1 Title: The influence of childhood nature experience on attitudes and tolerance towards

2 problem-causing animals in Singapore

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Highlights

- Human-wildlife conflicts are common in cities with abundant green areas
- Singapore residents have low wildlife affinity and tolerance
- Wildlife attitudes were strongly correlated with childhood nature experience
- Tolerance of problem wildlife decreased with increasing severity of damage caused
- Childhood nature experience has long-lasting consequences on wildlife tolerance

Abstract

Low vegetation cover in cities result in urbanites generally receiving less exposure to nature compared to people living in rural areas. Consequently, childhood experiences in a city tend to be less nature-oriented, leading to a detachment from nature in adulthood. However, some cities may have pockets of green spaces that harbour wildlife, and interactions between people and the wildlife around them may have an influence on wildlife conservation attitudes. To investigate the relationships between childhood nature experience and attitudes towards wildlife, we carried out a survey on 1004 Singapore residents about their attitudes and tolerance towards three types of wildlife commonly encountered in Singapore. Structured equation models (SEMs) were used to model the relationship between childhood experience, attitudes towards wildlife, and tolerance levels in three scenarios of increasing damage severity to humans. We found that most respondents had low childhood nature experience, and had neutral / negative attitudes towards all three types of wildlife. Childhood experience was the strongest predictor of wildlife attitude, which varied with age, gender, education level and type of wildlife. Attitude towards wildlife was the strongest predictor of tolerance in all scenarios, while tolerance decreased with increasing severity of damage. Our findings point to the importance of childhood nature experience in shaping adult perceptions of wildlife and their willingness to coexist with wildlife. Given that Singapore is continually developing on forested land for residential and commercial purposes, wildlife encounters are predicted to increase in the future. With proper planning and education, residents near wildlife habitats can learn to live with and appreciate the wildlife around them.

Keywords: coexistence with wildlife, structured equation modelling, urban wildlife, wildlife aversion

Introduction

As cities expand, wildlife habitats on city fringes are reduced, leading to increased human-wildlife interactions and conflicts. Media reports on human-wildlife conflicts are common in many cities, and may reflect the frequency, severity, and attitudes of the general public towards wildlife. However, peoples' perceptions towards wildlife are also influenced by their prior experiences and encounters with them (Røskaft et al., 2003; Kretser et al., 2009; Pinheiro et al., 2016).

The public's attitude and tolerance towards wildlife has a large influence on the management of problem-causing animals in cities. A survey done in ten metropolitan areas in the U.S. found that urban residents spent considerable time and money not only on repairing damage done by wildlife, but also on encouraging wildlife around their homes (Conover, 1997). Attitudes of urban residents towards wildlife were generally positive (Harrison, 1998; Dowle & Deane, 2009; McDonald et al., 2012), although bad experiences with animals may promote doministic and negative attitudes (Houston et al., 2010; Jonker et al., 2006). While the physical management of wildlife, such as containment within park boundaries, culling of wildlife etc. are direct methods to control wildlife numbers and their spread, understanding the human dimensions in human-wildlife interactions is equally important in creating an effective wildlife management programme, because it is ultimately human preferences that determine the way conflicts are resolved (Manfredo & Dayer, 2004). Effective wildlife management is dependent on minimizing negative impacts on wildlife while meeting people's expectations on how wildlife should be managed (Decker & Purdy, 1988; Lute & Attari, 2017). Public expectations may differ between countries and cultures, so what works for one social group may be ineffective for another group (Manfredo & Dayer, 2004).

As urban areas worldwide expand, people's exposure to wildlife and nature is expected to decrease, and generations increasingly live without constant contact with nature. 'Nature' is a word that has many interpretations. With regards to children and childhood, 'nature' has often been portrayed as being separate from 'culture' (Taylor, 2011; Taylor & Giugni, 2012). Young people themselves have described 'nature' as landscapes outside human influence (von Benzon 2018). Here we use a wide definition of 'nature' and associate it with words like 'outdoors', 'greenery', and 'wilderness'. In urban environments, nature would include semi-natural environments such as urban parks, gardens and farms.

People who are exposed to nature and animals from a young age would have had to deal with uncomfortable and conflicting feelings when coming into contact with nature, such as worms, ants, shadows and dirt (Milligan & Bingley 2007; Taylor & Pacini-Ketchabaw, 2015; 2017). The human instinct of caring for animals is also usually cultivated from young (Myers et al. 2004). Such interactions instill a sense of awareness about the world we share with other creatures and 'decentre the human as the sole learning subject' (Taylor & Pacini-Ketchabaw, 2015). Therefore we believe that early exposure to nature increases affinity to wildlife and cultivates tolerance towards problem-causing animals among urban residents. Children's nature experience has been shown to influence their intention to participate in nature-based activities in future (Cheng & Monroe, 2012) and their knowledge of (Chipeniuk, 1995) and willingness to conserve biodiversity (Soga et al., 2016). Childhood nature experience has also been shown to have a positive relationship to environmental attitudes and behaviors (Wells & Lekies, 2006; Chawla, 2007).

Singapore is a highly urbanized city that has developed rapidly in the past six decades (Gupta, 1992). More than 99% of the original forest cover has been cleared, although there is currently about 20% forest cover that is predominantly secondary growth (Yee et al., 2011).

In Singapore, urban wildlife species are usually those that can withstand disturbed habitats, such as secondary forests and open areas (Corlett, 1992). Common species include the Javan Mynah (*Acridotheres javanicus*), Long-Tailed Macaque (*Macaca fascicularis*), Wild Boar (*Sus scrofa*), Plantain Squirrel (*Callosciurius notatus*) etc. Some of these species cause problems when they turn aggressive on humans, rummage through garbage bins or steal food from homes (Sha et al., 2009). Reports about animals causing problems in cities are not uncommon (e.g. Houston et al., 2010; Cassidy & Mills, 2012), with complaints about wildlife increasing every year in Singapore (Fig. S1). However, it is unclear whether these increases are caused by a rise in wildlife abundance, or whether tolerance towards wildlife has decreased.

