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Flying-foxes in the Australian urban environment—community attitudes and opinions

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ABSTRACT

The urban presence of flying-foxes (pteropid bats) in eastern Australia has increased in the last 20 years, putatively reflecting broader landscape change. The influx of large numbers often precipitates community angst, typically stemming from concerns about loss of social amenity, economic loss or negative health impacts from recently emerged bat-mediated zoonotic diseases such as Hendra virus and Australian bat lyssavirus. Local authorities and state wildlife authorities are increasingly asked to approve the dispersal or modification of flying-fox roosts to address expressed concerns, yet the scale of this concern within the community, and the veracity of the basis for concern are often unclear. We conducted an on-line survey to capture community attitudes and opinions on flying-foxes in the urban environment to inform management policy and decision-making. Analysis focused on awareness, concerns, and management options, and primarily compared responses from communities where flying-fox management was and was not topical at the time of the survey. While a majority of respondents indicated a moderate to high level of knowledge of both flying-foxes and Hendra virus, a substantial minority mistakenly believed that flying-foxes pose a direct infection risk to humans, suggesting miscommunication or misinformation, and the need for additional risk communication strategies. Secondly, a minority of community members indicated they were directly impacted by urban roosts, most plausibly those living in close proximity to the roost, suggesting that targeted management options are warranted. Thirdly, neither dispersal nor culling was seen as an appropriate management strategy by the majority of respondents, including those from postcodes where flying-fox management was topical. These findings usefully inform community debate and policy development and demonstrate the value of social analysis in defining the issues and options in this complex human–wildlife interaction. The mobile nature of flying-foxes underlines the need for a management strategy at a regional or larger scale, and independent of state borders.

Introduction

Flying-foxes are nomadic fruit- and blossom-eating bats (family *Pteropodidae*) that forage by night and roost in arboreal colonies by day. Some Australian species can weigh up to 1 kg, with a wing-span of 1.2 m. Contemporary colonies generally comprise thousands or tens of thousands of bats, although historically, colonies of hundreds of thousands or millions of bats have been recorded [1–3]. They are protected under state and/or national legislation. In eastern Australia, flying-foxes have become increasingly urbanised in the last 20 years, putatively reflecting landscape change in both rural and urban environments. Paradoxically, food resources have increased in urban and peri-urban environments as a result of human demographic and lifestyle changes, but decreased in rural environments predominantly as a result of natural habitat loss associated with land-use change [4–8]. While small colonies in remnant urban and peri-urban bushland are generally tolerated, the influx of larger numbers of flying-foxes (most often associated with the large-scale nomadic movements of little red flying-foxes (*Pteropus scapulatus*)) often precipitates some community angst [9]. The reasons for this are broadly twofold: firstly, nuisance and loss of social amenity, and secondly, health concerns [10]. The former is a consequence of the noise, soiling and smell typically attendant with large numbers of flying-foxes; the latter primarily reflects public concern about bat-mediated zoonotic diseases such as Hendra virus and Australian bat lyssavirus, both of which have caused sporadic human fatalities. In fruit-growing areas, an additional trigger for public concern is the threat of crop damage and associated economic loss. Thus, local authorities and state wildlife authorities are increasingly asked to approve the dispersal or modification of flying-fox roosts to address expressed concerns [11], yet the scale of this concern within the community, and the veracity of the basis for concern are often unclear.

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The situation highlights the frequently complex nature of human, wildlife and ecosystem interactions, and the need for information-based decision-making. In this context, we conducted a survey to capture community attitudes and opinions about flying-foxes in the urban environment to inform community debate and to support management policy and decision-making. This paper presents the key survey findings.

Methods

Study population

Our target study population was the residents of the eastern Australian state of Queensland where flying-fox management is topical. While we accepted responses from other Australian states, our analysis included responses from Queensland only.

Survey delivery and sample selection

We presented the survey in an on-line format using the Survey Monkey™ platform, but also advertised the availability of paper copies. The on-line platform was configured to prevent multiple responses from the same device. The survey ran from 27 August to 12 October, 2012. It was promoted by the Queensland government via conventional media release and social media in weeks one and six, and via multiple radio and print media interviews in the intervening period. A number of horse industry and wildlife interest groups posted the survey URL on their official websites. Respondents were self-selected.

