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A citizen science survey: perceptions and attitudes of urban residents towards vervet monkeys

Lindsay Patterson[1] · **Riddhika Kalle**[1,2] · **Colleen Downs**[1]

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Abstract A diversity of indigenous and alien wildlife persists in suburbia, and provides residents with the opportunity to experience wildlife. Suburban gardens may serve as refugia and foraging grounds for many primate species allowing them to populate within a largely urbanized landscape. However, this has led to the increasing human interactions with them, resulting in conflict. Our study investigated the perceptions of suburban residents towards urban vervet monkeys *Cercopithecus aethiops pygerythrus* within the Msunduzi and Ethekwini municipalities, KwaZulu-Natal, South Africa. We assessed how these related to the monkeys' presence, activities and interactions in residential gardens, and the value of wildlife to residents. Assessment was conducted through an online questionnaire survey. General attitudes of residents to vervet monkeys were canvassed by assessing the respondents' level of active engagement in wildlife watching within their properties. We analyzed 603 surveys submitted online using logistic regression and ordinal regression models. We ascertained that vervet monkeys were disliked by 29% of residents due to their aggressiveness, destructive behaviour in gardens and households, and perceived threat to native wildlife. Frequency and duration of foraging vervet monkeys in residents' gardens was influenced by the presence of pet dogs, fruiting trees, tall trees (>2 m), ratio of indigenous to alien vegetation of gardens, residency type, and active and passive food provisioning. Despite conflict, the majority of respondents appreciated urban wildlife (67%) and actively engaged in wildlife watching (88%), emphasizing the importance of incorporating human dimension values into the management of urban biodiversity. Our study highlights the value of citizen science in providing mechanisms for identifying priority management and conservation efforts at the highly complex human-wildlife interface in an urbanized landscape.

Keywords Citizen science · Human wildlife conflict · Urban · Vervet monkey · Online wildlife survey

Introduction

Over half of the world's human population currently lives in towns and cities, and therefore for a substantial proportion of humanity, interactions with wildlife predominantly take place within an urban, human-dominated system (United Nations 2013). Human-animal relationships occur on a regular basis due to a shared history of interactions, allowing humans and wildlife to predict the others' regular behavior (Hosey and Melfi 2012) and can impact on the lives of both humans and wildlife (Waiblinger et al. 2006). Sometimes urban dwellers speak of a beneficial sense of well-being that comes from their interactions with urban wildlife. However, this is not always the case and feelings towards wildlife in urban environments range from tolerance and welcoming of interactions, to absolute intolerance and hatred (Hosey and Melfi 2012).

Largely because of the unavoidable presence of humans in urban areas, considerable effort is needed to understand some of the most important aspects of the urban ecosystem (Jones 2003). Community-based wildlife surveys are of most use when seeking information on the presence and abundance of easily identifiable species (Lunney et al. 1997; Kanowski et al. 2001),

✉ Colleen Downs
downs@ukzn.ac.za

1 School of Life Sciences, University of KwaZulu-Natal, P/Bag X01, Scottsville, Pietermaritzburg 3209, South Africa

2 Present address: School of Ecology and Environment Studies, Nalanda University, Bihar 803 116, India

particularly where residents have lived in the same area for long periods of time and can therefore provide insights into changes in the abundance and diversity of local wildlife (FitzGibbon and Jones 2006). Thus, regular evaluations of community-based knowledge and attitudes are of great value when ascertaining the best approach to operate urban wildlife management programmes (Marsh 1982; Chauhan and Pirta 2010). Surveying public opinions additionally provides important clues to the content of potential conflict resolution programmes, and increases the likelihood of these being accepted and supported by the public, financially and otherwise (Decker et al. 1992; FitzGibbon and Jones 2006). There is an increasing awareness that human-wildlife conflict (HWC) resolution has tended to focus on wildlife management (Smith et al. 2006a; b), with the incorporation of human dimensions (Baruch-Mordo et al. 2009).

In urban areas of South Africa, some species have greatly expanded their range within the last five decades, including the vervet monkey *Cercopithecus aethiops pygerythrus* (Whittaker 2013). The increasing urbanization of KwaZulu-Natal (KZN) has led to a marked increase in HWC in suburban areas and further development is likely to exacerbate the levels of HWC (Wimberger et al. 2010a; b). Urban ecology research on non-human primates (hereafter referred to as 'primates') shows that the shrinking, fragmentation and conversion of primate habitats increases in human-dominated habitats (Strum 2010; Priston and McLennan 2013), and these are the primary driving forces behind human-primate conflicts and one of the greatest threats to primate survival (Laurance et al. 2002). Additionally, urbanization may compromise the conservation of urban-adapted primate species by spatially restricting and concentrating their urban populations, leading to increased intraspecies conflicts and disease transmission (Patz et al. 2004). Of greatest concern to urban wildlife management is the increased aggression towards humans that results from vervet monkeys becoming accustomed and expectant of food directly from humans (Basckin and Krige 1973; Brennan et al. 1985; Wimberger et al. 2010a; b). This behaviour has been documented in other urban-adapted monkeys in various regions of Africa (Loudon et al. 2014). As a result, vervet monkeys are common wildlife in rehabilitation centers, mainly due to their pest status and/or injury in urban areas (Wimberger et al. 2010a; b).