Residents in Singapore typically receive very low exposure to natural landscapes and experiences (Kong et al., 1999). A qualitative study on nature perspectives of youths in Singapore found that they had low interest and affinity for nature, due to their upbringing in a highly urbanised environment, over-protective parents, and an abundance of other entertainment options (Kong et al., 1999). Another survey found that although most adults in Singapore were supportive of biodiversity conservation, they preferred manicured landscapes such as parks and gardens even though such landscapes do least in supporting biodiversity (Khew et al., 2014). Their responses were likely driven by aesthetic preferences and childhood exposure to such landscapes (Khew et al., 2014). Previous surveys about wildlife attitudes and preferences in Singapore tended to focus on the Long-Tailed Macaque, and were both qualitative (Yeo and Neo, 2010) and quantitative (Sha et al., 2009; Liu, 2018). Sha et al. (2009) conducted face-to-face surveys on both residents and visitors at parks where Long-Tailed Macaques frequented, and found that resident attitudes towards macaques were significantly more negative than visitors attitudes, given that residents experience more frequent negative interactions with macaques. However, both residents and visitors believed

that macaques should be conserved and preferred education-based solutions over eradication (Sha et al., 2009). Nevertheless, their findings may be biased towards nature-lovers and may not represent the average Singapore resident. Taken together, these studies showed that knowledge about wildlife was low among Singapore residents, and that tolerance for problem-causing animals depended on the kind of animals and the people interviewed (Liu, 2018).

This study aims to understand the attitudes and tolerance of Singapore residents towards three common problem-causing animals and the relative effects of the factors that influence them. To our knowledge, no such survey has been done in Singapore before, although studies with a similar theme have been done in the US and UK (e.g. Palmer & Suggate, 1996; Wells and Lekies, 2006; Thompson et al., 2008; Asah et al., 2012), and one in Japan (Hosaka et al., 2017). We believe that our study contributes to Asian perspectives of wildlife attitudes amongst the predominantly American / European perspectives reported in the literature. We constructed a structural equation model to analyse relationships between childhood nature experience, attitudes and tolerance towards wildlife (Fig. 1). We hypothesized that childhood nature experience (Experience) has a positive effect on affective attitudes (Attitude) towards problem-causing animals, and that Attitude in turn has a positive effect on tolerance (Tolerance). Experience may also have a direct positive effect on Tolerance (Fig. 1). Following findings from previous studies, we hypothesized that males will have higher tolerance than females (Butler et al., 2003; Campbell and Lancaster, 2010), and that respondents with children will have lower tolerance (Hosaka et al., 2017), but will increase with education level (Kellert, 1984; Bjerke & Østdahl, 2004). In addition, we hypothesized that older respondents, especially those born before independence (before widespread conversion of forest to urban centres; age ≥50), would have more positive attitudes and higher tolerance towards problem-causing animals.

Methods

Study site

We conducted a questionnaire survey in Singapore, a highly urbanised tropical country with 5.6 million inhabitants (Singapore Department of Statistics, 2017). With a population density of about 7800 persons per km^2, Singapore is the third densest country in the world (World Bank, 2018). The Singapore government has drafted a national 'Green Plan' since 1992 to tackle resource consumption and waste generation (Moiz, 1993). Nature conservation was included in the plan, but this occurred after the early phases of infrastructure development had been accomplished, during which two mangrove reserves were cleared and pressure mounted on the existing reserves (Anon., 1992). National Parks Board, the government agency that oversees public green spaces, currently has numerous national programmes to enhance and connect urban greenery, such as the Park Connector Network (NParks, 2018a). This may be a result of the government's 10-year Master Plan for city development, in which two key foci are recreation and public spaces, where green spaces and nature were prominently featured (URA, 2018).

Questionnaire

We designed a series of questions that covered the attitudes and tolerance of respondents towards three common nuisance animals – long-tailed macaque, hornets, and pythons. The online questionnaire was administered to 1004 Singapore residents aged 18-69 years by an Internet research company (Macromill, Inc.). We collected equal numbers of responses for

each gender group (502 males and 502 females) and comparable numbers for each age group (e.g. 63 of 18-19 year-olds, 100 of 20-24 year-olds, 114 of 25-29 year-olds, etc.), although there were fewer respondents in the groups ≥55 years old (Table S2). The survey was entirely online, and respondents were grouped into their respective gender and age groups until the target number of respondents was reached for each group. This method ensures an even sampling from different age and gender groups. We were also able to get a large sample size within a short period of time. Potential disadvantages include having a sample that may be biased towards those who were more internet-savvy (Hosaka et al., 2017). The data were rendered anonymous when we received it, so there is no potential risk to individual privacy.

Attitude was quantified by asking respondents to rate their affective attitude (like or dislike) towards each of these animals on a 5-point scale ranging from 1 (dislike) to 5 (like), with 3 as a neutral point. Tolerance was assessed by measuring the level of acceptance associated with different degrees of management actions in three scenarios for each animal (Table 1). The scenarios for encountering macaques (M1-M3), hornets (H1-H3), and pythons (P1-P3) were in increasing severity of damage. For all scenarios, five possible management actions were listed: (m1) do nothing, (m2) monitor the situation, (m3) alert the public, (m4) translocate the animal or nest, (m5) trap and eliminate the animal. For each of the five management actions, respondents chose a level of tolerance on a 5-point scale, ranging from 1 (totally unacceptable) to 5 (totally acceptable), with 3 as a neutral point.

Experience was quantified from a question about the frequency of green space use and another about frequency of participation in nature-related activities in their childhood (≤12 years of age). Green spaces included parks, forests, farms/plantations, and rivers/beaches, while nature-related activities included insect-catching, fishing, collecting flowers and fruits, bird-watching, tree-climbing, and swimming in the river/ocean. Respondents answered on a

5-point scale, ranging from 1 (never; no experience) to 5 (very often; almost every day), with 3 being sometimes (about once a month). Although such retrospective self-reporting may not provide high accuracy of actual childhood nature experience (Hardt & Rutter, 2004), we still used this method as it is difficult to obtain reliable objective data.

