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Q-methodology to understand stakeholder discourses on bat conservation and management in view of the COVID-19 pandemic

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Human-bat interactions are becoming more frequent with growing proximity between people and wildlife. As such, it is important to understand the perspectives of human stakeholders in these interactions, especially considering how media coverage of bats' potential roles as the reservoirs of the ancestral virus to SARS-Cov2 has exacerbated negative perceptions of bats. We used Q-methodology to describe diverse viewpoints on bat conservation and management and identify areas of consensus among stakeholders in Singapore. We derived perspectives, problems, and priorities for bat conservation and management based on qualitative and quantitative analyses. The results reveal three distinct discourses. The ecocentric viewpoint advocates conserving bats for their intrinsic value. The anthropocentric viewpoint outright rejects the idea of conserving bats because of the perceived public-health threat that bats pose. The third discourse prioritizes educating citizens and enhancing general appreciation for biodiversity. All stakeholders agree on the need to reconsider COVID-19-related concerns about bats and address misconceptions that could hinder conservation. The top recommendation by stakeholders is to assess and improve bat-related attitudes and beliefs so that citizens become more supportive of conserving bats for their inherent value and roles in maintaining Singapore's ecosystems. Considering both diverging and consensus viewpoints and engaging various stakeholders in conservation and management decisions can yield both attitudinal change and more effective solutions while meeting the ecological and social needs of conservation.

KEYWORDS

consensus, inclusive conservation, Q methodology, quantitative, qualitative Singapore, viewpoints

1 Introduction

Bats are critical to ecosystems because they sustain important ecological functions and provide multiple ecosystem services (ES) such as pollination and consumption of pest insects (Russo et al., 2022). However, they exhibit a high rate of endangerment, with the main conservation threats being forest loss, agricultural expansion, overharvesting, disturbance, and urbanization (Frick et al., 2020). Bats are further threatened by largely erroneous perceptions about their role in emerging infectious diseases – a phenomenon that undermines support for bat conservation, as recently observed in relation to the COVID-19 pandemic (Rocha et al. 2021; Shapiro et al., 2021). A misunderstanding of bats' role in emergence of SARS-CoV2, the causative agent of COVID-19 has strengthened negative attitudes towards bats, an issue likely exacerbated by misinterpretations of scientific evidence by the media and that may significantly threaten bats (Lu et al., 2021). Negative perceptions of people interacting with bats in some manner in their daily lives are especially important to address given that the conservation of a less charismatic species is at stake.

Conservation and management approaches must increasingly consider not only biophysical factors, such as habitat preservation, but also non-biophysical factors, such as human attitudes and perceptions, and stakeholder values and viewpoints (e.g., Chan et al., 2007; Vande Velde et al., 2019). This is especially pertinent for bat conservation in the Anthropocene, when humanity must urgently consider social aspects to ultimately change human behaviors towards bats (Straka et al., 2021). Additionally, social acceptability (e.g., willingness of residents to cooperate) is an important determinant of the sustainability and effectiveness of conservation and management approaches (Redman et al., 2004), especially since the COVID-19 pandemic. Indeed, limiting the propagation of negative bat-related attitudes and behaviors requires all human stakeholders (e.g., virologists, public-health officials, conservation scientists and practitioners) to collaborate on framing messages about bat-associated disease (MacFarlane and Rocha, 2020). Overall, effective biodiversity conservation and management hinges on integrating ecological science and planning practice and, in turn, improving communication among all relevant stakeholders (Gagné et al., 2020).

Quantitative surveys are useful for identifying the prevalence of different views on an issue and analyzing large samples, and are relatively easy to respond to, but they can also limit the type of participant responses (Eyvindson et al., 2015). In contrast, qualitative methods, which let participants respond more freely, are more suited to elucidating deeper social phenomena such as the genesis of attitudes and behaviors (Bennett et al., 2017). Combining both quantitative and qualitative techniques can paint a more holistic picture of human subjectivity. One

methodology that does this is Q Methodology (QM), which is increasingly applied to biodiversity conservation and management in various contexts (e.g., Vaas et al., 2019; Vande Velde et al., 2019; Arumugam et al., 2021; Bavin et al., 2020).

People are more likely to comply with conservation and management decisions that they find palatable. Identifying palatable decisions requires some consideration and understanding of the perspectives of affected people, in all their subjective complexity. We set out to understand stakeholder perspectives on the conservation and management of bats in Singapore, in the wake of the COVID-19 pandemic. Singapore has undergone extreme deforestation, urbanization and land-use conversion in pursuit of the economic prosperity it now enjoys, but at the expense of biodiversity (Davison et al., 2012). With the government pushing for a “biophilic city” as part of its nature conservation masterplan, residents are made to live near wildlife and must co-exist with the biodiversity around them to bring about a more sustainable and livable city (Er & Chan, 2016). It is therefore vital that this study considers a wide range of contextually relevant, socially and empirically informed values and viewpoints on bat conservation. Ultimately, we seek to integrate multiple approaches and conservation values in the framework of a means-ends objective network (MEON) to propose objectives and directional actions for bat conservation and management practitioners (Marttunen et al., 2017). A MEON is a problem structuring method that can facilitate the identification and structuring of shared objectives (e.g., Vande Velde et al., 2019; Marttunen et al., 2017). It distinguishes among four types of objectives: (1) fundamental objectives are the endpoints that define the basis for bat conservation and management; (2) means objectives are the actions needed to achieve fundamental objectives; (3) process objectives concern the decision-making process; and (4) strategic objectives are influenced by all decisions made over time (Marttunen et al., 2017). By highlighting how the four types of objectives relate to each other, a MEON can reveal the way to attain the fundamental objectives. Thus, prioritized shared objectives can be highlighted to inform and increase the palatability and overall effectiveness of bat conservation and management decisions.