To further explore what factors may play a part in human attitudes towards urban wildlife, and its presence in KZN, we used an online questionnaire survey to assess the perceptions of mainly middle to high-income, suburban residents. We assessed how these related to the vervet monkeys' presence, activities and interactions in residential gardens, and the value of wildlife to residents, within the Msunduzi and Ethekwini municipalities of KZN. In particular we were interested in urban residents' attitudes towards vervet monkeys, however the general attitudes of residents to all wildlife was canvassed by assessing the respondents' levels of active engagement in wildlife watching within their properties. We hypothesized that there would be a range of responses concerning urban wildlife in general. Our expected predictors for negative attitudes towards vervet monkeys included the people's perception of vervet monkeys carrying possible health risks, the presence of raiding, and incidences of aggressive interactions with homeowners, their pets and/or other wildlife. We further hypothesized that the presence and behaviours of vervet monkeys', natural (foraging, feeding, interacting with wildlife) and opportunistic behaviours (raiding from homes, refuse and potentially birds' nests) in residential gardens, would be significantly influenced by specific garden characteristics, including tree presence and height, tree coverage (%), fruiting tree (presence and %), food provisioning (actively put out and passively through bird feeders), dog(s) presence, and the types of interactions vervet monkeys have with residents and their pets (aggressive/non-aggressive).

Methods

Study area and survey design

The Ethekwini and Msunduzi municipalities of KZN (Ethekwini city 29°85′85. 30″, 31°02′60. 02″, Msunduzi city 29°34′48. 82″ 30°22′26. 91″, Fig. 1) are comprised of mosaics of natural greenbelts, conservancies, and human-modified habitats of varying housing density, all within human informal settlements, suburban residences and public urban spaces, and despite the continued development of these municipalities, there is still a wide array of biodiversity to conserve (Roberts and Deiderichs 2002). KZN is one of the smallest provinces, yet it contains the second largest human population of the nine provinces of South Africa (Statistics South Africa 2007), with Durban city supporting one-third of the Province's human population of approximately 3.012 million (South African Demographics Profile, 2014) , as well as 60% of its economic activity (Ethekwini Municipality 2003). Vervet monkey presence in KZN far outlives urban development within the city, however with increased urbanization has come increased interactions between vervet monkeys and urban residents (Wimberger et al. 2010a; b), and residents

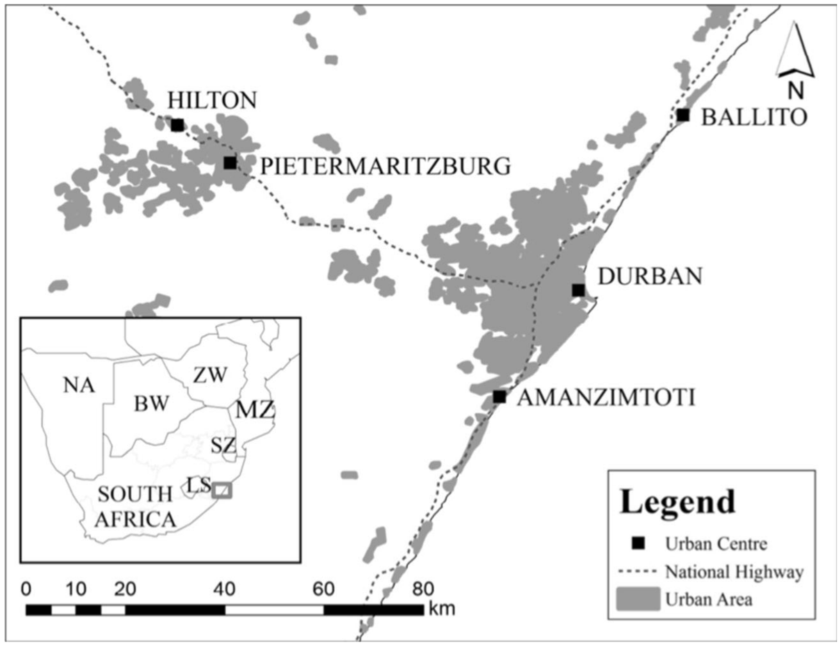

Fig. 1 Survey area inclusive of Ethekwini and Msunduzi municipalities of the KwaZulu-Natal Province, South Africa

deal with entire vervet monkey troops moving through their properties on a daily, weekly or monthly basis.

From March to September 2013 a self-administered electronic questionnaire was made available for suburban residents in the Ethekwini and Msunduzi municipalities to complete online through "Survey Monkey" (www.surveymonkey.com). The questionnaire's online link was distributed widely via email circulations, newspaper advertisements, online blog posts, school newsletters and advertisements at community meetings to suburban residents of these municipalities. University of KwaZulu-Natal (UKZN) postgraduate students and staff first assessed the survey before the online link was distributed to the public. The survey had UKZN ethical clearance, which complied with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008 (Protocol number HSS/0947/012 M). Photographs of vervet monkeys were included as an appendix to the questionnaire survey to aid each respondent's identification of the species and additional effort was made to use various colloquial names along with the reference images. The questionnaire consisted of 23 multiple-choice questions and six short answer questions, and was designed to take about 10 min to complete and submit. Recipients were asked to complete the survey only with regard to their own properties, unless asked otherwise.