Data analysis

We used the mean scores of m1-m3 for each scenario as a measure of tolerance, because the scores represented the acceptability of the animals without removal. The Cronbach's alpha for m1-m3 were higher than the recommended 0.8 reliability (Lance et al. 2006) for all the scenarios: 0.87 (M1), 0.85 (M2), 0.86 (M3), 0.84 (H1), 0.85 (H2), 0.87 (H3), 0.87 (P1), 0.87 (P2), 0.86 (P3). Experience was calculated as the mean scores of all the items in the two Experience questions (Cronbach's alpha = 0.91). Differences in attitudes towards the three nuisance animals were tested using the Kruskal-Wallis test.

For sociodemographic parameters, we used age, gender (1 – male, 2 – female), formal education level and whether or not respondents had children, because they have been shown to affect wildlife affective attitudes (Kellert, 1984; König, 2008; Hosaka et al., 2017). The full model consists of experience and the four sociodemographic parameters having direct effects on Tolerance, as well as mediated effects on Tolerance via Attitude (Fig. 1). The standard errors of the mediating effects were calculated using the Delta method. SEM fitness was checked using the χ^2 goodness-of-fit statistic and the p-value, the comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardised root mean square residual (SRMR; Table S3). All SEM analyses were done in R (R Core Team, 2018) using the lavaan package (lavaan 0.6-2).

Results

Experience was low among Singapore residents - 55.3% of respondents seldom / never played in natural environments or engaged in nature-related activities in their childhood (Fig. 2). Only 15.5% of respondents reported frequent visits to and played in natural environments in their childhood (Fig. 2).

Attitudes towards macaques were more positive than for snakes and hornets (Fig. 3; Kruskal-Wallis $\chi^2 = 435.64$, df = 2, $p < 0.001$). 52% of respondents had negative feelings towards hornets and snakes, while only 14% of respondents had negative feelings towards macaques (Fig. 3). Female respondents had significantly more negative attitudes towards the three animals compared to males (Fig. S4).

Tolerance was generally low for all animals, with most respondents choosing animal translocation as the most acceptable management solution (Fig. 4). However, killing of the animal was less acceptable than translocation, except in scenario H3. The python was the least tolerable of the three animals in all three scenarios, followed by the hornet and macaque. As the severity of damage done by animals increased, the acceptance of passive management decreased.

SEMs showed that attitude was the strongest predictor of tolerance in all scenarios except M3, where age was the strongest predictor (Fig. 5). The effect of attitude on tolerance decreased with increasing severity of damage (M1 to M3), remained similar from P1 to P3, while it increased from H1 to H2, and then decreased from H2 to H3. Age, gender, and experience were the next most important predictors of tolerance, while education and presence of children were significant predictors in 4 out of the 9 scenarios (Fig. 5).

Experience had positive and the strongest effect on attitude towards macaques and hornets, while gender had negative and the strongest effect on attitude towards pythons (Fig. 5). Education had a significant positive effect on attitude towards hornets, with lower-educated respondents showing proportionately more negative attitudes (Fig. S4), while age did not affect hornet attitudes. The opposite was found in the macaque and python models – age but not education had a significant negative effect on attitudes. The model fitness indices indicated good fits for all models (Table S3; model χ^2 p value > 0.05; CFI ≥ 0.95; RMSEA < 0.07; SRMR < 0.08; Hooper et al. 2008).

Discussion

Our results show that exposure to nature among Singapore residents was low, while attitude towards common problem-causing wildlife were largely neutral or negative. From surveys in Scotland and Japan (urban), the proportion of respondents who seldom / never participated in nature-related activities were 33% and 35% respectively (Thompson et al., 2008; Soga et al., 2018), compared to 55.3% in this study. From surveys on urban residents in the US, Wells & Lekies (2006) found a mean score of 2.78 for all nature participation items, based on a 4-point scale ranging from 'never' to 'often', showing that on average people were more 'often' engaged in nature-related activities. In addition, our findings support the hypothesis that childhood nature experience has positive effects on attitudes and tolerance towards problem-causing animals. Low levels of childhood nature experience was correlated with negative attitudes and low tolerance.

The terms 'nature deficit disorder' (Louv 2005) and the 'extinction of experience' (Miller, 2005; Soga & Gaston, 2016) have often been used to express the widening gulf between

humans and nature. It describes a self-reinforcing cycle where children that grow up in cities with little greenery having little exposure to nature, and eventually becoming estranged from nature as adults. Numerous studies on children's interactions with nature found that children generally held positive imagery of nature (Simmons, 1994; Billmann-Mahecha & Gebhard, 2009), but children from urban backgrounds tended to have more fears of natural elements such as wildlife and falling trees (Simmons, 1994; Bixler & Floyd, 1997). Direct participation in nature activities was found to be effective in fostering connections with nature (Mikels-Carrasco, 2010; Giusti et al., 2014; Barthel et al., 2018; von Benzon, 2018), and even vicarious experiences like reading books or watching TV programmes about nature help encourage such connections to nature (Soga et al., 2016 [IJERPH]).

Not surprisingly then, childhood nature experience has been linked to affinity towards nature (Tanner, 1980; Chawla, 1998; Kals et al., 1999) and active care for the environment in adulthood (Wells & Lekies, 2006; Chawla, 2007). Nature experience forms a foundation for environmental knowledge and perceptions that can lead to support for sustainable development (Bögeholz, 2006) and animal conservation (Zhang et al., 2014). People who have negative perceptions of problem-causing wildlife may feel that wildlife, or nature in general, are outside of their lives, i.e. humans are said to be alienated from nature, or from the environment (Vogel 1988; Stone 2014). Although humans have tamed and manipulated nature to an extent far greater than any other species (Sanderson et al., 2002), the erratic and unpredictable movements of wildlife may be a cause of distress for some people, especially when the animals are in close proximity.

