is crucial for guiding effective conservation strategies. This study used a self-administered questionnaire survey targeting Sabahan communities (n = 320; 100 in-person, 220 online across various districts in Sabah) to assess conservation attitudes, knowledge gaps, and factors influencing these attitudes. Statistical tests revealed approximately 70% of Sabahan respondents (68% in-person; 77% online), expressed conservation-positive attitudes toward flying foxes, providing a strong basis for expanding community-driven conservation efforts, although over half exhibited limited ecological understanding or held misconceptions about flying foxes. Generalised linear mixed models (GLMMs) identified knowledge level (Odds Ratio, OR = 7.43, $p < 0.05$), recognition of ecological importance (OR = 4.30, $p < 0.05$), and ethical opposition to culling (OR = 3.62, $p < 0.05$) as the strongest predictors of conservation support. Neither socio-demographic factors nor conflict-based experiences significantly predicted conservation attitudes. These findings highlight an urgent need for targeted education and community engagement to improve knowledge and dispel misconceptions, raise awareness of legal protections for flying foxes, such as hunting permit requirements, and proactive efforts to address misinformation about zoonotic transmission risks from flying foxes. The development of educational tools, community outreach programmes, and non-lethal conflict mitigation strategies should be prioritised as key intervention points to promote flying fox conservation. Such measures, although grounded in Sabah's context, can inform and strengthen flying fox conservation efforts in similar community settings elsewhere.

Keywords: Community survey, conservation attitudes, fruit bats, human-wildlife interactions, hunting & culling, knowledge, Palaeotropics, perceptions, *Pteropus hypomelanus*, *Pteropus vampyrus*.

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INTRODUCTION

Flying foxes are crucial for maintaining the ecological balance of many tropical regions (Fujita & Tuttle 1991; Aziz et al. 2017a; Parolin et al. 2021; Kingston et al. 2023). With their ability to fly long distances, flying foxes play pivotal roles in seed dispersal and pollination (Aziz et al. 2017b,c, 2021; Chen et al. 2017; Oleksy et al. 2017; Todd et al. 2022; Selan et al. 2023). Such an ecological role also has a positive economic impact since fruits like durian and kapok trees rely on the species for their reproduction (Fujita & Tuttle 1991; Nathan et al. 2005; Aziz et al. 2017b,c, 2021). Despite their ecological importance, over half of all flying foxes are classified as vulnerable, endangered, or critically endangered (Pulscher et al. 2021; Kingston et al. 2023). The species population decline is driven mostly by overhunting, habitat loss, and habitat degradation caused by extensive land-use changes (Tsang 2022; Kingston et al. 2023). Conservation efforts are further complicated by conflicting views towards these animals (Mo et al. 2022; Tsang 2022; Charerntantanakul et al. 2023). Issues such as crop raiding, fear of zoonotic diseases, and negative attitudes have led to conflicts between humans, and flying foxes (Aziz et al. 2016; Shapiro et al. 2020; Low et al. 2021; Yabsley et al. 2021; Mohd-Azlan et al. 2022a,b; Charerntantanakul et al. 2023; Kingston et al. 2023). For example, the Mauritian Flying Fox *Pteropus niger* has faced significant population declines over 50% since 2015 due to large-scale culling driven by perceived damage to commercial fruit crops (Kingston et al. 2018; Seegobin et al. 2022). As a result, flying foxes are often viewed as pests and face legal persecution (Florens 2016; Florens & Baider 2019; Seegobin et al. 2022). This undermines support for conservation and highlights the urgent need to address public perceptions and knowledge gaps regarding flying foxes.

The theory of reasoned action highlights how attitudes towards behaviours can shape, intentions, and actions (Albarracín et al. 2018; Hagger et al. 2018). Understanding threats to species, their conservation status, and public knowledge, attitudes, and perceptions can enhance outreach efforts aimed at promoting conservation and mitigating negative human-wildlife interactions (Bennett et al. 2019; Boso et al. 2021; Basak et al. 2022; Li et al. 2023). Assessing conservation attitudes is crucial as the views of local communities toward wildlife can significantly influence conservation outcomes (Li et al. 2023; Fotsing et al. 2024). Positive attitudes from local communities lead to greater support for conservation efforts, regulatory compliance, and active participation (Loyau & Schmeller 2016; Merz et al. 2023; Tang et al. 2023). Although negative attitudes towards flying foxes pose challenges, they also offer a chance to correct misconceptions, raise awareness, and promote coexistence (Aziz et al. 2016; Tsang et al. 2022; Kingston et al. 2023). To foster effective conservation, it is essential first to understand local communities' attitudes, perceptions, knowledge, and experiences with the species, in order to design conservation policies through the engagement, and participation of the communities (Bennett et al. 2019; Mubalama et al. 2020; Fotsing et al. 2024).

Borneo's diverse ecosystems provide vital habitats for flying foxes, ranging from coastal mangroves to dense rainforests. Sabah, Malaysia, is home to two species, including *Pteropus hypomelanus* and the regionally at-risk *Pteropus vampyrus* (Phillipps & Phillipps 2018; Mildenstein et al. 2022). Habitat loss caused by deforestation, agriculture, and urban expansion (Gaveau et al. 2014) increases their vulnerability, and leads to heightened human-wildlife conflicts, particularly fruit raiding. Despite flying foxes' protected status under the Sabah Wildlife Enactment 1997, hunting licences are still issued creating conflicting legal signals. In addition, Sabah is geographically positioned within a wider flying fox heavy trade region that includes North Sulawesi and Kalimantan (Harrison et al. 2011; Latinne et al. 2020). The absence of empirical data on public attitudes and behaviours in Sabah presents a barrier to effective, locally informed conservation planning, particularly as the state moves forward with the Sabah Biodiversity Strategy 2024–2034.

Given these gaps in understanding and the conservation importance of Sabah's flying fox populations, this study was designed to explore local community-level dynamics. This study addresses three core objectives: (1) to assess public attitudes toward flying fox conservation in Sabah, (2) to evaluate knowledge levels, and identify common misconceptions about flying fox ecology, and legal protection, and (3) to identify key predictors of conservation support, including demographic variables, human-flying fox experiences, and cognitive or ethical perceptions. To explore these dynamics across diverse segments of the population, data were collected by combining in-person interviews in high-contact areas with broader-reaching online surveys. This methodological approach was designed to optimise data quality, maximise response rates, and expand demographic reach across diverse geographic regions in Sabah, aiming to capture both direct, and general public perspectives to inform a more inclusive conservation response. The findings are intended to guide the development of targeted strategies to improve conservation awareness and promote the protection of flying fox populations in Sabah.

METHODS

Data collection

A self-administered survey was conducted using both in-person and online methods between September 2021 and September 2023, covering various districts in Sabah (Image 1). The questionnaire was designed in Bahasa Melayu using simple, non-technical language, and was pilot-tested on 10 individuals prior to full deployment. Feedback from the pilot informed minor revisions for clarity. Informed consent was obtained from all participants, who were briefed on the study's objectives, confidentiality, and voluntary participation. The study was approved under the Sabah Biodiversity Access Licence (Ref. JKM/MBS.1000-2/2 JLD.10 (25)) and supported by local district offices, and village heads. Two approaches were employed to maximise reach and improve representativeness: (1) In-person surveys, administered in five districts where *P. vampyrus* is known to occur, and (2) Online surveys, disseminated via Google Forms through social media, and local networks.

Given the context-specific nature of flying fox conservation, prioritising participants with firsthand interactions was considered essential. To achieve this, an in-person survey was conducted in September 2021 in Bahasa Melayu across five districts (Tambunan, Ranau, Telupid, Tongod, and Kinabatangan), where the IUCN Red List 'Endangered' *P. vampyrus* is distributed. Three trained surveyors administered the survey in key community areas, including villages and local markets. Participants were selected through snowball sampling, a method well-suited for accessing individuals with specific knowledge or experience, despite its lack of randomisation (Atkinson & Flint 2001; Palinkas et al. 2015). Village heads were first informed of the study and helped coordinate recruitment through local committee members. In market settings, participants were selected randomly from among sellers & buyers, and were briefed on the study's objectives, structure, and confidentiality measures. Particular emphasis was placed on the