Questionnaire

We posed 37 questions within four sections, capturing respondent demographics, flying-fox knowledge, opinions and concerns, and management options. Questions were typically closed, though we provided

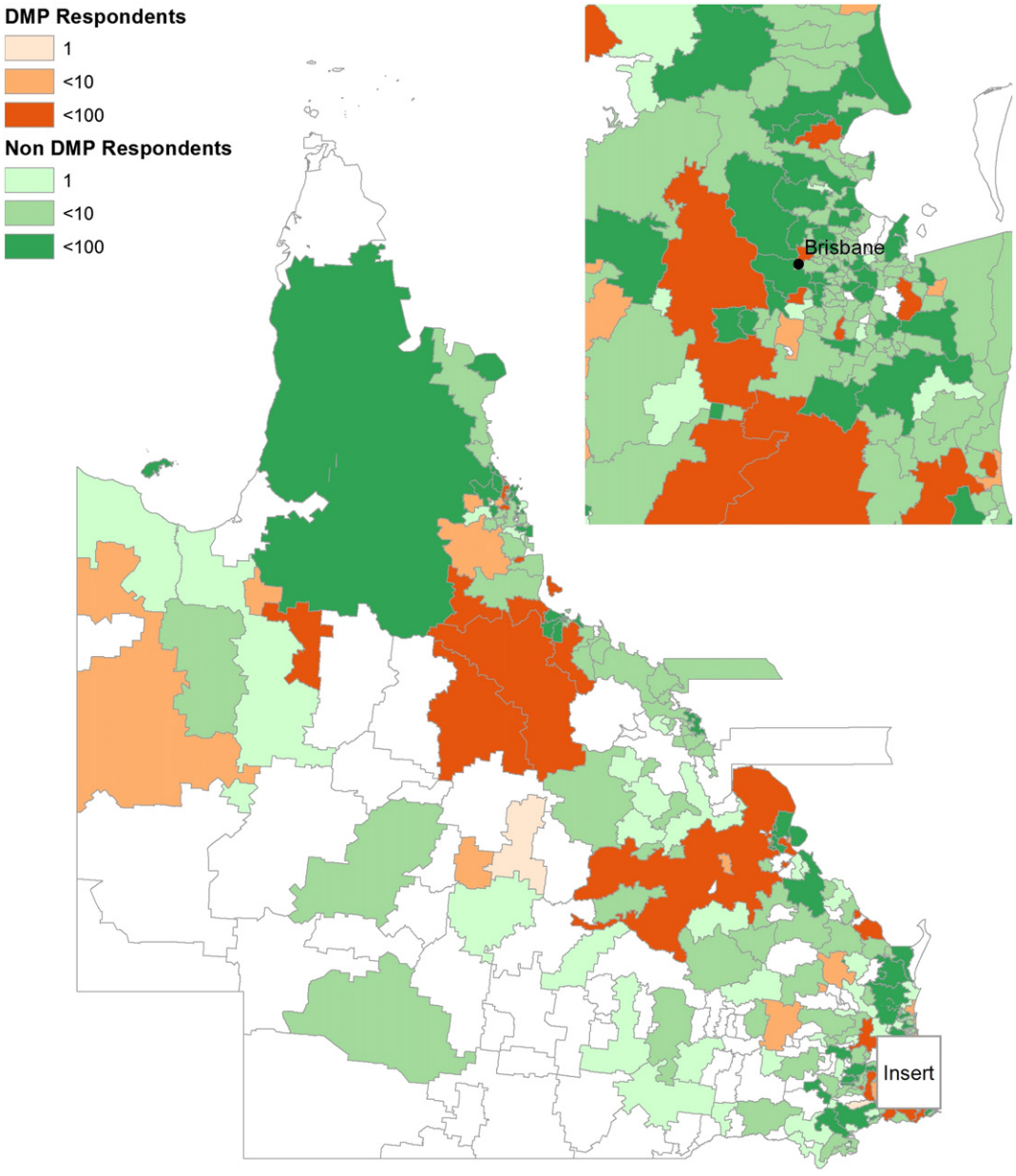

Fig. 1. Location and number of survey responses by postcode. Postcodes that contained roosts for which damage mitigation permits had been sought, granted or existed in the six months prior to the end-date of the survey are indicated by red toning.

opportunity for respondents to make additional comment on key questions. A number of questions allowed assessment of potential selection bias. The questionnaire was trialled on about 30 individuals from a cross-section of the community to assess comprehension and clarity, and refined accordingly prior to commencement of the survey.

