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Nonlethal management of baboons on the urban edge of a large metropole

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Abstract

The transformation of natural land for agricultural and urban use has displaced baboons from large parts of their historical distribution. Abundant resources within transformed areas, however, continue to attract baboons back into these human-dominated areas resulting in chronic levels of conflict throughout much of Africa. In the city of Cape Town, chacma baboons (*Papio ursinus*) have been raiding human-derived foods for over 200 years. In the last 20 years, the management of this conflict has shifted from predominantly lethal to nonlethal methods. In this study, we assess the success of field rangers to deter baboons from urban areas and investigate whether such management affects the diet and activity patterns of baboons. We opportunistically sampled baboon behavior and movement when field rangers were temporarily absent from managed troops in 2008. We also compared the intensity of baboon management by comparing one troop on days when the field rangers aggressively herded the troop away from the urban edge versus passively monitored them in 2004/2005. Our results reveal that when field rangers were absent, the two troops spent 70% and 80% of their time within the urban edge compared to 3% and 19% when they were present. Both troops also consumed more human-derived foods when field rangers were absent. There was no significant change in the activity budget or daily distance traveled for either troop with and without field rangers. The intensity of herding did have an impact on baboon activity and high levels of herding significantly reduced time spent feeding and increased time spent traveling, socializing, and resting. Habitat use and dietary composition did not differ between high- and low-herding days. Our results suggest that field rangers are a successful nonlethal method for reducing spatial overlap between baboons and urban areas but that intensive, unsystematic herding of the troop does have measurable impacts on behavior and should be prevented.

KEYWORDS

activity budgets, commensalism, human–wildlife conflict, management, *Papio*, raiding

1 | INTRODUCTION

Land transformation and the associated loss of natural habitat pose the single greatest threat to the survival of primates (Estrada et al., 2017). There are, however, a few primate species that are able to adapt, and even thrive, in human-altered environments. Baboons (*Papio* spp.), some macaques (*Macaca* spp.), and vervets (*Cercopithecus aethiops*) are all examples of species that are particularly adept at living in close proximity to human settlements (Brennan, Else, & Altmann, 1985; Else, 1991; Fehlmann et al., 2017; Forthman Quick &

Demment, 1988; Hoffman & O'Riain, 2011; Lee, Brennan, & Altmann, 1986; Priston & McLennan, 2013). These particular primates share several traits that predispose them to adapt successfully to a human-modified environment including dietary and behavioral flexibility, complex social organization, curious, aggressive and gregarious dispositions, manual dexterity and locomotive abilities that are both terrestrial and arboreal (Else, 1991; Hill, 2005; Lee & Priston, 2005; Richard, Goldstein, & Dewar, 1989).

Primate raiding as a foraging strategy brings primates into urban and agricultural areas and consequently into frequent conflict with humans (Hill, 2017; Lee & Priston, 2005; Sabbatini, Stammati, Tavares, Giuliani, & Visalberghi, 2006; Saj, Sicotte, & Paterson, 1999; Strum, 1994). High-quality foods associated with human habitation, such as crops and human food waste, generally have higher caloric content and are more palatable and digestible than natural food sources (Fehlmann et al., 2017; Forthman Quick, 1986a; Forthman Quick & Demment,1988; Johnson, Raubenheimer, Rothman, Clarke, & Swedell, 2013).

Spatial proximity with humans and reliance on similar ecological resources (e.g., low-lying land near permanent water sources) has resulted in baboons being regarded as the most troublesome of primate raiders throughout Africa (Hill, 2000a, 2005; Hoffman & O'Riain, 2011; Naughton-Treves, 2010). Baboons have incorporated the raiding of crops, private residences, tourist lodges, and human refuse into their foraging repertoire (Altmann & Muruthi, 1988; Strum, 1994, 2010). In many cases, successful raiding events have led to baboons losing their fear of humans and learning that aggression is a successful method to obtain food items from humans when necessary (Lee & Priston, 2005). Together these events lead to recurring human–wildlife conflicts and distressed communities feeling threatened by baboons from both food security and personal safety perspectives (Beamish, O'Riain, & King, in prep; Hill, 2000b; Lee & Priston, 2005; Mormile & Hill, 2017; Strum, 1986, 2010).