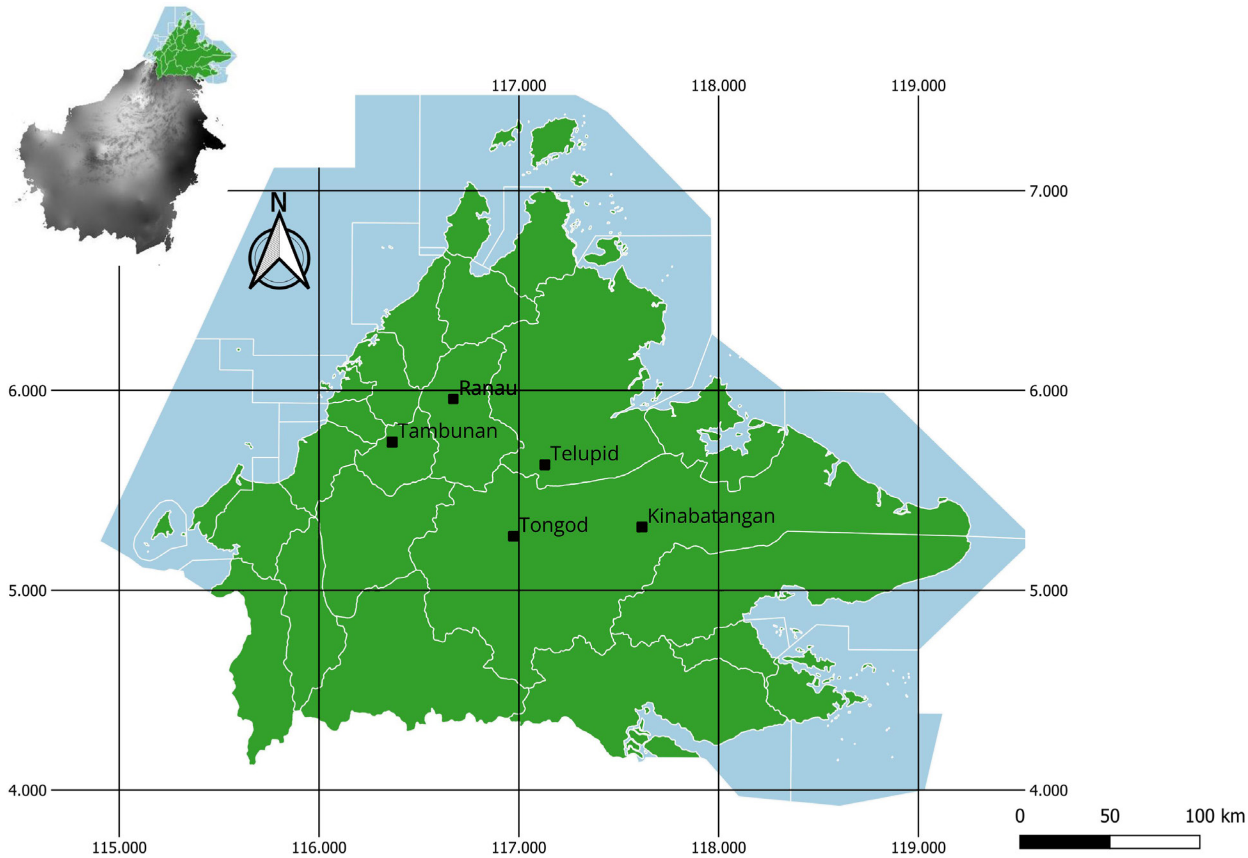

Image 1. Geographic distribution of in-person survey locations across five districts in Sabah, Malaysia.

sensitive nature of topics such as hunting, consumption, and fruit raiding, with surveyors reassuring participants of strict confidentiality to encourage honest responses. Participants completed the survey independently within 15 to 20 minutes, and surveyors were available to provide clarification or assistance to those with limited literacy to ensure full comprehension of the questions, and response options.

Due to a resurgence of COVID-19 cases and the reintroduction of movement restrictions, surveyors were unable to continue distributing questionnaires in person. As a result, the survey was shifted online via Google Forms, available in Bahasa Melayu and restricted to one response per email to ensure data integrity (Teitcher et al. 2015). While online surveys tend to attract more educated and environmentally aware individuals, combining both approaches helped improve representativeness (Kaplowitz et al. 2004). From October 2021 to September 2023, the survey was distributed via Facebook, and WhatsApp by local volunteers, who monitored participation to ensure demographic diversity. Targeted outreach through business associations, educational institutions, local social networks was employed to reach underrepresented groups, and minimise bias. Snowball sampling was used alongside strategic recruitment to ensure balanced participation across districts, age groups, and occupations.

Questionnaire design

A semi-structured questionnaire was used to collect data on four areas: (1) socio-demographics, (2) experience, (3) knowledge, and (4) attitudes and perceptions. Questions were adapted from Aziz et al. (2017a) and neutrally phrased (see Supplementary Material 1). The demographics section covered residential district, gender, age, education, monthly household income and ethnicity. Age and education were grouped into categorical ranges, and monthly income ranged from RM500– above RM3000.

The experience section assessed participants' direct interactions with flying foxes, specifically in relation to fruit-raiding, hunting, and consumption. Follow-up questions validated claims by investigating the types of fruit affected, and places the bats experienced it (for fruit-raiding); motivations, hunting locations, and methods used; and consumption frequency, and reasons. These responses enhanced contextual understanding of human–flying fox experience. Only data relevant to the present study objectives were analysed. Experience variables were coded as binary ("Yes" for confirmed experiences; "No" for inconsistent or negative responses).

The respondents' knowledge of key aspects of flying fox biology was assessed through five questions covering ecological roles (seed dispersal and pollination), roosting sites, legal considerations (hunting permits), and dietary habits. Some uncertain participants might have guessed instead of admitting a lack of knowledge, and social desirability bias could lead others to overestimate their expertise (Boso et al. 2021). To mitigate forced guessing, the survey included a "Don't know" option. Response options for each question were "Yes", "Don't know", and "No," with only correct answers scoring one point; incorrect and don't know responses received zero. Total knowledge scores ranged 0–5 points and were categorised based on previous conservation education research. Participants scoring below 50% (0–2 points) were classified as having limited knowledge of flying fox conservation, while those scoring above 50% (3–5 points) were deemed to have a sufficient understanding. This classification followed the frameworks established by Wendeye (2009) and Lubos (2019), with scores below 50% labelled as "Below Mastery Level", and scores above 50% as "Above Mastery Level".

The study included five fixed-response questions designed to assess perceptions and attitudes, using a mix of positive and negative statements to enhance response consistency. Attitudes reflect individuals' feelings and predispositions toward bats, which can influence their behaviours, while perceptions relate to people's beliefs, and awareness of bats in their environment (Castilla et al. 2020). This research specifically examined perceptions and attitudes towards flying foxes, addressing conservation-related aspects such as their importance, views on them as pests, attitudes toward culling, perceptions of population decline, and beliefs regarding extinction. Additionally, it explored the value of flying foxes in relation to tourism, feelings of fear, and awareness of diseases, including public perceptions of disease and attitudes towards COVID-19.

Questionnaire response validity

A systematic data-cleaning process was conducted before statistical analysis to ensure the validity and reliability of survey responses. This involved identifying and removing unreliable data, including duplicate entries, inconsistent answers, patterned responses, and excessive missing data, following best practices in survey research (Meade & Craig 2012; DeSimone et al. 2014; Curran 2016). To minimise misinterpretation and ensure response relevance, a visual screening step was incorporated at the start of the questionnaire. This

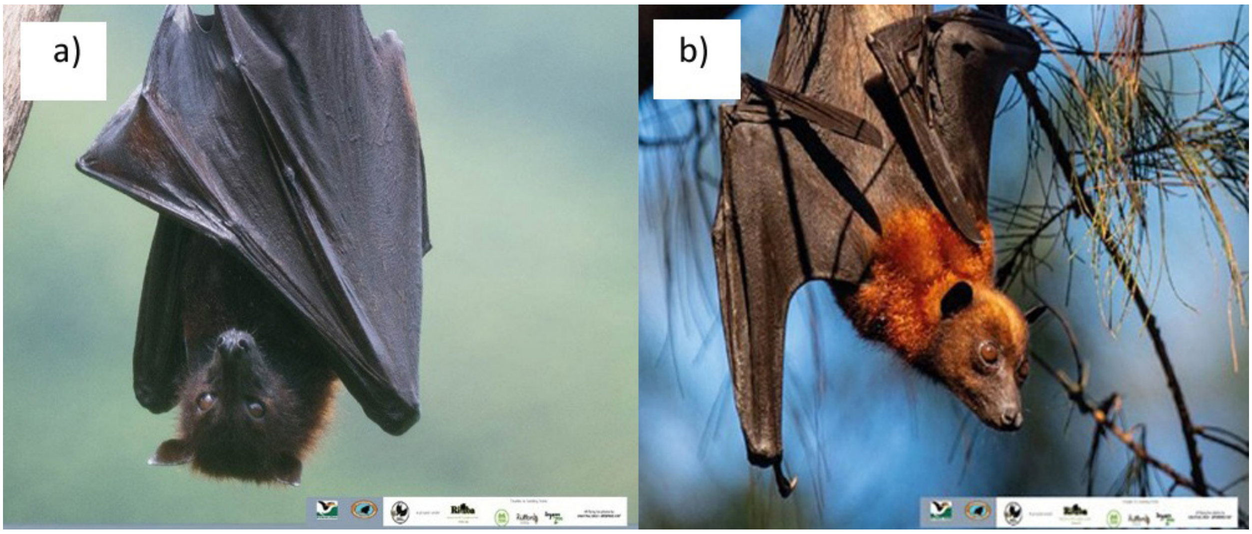

Image 2. Images of two flying foxes used in the survey to assess whether participants could recognise flying foxes as target species: a—*Pteropus vampyrus* | b—*Pteropus hypomelanus*. Source: Rimba (2021).

involved presenting two unlabelled images of flying foxes (Image 2) to assess whether participants could recognise the target species. Given the potential for confusion with other bat species or animals, this step served to clarify the survey context and confirm that responses pertained to the intended taxon.

Building upon this, further steps were taken to detect inattentive or careless responses that could compromise data quality. One common issue, known as patterned responses or straight-lining, occurs when respondents select the same answer for all questions without properly reading them (DeSimone et al. 2014). To identify such behaviour, some questions were reworded and reverse-coded across different sections (Meade & Craig 2012). For instance, the statement “Flying foxes should not be killed” was rephrased as “Should flying foxes be killed?”. Contradictory responses to these items were flagged as potentially careless (Huang et al. 2015). Inconsistent answers, showed contradictory responses to logically related items such as supporting and opposing the killing of flying foxes in different questions, were also flagged. Participants were removed from the dataset if they displayed contradictions in more than 50% of the reworded items or failed attention-check questions (Huang et al. 2015; Curran 2016). In the knowledge section, participants were also evaluated on their ability to correctly identify flying foxes and demonstrate a basic understanding of the species.