The landscape of Singapore has changed dramatically over the past 50 years – forests and farms were cleared, giving way to high-rise residential apartments, factories, roads, and other infrastructure (Savage, 1992). Consequently, natural landscapes were reduced to a few nature

forest reserves, the largest one being part of a system of water reservoirs in the central part of the island country. The lack of natural landscapes in Singapore mirrors the low level of childhood nature experience of Singapore residents. A qualitative survey found that youths in Singapore had little interest in and affinity for nature (Kong et al., 1999). One common image these youths had was that 'nature' was orderly and well-maintained (Kong et al., 1999), a characteristic of parks and gardens in Singapore. Trees and shrubs in parks and gardens are often planted widely-spaced apart, and are regularly pruned, while grasses are regularly mowed. A study about landscape preferences of Singapore residents found that manicured parks were the most favoured landscape (Khew et al., 2014). Fear of animals was also reflected in a statement by one youth - "you never know if the insect is going to bite you and whether it's going to cause a swelling or [cause you to] need an injection" (Kong et al., 1999). Those who felt safe and enjoyed being in nature either had plenty of childhood nature experience in other countries, or enjoyed exercising control over small animals such as insects and pets (Kong et al., 1999). This may be a sign that human-nature relationships in Singapore tend to be negativistic and doministic (Kellert 1984).

In addition, Singaporean children are put under tremendous pressure to excel academically from a young age. Many parents enrol their children in after-school tuition classes (Teng 2016), and Singapore teenagers spend an average of 9.4 hours on homework per week, about twice as much as the global average (Teng 2014). Singaporean children also spend more time online than the global average, with the most time spent on watching videos and playing online games, followed by using social media apps (Hio 2018). These are predominantly indoor activities, and are evidence that children in Singapore generally spend little time outdoors.

From our results, although macaques were the most well-liked animal among the three, translocating them was the most acceptable response, followed by education (Fig. 4, M1). This was the opposite result from Sha et al. (2009), who found that at the parks where macaques frequented, residents near the parks and the visitors largely preferred education about co-existence with macaques (63.6% of respondents) over eradication and removal from parks and urban areas (36.4%). This was surprising given that the overall proportion of respondents who showed strong or mild liking for macaques in their study was 32.9%, lower than in this study (39.4%). It may be interesting in future to study how attitudes may change when respondents are exposed to different environments.

Over 50% of respondents expressed dislike towards hornets and pythons, perhaps reflecting the negative images that these animals conjure. In a qualitative survey of elementary and high school students, causes of distress by hornets were described as ‘sting’ and ‘buzz’, while distress by snakes were described as ‘slimy’, ‘wiggle’, and ‘poisonous’ (Woolever, 1953). These fears, some of which were unfounded, were likely passed from parents to children without actual experiences with the animals (Woolever, 1953; Crane, 1976; Bixler & Floyd, 1997). For some people, the phobia for these animals may be so great that the terror caused by these fears overcome the actual physiological reactions, as in the case of a 28-year-old computer mathematician who died from heart failure mistakenly believing that he had been stung by a wasp (Crane, 1976). As with other kinds of fears, constant exposure to the cause of the fear in small steps, in this case nature and wildlife, can help to rationalise peoples’ feelings towards animals.

Contrary to our predictions, older people did not have more positive attitudes and tolerance towards wildlife, but instead had a higher intolerance and dislike towards wildlife. This may be due to the majority of the population being concentrated in the then colonial town, a plan

that was drawn up more than a century prior to independence (Savage, 1992). In 1966, 61% of the population resided in 16% of Singapore's area (Neville, 1969). The crowded living conditions and a proliferation of squatter settlements may not have allowed for much nature experience when the older respondents were growing up. Decreasing tolerance for wildlife with increasing age was also found in other cities (Butler et al., 2003; Campbell & Lancaster, 2010; Hosaka et al., 2017), so this observation may be a norm rather than an exception.

Our study found that males have more positive attitude and tolerance for problem-causing wildlife than females, similar to findings from other studies in USA (Kellert, 1985), Norway (Bjerke & Østdahl, 2004), Tanzania (Kaltenborn et al. 2006), China (Zhang et al., 2014) and Japan (Hosaka et al., 2017). This suggests that such inter-gender differences are common across different cultures. Although our study was not to elucidate the underlying mechanism of the differences, some previous studies reported that women often display higher levels of disgust sensitivity than men (Haidt et al., 1994) and specific phobias are far more common among women than men (Smith & Davidson, 2006). However, gender alone does not explain individual variation in attitudes (Herzog et al., 1991) and childhood nature experience had much greater effects on attitude and tolerance toward macaque and hornets than gender (Fig. 5).

The low affinity to nature of Singapore residents is also reflected in highly built-up cities of other countries, such as in Saudi Arabia (Seddon & Khoja, 2003) and Pakistan (Qureshi et al., 2013). The scarcity of nature areas in cities, coupled with indoor sedentary lifestyles of urban dwellers (Fitzgerald et al., 1995; Wong, 2009; Peltzer & Pengpid, 2016), often lead to reduced human-nature interactions. Besides a potential loss of health benefits associated with nature exposure (Takano et al., 2002; Maas et al., 2006), the declination of time spent with nature may result in disaffection towards nature, and result the "extinction of experience"

(Miller, 2005; Soga & Gaston, 2016) mentioned earlier. Such a phenomenon may lead to reduced public support for biodiversity conservation (Miller, 2005). It is interesting to note that wildlife-related complaints in Singapore increased sharply from 2013 to 2015, followed by an equally sharp decrease (Fig. S3). It is not clear why the number of complaints increased in 2013, but the decrease that followed was due to more intensive culling of animals by authorities in response to the complaints (Lee, 2016).