Analysis

The analysis focused on awareness, concerns, and management options. We were primarily interested in comparing responses from communities where flying-fox management was and was not topical at the time of the survey. The former were defined as post-codes that had sought, been granted, or had an existing damage mitigation permit (DMP) to disperse or modify a roost from the state wildlife authority in the six months prior to the end of the survey. In addition, we explored the role of some demographic variables. Response percentages were rounded to the nearest whole number. Respondents who declined to answer a question were excluded from the denominator in percentage calculations. The chi square statistic was used to examine statistical significance at the 95% confidence level. Chi square values were rounded to one decimal place.

Ethics

The survey and questionnaire were reviewed by the Human Research Ethics Committee of Queensland Health, and approved as a low/negligible impact process (HREC Reference number: HREC/12/QHC/24). Respondents were required to indicate informed consent by clicking a button to access the on-line questionnaire, and again to submit their completed questionnaire. The survey did not target minors, and the content was deemed not to pose harm or risk to minors, thus we did not specifically request informed consent from the next of kin, caretakers, or guardians on behalf of any minors enrolling.

Results

We analysed 2744 responses from Queensland respondents (Fig. 1). There was no statistically significant difference in respondent demographic characteristics between DMP and non-DMP postcodes (Table 1).

Awareness

Respondent sources of information and perceived reliability of sources are presented in Table 2. Eighty-six percent rated their general knowledge of flying-foxes as high (25%) or moderate (61%). Flying-fox knowledge did not vary with DMP postcode status, but respondents aged less than 35 years, and respondents whose highest formal education was high school, were more likely to indicate a lower level of knowledge ($\chi2 = 22.0$, $p < 0.001$ and $\chi2 = 4.96$, $p = 0.026$ respectively). Eighty-two percent rated their general knowledge of Hendra virus as high (22%) or moderate (60%). Hendra virus knowledge did not vary with DMP postcode, but respondents aged less than 35 years, and male respondents, were more likely to indicate a lower level of knowledge ($\chi2 = 7.41$, $p = 0.006$ and $\chi2 = 6.49$, $p = 0.011$ respectively). Additional data on respondent awareness and knowledge are presented in Table 3. About 1500 respondents provided additional comments. Recurring themes sympathetic to flying-foxes were media misinformation and scaremongering about risks, increased urban presence reflecting human changes, and the important ecological/biodiversity role of flying-foxes. Recurring themes critical of flying-foxes were severe loss of amenity of residential parks and yards, disease concerns, and bats given preferential consideration over humans.

Concerns

Respondent concerns about flying-foxes are presented in Table 4. Fifty-seven percent indicated that flying-foxes caused concern in their community, with male respondents more likely to respond so ($\chi2 = 30.3$, $p = <0.001$). Thirty-nine percent indicated that flying-foxes had caused them concern personally, with male respondents again more likely respond so ($\chi2 = 35.8$, $p = <0.001$). DMP postcode respondents were also more likely to respond in the affirmative to these two questions, and more likely to be concerned that flying-foxes might affect water quality, damage property, create noise, generate smell and cause disease. They were also more likely to be concerned if flying-fox numbers were increasing.

Management options

Forty-one percent of respondents supported dispersal as an appropriate flying-fox management strategy unequivocally (17%) or sometimes (24%), with male respondents and DMP postcode respondents more likely to do so ($\chi2 = 51.2$, $p = <0.001$ and $\chi2 = 20.5$, $p = <0.001$ respectively). Fifty-seven percent thought that dispersed flying-foxes were unlikely (36%) or highly unlikely (21%) to stay in a new location; 31% were unsure. Seventy-one percent thought it likely (41%) or highly likely (30%) that they would move to another town where they might cause similar issues; 18% were unsure. Twenty-eight percent said they would be less likely to support dispersal as a management strategy if it could result in an increase in flying-fox numbers in their town; 23% indicated similarly if it could mean an increase in numbers in another town. Respondent opinion on the decision-making process for roost dispersals is presented in Table 5. In addition, there was broad consensus that the process should be more inclusive and faster. DMP postcode respondents were less likely to support a dispersal option that required state government approval (43% vs 53%) and more likely to support an option that required local council approval (27% vs 19%).

Forty-two percent of respondents thought culling was an appropriate management strategy unequivocally (28%) or sometimes (14%),

Table 1
Respondent demographic characteristics.