To further ensure data integrity, a post hoc comparative analysis was carried out between online and in-person participants. Although not part of the original study objectives, this analysis was deemed necessary to assess potential biases introduced by the dual-mode sampling approach. Survey mode can influence response patterns due to factors such as perceived anonymity, literacy levels, and self-selection biases (Kaplowitz et al. 2004; Rand et al. 2019). Thus, differences in demographic characteristics and survey responses were examined between the two groups. These comparisons help validate the decision to pool responses and provide a clearer understanding of the sample’s representativeness.

Data analysis

To address the study objectives, attitudes (Objective 1) were measured using structured questions and statistical tests; knowledge and misconceptions (Objective 2) through a scored knowledge section; and predictors of conservation support (Objective 3) via GLMMs using demographic, experiential, and cognitive-ethical variables.

All analyses were conducted using R 4.3.3 (R Core Team 2024). Participants were categorised into two groups: in-person and online. To identify significant differences between these groups, chi-square was used to assess variations in attitudes, perceptions, fruit raiding, hunting, and flying fox consumption, while t-tests were used to compare knowledge scores. Effect sizes were calculated using the rstatix package in R (Kassambara 2021). Conservation attitudes were evaluated based on whether participants believed flying foxes should be conserved. Factors influencing these attitudes were examined using a Generalised Linear Mixed Model (GLMM; see Supplementary material 2) and the "lme4" package in R (Bates et al. 2015). Before running the GLMMs, socio-demographic covariates were assessed for significant correlations (|coefficient values| > 0.5) to ensure stable and interpretable parameter estimates (Aziz et al. 2017a). The correlation between conservation attitudes and socio-demographic covariates was assessed using the "vcd" package in R, leading to the selection of age, gender, and education as covariates (summary in Supplementary material 3).

To identify the best predictors of conservation attitudes toward flying foxes, three GLMMs were generated based on socio-demographic factors, experience (fruit raiding, hunting, consumption), and conservation-related parameters (knowledge and perception). These models were compared using Akaike's Information Criterion (AIC) and log-likelihood values. The corrected Akaike information criterion (AICc) was calculated using the "MuMin" package in R, and the Akaike weights (wAICc) were used to quantify the likelihood of each model being the best. The variance explained by fixed effects in each GLMM was assessed with R2m (Nakagawa & Schielzeth 2012). Model 1 included demographic factors (age, gender, education); Model 2 added experience-based predictors; and Model 3 further included knowledge levels, importance perception, and opposition to killing. "Method" was included in the model to address potential non-independence of responses from different sampling methods. Multicollinearity among predictors was assessed using Generalised Variance Inflation Factors (GVIFs) with the "car" package in R.

Binomial (logit-link) GLMMs were employed to model the binary response variables. Gender was coded as 1 for men and 2 for women; age as 1 for young (<35 years) and 2 for adult (>35 years); and education as 1 for secondary education or below and 2 for tertiary education. Experience with flying foxes was coded as 1 for those with experience and 0 for those without. Attitudes and perceptions were coded in binary form: "Yes" responses as 1 and "No" or "Unsure" responses were coded as 0, with negative statements recoded to ensure positivity. Important perceptions (coded as Important) and opposition to killing (coded as "Nokill") were included as covariates, along with knowledge scores, coded as 1 for scores below three and 2 for scores above three. Knowledge, importance perception, and anti-killing attitudes were the primary predictors in the models.

RESULTS

Socio-demographic information

Of the 330 participants, 320 were selected for analysis after screening, comprising 220 online, and 100 in-person participants. The demographic data collected from both in-person and online methods reveal some notable trends. Regarding gender distribution, both methods show an almost equal split, with males constituting 53% of in-person participants and 51% of online participants. The age distribution highlights a significant proportion of older individuals, with the 45–54 years age group being the largest in both methods (31% in-person, 24% online). The highest education level for both in-person (62%) and (45%) online participants were secondary education. Occupation reveals a substantial presence of self-employed individuals (43% in-person, 28% online). Ethnicity data indicate Kadazandusun as the predominant group, especially online (74%). The residential data point to a diverse geographic spread, with notable concentrations in Ranau (23% in-person), and Tambunan (28% online). Detailed social-demographic results are listed in Supplementary material 4.

Attitude on flying foxes among local participants

The study's results indicated no statistically significant differences in the distribution of responses regarding flying fox conservation, extinction, killing, fear, and perceived links to COVID-19 between in-person and online participants. Specifically, chi-squared tests revealed no significant differences for conservation ($x^2(320) = 4.64$, $p = 0.10$), Cramér's V = 0.12). This was similar with other attitudes, extinction ($x^2(320) = 0.60$, $p = 0.74$), killing flying foxes ($x^2(320) = 3.07$, $p = 0.22$), fear of flying foxes ($x^2(320) = 2.44$, $p = 0.30$), and COVID-19 ($x^2(320) = 0.65$, $p = 0.72$).

Most participants expressed positive attitudes toward flying fox conservation (Figure 1). Among in-person participants, 68% (n = 68) supported conservation, 25% (n = 25) were unsure, and only 7% (n = 7) opposed it (see Figure 1a). Similarly, 77% (n = 170) of online participants favoured conservation, 15% (n = 33) were unsure, and 8% (n = 17) opposed it. Concerning flying fox extinction, 69% (n = 69) of in-person participants, and 72% (n = 159) of online participants opposed it. Additionally, the fear of flying foxes was not a significant concern for most participants, with both 64% (n = 64) of in-person and 64% (n = 141) of online participants reporting no fear of these animals.

The majority of participants also opposed killing flying

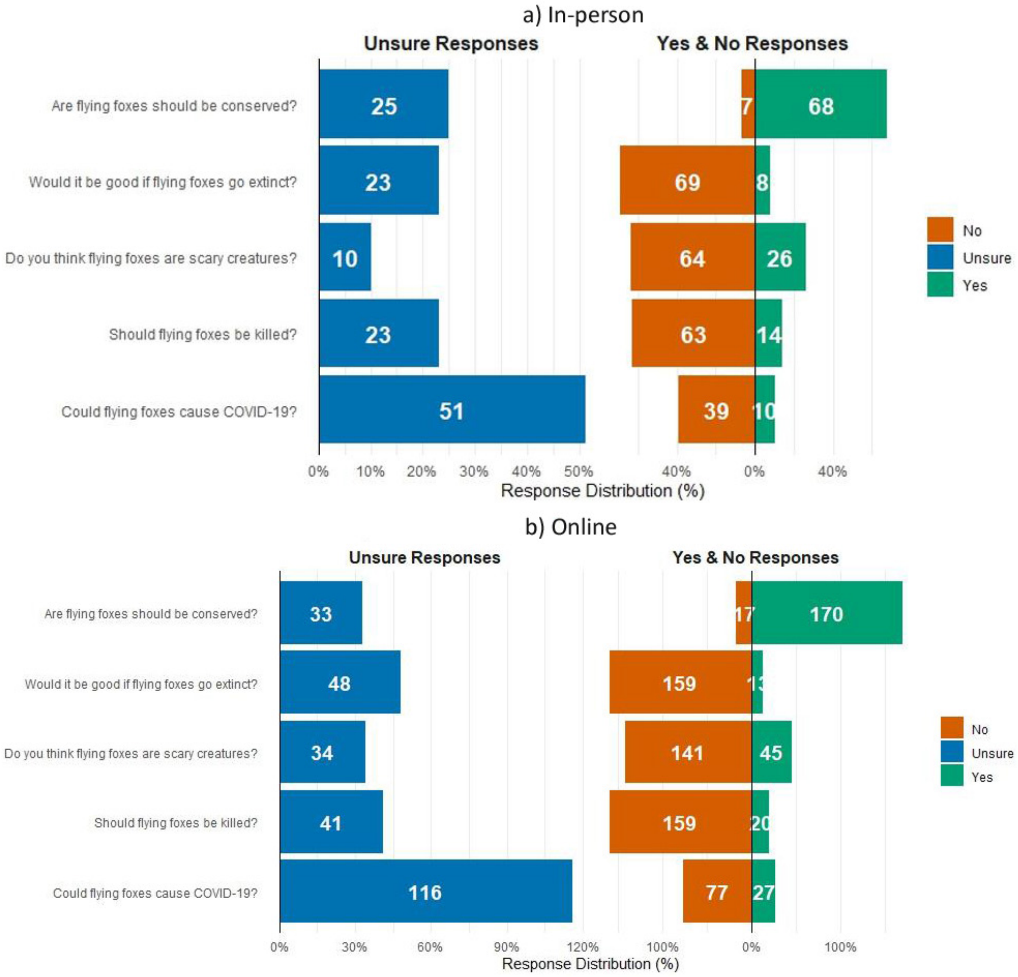

Figure 1. Conservation attitudes of in-person (Figure 1a, n = 100) and online (Figure 1b, n = 220) participants toward flying foxes in Sabah, categorised by responses to five key questions ("Yes," "Unsure," "No").

foxes, with 63% (n = 63) of in-person and 72% (n = 159) of online participants against this practice. Regarding the link between flying foxes and COVID-19, a slight majority were unsure: 51% (n = 51) of in-person participants and 53% (n = 116) of online participants. Disagreement with the idea that flying foxes are responsible for the virus was more prominent among in-person participants (39%, n = 39) compared to 35% (n = 77) of online participants, patterns which are illustrated in Figure 1.