Despite the low tolerance of wildlife, people prefer to avoid killing animals even when they cause problems (Fig. 4). Similar findings of preferences for non-lethal wildlife management have been reported from other studies (Reiter et al., 1999; Sha et al. 2009; Massei et al., 2010). Hosaka et al. (2017) found that urban and suburban residents in Japan preferred to eliminate hornets even if they were just sighted, while our survey respondents preferred not to kill animals if they had not done any harm yet, possibly indicating a slightly higher tolerance for wildlife. However, translocating animals received the most support from respondents, even if the animals were only sighted and were not causing problems. This may be due to perceived risks being higher than actual risk (Delfosse, 2005; Slimak & Dietz, 2006), with fear and misunderstanding driving potential actions (Hadidian, 2015). In Singapore, reports about animal roadkills are common (e.g. Anon., 2017; Lam, 2017a, 2017b; Tan, 2018), while human fatalities from wildlife are relatively rare, showing that certain fears about wildlife are unfounded. Therefore there is potential for residents to coexist with wildlife given the right understanding of animal behaviour and risks.

Amidst the scarcity of natural habitats in Singapore, the government has tried to maintain some existing green spaces, such as the Rail Corridor, an old railway track that spans 24 km from the north to south end of Singapore (NParks, 2018b). However, there are upcoming development that will result in a net loss of secondary forest cover, such as the Tengah

residential housing project (Yeo, 2016). This may reduce wildlife habitat and increase human-wildlife conflict in the future, but if planned properly, could provide residents plenty of opportunities to engage with nature.

Conclusions

We found that childhood nature experience had a significant effect on adult attitude and tolerance towards problem-causing animals in a tropical urban population in Singapore. Residents in Singapore generally had low childhood nature experience, and consequently had neutral or negative attitudes towards wildlife and low tolerance for them. Recent land development projects led by the government aim to incorporate greenery into residential areas, but these greenery are either artificial or are the result of forest removal, and has the ironic effect of reducing biodiversity. This is because habitat areas for wildlife are reduced, especially for large animals such as wild boar, macaques, and sambar deer, which require large areas of forest to roam and live. Nevertheless, there are pockets of 'wild' nature remaining in Singapore - small patches of primary forest and substantial areas of mature secondary forest. These wild habitats harbour a different kind of wildlife than the 'pest' species that live amongst humans, such as the Javan Mynahs that pick food scraps from leftovers, and Rock Pigeons that defecate on building ledges and vehicles. Rare plant and animal species have been found only in these wilder forests (Turner et al., 1994; Castelleta et al., 2005; Lane et al., 2006), so there is an obvious value in preserving them instead of 'manicuring' them. Indeed, perhaps it is time to start 'rewilding' green lawns, based on a survey that found that people in Singapore do not mind slightly wilder natural growth around them (Hwang et al., 2019).

There are efforts by government (Community in Bloom by National Parks Board) and non-governmental organisations (Every Singaporean a Naturalist by Nature Society Singapore) to engage Singaporeans in getting closer to nature. The Animal Concerns Research and Education Society (ACRES) has a 24-hour wildlife rescue hotline for the public to report wildlife that they do not know how to handle, as well as resources and volunteer opportunities to care for rescued wildlife. The above-mentioned programmes are among the scores of options that exist for those who are interested in organised nature-related activities. If 'rewilding' does occur, it would be important to follow up with surveys of flora and fauna in those areas, as well as more detailed surveys on how much time children spend outdoors in nature areas. A longitudinal study on nature and wildlife attitudes will contribute significantly to understanding peoples' relationships with nature.

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Authors' contributions

TH and SN conceived the ideas and designed methodology; KMN analyzed the data and led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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Figure legends

Figure 1. Model of the hypothesized relationships between tolerance, attitudes, childhood nature experience and various sociodemographic factors.

Figure 2. Levels of childhood nature experience among 1004 Singapore residents.

Figure 3. Attitudes of respondents towards macaques, hornets, and snakes.

Figure 4. Acceptance and tolerance of actions associated with animal encounters (M = macaque, H = hornet and P = python) of varying damage severity (1 = animal sighted/living near residence, 2 = animal caused light damage; 3 = animal caused severe damage).

Figure 5. Path coefficients of the SEM for attitude and tolerance towards macaque, hornet and pythons in three scenarios of increasing damage severity, after removal of non-significant paths. Line thickness represents significance levels in increasing order: $p < 0.05$, $p < 0.01$ and $p < 0.001$.

Figure 1.

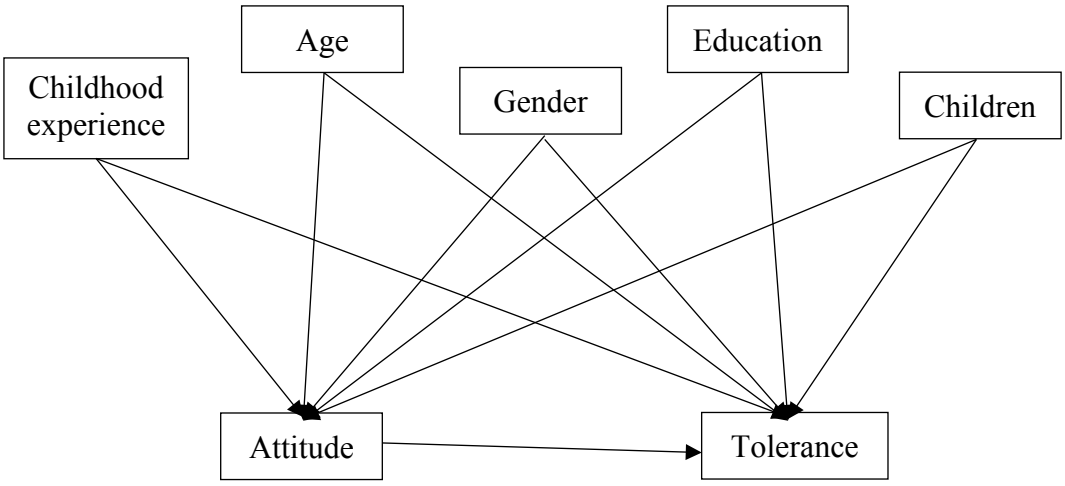
Childhood experience
Age
Gender
Education
Children
Attitude
Tolerance

Figure 2.