Specifically, we demonstrate the use of QM to 1) identify and describe stakeholder discourses (i.e., values and viewpoints) related to bat conservation and management in Singapore and, 2) recommend approaches that make sense in the wake of COVID-19 on the basis of consensus among stakeholder discourses.

2 Methods

2.1 Study area

Singapore is a tropical city-state with a land area of 728.3 km² (Singstat, 2022; Figure 1) and a fully urbanized population

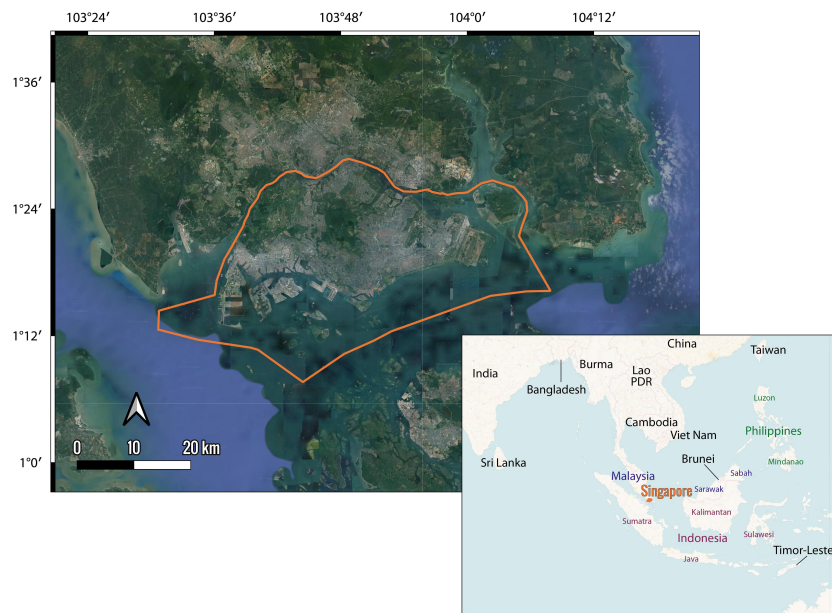


FIGURE 1

Study area. We worked in the Republic of Singapore, whose national boundaries (land and sea area) are in orange on the larger, satellite-view, map. The smaller map shows Singapore's location in Asia (orange marker, black-outlined orange font). Larger plain fonts denote other country names, with distinct colours for archipelago nations (their major islands in smaller font). We built this map in QGIS 3.14 (QGIS Geographic Information System, QGIS Association, <http://www.qgis.org>), with the base layer for the smaller map from Carto (https://a.basemaps.cartocdn.com/rastertiles/voyager_nolabels/{z}/{x}/{y}@2x.png).

of 5.45 million (Singstat, 2021). Extensive habitat loss due to historical land-use change caused bat diversity to decline by 33% to 72% (Lane et al., 2006), and the nation now has between 20 and 25 bat species (Simmons, 2005; Lane et al., 2006). Ongoing and intensified urbanization has resulted in significant forest loss (Lum and Kang Min, 2021) and consequently, increasing human-wildlife conflicts (Ngo et al., 2019). Despite its highly urbanized landscape, Singapore retains a high green cover of 46% (Gaw et al., 2019), including vegetation in four Nature reserves, more than 350 parks and in its streetscapes (Nparks, 2021a; Nparks, 2021b).

2.2 Q methodology

We used QM to identify and describe discourses about the conservation and management of bats in Singapore in view of COVID-19. Q method combines qualitative and quantitative techniques to explore and analyze subjective perspectives and shared values surrounding an issue (Zabala et al., 2018). One unique feature of Q methodology is that it works with small sample sizes because the goal is to describe a population of viewpoints on an issue, as opposed to how many people express a given viewpoint (Zabala et al., 2018). A QM study has four stages (Zabala et al., 2018):

1. **Research design** – Researchers define an issue and prepare a concourse by selecting representative Q-statements for the Q-sort.
2. **Data collection** – Participants rank statements according to how much they agree with each statement.
3. **Analysis** – Researchers apply multivariate data-reduction techniques to analyze the placement of the Q statements by looking for relationships between rankings that illustrate shared views or subjectivities.
4. **Interpretation** – Based on their analyses, researchers generate descriptives or narratives that represent the set of perspectives surrounding an issue.

Our Q-method study was reviewed and approved by the ethical board of the National University of Singapore (NUS-IRB reference code S-20-142E) and respondents gave informed consent.

2.3 Q participants – formation of P-set

To prepare for a QM study, the participants who will rank the Q-sort statements are selected to represent the P-set (i.e., group of participants in the Q-sort process; Zabala et al., 2018). To recruit a purposive sample of participants whose perspectives

we expected to be diverse or especially strong, we tapped into our local networks and mapped online profiles (i.e., snowball and purposive sampling). In total, 30 participants from eight sectors: research (n=7), tourism and cultural heritage (n=6), NGO (n=5), unemployed/self-employed (n=4), government (n=3), education (n=2), environmental consultancy (n=2) and pest management (n=1) constituted the P-set (Table S3).

2.4 Q statements – formation of Q-set

In Q method, researchers form a so-called Q-set (i.e., the set of Q-sort statements that will be used for the Q-sort). We first prepared a concourse – a population of statements representing the broad range of viewpoints – using information from three types of sources: 1) interviews conducted with six members of the P-set; 2) online social-media and newspaper articles and readers' comments; 3) the scholarly literature, which we searched using these key words (in both singular and plural forms): “bats”, “conservation”, “management”, “human-wildlife conflict”, “public health”, “beliefs”, “perceptions”, “threats”, “risk”, “pandemic”, “COVID-19” and “Southeast Asia”. We randomly obtained one participant from six of the eight sectors (representatives from the pest management and education sectors were not available) for the interviews (mentioned above) as part of the process of forming the Q-set. The concourse contained a total of 80 statements that we closely scrutinized for conflicting or contrasting interpretations, duplications, and ambiguity; we omitted such statements from the eventual Q-set (Watts and Stenner, 2012). The final Q-set contained 50 statements that we thematically identified and categorized (Table S1). We conducted a pilot test using these 50 statements with five specialists in local wildlife conservation and management who were not part of the P-set, and modified the statements based on their suggestions.