Perception of flying fox among local participants

Chi-squared tests revealed no significant differences between participant types in their views on the importance of flying foxes ($x^2(320) = 3.41$, $p = 0.18$) and disease transmission ($x^2(320) = 5.63$, $p = 0.06$). Significant differences were observed regarding perceptions of flying foxes as pests ($x^2(320) = 6.88$, $p = 0.03$), population decline ($x^2(320) = 39.16$, $p < 0.05$), and tourist attractions ($x^2(320) = 9.33$, $p = 0.03$).

A majority, 66% (n = 66) of in-person, and 76% (n = 167) of online participants recognised the environmental importance of flying foxes (see Figure 2). On the issue of pest perception, in-person participants were divided, with 39% (n = 39) rejecting the notion that flying foxes are pests, while 38% (n = 38) agreed, and 23% (n = 23) were unsure. In comparison, 42% (n = 93) of online participants did not view flying foxes as pests, while 25% (n = 54) did, and 33% (n = 73) were unsure. Regarding disease transmission from flying foxes to humans, 51% (n = 51) of in-person participants and 41% (n = 91) of online participants were uncertain. Notably, more online participants (45%, n = 99) believed in disease transmission than in-person participants (31%, n = 31). Nearly half of the participants believed that flying fox populations were declining, with 52% (n = 84) of online, and 42% (n = 42) of in-person participants expressing this concern. A higher percentage of participants, 61% (n = 61) of in-person, and 68% (n = 139) of online participants, viewed flying foxes as potential tourist attractions, while 27% (n = 27) of in-person, and 21% (n = 43) of online participants did not. A smaller proportion (12%, n = 12 in-person; 11%, n = 22 online) were unsure about this, as summarised in Figure 2. Among online participants, 204 responded to item on flying foxes as potential tourism and 163 to the item on population decline, with fewer responses due to skipped questions.

General knowledge of flying foxes among local participants

The mean knowledge score was 2.8 (Standard deviation, SD = 1.1) for in-person respondents and 3.0 (SD = 1.0) for online respondents. Statistical analysis using a t-test revealed no significant differences in knowledge between in-person and online participants (t(178.46) = -0.79, p = 0.43). Less than 10% of participants (7% in-person, 5% online) correctly answered all five knowledge questions, and over half of all participants scored below three, indicating low overall knowledge of flying foxes (see Figure 3).

Most participants recognised the importance of flying foxes in seed dispersal, with 58% (n = 58) of in-person and 68% (n = 150) of online participants acknowledging this. However, fewer participants were aware of their role in pollination, only 37% (n = 37) in-person compared to 52% (n = 114) online. Misconceptions were common, particularly concerning flying foxes' habitats, and feeding habits. Many participants incorrectly believed that flying foxes live in caves (48%, n = 48 in-person; 55%, n = 122 online), and some were unsure of their feeding habits. A minority believed that flying foxes feed on blood (10%, n = 10 in-person; 16%, n = 35 online). There was also a gap in knowledge about hunting regulations: 46% (n = 46) of in-person and 47% (n = 103) of online participants were unsure whether a licence is required to hunt flying foxes. In comparison, 43% (n = 43) of in-person and 36% (n = 79) of online participants knew about the licensing requirement, as illustrated in Figure 4.

Fruit raiding, hunting, and consuming experience

A chi-squared test revealed a significant difference between in-person and online participants in reported fruit raiding experiences ($x^2(1) = 10.16$, $p = 0.01$), whereas no significant differences were observed for hunting ($x^2(1) = 0.03$, $p = 0.85$) or consumption ($x^2(1) = 0.70$, $p = 0.40$). Fruit raiding was the most commonly reported experience, with significantly more in-person participants (44%) encountering crop losses than online (24%). Hunting experience was slightly higher in in-person surveys (11%) compared to online (8%). Consumption experience was around 23% for in-person

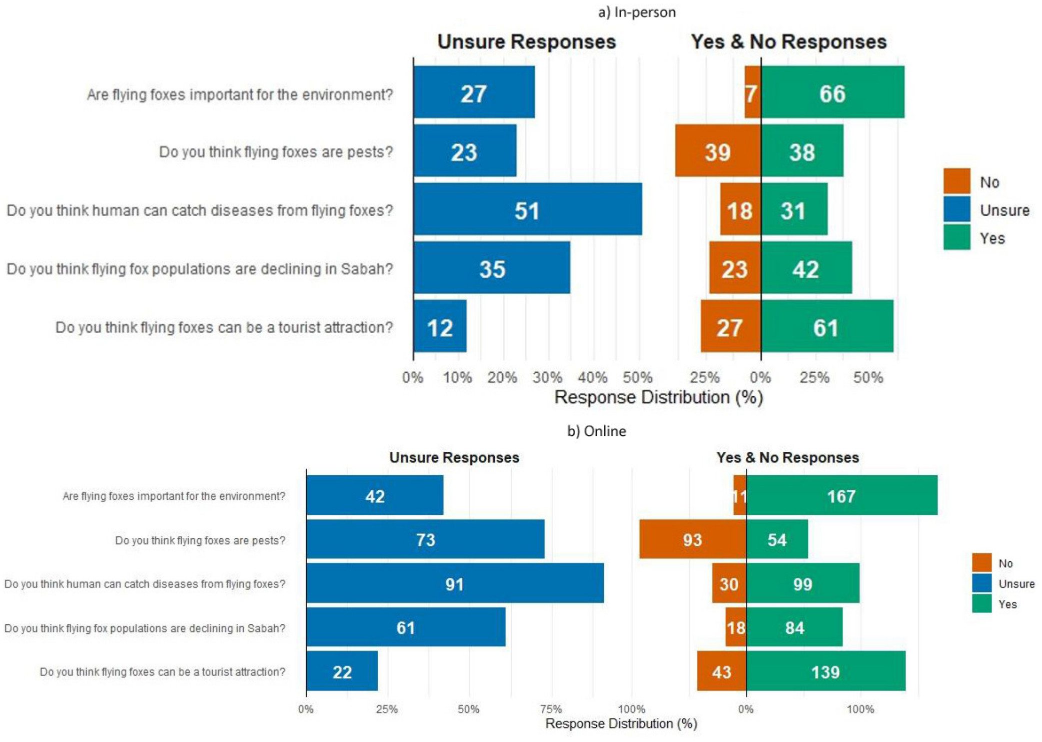

Figure 2. Participants' perceptions of flying foxes in Sabah are presented in Figure 2a (in-person) and Figure 2b (online), with responses categorised as "Yes", "Unsure", or "No".

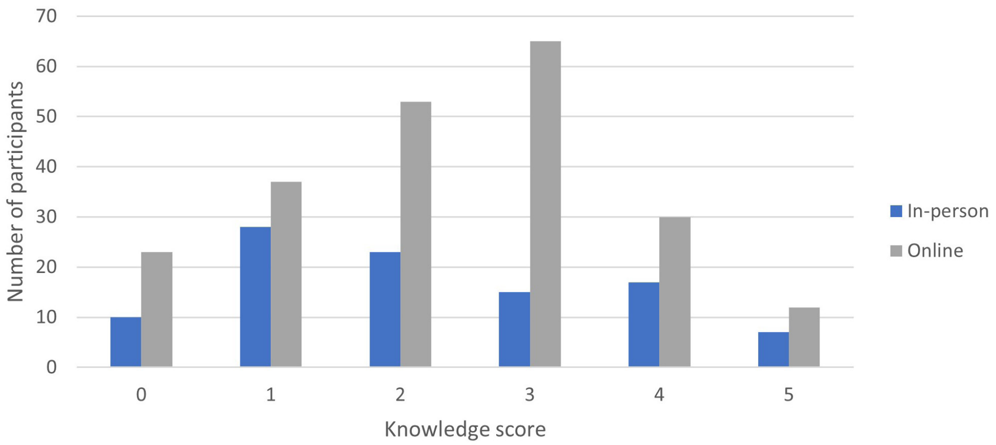

Figure 3. Summary of knowledge scores (from lowest score 0 to highest score 5) based on participant types, covering 100 in-person and 220 online participants in Sabah.