Several methods to reduce baboon raiding have been attempted throughout Africa, but most have limited long-term success. These methods include education, signage, reducing access to human food waste, electric fences, conditioned taste aversion, reflective prisms, provisioning, chasing with and without deterrents, repellents, guarding/patrolling, hunting, translocation, trapping, and poisoning (Forthman Quick, 1986b; Hill, 2000a, 2000b; Hoffman & O'Riain, 2012; Kaplan, O'Riain, van Eeden, & King, 2011; Lee & Priston, 2005; O'Brien & Hill, 2018; Strum, 1994, 2010). The success of these methods is dependent on the type of raiding (e.g., crop vs. house) and the physical and financial resources of those affected. Despite the importance of quantifying the success and efficacy of such methods, only a few have been tested rigorously (Kaplan & O'Riain, 2015; O'Brien & Hill, 2018).

In the Cape Peninsula, South Africa, the earliest account of raiding was in the late 18th century when baboons raided the gardens planted along the slopes of Table Mountain (Skead, 1980). More recently, baboons learned to forage on the contents of rubbish bins, fruits and vegetables within fenced gardens, and occasionally enter houses and stores. Once inside a building, baboons often make a considerable mess and damage property and goods. Up until 1995 the management of "pestilent" baboons in the Cape Peninsula included the capture and killing of entire troops (Kansky,2002; Lavin, 2008). A population census in 1998 and 1999 (Kansky & Gaynor, 2000) suggested that the Cape Peninsula baboon population was not sustainable given the high levels of human-induced mortality. This finding prompted the establishment of a "Baboon management strategy" which was to be implemented by the baboon management team (BMT; deVilliers Brownlie Associates, 2000). The BMT included the three local authorities (Table Mountain National Park [TMNP], Cape Nature and the City of Cape Town) that together are responsible for the management of biodiversity in the Cape Peninsula. In addition, the BMT included representatives from residential areas affected by raiding and biologists with relevant experience with baboons. The management strategy included education, guidelines for development, standards for electric baboon-proof fences, plans for low-cost baboon-proof rubbish bins, and the use of baboon "monitors" to actively herd baboons away from urban areas.

Of these management options, the use of baboon monitors was considered to be the most cost-effective approach for reducing human/baboon conflict in the Cape Peninsula as this approach resulted in immediate reductions in the time baboons spent in urban areas. Monitoring is unskilled labor of which there is surfeit in the City of Cape Town. When combined with low minimum wages in South Africa, employing large numbers of monitors to ensure almost continuous human presence is a cost-effective management intervention that delivers immediate relief to residents. Similar approaches including guards, chasers, and spotters have been used elsewhere in Africa to offset the advances of potential animal raiders, with varying degrees of success (Lee & Priston, 2005; Forthman Quick & Demment, 1988; Strum, 1994, 2010).

The monitor system differs from these approaches in that it aims to know the exact whereabouts of specific troops from sunrise to sunset by having two to three designated people, or monitors, actively monitor their whereabouts and herd the troop away from urban and rural areas whenever they move in those directions. This monitoring approach is thus largely preventative rather than reactionary as the monitors are capable of thwarting an advance on an urban or rural area while the baboons are still within their natural habitat. Monitors actively drive the troop away from the urban areas by shouting, clapping, waving sticks, and occasionally throwing stones. Monitors also block troop movement and hold them within a topographical area where they are able to maintain oversight and control of the troop (Fehlmann et al., 2017; van Doorn, O'Riain, & Swedell, 2010).

The original guidelines for monitors (Kansky & Gaynor, 2000) specify that monitors work daylight hours, locate the baboons before leaving their morning sleeping site and remain with the troop until they reach their sleeping site at night. These guidelines also advise monitors to maintain a minimum distance of 200 m when the baboons are foraging naturally; discuss a daily plan of what approach they will take to prevent the baboons from going to residential areas (but no specifics are provided), encourage the baboons to sleep in one or two sleeping sites, and push the baboons only after midday with the assumption that they have foraged naturally up to this point.

Despite monitors being used for the past 20 years on the Cape Peninsula, there are as yet no published studies on their success in preventing urban raiding and whether herding practices have measurable effects on baboon behavior. In this study, we took advantage of two periods in which monitors were removed from a troop, for the purposes of training ($n = 5$ days) and because of a dispute in pay ($n = 12$ days), to investigate baboon behavior with and without monitors in two different troops. In addition, we explored whether the behavior of monitors, specifically the intensity with which they herded baboons away from urban areas, had a measurable effect on the diet and activity budgets of a single troop. Together these data provide the first independent assessment of monitors as a deterrent for human–baboon conflict mitigation. The reporting of discrete, quantified field trials allow wildlife managers to assess deterrents with greater confidence and to avoid the costs (in terms of both time and budget) associated with ineffective deterrents.

2 | METHODS

Research reported here is original and adhered to the American Society of Primatologists (ASP) Principles for the Ethical Treatment of Non-Human Primates. We collected data according to protocols approved by the University of Cape Town and South African National Parks and adhered to the legal requirements of South Africa.