Direct sampling

Respondents' attitudes towards selected urban wildlife were categorized as negative (dislike or hate), positive (like or love) or neutral. The survey respondents were asked to provide data on selected predictor variables within their residences, however it was expected that there would be a degree of error and variation in some of the submitted data on predictors, such as the ratio of indigenous to alien vegetation and the density of fruiting trees. Therefore, given that these variables were key to explaining the presence/absence and frequency of vervet monkey visitation rates, direct sampling was conducted by the principal investigator (LP) on a subset of residential gardens within the Ethekwini and Msunduzi municipalities in order to assess the confidence of the data provided.

We analyzed the respondents' attitudes towards vervet monkeys, and their presence and behaviour as functions of selected predictors chosen within the respondents' residences from responses to the online survey (Table 1). Ecological systems are complex and, as a result, ecological variables frequently correlate with each other. Multicollinearity can lead to invalid model results. Pearson correlation r-values, greater than 0.28 are shown to potentially bias analyses (Graham et al. 2003). Therefore, Pearson correlations were used to test for multicollinearity among predictors, with $|r| > 0.28$ set as the threshold (Graham et al. 2003). The presence/absence of tall trees (> 2 m) was correlated with indigeneous tree cover (%) ($r^2 = -0.28$), presence/absence of fruit trees ($r^2 = 0.28$), and presence/absence of garden ($r^2 = 0.4$). The presence/absence of fruiting trees in garden was correlated with vervets feeding in the garden ($r^2 = 0.34$). In such cases of multicollinearity we retained only one covariate of the correlated pairs of variables that was meaningful for the particular response in our models.

Table 1 The predictors were provided by survey respondents of the Ethekwini and Msunduzi municipalities of the KwaZulu-Natal Province, South Africa

Measure	Definition
Garden	Presence/absence of garden in the property.
Tree coverage (%)	Percentage of tree coverage in garden.
Indigenous trees (%)	Percentage of indigenous trees in garden.
Bird feeder(s)	Presence/absence of bird feeder(s) in garden.
Birds nesting	Presence/absence of birds nesting in garden.
Time of the year birds nest	Presence/absence of birds nesting in dry season (June–August), wet season (December–February), and/or year round.
Vervets feeding	Presence/absence of vervet monkeys feeding in garden.
Food provided for vervets	Presence/absence of food provisioning for vervet monkeys in garden.
Fruiting trees	Presence/absence of fruiting trees in garden.
Tall trees (> 2 m)	Presence/absence of tall trees (> 2 m) in garden.
Dog(s)	Presence/absence of dog(s) in garden.
Trees fruiting	How long the fruiting trees in garden fruit for on average (September to February, Year-round)
Vervets hurt/killed pets	Presence/absence of incidences involving vervet monkeys injuring or killing pets, or pet's known of.
Vervets eating rubbish	Presence/absence of vervet monkeys eating from rubbish bags or bins in or near property.
Vervets raiding homes	Presence/absence of vervet monkeys raiding home, or evidence of raiding.
Health risk	Presence/absence of perceived health risk of vervet monkeys.
Vervets raiding nests	Presence/absence of vervets raiding nests in garden.
Animals interacting with vervets	Presence/absence of animals interacting with vervets in garden.

Statistical methods

Relations between the response and predictors (Table 1) were investigated based on logistic regression models. The binary response variables; presence/absence of active engagement of urban wildlife watching by respondents, vervet monkeys feeding in gardens of respondents and presence/absence of aggressive interactions between respondents and vervet monkeys were modelled with binary logistic regressions. Each response variable was modelled separately with a binomial error distribution and a logit-link function. Further on, we modeled the respondents' attitudes towards vervet monkeys, the average frequency of vervet monkey visits, the average duration of vervet monkey presence, and the frequency of vervet monkeys raiding in respondents' homes using cumulative link models (also called ordinal logistic regression models) as functions of predictors (Table 1). Cumulative logit models were fitted to these categorical responses with the "*clm*" function in package "ordinal" (Christensen 2013). The "convergence" and "slice" functions in package "ordinal" were used to check model convergence. All independent variables considered as having the potential to influence the dependent variables were included in the model.

We used Akaike's Information Criteria (AIC) (Akaike 1973) to evaluate the relative fit of each model via calculation of Akaike weights (Burnham and Anderson 2002), with the best models ($\Delta AIC \leq 2$) having the greatest weight. Model-averaged estimates of regression coefficients and their standard errors were calculated across models with $\Delta AIC \leq 2$ (Burnham and Anderson 2002). All statistical analyses were done in program R version 3.1.1 (R Development Core Team 2014) using other supportive packages "rJava" (Urbanek 2010), "glmulti" (Calcagno and de Mazancourt 2010) and "MuMIn" (Barton 2014). We used the package "effects" to visualize the variable effects of predictors on the responses from the top models (Fox et al. 2014).