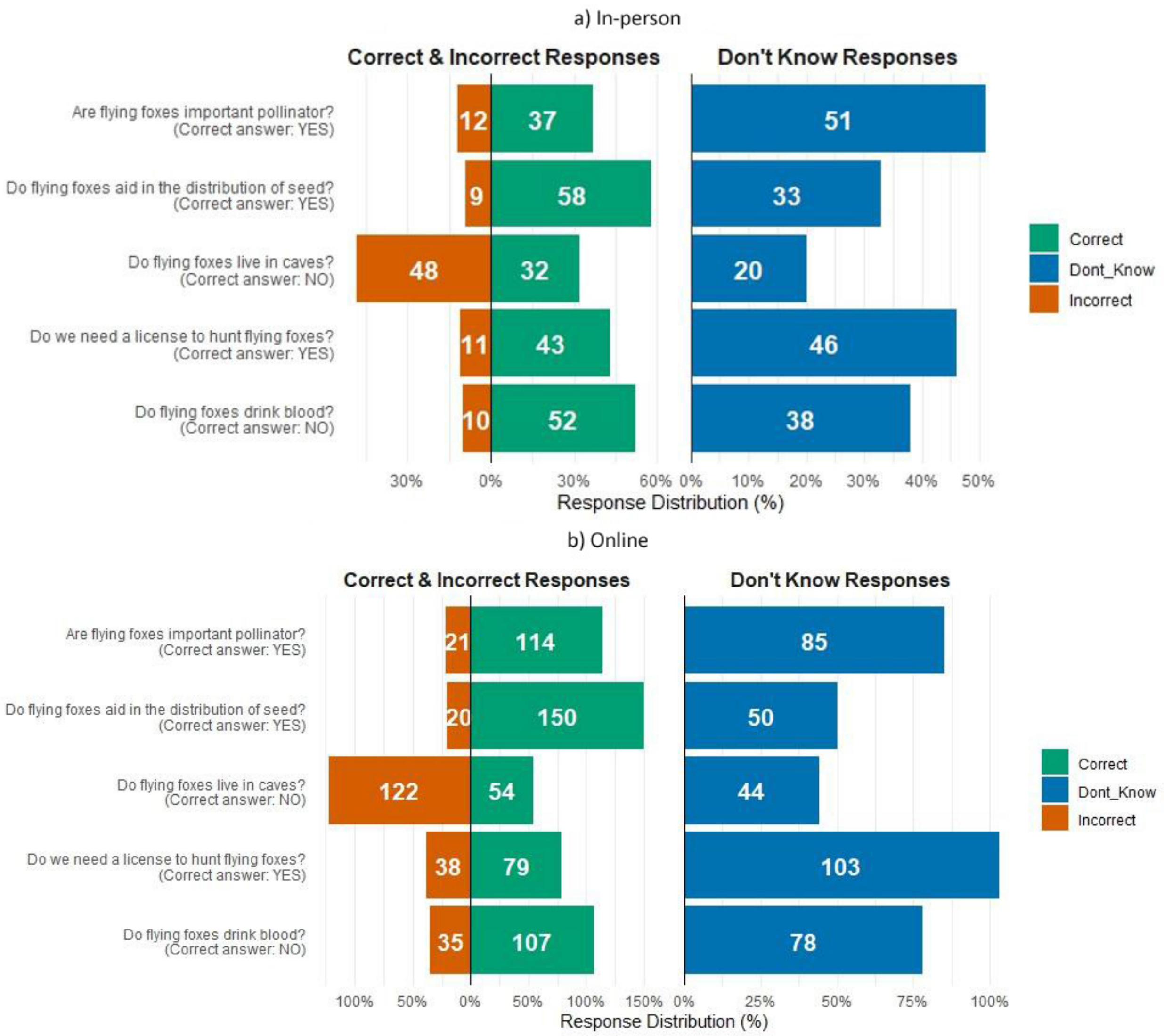

Figure 4. The knowledge of in-person (Figure 4a, n = 100) and online (Figure 4b, n = 220) participants toward flying foxes in Sabah is based on five questions grouped by "Yes", "Don't know", and "No".

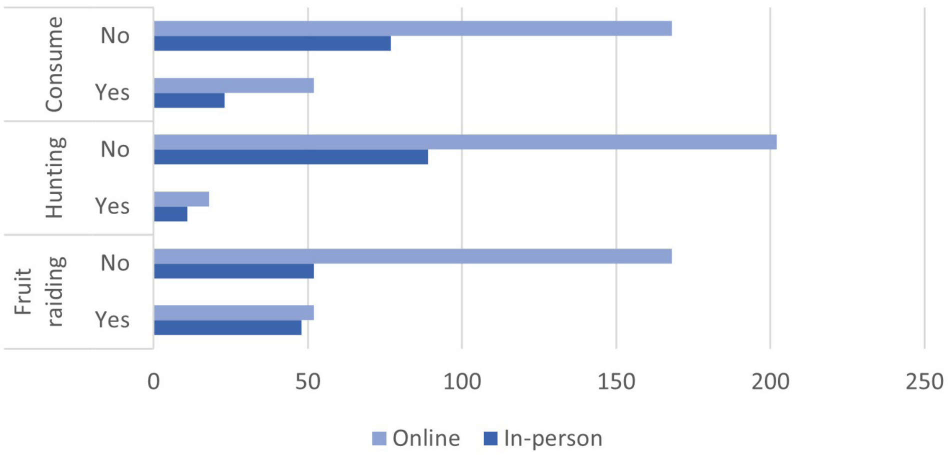

Figure 5. Proportion of in-person (n = 100) and online (n = 220) participants who reported direct experiences with flying foxes in Sabah, including fruit raiding (in-person, n = 48; online, n = 52), hunting (in-person, n = 11; online, n = 18), and consumption (in-person, n = 23; online, n = 52).

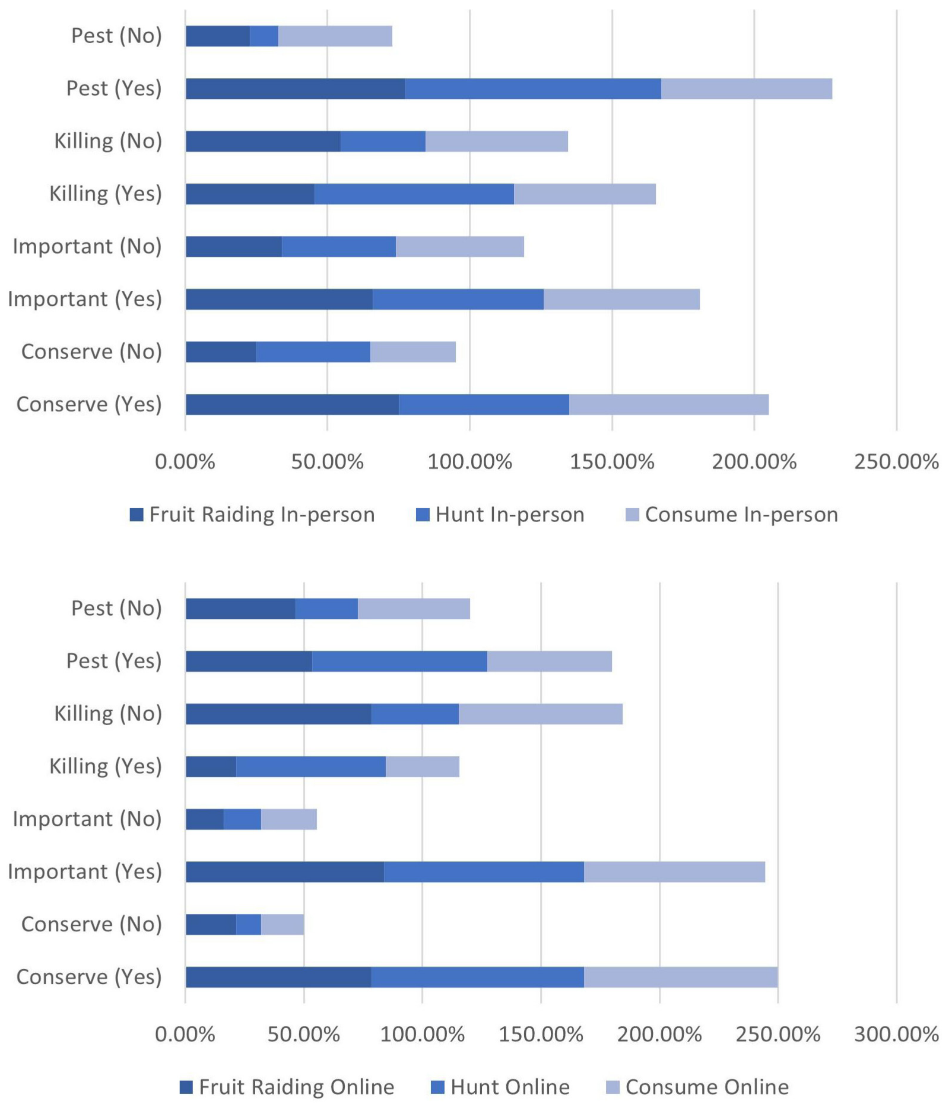

Figure 6. Proportion of participants experienced fruit raiding (in-person, n = 48; online, n = 52), hunting (in-person, n = 11; online, n = 18), consumption (in-person, n = 23; online, n = 52) with their attitudes (conservation and killing), and perceptions (important and pest).

Table 1. The comparison of the GLMM model is based on demographic, negative experience, and conservation-related variables.

Model		K	LL	AIC	BIC	dAICc	wAICc	R^2m
Model 1	Conserve ~ Age + Gender + Education + (1|Method)	3	396.50	362.60	411.30	55.04	~0	0.09
Model 2	M1 + Fruit raiding + Hunt + Consume + (1|Method)	6	-171	366.10	396.50	58.99	~0	0.11
Model 3	M2 + Knowledge score + Important + No Kill + (1|Method)	9	-133.80	305.60	377.20	0	1.00	0.39

Term abbreviations: k—number of parameters | LL—maximum log-likelihood | AIC—The Akaike Information Criterion | BIC—Bayesian Information Criterion | dAICc—difference in AICc for each model from the most parsimonious model | wAICc—AICc weight | R^2m—marginal R^2.

Table 2. Key predictors of conservation attitudes in the final generalised linear mixed model (Model 3).

Predictor	Odds ratio (OR)	95% CI (OR)	p-value
Knowledge score = 3	7.43	(2.33, 23.65)	<0.05
Knowledge score = 5	8.40	(0.85, 83.33)	<0.05
Importance perception	4.30	(2.11, 8.77)	<0.05
Opposition to killing	3.62	(1.90, 6.90)	<0.05

and online participants (see Figure 5).

In-person respondents (77%) were more likely to perceive fruit raiding as a pest problem than online respondents (54%). In-person respondents (45%) may have more direct conflicts with fruit raiding, leading to a higher acceptance of killing as a solution. Online respondents were less likely to associate fruit raiding with pest issues. There was high support for killing among hunters (In-Person: 70%, Online: 63%). For consumer participants, both in-person and online respondents lean more towards conservation rather than supporting killing (summarised in Figure 6).