2.1 | Study site and subjects

We studied two troops of chacma baboons (*Papio ursinus*) on the Cape Peninsula, South Africa (34°16′96.87″S; 18°37′36.63″E). The Da Gama troop ($n = 35$-38 individuals, 2–5 adult males and 10–14 adult females) and the Slangkop troop ($n = 24$ individuals, 5 adult males and 9 adult females) have been part of the monitor program since its inception in 1998. The home range of the two troops overlaps and fall predominantly within TMNP (Hoffman & O'Riain, 2012). The study site is surrounded on the north, east, and west by human developments, including roads, houses, recreational facilities, and commercial buildings. The central portion of each troop's home range includes patches of alien pine trees, cleared alien plants, endemic mountain fynbos, and areas of mixed alien/fynbos. The large suburban residential areas of Da Gama Park, Kommetjie Village, and to a lesser extent Ocean View are the primary targets for raiding by the troops. The study troops were already habituated to human presence at the onset of this study due to frequent prior interactions with humans and were followed on foot (<10 m) by one or two observers.

2.2 | Data collection

All observations were conducted from sunrise to sunset. We recorded instantaneous scan samples (Altmann, 1974) every 20 min and recorded the behavior of all visible adult troop members, the habitat that the majority of troop members were in, and the GPS (Global Positioning System) location of the center of the troop. Activities recorded included *feed* (actual ingestion of food), *forage* (preparation, handling, or manipulation of foodstuffs), *search* (slow movement while scanning the environment for food), *raid* (searching for and/or acquiring human-derived food), *travel* (nonsocial directional movement such as walking, running or climbing), *rest* (nonsocial, inactive postures, such as sitting or lying down either alone or in contact with another individual), and *social* (aggressive and affiliative interactions, including grooming or being groomed by others). In addition, the behavior of the monitors (Table 1) was recorded for each scan.

2.2.1 | Monitor presence versus absence

The monitor program was temporarily discontinued on two separate occasions in 2008. The first interruption was to allow monitors from the Da Gama troop to attend a 5-day training workshop and data was collected for 5 full days before and during the workshop. The second interruption was caused by a pay dispute and resulted in monitors being absent for 18 consecutive days with data collected for 12 days of monitor absence and then 11 days following their return to work.

For our first study period (July 18–27, 2008), we observed the Da Gama troop and recorded 5 full days with the monitors present (49.5 hr, 146 scans) followed by 5 full days without monitors (51 hr, 156 scans) with a mean of nine individuals (range, 3–16) per scan. During our second study period (September 30–November 19, 2008)

TABLE 1 Definitions of monitor behavior

Stationary	Sitting, standing, or lying down
Following troop	Passively walking behind the troop at a distance of >30 m
Herding	Actively driving the troop by physically approaching and/or shouting, clapping hands, throwing stones
Unseen	Out of sight of the troop but present
Unknown	Unknown
Absent	At the beginning and end of a monitored day and all unmonitored days

we observed the Slangkop troop and recorded 10 full days with the monitors present (111 hr, 344 scans) and 12 full days when the monitors were absent (118.5 hr, 378 scans) with a mean of eight individuals (range, 4–13) per scan.

2.2.2 | High- versus low-herding days

We assessed the effects of herding intensity on the Da Gama troop from December 2004–March 2005. We categorized high-herding days as those in which the monitors actively herded the troop in more than 25% of all scans (mean ± standard deviation [*SD*]: 35 ± 9% of 746 scans), whereas low-herding days were days in which the monitors actively herded the troop in less than 10% of all scans (5 ± 5% of 746 scans). We included only full days (sunrise to sunset) in the analyses and the period of data collection was restricted to a single season (summer of 2004/2005) to control for the confounding factors of seasonality. These criteria resulted in a final data set of 20 full days, 210.33 hr, and 599 instantaneous scans, including 10 high-herding days (322 scans) and 10 low-herding days (278 scans), with a mean of eight individuals per scan (range, 4–16).

2.3 | Data analyses

We determined activity budgets by calculating a daily proportional mean (which was then converted to a percentage for reporting purposes) of each behavior during days when the monitors were present or absent. We used this method as animals were not all individually recognizable (Hoffman & O'Riain, 2011). The data were not normally distributed and the data set was small, so we used the Mann–Whitney *U* test to compare behavioral proportions between treatments (Fowler, Cohen, & Jarvis, 1998). We calculated activity budgets on high-/low-herding days for each adult by dividing the number of scan records in which the individual engaged in a specific activity by the total number of scans for that individual. The behavioral data were not normally distributed therefore we used a nonparametric two-sample test (Wilcoxon matched-pairs test) to compare the activity budget of individually recognizable troop members on high- versus low-herding days. For both treatments, we compared diet at the level of the troop with the amount of each food item consumed being expressed as a proportion of the total number of behavioral records per day. We then statistically compared the monitor present and absent days and high- and low-herding days using a Mann–Whitney *U* test.