Results

We selected the candidate models that included one or more of the selected predictors (Table 1) to be the final first-, second- and third-ranked models as they had lower AIC values ($\Delta AIC \leq 2$) than all other candidate models (Table 2). Most of the respondents (70%, n = 422) lived in suburban houses, while 23% (n = 137) lived in flats or complexes, and 7% (n = 43) lived in private housing estates acting as autonomous suburbs. One-quarter of the respondents (24%, n = 145) had already lived in their neighbourhood for two decades or more, one-fifth (21%, n = 127) for one to two decades, and over half (55%, n = 330) for one decade or less. The majority of respondents (67%, n = 404) indicated they appreciated living amongst wildlife. A few respondents (11%, n = 65) were unsure for how long they had observed vervet monkeys in their gardens, while most (79%, n = 477) had seen them in their gardens in the last decade, and a few (10%, n = 60) for more than a decade. Over half of the respondents (66%, n = 399) had dogs on their property, and half of those respondents (46%, n = 182) had interactions with vervet monkeys. A further half of those respondents (16%, n = 94) had, or knew of pets that were hurt or killed by vervet monkey(s). Around one-third of the respondents (27%,

Table 2 The top ranked models of factors influencing 1) the active engagement of urban wildlife watching by respondents, 2) the respondents' attitudes towards vervet monkeys, 3) the average frequency of vervet monkey visitations, 4) the average duration of vervet monkey visitations, 5) the presence of vervet monkeys feeding, 6) the presence of vervet monkeys raiding, and 7) the aggressive interactions between respondents and vervet monkeys in urban areas of the KwaZulu-Natal Province, South Africa

Models	df	logLik	AICc	ΔAICc	*wi*
1. Active engagement in wildlife watching*					
Garden + tree coverage (%) + indigenous trees + bird feeder(s) + birds nesting	13	-192.75	412.12	**0.00**	**0.51**
Indigenous trees + bird feeder(s) + birds nesting	7	-199.69	413.56	**1.44**	**0.25**
2. Respondents' attitudes towards vervet monkeys#					
Aggressive interactions + health risk + vervets raiding nests + vervets raiding houses	12	-894.43	1813.38	**0.00**	**0.51**
Aggressive interactions + health risk + vervets raiding houses	11	-896.09	1814.64	**1.26**	**0.27**
3. Average frequency of vervet monkey visits#					
Dog(s) + tree coverage (%) + time of year birds are nesting	10	-616.31	1253.06	**0.00**	**0.37**
Dog(s) + tree coverage (%)	7	-620.05	1254.33	**1.27**	**0.19**
Dog(s) + time of year birds are nesting	7	-620.11	1254.44	**1.38**	**0.18**
4. Average duration of vervet monkey visits#					
Provisioning for vervets + fruiting trees (%) + vervets feeding	10	-712.84	-712.59	**0.00**	**0.38**
Birds nesting + provisioning for vervets + fruiting trees (%) + vervets feeding	11	-712.46	1447.44	**1.33**	**0.20**
Bird feeder(s) + provisioning for vervets + fruiting trees (%) + vervets feeding	11	-712.59	1447.71	**1.60**	**0.17**
5. Vervet monkeys feeding*					
Fruiting trees + tall trees (> 2 m)	3	-216.00	438.05	**0.00**	**0.45**
Dog(s) + fruiting trees + tall trees (> 2 m)	4	-215.41	438.90	**0.86**	**0.29**
6. Vervet monkeys raiding#					
Fruiting trees + vervets eating rubbish	5	-751.11	1512.33	**0.00**	**0.37**
Fruiting trees + dog(s)	5	-751.45	1513.01	**0.68**	**0.26**
Bird feeder(s) + fruiting trees + vervets eating rubbish	6	-751.06	1514.26	**1.94**	**0.14**
7. Aggressive interactions*					
Attitudes towards vervets + dog(s) + animals interacting with vervets + vervets hurt/killed pets + vervets eating rubbish + vervets raiding house	13	-285.94	598.5	**0**	**0.65**
Bird feeder(s) + attitudes towards vervets + animals interacting with vervets + vervets hurt/killed pets + vervets eating rubbish + vervets raiding houses	13	-286.86	600.34	**1.84**	**0.26**

df Residual degrees of freedom, *logLik* Log likelihood, *AICc* corrected Akaike's Information Criterion, *ΔAICc* change in AICc between each model, *wi* Akaike weight

* The response modelled using binary logistic regressions

The response modelled using ordinal logistic regressions

n = 160) observed a human visitor to their residence having an aggressive interaction with vervet monkey(s) in their garden.

Active engagement in wildlife watching

When asked 'Do you actively engage in wildlife watching?' the majority of respondents (88%, *n* = 531) answered 'yes', with half (55%, *n* = 332) actively engaged in wildlife watching regularly. The level of active engagement was best explained by the presence/absence of indigenous trees, tree coverage (%), presence/absence of bird feeder(s), and presence/absence of nesting birds in their gardens, and two competitive models with ΔAIC ≤ 2 contained these factors (total AIC weight = 0.76; Table 1). The top- and second-ranked models showed that active engagement in wildlife watching increased with the presence of bird feeder(s) and birds' nesting, as well as increasing tree coverage (%) (Appendix 1). Wildlife watching increased with the presence of indigenous forests, but it was not significant, as respondents were unsure of the presence of indigenous forest.