Factors influencing the conservation attitude

The random effect for survey method (online vs. in-person) had near-zero variance across all models (Variance = 2.0766×10^{-17}, SD = 4.55×10^{-9}), indicating that survey mode did not meaningfully influence conservation attitudes. This suggests that responses were consistent across both survey formats. Given this result, including the survey method as a random effect does not improve model performance.

Model 3 had the lowest AIC (305.60) and highest log-likelihood (-133.80), indicating the best model fit (Table 1). Consequently, Model 3 was selected as the final model for predicting conservation attitudes. The final model revealed that age, gender, education level, and experiences with flying foxes (hunting, fruit raiding, consumption) were not significant predictors of conservation attitudes ($p > 0.05$ for all).

The final model (Model 3) identified knowledge level, importance perception, and opposition to killing as the strongest predictors of conservation attitudes (Table 2). All variables had Generalized Variance Inflation Factor, GVIF^(1/(2*Df)) values below 2 (Min: 1.05, Max: 1.20), indicating that multicollinearity was not a concern in the model (Fox & Monette 1992). Therefore, all predictors were retained in the final analysis. Higher knowledge levels significantly increase the likelihood of conservation support (OR = 7.43, $p < 0.05$). Perceiving flying foxes as ecologically important is a strong predictor of conservation attitudes (OR = 4.30, $p < 0.05$). Opposition to killing flying foxes significantly increases conservation support (OR = 3.62, $p < 0.05$). Knowledge Score 5 also exhibited a strong positive effect (OR = 8.40), though it was marginally significant ($p < 0.05$), suggesting that higher knowledge levels may play an increasing role in conservation attitudes.

DISCUSSIONS

Flying fox conservation attitudes and knowledge gaps among locals in Sabah

The findings reveal broad public support for flying fox conservation in Sabah, with 68–77% of respondents expressing favourable attitudes. This strong sentiment provides a valuable foundation for community-led initiatives, particularly when paired with education, and engagement strategies aligned with public values. Attitudes toward flying foxes vary across other regions in Malaysia; for instance, negative perceptions were more prevalent among orchard farmers on Tioman Island (Aziz et al. 2017a), while more favourable attitudes were documented in western Sarawak, where respondents recognised the species' ecological value, and eco-tourism potential (Mohd-Azlan et al. 2022a). Research indicates that positive attitudes, while not always directly translating into behaviour, are critical precursors to conservation action when supported by enabling factors such as incentives, emotions, and social norms

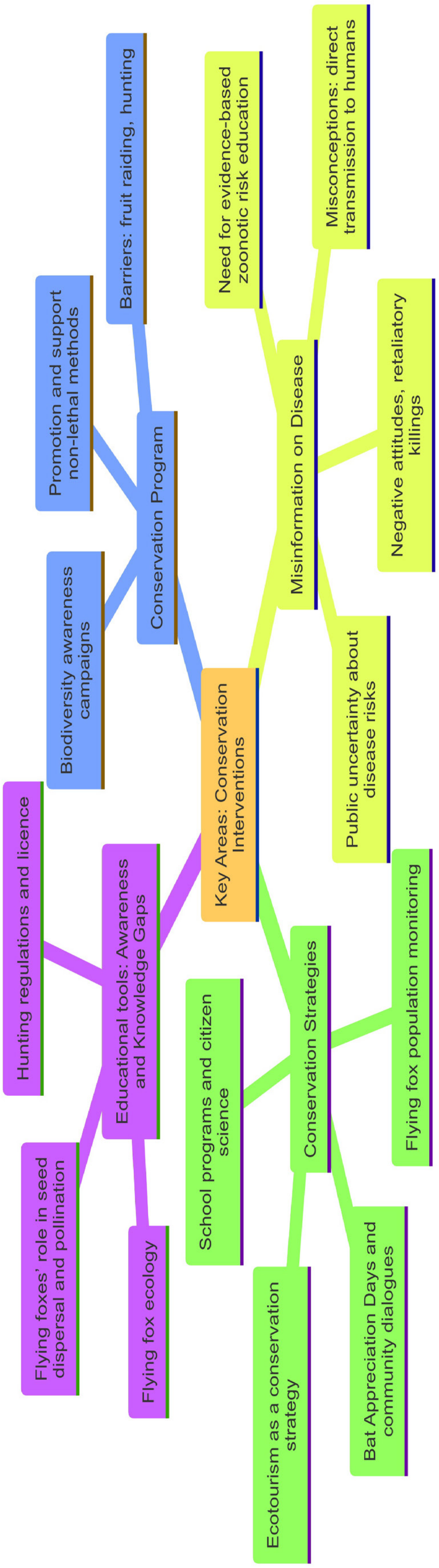

Figure 7. Summary of recommended intervention areas for flying fox conservation in Sabah.

(Bennett et al. 2019; Nguyen-Van et al. 2021; Vaske et al. 2021). Although the present study focused on attitudes rather than behaviours, the level of public goodwill suggests a promising readiness for outreach efforts aimed at fostering long-term conservation engagement.

Overall attitudes toward flying fox conservation were generally supportive, the study revealed notable gaps in ecological knowledge, with mean knowledge scores ranging from 2.8– 3.0 out of 5. The results revealed that many respondents were unaware of the species' roosting sites, diet, and protected status, with common misconceptions including beliefs that flying foxes inhabit caves or feed on blood. Nearly half of the respondents (46%) were also unaware of existing hunting regulations. Comparable trends have been documented in other regions of Malaysia and internationally. For example, Aziz et al. (2016) reported widespread misconceptions about pteropodid bats, commonly perceived as pests, while orchard farmers on Tioman Island demonstrated limited awareness of the species' ecological roles despite frequent encounters (Aziz et al. 2017a). In western Sarawak, Mohd-Azlan et al. (2022a) found that although 76% of respondents acknowledged the ecological importance of flying foxes, 47% still considered them pests and 52% regarded them as a food source. Similarly, on Japan's Ishigaki Island, respondents were familiar with flying foxes but remained unaware of their ecological significance (Vincenot et al. 2015). These findings underscore the variability of knowledge across different regions, influenced by species visibility, and local interactions, and highlight the critical need for context-specific, narrative-based education to improve conservation awareness and outcomes.

Factors affecting conservation attitudes among locals in Sabah

Model 3 showed that demographic factors (age, gender, education) and experiences (hunting, fruit raiding, consumption) were not significant predictors of conservation attitudes ($\Delta AICc > 10$, $R^2 < 11\%$). This non-significance is plausible when between-group variation, such as survey mode, is minimal or captured by fixed effects. In such cases, random effects with near-zero variance add little value and are often excluded to enhance model parsimony (Bates et al. 2015). This decision is supported by prior chi-square and t-tests, which found no significant differences in attitudes or knowledge between online and in-person participants.

In contrast to findings from a similar study where demographic factors such as age and occupation predicted conservation attitudes in Tioman Island (Aziz et al. 2017), current findings highlight that cognitive and moral variables, namely knowledge, perceived importance, and ethical opposition to killing, are more consistent, and stronger predictors of conservation-positive attitudes. This should be interpreted cautiously, as non-significant results may reflect limitations such as small sample size, variable design, or contextual factors specific to Sabah. Demographic effects may only become apparent through interactions with psychological or cultural variables, which are often stronger predictors of conservation attitudes than demographics alone (Schultz 2011; Kansky & Knight 2014; Wilbur et al. 2018; Bhatia et al. 2019; Clayton et al. 2021). Likewise, the weak predictive power of conflict-based experiences such as fruit raiding, indicates that personal encounters alone may not drive attitudes without mediation by prior knowledge, social norms, or media exposure (Dickman 2010; Slagle et al. 2013). This may also reflect the use of binary coding, which can mask variation, and reduce statistical power (MacCallum et al. 2002). Beyond these demographic and experiential factors, broader contextual factors including education, income, civic engagement, and participation in environmental activities have been shown to influence conservation attitudes (Oliveira et al. 2024). Future research should prioritise mixed-methods approaches to better capture the nuanced sociocultural, psychological, and contextual drivers of conservation attitudes beyond demographic, and experiential factors.

Knowledge emerged as the strongest predictor of conservation attitudes, with higher scores significantly associated with conservation-positive views. This association is consistent with findings in conservation psychology, where greater understanding of conservation issues is often correlated to stronger support for wildlife protection (Bennett et al. 2019). This insight can support flying fox conservation by highlighting that increased knowledge may lead people to tolerate negative experiences when they recognise the wildlife species' overall ecological benefits (Deshpande & Kelkar 2015; Hallwass et al. 2024). While knowledge is important, it may be insufficient on its own, especially in contexts shaped by utilitarian views or disease-related fears. Reid (2016) found that even knowledgeable individuals in Costa Rica expressed intentions to kill bats, influenced by fear, and cultural norms. This reinforces the view that knowledge must be complemented by value-based or emotionally resonant messaging to effectively shape conservation attitudes (Otto & Pensini 2017). This underscores the need for targeted, culturally resonant education efforts that combine factual information with ethical framing to correct misconceptions, and enhance conservation outcomes.

In addition to knowledge, moral variables such as perceived ecological importance and ethical opposition to killing also significantly predicted conservation attitudes in Sabah. Similar patterns were observed in western Sarawak, where communities recognised the ecological roles of flying foxes and their potential for eco-tourism, despite the absence of formally measured cognitive or moral predictors (Mohd-Azlan et al. 2022). Internationally, studies in Greece, and Vietnam similarly found that moral values (such as opposition to killing and recognition of species importance) had a greater influence on conservation attitudes than demographic factors (Liordos et al. 2017; Huong et al. 2024). These findings are consistent with the Value-Belief-Norm theory (Stern et al. 1999), which emphasises moral obligation as a central driver of pro-environmental behaviour, and reinforce critiques of demographic-based outreach. Consequently, conservation strategies are more effective when grounded in ethical responsibility and aligned with locally shared values (Kollmuss & Agyeman 2002), an approach that may be particularly relevant in the Sabah context.