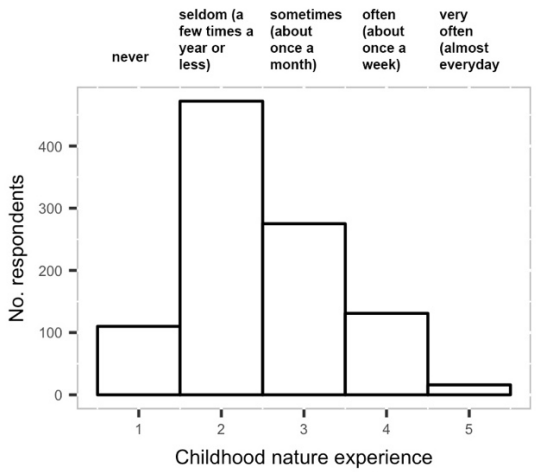
never
seldom (a few times a year or less)
sometimes (about once a month)
often (about once a week)
very often (almost everyday
No. respondents
0
100
200
300
400
1
2
3
4
5
Childhood nature experience

Figure 3.

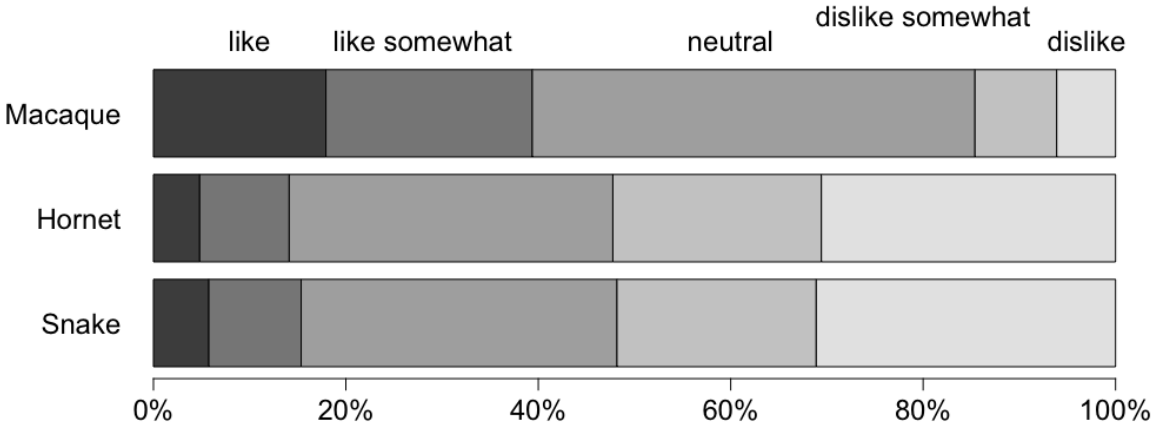
like
like somewhat
neutral
dislike somewhat
dislike
Macaque
Hornet
Snake
0%
20%
40%
60%
80%
100%

Figure 4.

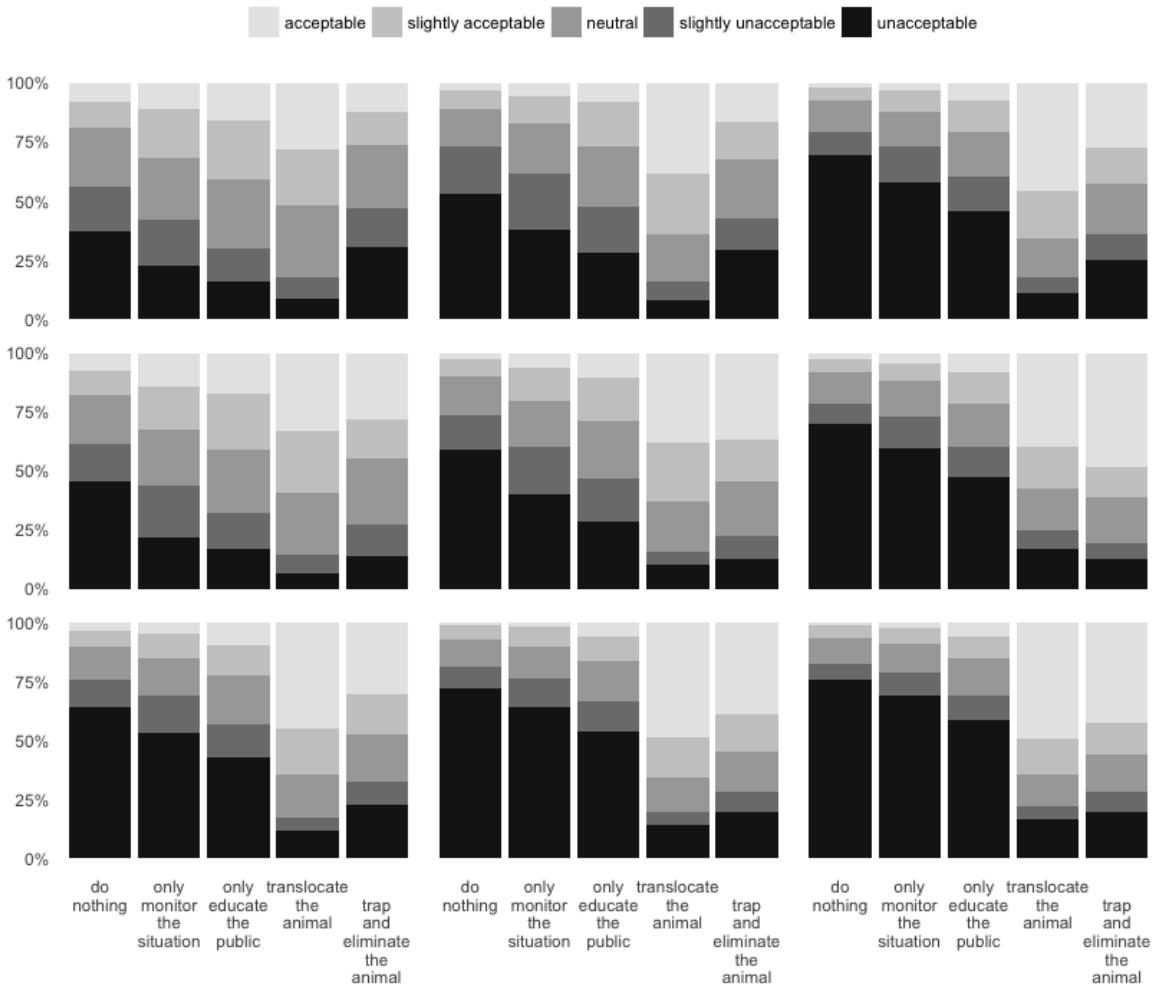
acceptable
slightly acceptable
neutral
slightly unacceptable
unacceptable
100%
75%
50%
25%
0%
do nothing
only monitor the situation
only educate the public
translocate the animal
trap and eliminate the animal

Figure 5.