Characteristic	Category	Number (%) of respondents		
		Total	DMP postcode	Non-DMP postcode
Gender				
	Male	993 (36)	269 (39)	724 (35)
	Female	1751 (64)	420 (61)	1331 (65)
Age in years[a]				
	<16	10 (1)	4 (1)	6 (1)
	16–34	544 (20)	123 (18)	421 (20)
	35–54	1191 (43)	305 (44)	886 (43)
	>55	999 (36)	257 (37)	742 (36)
Years at current address				
	<1	143 (5)	36 (5)	107 (5)
	1–5	685 (25)	156 (23)	529 (26)
	6–10	528 (19)	119 (17)	409 (20)
	>10	1388 (51)	378 (55)	1010 (49)
Highest formal education				
	High school	515 (19)	141 (20)	374 (18)
	TAFE/trade	570 (21)	153 (22)	417 (20)
	University	1555 (56)	363 (53)	1192 (58)
	Other	104 (4)	32 (5)	72 (4)
DMP postcode status				
		2744 (100)	689 (25)	2055 (75)

There was no statistically significant difference between DMP and non-DMP postcodes for any variable.

[a] Respondent age categories were collapsed from seven (Q. 17 in the questionnaire) to five to facilitate analysis.

Table 2
Respondent sources of information on flying-fox issues and perceived reliability of sources.

Information source	Number (%) of respondents accessing source				Number (%) of respondents reporting source as reliable[a]			
	Total	DMP postcodes	Non-DMP postcodes	Chi-square value, *p* value	Total	DMP postcodes	Non-DMP postcodes	Chi-square value, *p* value
State govt	1780 (65)	444 (64)	1336 (65)	ns	1967 (72)	489 (71)	1478 (72)	ns
Internet	1257 (46)	323 (47)	934 (45)	ns	751 (27)	206 (30)	545 (27)	ns
Wildlife group	1241 (45)	274 (40)	967 (47)	11.1, 0.001	1646 (60)	380 (55)	1266 (62)	8.95, 0.003
Local council	967 (35)	275 (40)	692 (34)	8.80, 0.003	1217 (44)	312 (45)	905 (44)	ns
Private vet	512 (19)	111 (16)	401 (20)	3.94, 0.047				
Horse industry	282 (10)	77 (11)	205 (10)	ns	688 (25)	201 (29)	487 (24)	8.23, 0.004
Friends/family	202 (7)	55 (8)	147 (7)	ns				
Radio & TV[b]	167 (6)	71 (10)	96 (5)	28.6, <0.001	623 (23)	195 (28)	428 (21)	16.4, <0.001
Newspapers	162 (6)	57 (8)	105 (5)	9.29, 0.002	271 (10)	92 (13)	179 (9)	12.5, < 0.001
Social media	117 (4)	35 (5)	82 (4)	ns	103 (4)	25 (4)	78 (4)	ns
Unsure	39 (1)	9 (1)	30 (1)	ns				

[a] Percentage of respondents answering 'Mostly reliable'. The information sources of 'Private vet', 'Friends & family', and 'Unsure' were not included in the question.
[b] Responses for radio and for television on source of information and reliability of information (Q. 8 and Q. 20 in the questionnaire) were combined to facilitate analysis.

with male respondents and DMP postcode respondents more likely to think so ($\chi2 = 60.6$, $p = <0.001$ and $\chi2 = 25.3$, $p = <0.001$ respectively). Additional opinion on flying-fox management strategies are presented in Table 6. About 1200 respondents provided additional comments on management options. The majority favoured alternatives to dispersal and culling, with suggestions including establishing food resource precincts away from urban areas, not allowing residential construction close to existing roosts, financial rebates for residents directly affected, dispersal of roosts in backyards, and sustainable harvesting of flying-foxes.