2.5 Q sorting

From 19 April to 28 May 2021, we conducted the Q-sort interviews over Zoom and using an online Q-method software (Lutfallah and Buchanan, 2019), as follows. First, we asked each P-set participant to sort the 50 statements into three groups: 1) agree; 2) disagree; 3) no opinion/undecided/neutral. Next, we asked them to place statements on a pyramid – essentially, a “quasi-normal” distribution – in a way that reflected their opinions on a scale from strongly disagree (= - 4) to strongly agree (= + 4; Zabala et al., 2018; Figure S1). Finally, in a post-sorting interview, we invited participants to elaborate on how they placed statements, notably the salient ones (i.e., at the two extreme ends), and to raise any points or issues they felt were lacking in the Q-set. The post-sorting interview promotes flexibility and a deeper, qualitative understanding of

participant responses, thereby complementing the quantitative sorting of statements that provides structure to the interview and data analysis (Mukherjee et al., 2018).

2.6 Factor analysis

After calculating a Pearson correlation coefficient matrix to compare similarities between pairs of Q-sorts, we used principal component analysis (PCA) to group participants (fixed variables) based on the calculated matrix of association between Q-sorts (dependent variables). Grouping similar sorts of similar views reduces the number of discourses, so that participants who sort similarly are grouped in the same factor or component by PCA. We used a combination of Humphrey's rule of extraction, Kaiser-Guttman criterion and visualization of the scree plot of eigenvalues to determine how many factors to extract, and varimax rotation to rotate the matrix to ensure maximum variation within each group (Zabala et al., 2018). We eventually extracted eight factors, then rotated and retained three based on the criteria mentioned, while ensuring at least two significant loading Q-sorts per factor ($P < 0.01$, significant factor loading threshold value = $2.58 \times (1/\sqrt{\text{no. of items in Q-set}}) = 0.37$; see also Balch and Brown, 1982). Factor loadings represent the extent to which each Q-sort is associated with each retained factor, so Q-sorts that load significantly on a given factor (i.e., factor exemplars) share a closely related sorting pattern. We used “QMethod” online software (Lutfallah and Buchanan, 2019; <https://qmethodsoftware.com>) to conduct all analyses.

2.7 Factor interpretation

We combined factor exemplars to form composite Q-sorts, or factor arrays, to represent each rotated factor. We then described the discourses by interpreting each statement's factor array and z-score (i.e., weighted average of statement ranks by participants grouped within a factor), including an analysis of the post-sorting interviews. We also considered the placement of salient statements and the statements that could be considered consensus (do not distinguish any pairs of factors) and distinguishing (significantly different) between factor arrays to develop the discourse narratives.

3 Results

A total of 30 participants were included in the Q-sort from eight stakeholder groups (Table S3). The three factors extracted each represented a stakeholder discourse (factor interpretations) and collectively explained 57% of the total variance. This is well above the range of expected variance (35 – 40%) suggested by

Watts and Stenner (2012). Below, we describe each discourse according to three main themes: (1) the perspective (general view on bat conservation); (2) the problem (main issues identified); and (3) the priorities (actions to take), with the aim to elucidate these encompassed viewpoints. We have bracketed Q statements and associated ranks such that, for example, (S1: +2) represents statement 1, rank +2 (Table 1).

3.1 Areas of disagreement among discourses

Discourse 1 – Do we need a reason to conserve bats?

Interpreted from factor 1, D1 explains 45% of the variance (Eigenvalue = 13.5). Discourse 1 had the most participants (18 of 30) from multiple stakeholder groups (six of eight) loading onto this factor.

Perspective – Discourse 1 exemplars hold ecocentric viewpoints. Bats should be conserved primarily for their intrinsic worth (S7: +4; S5: +3; S9: +3), and bat conservation is an ethical duty rather than a means to maintain ES.

Problem – Discourse 1 reflects a neutral, non-critical view of local media in its negative influence on people's perceptions of bats (S50: 0; S14: 0). In referring to COVID-19 and bats, one participant explained that “the local media does an impeccable job in informing the public with factual rather than sensational pieces”. Another remarked that the “well-educated Singaporean society live (*sic*) in a city with one of the largest green covers (*sic*)”, so residents are generally “well-accustomed to Nature”. Discourse 1 exemplars are therefore not convinced that negative public perceptions are the biggest conservation threat to bats (S14:0; S50: 0; S27: 0; S10: -1), saying that Singaporeans are “less likely (*sic* than other nationalities) to get carried away” with myths and misinformation. Rather, the biggest threats are extensive habitat loss (S42: +2) and a lack of emphasis on bats in environmental impact assessments (EIAs; S18: +3).

Priorities – Although D1 exemplars deem bat-mediated ES as unique, important, and irreplaceable (S29: +3; S2: -4), they are not convinced that bat conservation and management should prioritize quantifying and valuating these services (S44: 0). They highlight the need to better integrate urban and Nature spaces so residents can co-exist peacefully with wildlife (S4: +2; S45: +2; S38: -2). They stress the importance of protecting remnant forest patches to prevent further habitat loss and agree that doing so should accompany equally important governmental greening efforts (S39: 0). All while acknowledging the need for more coordinated conservation and management by stakeholders (S16: +1), D1 exemplars say the government should remain the most important decision-maker (S48: +1).

Discourse 2 – Why would we even consider conserving bats?

Discourse 2, interpreted from factor 2, explains 7% of the variance (Eigenvalue = 2.23) with four participants from two stakeholder groups loading on this factor.