Enhancing Flying Fox Conservation through Conservation Initiatives in Sabah

The current results indicate that local communities demonstrate substantial conservation support, influenced by knowledge and moral values, highlighting the need to engage them through targeted awareness campaigns, participatory initiatives, and policy interventions to sustain conservation outcomes. Effective strategies should prioritise public education, the dissemination of ecological knowledge, protection policy, and the promotion of non-lethal methods to mitigate human flying fox conflict. These approaches are fundamental to fostering sustainable coexistence between humans and flying fox populations. This aligns with the Sabah Biodiversity Conservation Strategy 2024–2034, which emphasises the importance of enhancing the capacities of all stakeholders, including local communities to manage, and conserve biodiversity effectively (Sabah Biodiversity Centre 2024). With this, the current study suggests some key areas for flying fox conservation initiatives in Sabah:

1. Educational tools: Conservation Awareness and Knowledge Gaps

Findings from the study indicate that baseline knowledge regarding flying foxes among participants was generally low. To address these challenges, it is essential to develop educational tools that are accessible and culturally appropriate for local communities. Such materials should aim to improve understanding of flying fox ecology, particularly their roles in seed dispersal, and pollination, while also clarifying existing hunting regulations, and licensing procedures. Enhancing public knowledge in these areas may contribute to stronger community support for conservation policies and practices.

2. Flying Fox Conservation Programme: Capitalise on Existing Positive Attitudes

Although several respondents reported fruit raiding by flying foxes, most expressed opposition to lethal control. This indicates that, despite human–wildlife conflict, there is a foundation of positive attitudes that can be harnessed to support conservation. Effective efforts should therefore address community concerns such as crop damage and hunting, through inclusive dialogue and participatory strategies. Public biodiversity awareness campaigns can further strengthen support, while the adoption of non-lethal crop protection methods, such as those demonstrated by Berthinussen et al. (2021), offers a practical solution that balances conservation objectives with local needs.

3. Misinformation on Disease Transmission and Public Perception

The findings also revealed substantial misinformation about disease transmission, with many participants believing flying foxes spread illnesses like COVID-19 or expressing uncertainty about zoonotic risks. Some respondents reported hunting or consuming flying foxes, practices linked to increased risk of zoonotic diseases such as the Nipah virus. Addressing these misconceptions is critical. Public communication strategies should aim to provide evidence-based information that distinguishes between actual and perceived risks associated with flying foxes. Emphasis should be placed on correcting inaccurate beliefs about direct transmission of diseases to humans, while simultaneously promoting a more informed and nuanced understanding of zoonotic pathways. Accurate risk communication may help to mitigate fear-based attitudes and reduce retaliatory behaviours that undermine conservation efforts.

4. Conservation Strategies and Community Involvement

The results indicate strong community interest in conservation, with many respondents supporting flying fox monitoring. Flying foxes were also widely viewed as potential tourist attractions, suggesting opportunities to align conservation with ecotourism, provided public health concerns are addressed. Conservation strategies should prioritise community involvement through school-based programmes, citizen science, and participatory initiatives to raise awareness, and encourage stewardship (Ballard et al. 2017). Events like Bat Appreciation Days can help shift public perceptions, while ecotourism offers a sustainable, incentive-driven model that supports both local livelihoods, and species protection.

Together, these pillars provide a framework for action. linking the study key findings to broader contributions in conservation science and policy. As shown in Figure 7, the colour coded fremaework illustrates coordinated multi-sectoral strategies: purple—educational tools and awareness building | blue—community conservation programmes | yellow—misinformation mitigation and risk communication| green—local community participatory initiativesand ecotourism opportunities.

Challenges and limitations

The study faced post-COVID-19 constraints, particularly movement restrictions and health concerns in 2021, which impacted in-person participation. Although surveys were conducted during Phase Four of the National Recovery Plan, privacy, and health worries remained a barrier. To maximise reach and sample diversity, a dual-mode strategy combining in-person interviews and online surveys was adopted. This approach is supported by methodological research showing that mixed formats improve demographic and behavioural representativeness (De Leeuw 2017; Rand et al. 2019; González & Revilla 2020). While online surveys tend to overrepresent younger or more conservation-aware individuals, in-person formats may suffer from interviewer effects, and social desirability bias (Bethlehem 2010). By leveraging the strengths of both, the study aimed to create a more balanced dataset.

Both in-person and online survey methods introduced distinct but complementary biases. Face-to-face surveys reached individuals with direct experience of flying foxes, as seen in higher reports of fruit-raiding; however, this did not translate to greater knowledge of flying foxes, suggesting that personal exposure does not necessarily improve conservation literacy. Online surveys offered broader demographic reach but were more prone to voluntary response bias, often attracting conservation-leaning participants. To minimise this, distribution included non-environmental channels. Importantly, conservation attitude scores were consistent across both methods, indicating that survey mode did not significantly affect responses. Nonetheless, some bias may remain, online anonymity may reduce social desirability bias, whereas in-person responses could be influenced by social expectations. Future research could apply indirect questioning techniques such as the Unmatched Count Technique (UCT) or Randomised Response Technique (RRT) to further minimise bias, though these require larger samples (Coutts & Jann 2011; Hinsley et al. 2019). Overall, the mixed-method approach enhanced representativeness and provided a more balanced perspective on human–flying fox interactions (Nissen et al. 2018).

Although this study focuses on Sabah, its findings may be applicable to other regions where flying foxes face similar threats. Key predictors (knowledge, perceived ecological importance, and ethical opposition to killing) can inform conservation strategies elsewhere. Adaptation to local contexts, including cultural beliefs and legal frameworks, is essential. Future studies can test these predictors in other regions to support broader, community-based conservation efforts.

CONCLUSION

This study examined conservation attitudes, flying fox knowledge, and the key factors influencing public support for flying fox conservation in Sabah. The findings demonstrate a strong foundation of public support, but also reveal significant knowledge gaps and persistent misconceptions. Importantly, positive conservation attitudes were closely linked to flying fox knowledge, and ethical norms, while demographic, and experiential variables played a comparatively minor role.

Key contributions of the study include:

1. A novel framework—four actionable pillars tailored to Sabah: targeted education, enhanced conservation programmes, disease misinformation mitigation, and locally driven participatory strategies to address critical gaps in current efforts.

2. Theoretical insight—confirmation that conservation attitudes are primarily shaped by ethical and ecological considerations, consistent with global literature but newly contextualised for flying foxes in Southeast Asia.

3. Policy relevance—direct alignment with the Sabah Biodiversity Strategy 2024–2034, offering practical guidance for strengthening stakeholder capacities, and fostering inclusive biodiversity management.

By integrating scientific evidence with community perspectives, this study offers a replicable model for advancing conservation outcomes, and promoting coexistence with ecologically important yet vulnerable species.

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Abstract vernacular: Keluang (*Pteropus* spp.) merupakan agen pendebungaan dan penyebar biji benih yang penting dalam ekosistem tropika, namun lebih separuh daripada spesies ini diancam kepupusan, menjadikan pemuliharaan mereka sebagai keutamaan global. Di Sabah, Malaysia, pemahaman terhadap sikap komuniti tempatan terhadap kelawar buah amat penting bagi merangka strategi pemuliharaan yang berkesan. Kajian ini menggunakan tinjauan soal selidik kendiri yang disasarkan kepada komuniti Sabah (n = 320; 100 bersemuka, 220 atas talian merentasi pelbagai daerah di Sabah) bagi menilai sikap pemuliharaan, jurang pengetahuan, dan faktor yang mempengaruhi sikap tersebut. Ujian statistik menunjukkan anggaran 70% responden Sabah (68% bersemuka; 77% atas talian) mempunyai sikap positif terhadap pemuliharaan keluang, sekali gus menyediakan asas kukuh untuk memperluaskan usaha pemuliharaan berasaskan komuniti, walaupun lebih separuh masih mempunyai kefahaman ekologi yang terhad atau salah tanggapan tentang keluang. Generalised linear mixed models (GLMM) mengenal pasti tahap pengetahuan (OR = 7.43, $p < 0.05$), pengiktirafan kepentingan ekologi (OR = 4.30, $p < 0.05$), dan penentangan beretika terhadap pembunuhan keluang (OR = 3.62, $p < 0.05$) sebagai peramal paling kuat kepada sokongan pemuliharaan keluang. Faktor sosio-demografi mahupun pengalaman konflik tidak menunjukkan pengaruh yang signifikan terhadap sikap pemuliharaan. Dapatan ini menekankan keperluan bagi pendidikan berfokus dan penglibatan komuniti untuk meningkatkan pengetahuan dan memperbaiki salah tanggapan, meningkatkan kesedaran tentang perlindungan undang-undang terhadap keluang, seperti keperluan permit memburu, serta usaha proaktif untuk menangani maklumat tidak sahih mengenai risiko penularan zoonosis daripada keluang. Pembangunan instrumen pendidikan, program jangkauan komuniti, dan strategi mitigasi konflik tanpa pembunuhan perlu diberikan keutamaan sebagai titik intervensi utama untuk mempromosikan pemuliharaan keluang. Langkah-langkah ini, walaupun berasaskan konteks Sabah, boleh dijadikan panduan untuk memperkukuh usaha pemuliharaan keluang dalam konteks komuniti lain di tempat lain.