We assessed habitat use from GPS positions and then transformed them into decimal degrees. We imported GPS points into Arcview 3.3 (Universal Transverse Mercator projection, Spheroid WGS 84 datum, with Central Meridian 19, Reference latitude 0, and scale factor 1). We computed daily distance moved by adding the linear distances between successive GPS points recorded over full days, using the Nearest Features extension for Arcview 3.3 (Jenness, 2006). We calculated the hourly speed of travel by dividing the total distance covered between successive GPS points recorded at 20 min intervals and converting this to an hourly rate. We used observer records and aerial photography of the region (with a pixel resolution of 0.25 m) to digitize habitat types, as the detail of currently existing geographic information system layers was insufficient. We then compared the daily distances traveled with a Mann–Whitney *U* test. We log-transformed the rate of travel data to give a normal distribution and performed linear regression analyses to determine if different herding intensities and the presence versus absence of monitors had an effect on the hourly rate of travel. We performed all statistical tests using Stata 10 software and all sample tests are two-tailed.

3 | RESULTS

3.1 | Monitor presence versus absence

3.1.1 | Time in town and raiding

Both troops spent significantly less time in urban areas on days when monitors were present compared to days when the monitors were absent. The Da Gama troop spent 19% of scans in urban areas on days when the monitors were present compared to 80% of scans when monitors were absent (Figure 1). When monitors were present there were 27 scans (18%) in which at least one individual was recorded as raiding urban areas with a total of 89 individual raids (mean = 3.3 individuals raiding per scan, range = 1–12 individuals, *N* = 5 days). During the days when monitors were absent there were 67 scans (43%) in which at least one individual was recorded as raiding with a total of 173 individual raids (mean = 2.58 individuals raiding per scan, range = 1–8 individuals, *N* = 5 days). The Da Gama troop also consumed significantly less raided food items (Mann–Whitney *U* test: $Z = 2.41$, $p = .016$, $N = 10$ days) on days when the monitors were present (10%) than on days when the monitors were absent (43%).

The Slangkop troop spent 3% of scans in urban areas on days when the monitors were present compared to 70% of scans when monitors were absent (Figure 1). During days when monitors were absent there

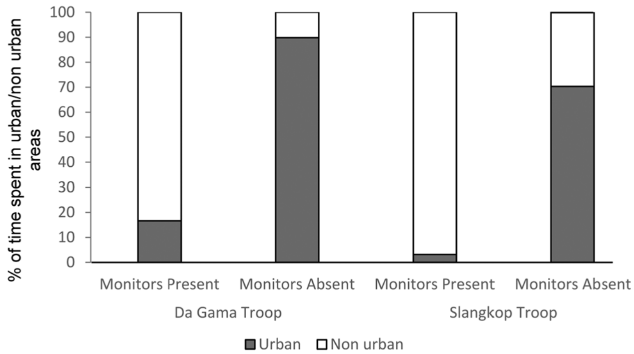

FIGURE 1 The percentage of time the Da Gama and Slangkop troops spent in urban (gray) and nonurban (white) areas when monitors were present and absent

were 62 scans (16%) in which at least one individual was recorded as raiding with a total of 102 individual raids (mean = 8.5 individuals raiding per scan, range = 1–20 individuals, $N = 12$ days). The Slangkop troop also consumed significantly less raided food items (Mann–Whitney *U* test: $Z = 2.89$, $p = < .001$, $N = 21$ days) on days when the monitors were present (0%) than on days when the monitors were absent (11%).

3.1.2 | Activity budget

We found no significant difference in the percentage of time the Da Gama troop spent engaged in four primary activities on days with monitors compared to days without monitors (Mann–Whitney *U* test: feeding: $Z = 0.94$, $p = .34$; resting: $Z = 0.94$, $p = .34$; socializing: $Z = -0.73$, $p = .46$; traveling $Z = -0.52$, $p = .60$, $N_{present} = 5$, $N_{absent} = 5$). Slangkop showed the same trend with no significant differences in the percentage of time the troop engaged in these activities on days with monitors compared to days without monitors (Mann–Whitney *U* test: feeding: $Z = 0.00$, $p = 1.00$; resting: $Z = -.25$, $p = .81$; socializing: $Z = -0.11$, $p = .92$; traveling $Z = -0.25$, $p = .81$, $N_{present} = 10$, $N_{absent} = 12$).