Perspective – Discourse 2 stands out in its outright rejection of bat conservation. This anthropocentric view prioritizes public health and safety over ES by bats (S23: +3; S26: +4). Bats should not be conserved for their ES because “these services are replaceable by less dangerous and more charismatic biodiversity groups such as birds” (S1: +2; S2: +2; S29: -2; S44: -2). Post-sorting interviews clarified that despite a generally negative view of bat conservation, D2 exemplars appreciate local biodiversity as part of Singapore's “City in Nature” concept (see also, e.g., Koh et al., 2022) but “prefer not to conflict with them (*sic* referring to biodiversity) so long as they rest (*sic*) in Nature and refrain from entering urban habitation”.

Problem – Discourse 2 exemplars disapprove of the presence of bats in human dwellings (S26: +4; S15: +3; S4: -2) for two main reasons. One, the perceived health risk (S26: +4; S23: +3), e.g., “television programs and online articles have reported bats carrying pathogens transmissible to humans” and the consequent belief that bats “pose a real danger”. As such, they agree that the media strongly influences negative perceptions (S14: +1; S50: +2). Two, their dissatisfaction with bats entering and roosting in houses and feeding on fruit trees, and the lack of effective solutions by relevant agencies (S43: -4; S47: -4). One participant said: “hotlines are ineffective as they are mostly unanswered”, and while the general advice is to not bother bats, “they still fly into my house and feed on fruits, and sometimes fly too close to my face”. Discourse 2 supporters also emphasize the lack of cooperation among stakeholders (S16: +3), elaborating that “different agencies (e.g., Animal Concerns Research and Education Society (ACRES), National Parks Board (NParks), pest management companies) provide different information and advice”, leaving them “confused and unsure of what action would be most effective”.

Priorities – Discourse 2 exemplars highlight that local bat research must be more publicly accessible and used to promote appreciation and interest in bats (S25: +4). They are uncertain about whether a bottom-up or top-down approach to bat management would work best (S48: 0). Instead, they suggest targeted engagement (S37: +3) to help people “better understand the behaviors of bats” and more collaborative efforts by all stakeholders in deterring bats from entering dwellings (S16: +3).

Discourse 3 – We must show people why we should conserve bats.

Discourse 3, from factor 3, explains 5% of the variance (Eigenvalue = 1.56) with eight participants from five stakeholder groups loading on this factor.

TABLE 1 Statements (S) and their respective z-scores (z-sc) and ranks (r) for each of the three respective identified factors.

Statements (S)	Factor 1		Factor 2		Factor 3	
	z-sc	r	z-sc	r	z-sc	r
1 Bats in Singapore are associated with more disservices than ecosystem services.	-0.56*	-2	0.99*	2	-1.22*	-2
2 Bats are not required in the ecosystem since other taxa such as birds present in the environment perform similar ecosystem services.	-2.42	-4	1.01*	2	-2.05	-4
3 Bats are essential to the integrity of natural ecosystems in Singapore.	1.90	4	1.38	2	0.55*	1
4 Citizens should be inherently proud of the biodiversity present in Singapore and learn to, of their own accord, co-exist peacefully with wildlife such as bats.	1.20*	2	-0.95*	-2	0.09*	0
5 Like all native species, bats are part of the land and inherently have the right to exist.	1.51*	3	-0.34	-1	0.17	0
6 Bats should be conserved for their significance in certain religions.	-0.43	-1	-1.62*	-3	-0.44	-1
7 Biodiversity is inherently good and needs to be conserved regardless of its value to humans.	1.75*	4	-0.11	0	0.46	1
8 In Singapore, the negative aspects of bats in relation to human health outweigh the positive aspects regarding ecosystem functioning.	-1.60	-3	0.44*	1	-1.56	-3
9 Bats are an important part of Singapore's natural heritage.	1.44*	3	-0.45*	-1	0.38*	1
10 The COVID-19 pandemic has not significantly changed perceptions about bats since Singaporeans already previously held negative opinions about bats. *	-0.42	-1	-0.11	0	-0.60	-1
11 Human-bat encounters in Singapore hinder the conservation of bats as residents generally face more negative than positive bat encounters.	-0.34	-1	0.94*	2	-0.47	-1
12 COVID-19 has made Singaporeans more aware that bats can carry pathogens that are deadly for humans and has therefore heightened fears about bats.	-0.24*	-1	0.94	2	0.43	1
13 The government should urgently address the increased misconceptions of bats resulting from COVID-19 as this directly threatens the survival of bat populations in Singapore. *	-0.50	-1	0.22	1	-0.24	-1
14 Local tabloid journals tend to sensationalize issues about bats thereby negatively affecting perceptions and hindering conservation efforts.	-0.08	0	0.78*	1	-0.10	0
15 Protection of bat populations in Singapore rely on keeping bats away from human habitation as far as possible.	-1.26	-2	1.49*	3	-1.52	-3
16 There needs to be better integration among all stakeholders concerning the conservation of bats in Singapore.	0.74	1	1.52*	3	0.58	1
17 Protection of less charismatic species like bats should be a priority for wildlife management in Singapore.	0.53	1	-0.12*	0	0.71	1
18 Bats should be included as a mandatory component of all environmental impact assessments (EIAs).	1.41	3	0.56*	1	1.24	3
19 Underlying misconceptions about bats are largely due to inadequate knowledge and awareness of bats.	0.89	2	-0.50*	-1	1.26	3
20 Humans encroaching into bat habitats is primarily a conservation issue as bats tend to colonize urban areas only when they lack natural habitats. *	-0.75	-2	-0.37	-1	-0.02	0
21 Having more green spaces surrounding human habitation can help promote more positive human-wildlife interactions, which in turn can be positive for bat conservation.	0.32*	1	-0.41	-1	-0.55	-1
22 The lack of legal protection and laws preventing people from disturbing bats is a major hindrance to their protection. *	-0.27	-1	-0.25	0	-0.14	-1
23 Public health safety takes precedence over the protection of bats, and bat populations found to carry deadly pathogens should therefore be exterminated.	-1.42	-3	1.56*	3	-1.48	-2
24 The link between bat tourism and conservation could be highly valuable and should be looked at as a potential avenue to further bat conservation efforts in Singapore. *	-0.65	-2	-0.41	-1	0.09	0
25 Research conducted on bats should go hand-in-hand with public outreach, as this serves as an avenue to get people interested in bats.	0.57*	1	1.58	4	1.11	3
26 As bats are natural reservoirs of many coronaviruses, they pose a major public health risk and should not be co-existing among urban residents.	-1.92	-3	1.96*	4	-1.55	-3
27 The way that Singaporeans can get paranoid and overreact to things they perceive to be dangerous and risky is a hindrance to bat conservation.	-0.17*	0	-0.91*	-2	0.85*	2
28 Investing in bat conservation is only necessary when the species in question is endangered.	-1.95	-4	0.10*	0	-1.55	-3
29 The ecosystem services that bats provide in Singapore (e.g., pollination, seed dispersal) are highly valuable and bats should therefore be protected.	1.32*	3	-0.80*	-2	0.37*	0
30 Many residents are unaware of the existence of bats in Singapore which poses a challenge for bat conservation. *	0.02	0	0.11	1	0.19	0
31 Bats are slow-breeding mammals with very few offspring and should therefore be protected as their populations take a long time to recover. *	0.56	1	0.77	1	1.01	2
32 Bats are traditional symbols of good fortune and prosperity.	-0.27*	-1	-1.42*	-3	0.24*	0