Attitudes towards vervet monkeys

When asked 'How do you feel about vervet monkeys?' nearly a third answered 'negative' (29%, *n* = 174), nearly half answered 'positive' (44%, *n* = 267), and the remaining quarter answered 'neutral' (25%, *n* = 162). Their attitudes were best explained by the presence/absence of aggressive interactions with vervets, raiding from their residences, and beliefs that vervet monkeys pose a health risk. Two competitive models with ΔAIC ≤ 2 contained these factors (total AIC weight = 0.78; Table 2). The top- and second-ranked model predictors showed that negative attitudes by respondents increased significantly with the presence of aggressive interaction(s), beliefs that monkeys pose a health risk, and observed raiding of residences. However, neutral attitudes increased significantly with increasing uncertainty of whether or not vervet monkeys pose a health risk, and positive attitudes increased significantly with the absence of observed raiding of residences (Appendix 2). Respondents additionally cited the local vervet monkeys' perceived population growth and negative impact on urban birdlife as concerns.

Observed frequency and duration of vervet monkey visitations

When asked "How frequently do vervet monkeys visit your garden on average?' a few respondents answered 'on a monthly basis' (9%, n = 52), the majority answered 'on a weekly or daily basis' (70%, n = 425), and the remaining one-fifth were unsure (21%, n = 126). The average frequency of observed vervet monkey visits was best explained by the presence/absence of dogs, tree coverage (%) and the time of year birds were seen nesting in the respondents' gardens. Three competitive models with ΔAIC ≤ 2 contained these factors (total AIC weight = 0.74; Table 2). The top-ranked model predictors showed that observed vervet monkey visitations decreased significantly with increasing presence of dogs and decreasing tree coverage (%) in respondents' gardens. However, observed vervet monkey visitations increased significantly with increased observations of birds' nesting in gardens during summer (wet season) (Appendix 3).

When asked 'How long do vervet monkeys stay in your garden on average?' half of the respondents answered 'a few minutes' (50%, n = 303), one-third answered 'a few hours' (33%, n = 199), a handful answered 'half the day' (2%, n = 14), and some were 'unsure' (14%, n = 87). The average duration of observed vervet monkey visits was best explained by the presence/absence of actively provisioned food, fruiting trees (%), and the observed presence/absence of vervet monkeys feeding in respondents' gardens. Three competitive models with ΔAIC ≤ 2 contained these factors (total AIC weight = 0.75; Table 2). The top-ranked model showed that the duration of observed visitations by vervet monkeys increased significantly with the increasing presence of active food provisioning, fruiting trees and observations of vervet monkeys feeding in respondents' gardens (Appendix 4).

Observed feeding and raiding by vervet monkeys

When asked 'Do vervet monkeys feed in your garden?' Most of the respondents (90%, n = 543) answered 'yes'. One-third (30%, n = 181) reported vervet monkeys feeding in their gardens on a daily basis. Observed feeding in gardens was best explained by the presence of fruiting trees and tall trees (> 2 m), and two competitive models with ΔAIC ≤ 2 contained these factors (total AIC weight = 0.74; Table 2). The top- and second-ranked models showed that observations of vervet monkeys feeding increased significantly with the increasing presence of fruiting trees and tall trees (> 2 m) (Appendix 5).

When asked 'Have you ever seen vervet monkeys raiding from inside your home, or evidence of stealing?' the majority of the respondents answered yes (73%, n = 442). Vervet monkey raiding was best explained by the presence of fruiting trees, and three competitive models with ΔAIC ≤ 2 contained this factor (total AIC weight = 0.62; Table 2). The top, second- and third-ranked models showed that observations of vervet monkeys raiding homes increased significantly with the presence of fruiting trees and observations of vervet monkeys eating refuse from bins/bags on or outside properties. In addition, observations of vervet monkeys raiding homes increased significantly with the presence of dog(s) in respondents' gardens (Appendix 6). A likely reason for this result may be that the monkeys avoid the gardens on properties where dogs are roaming, and instead focus on raiding the homes where the dogs may be unable to reach them as easily.

Supplemental food provisioning and aggressive interactions between respondents and vervet monkeys

When asked 'Is food put out for the vervet monkeys in your garden?' some respondents answered yes (10%, n = 59), however the amount was deemed too small as to be significant to the overall analyses. When asked 'Have you ever had an aggressive interaction with a vervet monkey?' just under one-third of respondents answered yes (27%, n = 160). The presence of aggressive interactions between respondents and vervet monkeys was best explained by their attitude towards vervet monkeys, the presence/absence of vervet monkeys interacting with other animals, incidents of pets being hurt or killed by vervet monkeys, vervet monkeys feeding from refuse bins/bags in or just outside properties, and raiding from the respondent's homes. Two competitive models with ΔAIC ≤ 2 contained these factors (total AIC weight = 0.91; Table 2). The top- and second-ranked models showed that the incidence of aggressive interactions with vervet monkeys increased significantly with increasing negative attitudes of respondents towards vervet monkeys, observed interactions between vervet monkeys and other animals (wildlife and pets), incidences of pets being hurt or killed by vervet monkeys, observations of vervet monkeys eating from rubbish bins/bags on or near respondents' properties, and observations of home raiding by vervet monkeys. In contrast, the incidence of aggressive interactions decreased significantly with increasing positive attitudes of respondents towards vervet monkeys and decreasing observations of home raiding by them. In addition, incidences of aggressive interactions with vervet monkeys may potentially decrease with increasing dog(s) presence, with dogs acting as barriers, however dog(s) presence was not found to be a significantly influential predictor (Appendix 7).