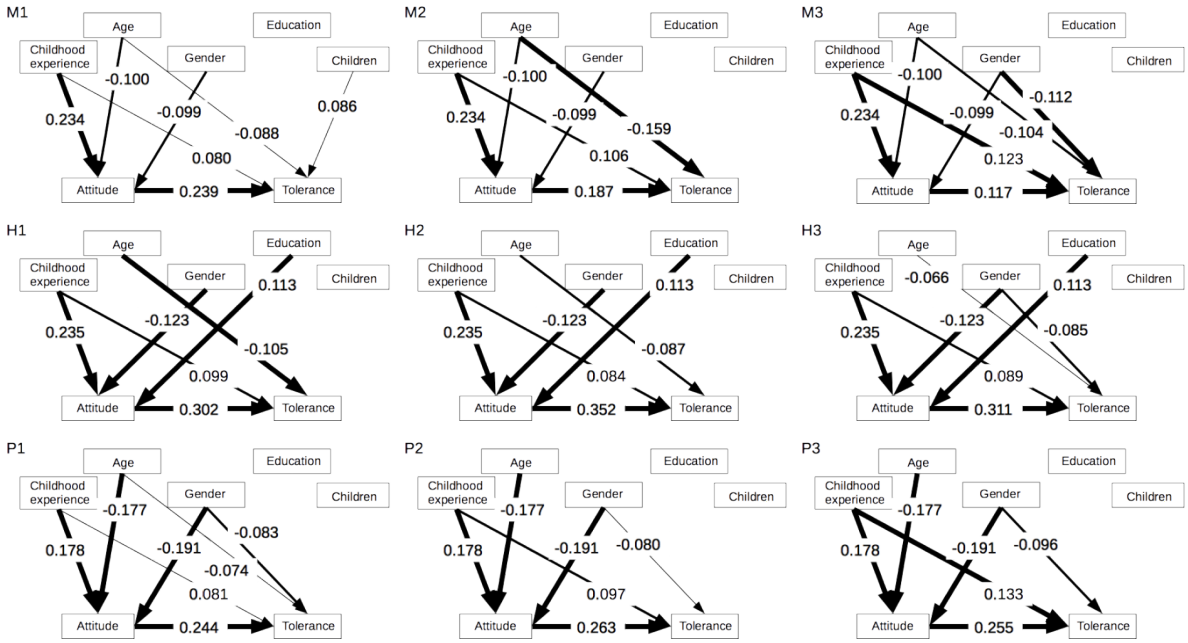
M1
Age
Education
Childhood experience
Gender
Children
-0.100
0.234
-0.099
0.086
-0.088
0.080
Attitude
0.239
Tolerance
M2
Age
Education
Childhood experience
Gender
Children
-0.100
0.234
-0.099
-0.159
0.106
Attitude
0.187
Tolerance
M3
Age
Education
Childhood experience
Gender
Children
-0.100
-0.112
0.234
-0.099
-0.104
0.123
Attitude
0.117
Tolerance
H1
Age
Education
Childhood experience
Gender
Children
0.113
0.235
-0.123
-0.105
0.099
Attitude
0.302
Tolerance
H2
Age
Education
Childhood experience
Gender
Children
0.113
0.235
-0.123
-0.087
0.084
Attitude
0.352
Tolerance
H3
Age
Education
Childhood experience
-0.066
Gender
Children
0.113
0.235
-0.123
-0.085
0.089
Attitude
0.311
Tolerance
P1
Age
Education
Childhood experience
Gender
Children
-0.177
0.178
-0.191
-0.083
-0.074
0.081
Attitude
0.244
Tolerance
P2
Age
Education
Childhood experience
Gender
Children
-0.177
0.178
-0.191
-0.080
0.097
Attitude
0.263
Tolerance
P3
Age
Education
Childhood experience
Gender
Children
-0.177
0.178
-0.191
-0.096
0.133
Attitude
0.255
Tolerance

Table 1. Human-wildlife interaction scenarios with increasing severity of problem for each animal.

No.	Scenario
H1	Hornets have flown to a park near your house. There is a chance that park visitors will encounter them.
H2	Hornets have made a nest in a park near your house. There is a chance that park visitors will get stung by them.
H3	Hornets nesting in a park near your house have attacked and severely injured a park visitor.
M1	A troop of macaques lives in a park near your house. There is a chance that park visitors will encounter them.
M2	A troop of macaques living in a green space near your house have disturbed gardens and damaged fruits and vegetables.
M3	A troop of macaques living in a park near your house have attacked and severely injured a park visitor.
P1	Pythons live in a park near your house. There is a chance that park visitors will encounter them.
P2	Pythons living in a park near your house has killed your pets.
P3	Pythons living in a park near your house have attacked and severely injured a park visitor.