(Continued)

TABLE 1 Continued

Statements (S)	Factor 1		Factor 2		Factor 3	
	z-sc	r	z-sc	r	z-sc	r
33 It is not a priority to reconsider the concerns raised by residents about bats in Singapore since the COVID-19 pandemic as these are unlikely to have changed. *	-0.97	-2	-0.97	-2	-1.21	-2
34 COVID-19 has made Singaporeans more aware of the presence of bats around them in a way that has brought about more concerns than interest. *	-0.02	0	-0.33	-1	0.20	0
35 Humans negatively impact bat ecosystems which in turn results in the emergence of diseases and related health issues.	0.87*	2	-1.38*	-3	-0.23*	-1
36 Relative to the past, bats currently do not face major conservation threats in Singapore.	-1.61	-3	-0.21*	0	-1.92	-4
37 As it is difficult to broach the subject of bats, tailored public outreach is crucial to dispel myths and support bat conservation efforts.	0.06*	0	1.52*	3	0.73*	1
38 The government's initiative of planting native species of trees is not crucial for the conservation of bat populations since most species are adapted to the urban matrix.	-0.99	-2	0.06*	0	-1.25	-2
39 Rather than greening the landscape with more native trees, conservation of bat populations in Singapore should focus on protecting existing green spaces. *	0.08	0	0	0	-0.40	-1
40 Webinars, guided walks, and public forums on wildlife have strong potential to educate the public about bats and soothe any fears.	0.71	1	-0.208*	0	1.09	2
41 It is the way we interact with bats rather than their presence in our environment which poses a problem.	0.45*	1	-0.73*	-2	1.03*	2
42 The loss of natural habitats has always been and remains the biggest challenge to the conservation and management of bats in Singapore.	0.95	2	-0.37*	-1	0.85	2
43 The government has been successful in managing human-bat conflicts, such as by providing adequate and effective measures to deter bats from entering houses.	-0.48*	-1	-2.26*	-4	-1.36*	-2
44 Quantifying and valuing ecosystem services of bats should be the focus of conservation and management of bats in Singapore.	0.01	0	-0.72*	-2	0.25	0
45 To be a successful 'City in Nature', Singapore must encompass as many wildlife taxa as possible (including bats), regardless of their charisma and popularity among residents.	0.78*	2	-1.56*	-3	1.71*	4
46 Classes about local biodiversity and Nature-related topics should be taught more in schools.	0.81	2	0.39	1	1.36*	3
47 Bats entering and roosting in houses or feeding on fruit trees of residents in Singapore are common occurrences associated with being a 'City in Nature' and does not warrant exceptional concern.	-0.13*	0	-2.17*	-4	0.77*	1
48 The management of bats in Singapore requires a top-down approach to effectuate coordination among stakeholders.	0.48	1	0.09	0	-0.64*	-2
49 Residents lacking an attachment towards Nature are likely to have more conflicts with wildlife including bats.	0.15	0	0.19	1	1.79*	4
50 Media outlets (e.g., local news journals, social media) need to exercise more prudence with their content creation, given their highly influential role on bat perceptions.	-0.07*	0	1.07	2	1.02	2

Asterisks after z-scores represent distinguishing statements at $p < 0.01$. Asterisks after statements represent consensus statements at $p < 0.01$.

Perspective – Discourse 3 recognizes the influential role of citizens in bat conservation and management through their interactions with and perceptions of Nature (S49: +4; S46: +3; S41: +2). This discourse recognizes negative attitudes and perceptions as the biggest barriers to bat conservation (S49: +4; S19: +3; S27: +2).

Problem – Discourse 3 exemplars worry about urbanites' detachment from Nature and how this might drive reduced understanding and knowledge of Nature. They emphasize that because Singaporeans tend toward paranoia and overreacting to things they perceive as dangerous (S27: +2), conservation issues lie in certain human-bat interactions rather than in the presence of bats in urban areas (S41: +2).