Discussion

The majority of respondents had a level of interest in and/or concern for local wildlife. The survey was successful in gathering general demographic information about residents, their experiences with urban wildlife and their opinions of urban wildlife, in particular vervet monkey. The amount of submissions in the current study compared favorably to that reported in other community-based wildlife surveys (Mannan et al. 2004; Stewart 2011). Perceived trends in the presence and frequency of natural foraging as well as raiding by vervet monkeys were assessed through an examination of landowners' histories regarding the persistence of vervet monkey presence in their gardens, pet behaviour and observed interactions with vervet monkeys, and the degree of food provisioning and habituation of vervets at each residence.

Overall, surveyed residents expressed a high level of appreciation for native wildlife, however perceived health threats were raised and negative attitudes towards vervet monkeys, were highly influenced by the level of negative interactions the respondents and/or their pets had experienced. In many cultures views of monkeys being sacred, however also being pests' overlap, leading to a love/hate relationship, in the midst of which conservation efforts must be managed (Lee and Priston 2005). The results showed that the residents' attitudes towards vervet monkeys were significantly influenced by the kind of interactions they or their pets have had with vervets in the past, particularly with aggressive interactions influencing dislike or hatred towards them. Such conflict presumably leads to a heightened awareness of the implicated species' presence, and may bias residents' reports of their impacts in their area. The respondent's attitudes were a function of the degree of contact with vervet monkeys as pests. Research has shown that contact with monkeys in the absence of home damage or risks tends to promote positive attitudes (King and Lee 1987; Knight 1999), while even minimal experience of raiding or aggression leads to an attribution of blame that may greatly outweigh the extent of damage (Priston 2001).

Vervet monkey habitat preferences

Monkeys are widely distributed throughout the world and have adapted to exploit human habitation and resources (Eudey 1987; Dela 2011). Wild vervet monkeys are habitat generalists with their only limiting factors seeming to be water availability and roosting tree presence (Wolfheim 1983; Pasternak et al. 2013). By quantifying the number of trees within each respondents' garden into a categorical density range, we were able to see that the predictors of observed vervet monkey presence by respondents showed favoritism for urban gardens with larger amounts of taller trees. Dogs, humans and birds of prey are predators of urban vervets (Zinner et al. 2002) and therefore the vervet monkeys' preference for taller trees may be for predator avoidance, as has been found in previous studies (Enstam and Isbell 2004). Wild vervet monkeys roosting in trees are characteristically found in wooded areas, with trees averaging at 7.7 m tall, and their use of tall trees has been found to decrease their risk of predation (Nakagawa 1999). Wild troops have also shown preferential use of areas with tall food plants both for predator avoidance, as well as consumption (Chapman 1987). Their habitat preference corroborates with our earlier study that showed 79% of artificial nests were depredated by vervet monkeys in winter and in areas with less canopy cover (Patterson et al. 2016). Vervet monkeys, along with baboons *Papio spp*. and chimpanzees *Pan spp.*, are the most omnivorous of primates, yet they have a dietary preference for indigenous, seasonal fruits and flowers (Fedigan and Fedigan 1988). In this study we found that the frequency and duration of vervet monkey visits increased with increasing indigenous vegetation in gardens, as well as higher densities of fruiting trees, further supporting this.

Vervet monkey food provisioning and raiding

Because of the biological, phylogenetic, and behavioral overlaps between humans and vervet monkeys, the relationship between the two groups has a special significance (Fuentes 2006), and provisioning by people who seek contact with urban wildlife is often a causal factor of human-wildlife conflict, particularly with monkey species, which are known to develop a taste for human foods, lose their fear of humans, and then become proactive (sometimes aggressive) in seeking them out (Brennan et al. 1985; Fa and Lind 1996). In urban and agricultural settings, vervet monkeys are found to be less subject to nutritional stress that comes from fluctuations in seasonal food availability as they have become reliant on sources of food provisioned by humans, including cultivated fruits, vegetables and crops (Saj et al. 2001). Raiding is integral to the ecology of primates inhabiting areas of human-animal interface and the cercopithecoids, most notably macaques *Macaca spp*., vervet monkeys, and baboons *Papio spp.* are frequent culprits (Naughton-Treves 1998; Fuentes 2006). This is in all likelihood due to their generalized diet and adaptive qualities; they are all opportunistic frugivores with enhanced intelligence and manipulative capabilities (Gautier and Biquand 1994). When natural foods are limited, high quality, easily digested human foods provide an alternative source of nutrition for monkeys, and raiding may intensify (Horrocks and Baulu 1994; Hoffman and O'Riain 2012). Rainfall, season, wild food variety and availability, garden characteristics, and home protection methods are all known to impact on raiding (Mohnot 1971; Hill 1997) and the raiding frequency and intensity feeds back into the attitudes urban residents hold towards these co-inhabitants. This community-based urban wildlife survey has shown that citizen science contributes to the understanding and promotion of rigorous research and monitoring of ecosystems, but also the need to interpret this information with the knowledge that attitudes are influenced by individual experiences. Despite numerous examples of wildlife alteration around South Africa's cities, further urban research is needed to identify solutions to urban wildlife management (Cilliers and Siebert 2012).