Discussion

Community surveys have been used effectively to elaborate public perceptions and behaviour regarding bat-human interactions [12,13]. With no practical sampling frame available, and with alternatives such as random digit dialling prohibitively expensive, we used an on-line survey tool. Notwithstanding the potential for selection bias with this methodology [14], we believe the wide and diverse promotion of the survey, the large sample size, and the statistically similar demographic characteristics of the DMP and non-DMP postcode respondents allow us to validly compare community attitudes and opinions across the two groups. Given the apparent mixed community sentiment regarding flying-foxes in urban environments, a likely source of selection bias could be response-stacking, where 'pro' or 'anti' bat respondents are systematically mobilised. However, the responses to a number of questions suggest that the impact of any stacking is equal and opposite, resulting in washout of any bias [15]. For example, nearly 40% of respondents indicated that flying foxes had caused them personal concern. This response is not consistent with a net over-representation of 'pro' bat respondents. Similarly, 45% of respondents identified 'wildlife group' as a source of information, a response not consistent with an over-representation of 'anti' bat respondents. DMP postcodes comprised 10% of all postcodes from which responses were received, yet DMP respondents represent 25% of total respondents. While postcode area and population vary, we would expect similar variation in both DMP and non-DMP postcodes, thus these figures suggest a greater participation rate in DMP postcodes, not unexpected given the likely topicality of flying-fox management in these postcodes. Based on Australian Bureau of Statistics (ABS) data indicating that the gender ratio in Queensland approaches unity [16], females are over-represented in the survey sample. Similarly, the ABS age profile for Queensland residents (52% > 35 years) indicates that older residents are over-represented. While neither is unique to this survey [17–19], and neither necessarily impacts external validity, generalisation of the findings should be mindful of these features.

Awareness

A majority of respondents expressed moderate to high levels of knowledge about flying-foxes, consistent with the predominant source of information being the authoritative state government. Interestingly, while the internet was a secondary source of information, its reliability was heavily discounted. Notably, few respondents identified social media as an important source of reliable information.

Less than a quarter of all respondents reported a flying-fox colony in their neighbourhood, indicating more broadly that a minority of community members are likely directly impacted by the potential negative impacts of urban roosts. Indeed, the figure may be an over-estimate, given the likely DMP respondent over-representation. Interestingly, DMP respondents were less likely to report flying-foxes foraging in their garden, suggesting that the presence of an urban roost may not necessarily translate to increased flying-foxes foraging in urban gardens, but rather in urban and peri-urban remnant vegetation.

Nearly three-quarters of all respondents thought the ecological role of flying-foxes was important, including a majority of DMP postcode respondents. Similarly, a majority of respondents did not believe flying-fox numbers were increasing.

Table 3
Respondent awareness and knowledge of flying-foxes and Hendra virus.

Topic	Number (%) of respondents replying in the affirmative			
	Total	DMP postcodes	Non-DMP postcodes	Chi-square value, *p* value
Thought the ecological role of flying-foxes was important[a]	1977 (72)	448 (65)	1529 (74)	22.6, <0.001
Reported a flying-fox roost in their neighbourhood	592 (22)	227 (33)	365 (18)	70.3, <0.001
Reported flying-foxes feeding in their garden	1348 (49)	295 (43)	1053 (51)	14.7, <0.001
Thought that flying-fox numbers were increasing	906 (33)	300 (44)	606 (29)	46.1, <0.001
Thought it likely or highly likely they could contract Hendra virus from flying-foxes	380 (14)	134 (20)	246 (12)	24.0, <0.001

[a] Number (%) of respondents who thought that the ecological role of flying-foxes was as important as, or more important than that of other wildlife.

Table 4
Respondent concerns about flying-foxes.

Nature of concern		Number (%) of respondents replying in the affirmative			
		Total	DMP postcodes	Non-DMP postcodes	Chi-square value, *p* value
Thought flying-foxes cause concern in their community		1552 (57)	485 (70)	1067 (52)	71.6, <0.001
Flying-foxes had caused personal concern		1058 (39)	325 (47)	733 (36)	28.8, <0.001
Were very concerned that flying-foxes					
	Affect water quality	534 (20)	194 (29)	340 (17)	45.2, <0.001
	Damage property	573 (21)	200 (30)	373 (18)	38.0, <0.001
	Create noise	537 (20)	213 (31)	324 (16)	75.6, <0.001
	Generate smell	606 (22)	244 (36)	362 (18)	97.6, <0.001
	Cause disease	924 (35)	294 (44)	630 (32)	33.9, <0.001
Would be concerned if flying-fox numbers were increasing		1124 (41)	341 (49)	783 (38)	27.7, <0.001

Our questions on potential health issues were contained to Hendra virus because of the high public profile of the associated disease from media coverage of cases and from active communication strategies by animal and public health authorities [20,21]. All human cases of Hendra virus have resulted from direct and close contact with infected horses [22], and there is no evidence to suggest flying-fox to human transmission, yet 14% of respondents thought it likely or highly likely that they could contract Hendra virus directly from flying-foxes. This finding suggests the need for on-going communication from public health authorities regarding Hendra virus exposure risk. The figure approaches 20% for DMP respondents, and the magnitude of this misunderstanding may explain at least in part the stronger anti-flying fox sentiment from this sector.