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Supplementary Material 1. Questionnaire Sample

SECTION A: SOCIO-DEMOGRAPHY

Residential: ____

Age:

- 18 – 29 years old
- 30 – 39 years old
- 40 – 49 years old
- 50 years old and above

Sex:

- Male
- female

Ethnic:

- Kadazandusun
- Rungus
- Bajau
- Cina
- Melayu
- Sungai
- Others (State): ____________

Highest education level:

- SRP/PMR/PT3
- SPM
- STPM/Diploma/Certificate
- Bachelor Degree
- Master/ PhD

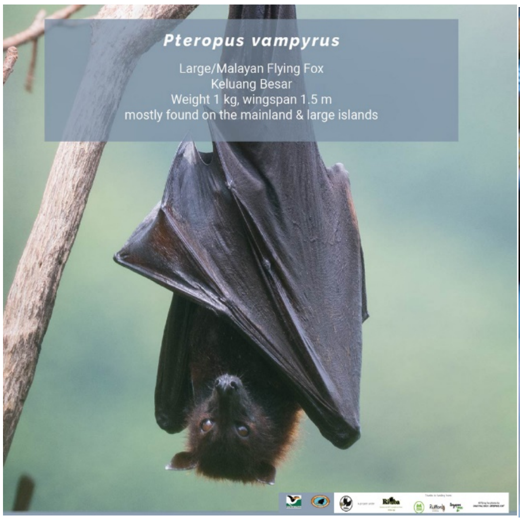
Occupation:

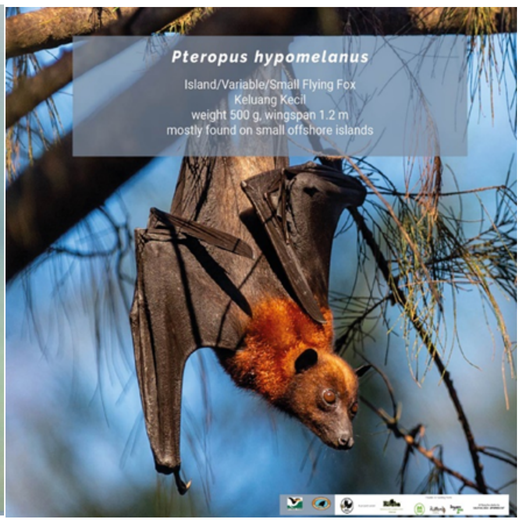
- Own (State): ____
- Government servant (State): ____
- Private (State): ____
- Others (State): ____

Gross Income:

- RM500- RM1000
- RM1001-RM2000
- RM2001-RM3000
- >RM3000

Please refer to the following figure:





1. These are flying foxes. Can you differentiate them from other animals, especially small bats and birds?

Yes / No

SECTION B: EXPERIENCE

2a. Do you experience flying fox raiding your fruiting trees?

Yes / No

2b. List the name of your fruiting trees affected by the flying fox fruit raiding.

____

2c. Where is/are district/s that you experience this fruit raiding by flying fox?

____
____

3a. Based on your experience, have you hunt flying foxes?

Yes / No

3b. What is/are the reason/s of hunting flying foxes?

____
____

3c. Where do you usually hunt flying foxes? (For example: forest, mangrove)

____

3d. What do you use for flying fox hunting?

____

4a. Do you consume flying foxes? (if the answer is No, skip the remaining questions and go to part 3)
Yes / No
4b. What is/are the reason/s of consuming flying foxes?
____
____
4c. What is the frequency of you consuming the flying foxes?

Often: A few times in a year

Frequent: Subject to availability/once a year

Sometimes: Once in several years

Rare: Last ten years ago

SECTION C: KNOWLEDGE, ATTITUDE & PERCEPTION

**Additional Note: Local names for flying foxes are *gawir* or *mengkawot*. Respondents need to identify the flying fox pictures before answering the questioners.

C1: KNOWLEDGE

No	Item	No (0)	Don't know (0)	Yes (1)
1	Are flying foxes important pollinators?			
2	Do flying foxes aid in the distribution of seed?			
3	Do flying foxes live in caves?			
4	Do license is required to hunt flying foxes?			
5	Do flying foxes drink blood?			

C2: ATTITUDE

No	Item	No (0)	Unsure	Yes (1)
6	Are flying foxes should be conserved?			
7	Would it be good if flying foxes go extinct?			
8	Do you think flying foxes are scary creature?			
9	Should flying fox be killed?			
10	Could flying fox cause COVID-19?			

C3: PERCEPTION

No	Item	No (0)	Unsure	Yes (1)
11	Are flying foxes important for the environment?			
12	Do you think flying foxes are pests?			
13	Do you think human can catch diseases from flying foxes?			
14	Do you think flying fox populations are declining?			
15	Do you think flying foxes can be tourist attractions?			

Supplementary Material 2. R scripts for GLMM.

```
library(openxlsx)
library(dplyr)
library(tableone)
library(lme4)
library(MuMIn)
library(performance)
setwd("C:/Users/USER/data objective 3")
datreg <- read.xlsx("regall.xlsx")
nrow(datreg)
datreg$Age <- as.factor(datreg$Age)
datreg$Gender <- as.factor(datreg$Gender)
datreg$Education <- as.factor(datreg$Education)
datreg$Knowledge.Score <- as.factor(datreg$Knowledge.Score)
datreg$Highest.monthly.income <- as.factor(datreg$Highest.monthly.income)
datreg$Fruit.raiding <- as.factor(datreg$Fruit.raiding)
datreg$Hunt <- as.factor(datreg$Hunt)
datreg$Consume <- as.factor(datreg$Consume)
datreg$Important <- as.factor(datreg$Important)
datreg$Kill <- as.factor(datreg$NoKill)
datreg$Conserve <- as.factor(datreg$Conserve)

model1a <- glmer(Conserve ~ Age + Gender + Education + (1 | Method),family = binomial, data = datreg)
summary(model1)
model1b <- glmer(Conserve ~ Age + Gender + Education + Hunt + Fruit.raiding + Consume + (1 | Method),family = binomial,
data = datreg)
summary(model2)
model1c <- glmer(Conserve ~ Age + Gender + Education + Hunt + Fruit.raiding + Consume + Knowledge.Score + Important +
NoKill + (1 | Method),family = binomial, data = datreg)
summary(model3)

AICc(model1)
AICc(model2)
AICc(model3)
# Compute AICc
aicc_values <- c(AICc(modela), AICc(model1b), AICc(model1c))
min_aicc <- min(aicc_values)
dAICc <- aicc_values - min_aicc
dAICc
# Compute wAICc
wAICc <- exp(-0.5 * dAICc) / sum(exp(-0.5 * dAICc))
wAICc
#compute R²m
r.squaredGLMM(model1)[1]
r.squaredGLMM(model2)[1]
r.squaredGLMM(model3)[1]
#multicollinearity check among covariates
library (car)
vif_values <- vif(model1c)
```

Supplementary Material 3. Summary of association between demographic variables and conservation attitude.

Demographic Variable	Group	Pearson χ^2 (df)	p-value	Cramér's V
Education	Online	15.75 (2)	0.0004	0.268
Income	Online	3.84 (4)	0.427	0.132
Ethnicity	Online	13.64 (13)	0.400	0.249
Residential Area	Online	18.69 (18)	0.411	0.291
Occupation	Online	5.25 (6)	0.512	0.154
Gender	Online	1.08 (1)	0.299	0.070
Age	Online	7.99 (4)	0.052	0.191
Gender	In-person	2.89 (1)	0.039	0.170
Age	In-person	3.55 (4)	0.471	0.188
Education	In-person	0.58 (2)	0.750	0.076
Income	In-person	4.79 (3)	0.188	0.219
Ethnicity	In-person	16.23 (8)	0.089	0.403
Residential Area	In-person	7.57 (8)	0.477	0.275
Occupation	In-person	11.85 (6)	0.065	0.344

Supplementary Material 4. Demographic characteristics of in-person and online participants.

	Category	In-person (n)	Online (n)	n (%)
Gender	Male	53	111	164 (51)
	Female	47	109	156 (49)
Age	<24 years old	18	29	47 (14.7)
	25-34 years old	11	36	47 (14.7)
	35-44 years old	16	54	70 (21.9)
	45-54 years old	31	53	80 (26.2)
	>55 years old	24	48	72 (22.5)
Highest education level	No formal/ Primary education	25	21	46 (14.4)
	Secondary education	62	100	162 (50.6)
	Tertiary education	13	99	112 (35)
Highest Monthly Income	<RM500	0	23	23 (17)
	RM500-RM1000	15	69	84 (26.2)
	RM1001-RM2000	20	30	50 (15.6)
	RM2001-RM3000	1	32	33 (10.3)
	>RM3000	64	66	130 (40.6)
Occupation	Students	9	23	32 (10)
	Self-employed	43	61	104 (32.5)
	Private sectors	13	35	48 (15)
	Government servants	26	76	102 (31.9)
	Pensioners	1	10	11 (3.4)
	Non-employed	8	15	23 (6.8)
Ethnicity	Kadazandusun	52	162	214 (66.7)
	Sungai	35	3	38 (11.9)
	Bajau	3	24	27 (8.4)
	Others	10	131	141 (43.9)
Current residential area	West Coast Division	25	91	116 (36.3)
	Interior Division	22	91	113 (35.3)
	Kudat Division	1	23	24 (7.5)
	Sandakan Division	52	10	62 (19.4)
	Tawau Division	0	5	5 (1.6)

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