Priorities – Discourse 3 stresses the need for conservation efforts to focus on citizens. This includes nurturing an interest in and attachment to Nature from a young age (S46: +3) and remediating negative bat-related attitudes, behaviors, and perceptions (S19: +3;

S25: +3) through specific outreach and education targeting a wider audience than the scientific or Nature-loving communities (S25: +3; S37: +1). Post-sorting interviews reveal that whereas webinars and public forums may not be very "effective with the general public" because they largely "preach to the converted", guided tours encompassing diverse local species may be "more exciting" and could attract more people. Exemplars say a bottom-up approach to conservation and management decisions would work best (S48: -2), highlighting how current local wildlife working groups form this way, with most bat education and outreach conducted by NGOs.

3.2 Areas of consensus among discourses

None of the stakeholders are sure of how COVID-19 has affected public perceptions of bats, with many pointing out that

little is known about pre-COVID-19 and current perceptions of bats. However, one point of consensus is that Singaporeans now are more likely aware of bats and their potential to carry deadly pathogens and so, fear them more. Stakeholders emphasize the need to reconsider residents' concerns about bats in the wake of COVID-19 – doing so is indeed crucial to address possible misconceptions that could hinder conservation.

Where management is concerned, participants agree that bats in Singapore have sufficient legal protection, although EIAs must emphasize bats more. Post-sorting interviews clarified that under the Wildlife Act, it is legal to kill, trap or remove bats that are found damaging or destroying private property (see also [Singapore Statutes, 2021](#)). Participants revealed that this has resulted in instances of “nettings put-up deliberately in houses to trap bats, causing them to die from stress or exhaustion”.

There is insufficient appreciation for cultural ES. Stakeholders describe local bat tourism as “not feasible” due to a lack of big colonies of charismatic species, while some think such tourism could disturb bat populations. Participants agree that bats are rarely associated with the concept of blessings or prosperity, and that such “less valuable” cultural ES should not be promoted for conservation.

3.3 Means-ends objective network

Stakeholders highlighted several aspects of the role of residents in bat conservation and management. One necessary action is to instill an attachment to Nature in residents, especially the youth, through classes about biodiversity and Nature ([Figure 2](#)). Bat research must be made more publicly accessible so that it is understandable and improves awareness and knowledge of bats, ultimately dispelling myths and addressing misconceptions ([Figure 2](#)). Concerning the decision-making process, stakeholders raised the need for better integration and inclusion of all stakeholders ([Figure 2](#)). Particularly, they highlighted that bats must be included in all wildlife-related EIAs, and that existing natural habitats must be protected to ensure no further habitat loss ([Figure 2](#)). Stakeholders added that proper, reliable EIAs need more expertise, and that coherent delivery of conservation and management messages hinges on better communication among stakeholders ([Figure 2](#)). The overall objective for bat conservation and management in Singapore first revolves around protecting and conserving bats for their intrinsic value. Also, for Singapore to be a true ‘City in Nature’, citizens should be proud of and co-exist peacefully with Singapore’s wild biodiversity ([Figure 2](#)).

4 Discussion

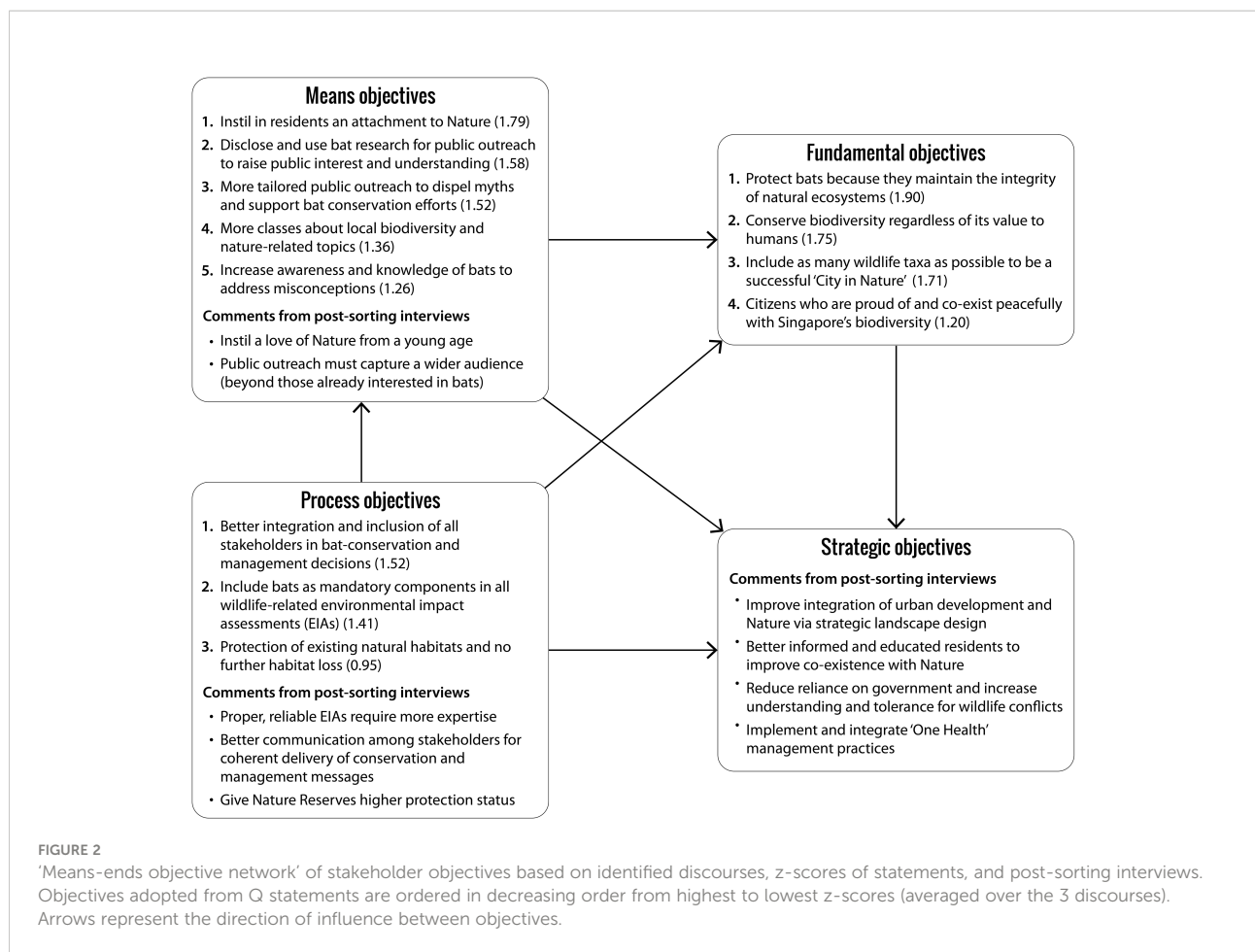
Our study – the first to consider the socio-ecological aspect of bats in Singapore – demonstrates the utility of Q methodology to uncover different stakeholder perspectives on the conservation and management of bats in Singapore in the wake of COVID-19. Polarity among the three discourses reflect the divergent interests of groups of human stakeholders in the local conservation and management of bats. Consensus among the discourses can be used to determine shared stakeholder objectives in the form of overall perspectives, problems, and priorities for decision-making.