Concerns

As expected, respondents from DMP postcodes were more likely to indicate that flying-foxes caused community concern than respondents from non-DMP postcodes. Yet less than half reported flying-foxes causing them personal concern, and only about a third were concerned about potential direct negative impacts. Further, DMP respondents expressed net neutral concern with respect to a hypothetical increase in flying-fox numbers. These findings indicate that while there is heightened concern in DMP postcodes, those concerns are not held by the majority of DMP respondents. There clearly will be aggrieved individuals, most plausibly those living in close proximity to a flying-fox roost. There is also a gender perspective evident, with male respondents more likely to indicate concern. This may reflect greater frustration felt by males at being constrained from direct action by regulation. Additional comments support this interpretation in that they frequently expressed anger and resentment at the perception that flying-foxes were being put before people, reflected in the legislative protections afforded flying-foxes and the complexity of the formal damage mitigation process. Comments also expressed frustration and resentment that roosts immediately adjacent to residential areas resulted in faecal soiling and smell that prevented families using their yards, damaged property and negatively impacted property values, the latter preventing respondents from selling and moving.

That more respondents were concerned about potential health impacts than any other potential direct negative impacts is not surprising given the number of emerging diseases associated with bats in recent years, and the several human deaths in Queensland from Hendra virus and Australian bat lyssavirus [22–25]. Perceived disease risk was also a recurring theme in additional comments. While the consequences of infection with such agents can be dire, the likelihood of infection is low, and can be mitigated with simple measures [26]. Public health, livestock health and wildlife authorities strive to communicate this information, but our findings suggest that some community members are not receiving or not believing this message. This interpretation is supported by the related finding (discussed above) that a substantial minority of respondents thought it likely or highly likely that they could contract Hendra virus directly from flying-foxes. The figure in DMP postcodes is nearly double that in non-DMP postcodes (above), suggesting additional factors are influencing risk perception. At an individual level, it is plausible that the proximity of the perceived threat causes belief in expert advice to waiver; at a community level, where emotions can become inflamed and arguments polarised, it is equally plausible that misinformation or misrepresentation play a role. This interpretation is supported by Degeling and Kerridge [27] who argue the potential for media and vested interest groups to inaccurately shape public concern and opinion about Hendra virus risk. Mainstream media typically portrays the anger and frustrations of negatively impacted individuals or groups, thereby engendering a general public and political perception that flying-foxes are negatively perceived by most. Misunderstanding, misinformation and scaremongering were recurring themes in additional comments, with many respondents believing that media and interest groups overstated potential disease risks and understated potential ecological benefits of flying-foxes.

Management options

Neither dispersal nor culling was seen as appropriate management strategies by the majority of respondents, both DMP and non-DMP. There was broad recognition that dispersal is a temporary measure, and that flying-foxes dispersed from one community are likely to end up in another [28]. Recognition of the limited effectiveness of dispersal

Table 5
Respondent support for stakeholder group involvement in flying-fox dispersal decision-making process.

Stakeholder group	Number (%) of respondents supporting involvement			
	Total	DMP postcodes	Non-DMP postcodes	Chi-square value, *p* value
State government or Biosecurity agency	1997 (86)	492 (85)	1505 (86)	ns
Independent scientific experts	1900 (84)	452 (82)	1448 (85)	ns
Local council	1636 (75)	447 (78)	1189 (74)	ns[a]
Affected local residents	1597 (74)	431 (78)	1166 (72)	5.63, 0.018
Wildlife groups	1497 (72)	340 (67)	1157 (73)	7.09, 0.008
All local residents	1181 (59)	328 (66)	853 (57)	10.9, 0.001

[a] Approaching statistical significance ($x^2 = 3.65$ $p = 0.056$).

Table 6
Respondent support[a] for alternative management options in hypothetical management scenarios.