Supplementary information

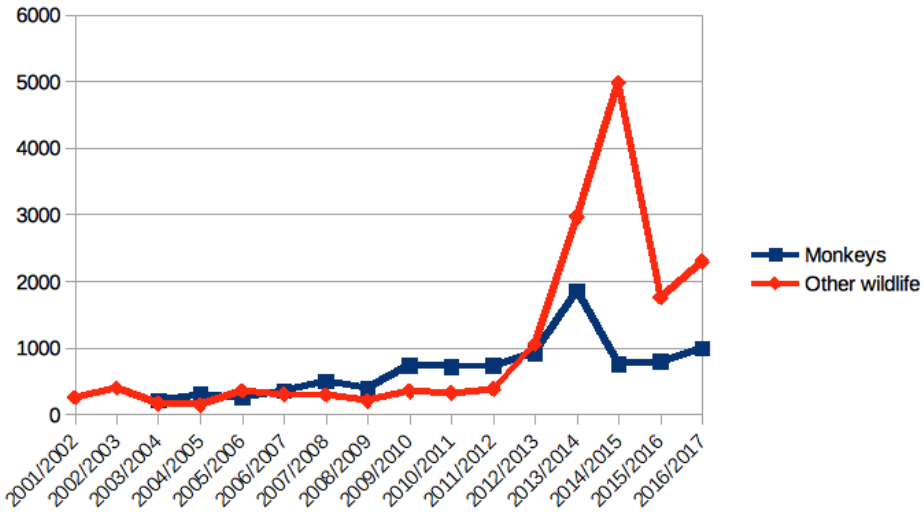

Figure S1. Number of wildlife-related reports to the Agri-Food and Veterinary Authority of Singapore (AVA Annual Reports 2002-2017). Other wildlife may include snakes, wild boar, or birds.

Table S2. Number of respondents in each age group.

Age group	Number of respondents
18-19	63
20-24	100
25-29	114
30-34	111
35-39	91
40-44	147
45-49	114
50-54	106
55-59	79
60-64	50
65-70	29

Table S3. SEM fitness indicators for each model.

Scenario	χ^2	*df*	*p*	CFI	RMSEA	SRMR
M1	4.238	2	0.120	0.986	0.034	0.013
M2	2.698	1	0.101	0.989	0.042	0.013
M3	0.000	0	-	1.000	0.000	0.000
H1	2.610	3	0.456	1.000	0.000	0.011
H2	2.796	3	0.424	1.000	0.000	0.010
H3	0.963	2	0.618	1.000	0.000	0.006
P1	0.000	0	-	1.000	0.000	0.000
P2	2.701	1	0.100	0.992	0.041	0.012
P3	2.891	1	0.089	0.992	0.044	0.013

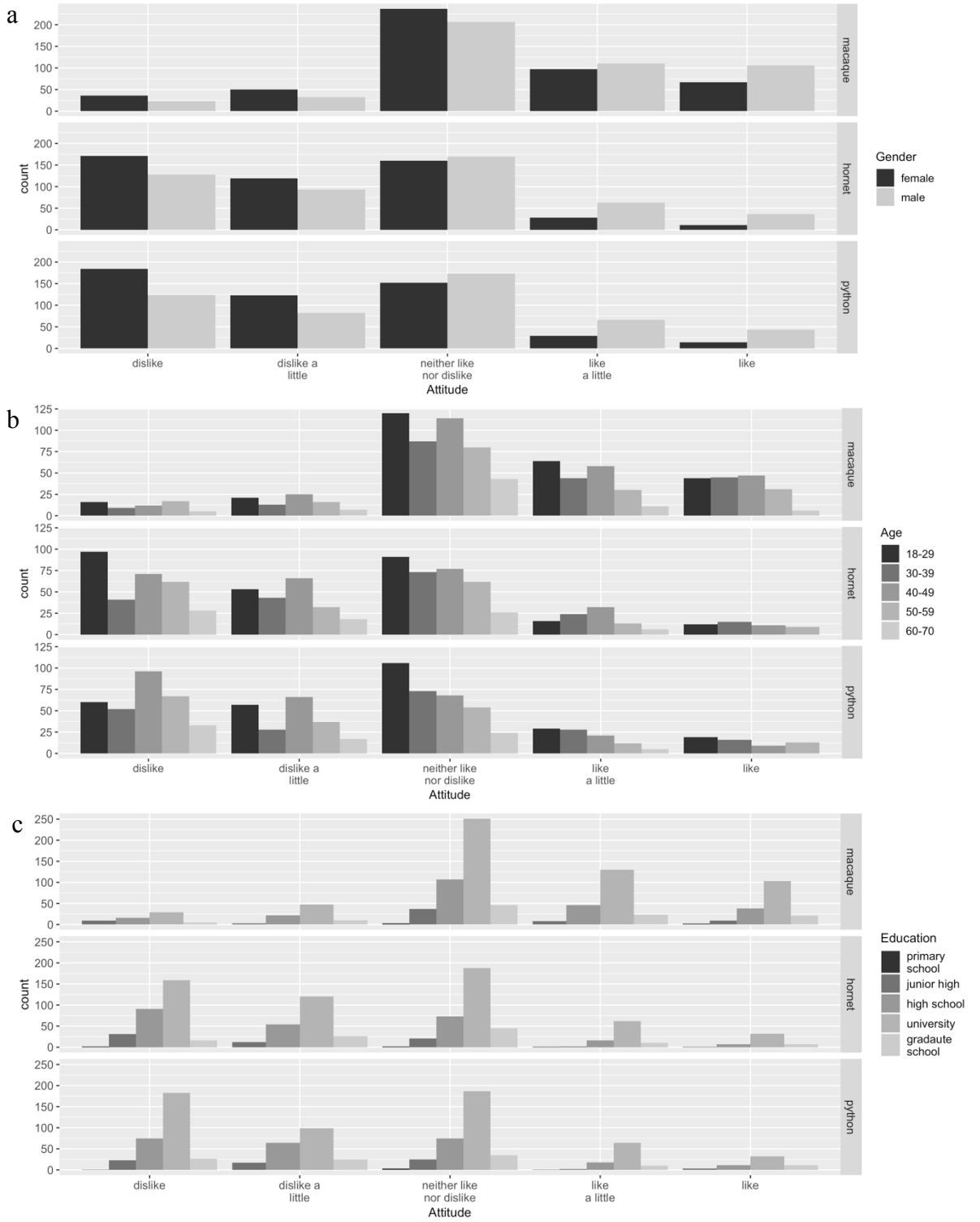

Figure S4. Attitudes towards the three animals grouped by a) gender, b) age, and c) education level.