4.1 Diverging viewpoints

We observed distinct polarization among the identified discourses.

Discourse 1, emerging from the widest range of stakeholder groups, takes an ecocentric, environmentalist stance that embodies the idea that protecting bats requires no justification. Rather, it is an ethical obligation of humankind. Such ecocentric or biospheric attitudes to conservation appreciate Nature for its intrinsic rather than utilitarian values ([Thompson and Barton, 1994](#)). Despite their range of professional profiles, D1 exemplars all agree that bats play an integral role in Singapore’s natural ecosystems and in providing regulation and maintenance ES such as seed dispersal of native plants ([Chan et al., 2020](#)) and pollination of durian (*Durio zibethinus*; [Russo et al., 2022](#)). Most D1 stakeholders have environmental or natural sciences backgrounds ([Table S3](#)) and, as such, likely have preconceived attachments to Nature and wildlife, which could explain their ecocentric, environmentalist point of view.

Discourse 2, which is anthropocentric and contrasts with D1 and D3, strictly de-prioritizes the protection of bats mainly due to perceived public-health and safety concerns. This discourse criticizes current management of bats, highlighting the lack of coherence among responsible agencies and the ineffectiveness of current efforts to deter bats from entering residences. Although there is zero evidence that bats are hosts of SARS-CoV-2 (see also [Shapiro et al., 2021](#)) and no local media have reported otherwise ([Table S2](#)), D2 reveals persistent fears of bats. A review of stakeholder characteristics ([Table S3](#)) shows that exemplars have likely based their perceptions on their prior encounters with bats without necessarily knowing about bats’ ecological roles or ES. Discourse 2 is therefore likely to have been shaped by stakeholders’ negative experiences and encounters ([Table S3](#)).



Discourse 3 champions public education and outreach, so exemplars believe that people need a convincing reason to conserve bats. This opinion distinguishes D3 from D1. Participants loading on D3 hold roles as educators, whether in school settings or with the general public (Table S3). Although local bat-related public education and outreach efforts exist, bats are rarely the only focal taxa and are hardly addressed individually (Nparks, 2021c). This makes bats unlike some other taxa, such as macaques (*Macaca fascicularis*) and wild boars (*Sus scrofa*), that have received individual attention because of their propensity to be involved in conflicts (Nparks, 2021d; Nparks, 2021e). However, it must be noted that teaching the public about the importance of bats and the need to address the threats to their conservation does not guarantee a change in attitude or behavior towards bats (see also Frick et al., 2020). Changing negative attitudes and (more importantly) behaviors toward bats necessitates carefully planned and interdisciplinary studies firmly grounded in social science theories (e.g., Theory of Planned Behavior, Cognitive Hierarchy Theory, etc.) and methodologies (see also Kingston, 2016; Straka et al., 2021).

4.2 Converging viewpoints

4.2.1 Perspectives

Ongoing urban development in Singapore continues to threaten bats – a problem amplified by residents' negative bat-related viewpoints – viewpoints that participants agree have likely been exacerbated by COVID-19. Participants have noticed an increase in Singaporeans raising concerns about bats and being more aware of their presence compared to before the pandemic. However, any increased awareness does not necessarily translate to greater bat-related knowledge or interest. Participants also highlight the importance of how the media presents information on bats, given how influential the media in Singapore is and the consequent potential for the public to misunderstand articles about bats (see MacFarlane and Rocha, 2020), especially in relation to public health. Indeed, misinterpretation of scientific evidence by the media can pose a serious threat to bats (López-Baucells et al., 2018; MacFarlane and Rocha, 2020). Still, most participants agree that Singapore's local media has recently been disseminating largely accurate

information about bats. In contrast to previous portrayals of bats in Singapore as the “culprits” behind the SARS virus (Chang, 2013), the media have reported that bats are “highly unlikely” to carry the coronavirus that causes COVID-19 (Toh, 2020; Table S2).

4.2.2 Problems

As a highly developed small-island city-state, Singapore faces severe land scarcity. Urban development threatens approximately 22% of the nation’s remaining forest patches (Gaw et al., 2019) and stands to cause further forest degradation and fragmentation – a reality that ultimately forces bats into residential areas and raises the frequency of human-bat interactions. Further, low bat-related awareness, understanding and interest will likely create and/or exacerbate tension between bats and human urbanites. Post-sorting interviews reveal that post-COVID-19, residents have been increasingly complaining about bats entering and roosting in houses and feeding on fruits in gardens. Such negative perceptions of these interactions have likely developed or worsened due to sensationalized global media reports following the pandemic.