Management scenario	Management option	Number (%) of respondents expressing support			
		Total	DMP postcodes	Non-DMP postcodes	Chi-square value, *p* value
Flying-foxes feeding in an orchard	Exclusion netting	1469 (56)	339 (52)	1130 (58)	7.18, 0.007
	Culling	667 (25)	191 (29)	476 (24)	6.00, 0.014
	Dispersal	254 (10)	76 (12)	178 (9)	ns
	Do nothing	105 (4)	23 (4)	82 (4)	ns
	Tree lopping	20 (1)	7 (1)	13 (1)	ns
Flying-foxes roosting in a town park	Do nothing	1051 (40)	218 (33)	833 (43)	18.2, < 0.001
	Dispersal	574 (22)	177 (27)	397 (20)	12.6, < 0.001
	Culling	568 (22)	167 (25)	401 (21)	6.96, < 0.001
	Exclusion netting	149 (6)	34 (5)	115 (6)	ns
	Tree lopping	119 (5)	34 (5)	85 (4)	ns
Flying-foxes roosting in a school ground	Culling	692 (26)	207 (32)	485 (25)	11.2, < 0.001
	Dispersal	670 (26)	180 (27)	490 (25)	ns
	Do nothing	471 (18)	106 (16)	365 (19)	ns
	Tree lopping	321 (12)	68 (10)	253 (13)	ns
	Exclusion netting	279 (11)	66 (10)	213 (11)	ns
Flying-foxes roosting in a backyard	Dispersal	593 (23)	179 (27)	414 (21)	10.3, < 0.001
	Culling	585 (22)	172 (26)	413 (21)	7.23, < 0.001
	Do nothing	545 (21)	108 (16)	437 (22)	10.4, < 0.001
	Tree lopping	415 (16)	99 (15)	316 (16)	ns
	Exclusion netting	271 (10)	55 (8)	216 (11)	ns[b]

[a] The number (%) of respondents indicating 'Unsure' were 104 (4), 151 (6), 172 (7), and 199 (8) respectively.
[b] Approaching statistical significance ($x^2 = 3.79$, $p = 0.052$).

and culling was also evident in responses to the hypothetical management scenarios, where for three of the four scenarios, majority opinion was fairly equally divided between 'dispersal', 'culling' and 'do nothing'. For the fourth (flying-foxes foraging in an orchard), exclusion netting was favoured by half the respondents. 'Tree lopping or removal' received modest support in the 'colony in the backyard' and 'colony in the school ground' scenarios.

There was strong support for the decision-making process for dispersals to be more inclusive, with both DMP and non-DMP respondents believing that independent scientific experts and wildlife groups should also participate. This finding, combined with the lack of consensus on the management scenarios suggests that many respondents feel that existing options are inadequate. Two key findings – that a limited number of people are directly negatively impacted, and that dispersal or culling are not popular or effective strategies – suggest the need for a more targeted, management option for urban settings. Additional comments on management options argued for the planting and maintenance of dedicated food resource precincts for flying-foxes, and for pre-emptive town-planning decisions preventing residential encroachment on existing roost locations, and ensuring future remnant urban bushland patches are large enough to avoid potential conflict.

There have been two notable roost dispersals that have been effective long-term: the Melbourne Botanical Gardens colony, commenced in 2003 [29,30], and the Sydney Royal Botanical Gardens colony, commenced in 2012 [31]. Both sought to relocate a colony to another location nearby, rather than disperse per se, both continue to require on-going monitoring and disturbance at the original location to avoid re-establishment, and both required substantial initial and on-going expense. In contrast, multiple attempts to disperse a colony in the NSW town of Maclean over a 10 year period have been spectacularly unsuccessful, with an escalation of the scale of negative community impact (as the original roost fragmented) and a compounding of the management and economic consequences [32].

Conclusion

The study outputs demonstrate the value of social analysis in defining the issues and options in this complex human–wildlife interaction scenario. Our finding that a substantial minority of respondents mistakenly believe that flying-foxes pose a direct infection risk to humans suggests that misunderstanding, miscommunication or misinformation is a real issue, and highlights the need for additional risk communication strategies. Our finding that only a minority of community members are directly impacted by urban roosts suggests that targeted management options should receive more consideration. The latter is supported by the finding that neither dispersal nor culling was seen as appropriate management strategy by the majority of respondents, including those from DMP postcodes. More broadly, the mobile nature of flying-foxes underlines the need for a management strategy at a regional or larger scale, and independent of state borders.

While the focus of this study has been community perspectives on flying-foxes in the urban environment in Australia, the approach and insights gained could readily apply to complex human–wildlife scenarios anywhere. Fundamentally, such scenarios require a broad 'one health' approach.

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