Conclusion

Several garden characteristics were found to influence vervet monkey presence, including the presence of tall trees (> 2 m), fruiting trees, bird feeder(s), higher tree coverage (%), indigenous vegetation (%), and the absence of dogs, within urban gardens. These garden characteristics help in urban landscape planning and management to help minimize the tension between humans and problem animals. Knowledge of the human dimensions of human-wildlife conflict may additionally help equip us with more effectively targeted management strategies, promoting peaceful coexistence between urban wildlife and people. This wildlife survey also indicates that there are residents of KZN that appreciate and value local urban wildlife, and therefore it is important that residents develop an understanding of what steps may be necessary to minimize aggressive interactions and raiding events, and encourage peaceful co-existence. Where conflict levels are too high and/or the absence of vervet monkeys is desired, adjustments to the landscape may discourage vervet monkey presence. Incorporating human dimension issues into urban spatial ecology studies will be particularly important for the future management of habitat fragments and wildlife in urban areas of KZN.

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Appendix 1

Table 3 Model-averaged coefficients of the top binary logistic regression models for factors influencing wildlife watching and engagement by respondents in KwaZulu-Natal Province, South Africa

	Estimate	Std. Error	Adjusted SE	z value	p (>|z|)
(Intercept)	0.773	51.766	51.872	0.015	0.988
Garden (Present)	1.065	0.766	0.768	1.387	0.166
Tree coverage (10–20%)	0.519	0.378	0.379	1.369	0.171
Tree coverage (20–50%)	0.914	0.389	0.390	2.345	0.019*
Tree coverage (50–70%)	1.553	0.558	0.560	2.779	0.006**
Tree coverage (Not sure %)	1.335	0.691	0.693	1.927	0.054
Tree coverage (Over 70%)	1.368	1.082	1.085	1.261	0.207
Indigenous trees (0%)	-1.236	0.914	0.916	1.350	0.177
Indigenous trees (50%)	-0.258	0.497	0.498	0.518	0.605
Indigenous trees (80%)	0.080	0.523	0.524	0.152	0.879
Indigenous trees (Not sure %)	-1.410	0.458	0.459	3.071	0.002**
Bird feeder(s) (Present)	0.658	0.283	0.283	2.323	0.020*
Birds nesting (Present)	0.595	0.294	0.294	2.024	0.043*

Significance codes: $P < 0.001$ - ***, 0.01 - **, and 0.05 - *

Appendix 2

Table 4 Model-averaged coefficients of the top ordinal logistic regression models for factors influencing the attitudes of respondents to vervet monkeys in KwaZulu-Natal Province, South Africa

	Estimate	Std. Error	Adjusted SE	z value	p (>|z|)
Dislike|hate	-1.218	0.391	0.391	3.111	0.002**
Hate|like	-0.719	0.388	0.388	1.851	0.064
Like|love	0.573	0.388	0.388	1.477	0.140
Love|neutral	1.379	0.391	0.392	3.520	0.000***
Vervets pose health risk (Not sure)	1.184	0.466	0.467	2.532	0.011*
Vervets pose health risk (Yes)	-0.718	0.181	0.182	3.955	0.001***
Vervets raiding birds' nests (Yes)	-0.353	0.194	0.195	1.814	0.070
Aggressive interactions with vervets (Yes)	-0.342	0.187	0.187	1.832	0.070
Vervets raiding houses (Occasionally)	0.596	0.368	0.368	1.619	0.106
Vervets raiding houses (Once)	0.551	0.400	0.401	1.375	0.170
Vervets raiding houses (Weekly)	-0.059	0.418	0.419	0.141	0.890
Vervets raiding houses (No)	0.916	0.386	0.387	2.368	0.018*

Significance codes: $P < 0.001$ - ***, 0.01 - **, and 0.05 - *

Appendix 3

Table 5 Model-averaged coefficients of the top ordinal logistic regression models for factors influencing the average frequency of vervet monkey visits to respondents' gardens in KwaZulu-Natal Province, South Africa

	Estimate	Std. Error	Adjusted SE	z value	p (>|z|)
Daily|monthly (Presence of vervet monkeys)	-1.096	0.600	0.600	1.856	0.063
Monthly (Presence of vervet monkeys) (No)	-0.670	0.600	0.600	1.137	0.256
No|weekly|biweekly (Presence of vervet monkeys)	-0.215	0.600	0.600	0.366	0.714
Dog(s) (yes)	-0.401	0.200	0.200	2.197	0.028*
Tree coverage (%) (21–50)	0.281	0.240	0.240	1.191	0.234
Tree coverage (%) (Unsure)	0.323	0.401	0.402	0.805	0.421
Tree coverage (%) (0–20)	0.609	0.230	0.230	2.667	0.008**
Time of year birds' nesting (Unsure)	-0.500	0.500	0.500	1.054	0.300
Time of year birds' nesting (Wet season)	-0.900	0.500	0.500	1.881	0.100
Time of year birds' nesting (Year round)	-0.440	0.500	0.500	0.885	0.400