4.2.3 Prioritizations

There is a need to bolster public education and awareness campaigns to address negative views of bats and misconceptions that they pose a public health threat. Bat conservation and management in Singapore can be made more effective with the knowledge of current attitudes towards bats as outreach efforts can be tailored to the society. All participants agree that in the wake of COVID-19, perceptions of bats must be studied to address misunderstandings that could affect bat conservation and management. Because it is almost impossible to keep urban bats away from human dwellings, residents must learn to co-exist with them as part of a ‘City in Nature’ – for this to happen, negative bat-related attitudes must be dispelled. Indeed, during post-sorting interviews, stakeholders recounted anecdotes of residents increasingly asking for bats to be removed from their premises, and trapping and killing bats. Still, participants agree that bats are generally well-protected by law and are relatively undisturbed. Local conflicts largely involve one common species, *Cynopterus brachyotis*, which is well-adapted to the urban landscape, and rarely involve uncommon or endangered species, which occur in forest patches (Lane et al., 2006). This speaks to how important it is to preserve remnant forests. There is also a need for the public to support naturalization, e.g., planting native trees that could provide alternate food resources for bats, or restoring connectivity among fragments. Additionally, better integration of future urban development and wildlife through strategic landscape design (see

also Hwang and Jain, 2021) is required to strengthen relationships between urbanites and wildlife and thus to promote conservation and mitigate conflicts.

4.3 Relevance to conservation and management

Conservation and management decisions are complex and increasingly expected to integrate the objectives of multiple stakeholders to improve attitudes (Sterling et al., 2017). Furthermore, the consequences of most conservation policies and interventions affect different stakeholders differently (Grimble and Wellard, 1997). Yet, considering and integrating multiple stakeholder objectives can be challenging and may divert attention from the decision-making process, which would therefore be easier if policymakers would consider a compromise or trade-off among stakeholders. The discourses we identified may provide a foundation to consolidate and integrate major perspectives into shared objectives for bat conservation and management *via* a ‘means-ends objective network’ (Figure 2). The points of consensus among stakeholders in this study can be directly applied to conserving and managing bats in Singapore. Effective public outreach necessitates understanding current bat-related attitudes (Figure 2). Finally, for citizens to peacefully coexist with wildlife (Figure 2), it takes coordinated efforts of stakeholders with possible consideration of ‘One Health’ management practices, which ensure the wellbeing of bats and people (Mackenzie and Jeggo, 2019).

Biodiversity conservation and management increasingly considers gender equity as integral to inclusive decision-making (Tallis & Lubchenco, 2014; Matulis & Moyer, 2017; Lau, 2020). Even though women play influential roles in conservation, environmental activism, and leadership at local, national, and international scales (Bell and Braun, 2010), gender inequality in conservation remains pervasive (Jones and Solomon, 2019; James et al., 2021). This is a serious problem because gender inequality hinders the achievement of biodiversity protection and ecological stewardship (Tallis & Lubchenco, 2014; Matulis & Moyer, 2017). Besides, given documented gender-based differences in knowledge and views of bats (e.g., Boso et al., 2021; Musila et al., 2018; Lu et al., 2021), stakeholder viewpoints of all genders matter. In this study, 40% of P set participants identified as women – they were distributed among six different stakeholder groups and represented all three discourses (Table S3). Although we did not test for gender-based differences in stakeholder viewpoints (and QM is likely unsuited to such analyses), we encourage future researchers to explore the role of gender in viewpoints on bat conservation and management so that decisions respect the ethical

norm of inclusivity and are thus more likely to be effective than when such consideration is not given.

5 Conclusion

It seems people are complaining more about bats in their buildings now than pre-pandemic and some are resorting to evicting or killing bats (e.g., Tsang, 2020; Zhao, 2020). Behaviors like this stand to raise societal tension, e.g., with exemplars of D1 – a situation that could boil over and become acrimonious in a densely populated city-state where people of all stripes literally live one on top of the other. As such, we propose that the responsible agency, in this case NParks, explore the applicability of a multi-pronged campaign to solve the issue in a safe and palatable way. More specifically, we point to the apparent success of efforts to mitigate human-macaque conflicts – efforts that combine: (1) teaching residents about macaques' non-verbal cues and the dangers of feeding them and (2) monkey guards who deter macaques from venturing near dwellings on the fringes of macaque habitat. Perhaps NParks could investigate imparting information about how to prevent bats getting into dwellings (e.g., sealing holes, installing window screens) and what to do when they find their way in, while also examining how urban greening strategies (i.e., plantings) might be tweaked to maximize the ecosystem services that bats render while reducing their tendency to approach buildings.

In the Anthropocene, the diverse and contextualized stakeholder discourses gathered from this study pave a path to better bat conservation and management, especially since COVID-19. Our QM findings are useful for resolving conflicts, appraising policies, and facilitating discussion and eventual critical reflection related to current bat conservation and management strategies in Singapore. While we elaborated most strongly on stakeholder discourses, our MEON helps to incorporate findings in a way that is more focused and easier for policy makers to understand. Singapore, with its dense human population, land scarcity and ongoing urban renewal and expansion, exemplifies the tension between development and conservation. This tension must be resolved. Specifically, residents' viewpoints and attitudes must be understood and, if necessary, modified to facilitate co-existence with bats in a "City in Nature" where bats are appreciated and conserved for their intrinsic worth and ecological roles. Moving forward, sustainable bat conservation and management should continue to involve discussion among all relevant stakeholders and consideration of their diverse viewpoints.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary Material](#). Further inquiries can be directed to the corresponding author.

Ethics statement

Our Q-method study was reviewed and approved by the ethical board of the National University of Singapore (NUS-IRB reference code S-20-142E) and respondents gave informed consent.

Author contributions

RL: conceptualization, methodology, writing – original draft, review and editing. CL: conceptualization, writing – review and editing. JZ: writing – review and editing. JC: conceptualization, methodology, writing – review and editing. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcosc.2022.1003925/full#supplementary-material>

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