Significance codes: $P < 0.001$ - ***, 0.01 - **, and 0.05 - *

Appendix 4

Table 6 Model-averaged coefficients of the top ordinal logistic regression models for factors influencing the average duration of vervet monkey presence in the respondents' gardens in KwaZulu-Natal Province, South Africa

	Estimate	Std. Error	Adjusted SE	z value	p (>|z|)
A few minutes|a few hours (Duration of vervet monkey presence)	-1.125	0.369	0.369	3.046	0.002**
A few minutes|an hour (Duration of vervet monkey presence)	-0.039	0.363	0.364	0.108	0.914
Half an hour|an hour (Duration of vervet monkey presence)	0.938	0.370	0.369	2.545	0.011*
Half an hour|half a day (Duration of vervet monkey presence)	4.273	0.454	0.456	9.382	< 2e-***
Fruiting trees (%) (Less than a quarter)	0.383	0.284	0.284	1.346	0.178

Table 6 (continued)

	Estimate	Std. Error	Adjusted SE	z value	p (>|z|)
Fruiting trees (%) (More than half)	-0.944	0.600	0.557	1.695	0.090
Fruiting trees (%) (Not sure)	0.061	0.283	0.284	0.216	0.829
Provisioning (Yes)	-0.740	0.300	0.259	2.851	0.004**
Vervets feeding (Not sure)	0.752	0.320	0.321	2.343	0.019*
Vervets feeding (Yes)	0.700	0.215	0.215	3.197	0.001**
Birds nesting (Yes)	-0.168	0.188	0.188	0.891	0.373
Bird feeder(s) (Yes)	0.130	0.164	0.165	0.767	0.443

P < 0.001 - ***, 0.01 - **, and 0.05 - *

Appendix 5

Table 7 Model-averaged coefficients of the top binary logistic regression models for factors influencing vervet monkeys feeding in gardens of respondents in KwaZulu-Natal Province, South Africa

	Estimate	Std. Error	Adjusted SE	z value	Pr(>|z|)
(Intercept)	-0.653	0.470	0.472	1.384	0.166
Fruiting trees (Present)	1.561	0.258	0.258	6.049	< 2e-16***
Tall trees (> 2 m) (Present)	1.266	0.392	0.393	3.221	0.001**
Dog(s) (Present)	-0.306	0.275	0.276	1.110	0.267

Significance codes: *P* < 0.001 - ***, 0.01 - **, and 0.05 - *

Appendix 6

Table 8 Model-averaged coefficients of the top ordinal logistic regression models for factors influencing the frequency of vervet monkeys raiding in the respondents' homes in KwaZulu-Natal Province, South Africa

	Estimate	Std. Error	Adjusted SE	z value	p (>|z|)
Occasionally|once (Presence of vervet monkeys)	-0.391	0.234	0.234	1.670	0.095
Once|never (Presence of vervet monkeys)	0.227	0.230	0.230	0.984	0.325
Weekly|never (Presence of vervet monkeys)	1.735	0.245	0.245	7.088	<2e-16***
Vervets eating rubbish (Present)	-0.328	0.157	0.157	2.085	0.037*
Fruiting trees (Present)	-0.369	0.169	0.169	2.183	0.029*
Dog(s) (present)	0.280	0.169	0.169	1.653	0.098
Bird feeder(s) (Present)	-0.068	0.159	0.159	0.429	0.668

Significance codes: *P* < 0.001 - ***, 0.01 - **, and 0.05 - *

Appendix 7

Table 9 Model-averaged coefficients of the top binary logistic regression models for factors influencing aggressive interactions between respondents and vervet monkeys in KwaZulu-Natal Province, South Africa

	Estimate	Std. Error	Adjusted SE	z value	p (>|z|)
(Intercept)	-0.121	0.582	0.583	0.207	0.836
Vervets raiding (Occasionally)	-1.064	0.498	0.5	2.13	0.033*
Vervets raiding (Once)	-1.629	0.571	0.572	2.848	0.004**
Vervets raiding (Weekly)	-0.156	0.56	0.561	0.277	0.782
Vervets raiding (Absent)	-1.693	0.547	0.548	3.091	0.002**
Vervets eating rubbish (Present)	0.575	0.219	0.22	2.626	0.009**
Dog(s) (Present)	-0.385	0.235	0.235	1.639	0.101
Attitude towards vervets (Hate)	0.849	0.393	0.394	2.153	0.031*
Attitude towards vervets (Like)	-0.632	0.292	0.293	2.16	0.031*
Attitude towards vervets (Love)	-1.028	0.366	0.367	2.803	0.005**
Attitude towards vervets (Neutral)	-0.484	0.293	0.294	1.649	0.099
Animals interact vervets (Present)	0.747	0.22	0.221	3.387	0.001***
Vervets hurt/killed pets (Present)	0.848	0.275	0.276	3.077	0.002**
Bird feeder(s) (Present)	0.191	0.21	0.21	0.907	0.364

Significance codes: $P < 0.001$ - ***, 0.01 - **, and 0.05 - *

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