3.1.3 | Diet

Da Gama Park adult troop members consumed significantly more fynbos (Mann–Whitney *U* test, $Z = -2.05$, $p = .04$, $N = 10$) and alien seeds ($Z = 2.35$, $p = .019$) on days when monitors were present and consumed significantly more "other alien" vegetation ($Z = -2.353$, $p = .02$, $N = 10$) and raided food items ($Z = 2.41$, $p = .016$, $N = 10$) when the monitors were absent. There were no significant differences in the percentage of pine cones ($Z = 0.952$, $p = .34$) or annuals ($Z = 0.940$, $p = .35$, $N = 10$) consumed on days when monitors where absent versus present.

3.1.4 | Movement

The daily distance traveled on days when monitors were present (mean = 3.28 ± 0.78 km, range = 2.49–4.50 km) or absent (2.79 ± 0.20 km, range: 2.70–3.06 km) were similar for the Da Gama troop (Mann–Whitney *U* test, $Z = 1.66$, $p = .09$, $N_{present} = 5$, $N_{absent} = 5$) and the Slangkop troop (Mann–Whitney *U* test, $Z = -1.126$, $p = 0.26$, $N_{present} = 10$, $N_{absent} = 11$) on days when monitors were present (mean = 3.47 ± 1.69 km, range = 1.58–6.74 km) or absent (3.87 ± 1.22 km, range: 2.65–6.81 km).

3.2 | Management intensity: High- versus low-herding days

3.2.1 | Monitor behavior

The mean ± *SD* percentage of scans per day that included active herding during the 2004/2005 study period was 19 ± 14% of 746 scans (range: 0–57%). Of these, 28% were high-herding days and 28% were low-herding days. Overall the monitors spent the majority of their total time stationary (55 ± 17%) followed by herding (19 ± 14%), out of sight (14 ± 11%), absent (7 ± 10%), and passively following (5 ± 5%) the troop.

3.2.2 | Time in town and raiding

The Da Gama troop spent 5% of scans in urban areas on low-herding days and 8% of scans in urban areas on high-herding days. There was no difference in the amount of raided food consumed during high (0.77%)- and low (0.79%)-herding days (Mann–Whitney *U* test ($Z = -0.16$, $p = .87$, $N = 12$).

3.2.3 | Activity budget

Adult troop members spent significantly less time feeding (Wilcoxon matched-pairs test: $Z = 3.06$, $p = .002$, $N = 12$); and more time traveling ($Z = 2.27$, $p = .024$, $N = 12$) on high-herding days compared to low-herding days (Figure 2). Conversely, adult troop members spent more time socializing (Wilcoxon matched-pairs test: $Z = 2.74$, $p = .006$, $N = 12$) and resting ($Z = 1.96$, $p = .050$, $N = 12$) on high-herding days.

3.2.4 | Diet

There were no significant differences in the percentage of each dietary item consumed by Da Gama adults on high- versus low-herding days (Mann–Whitney *U* test: fynbos: $Z = -2.45$, $p = 0.81$; alien seeds: $Z = -1.24$, $p = .22$; pine cones: $Z = 1.20$, $p = .23$; annuals: $Z = -.70$, $p = .49$; other alien vegetation: $Z = -0.35$, $p = .72$; $N_{high} = 10$, $N_{low} = 10$).

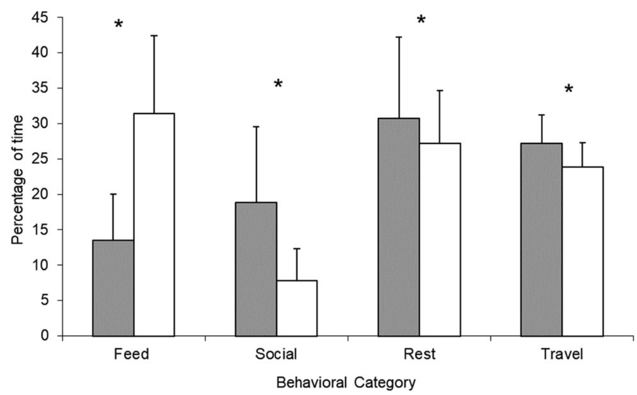

FIGURE 2 The percentage of the total time that the adult individuals in the Da Gama troop engaged in each of the four most common main behaviors (comprising > 95% of all activities) on high- (gray) versus low- (white) herding days. Significant differences ($p < .05$) are denoted by an asterisk

3.2.5 | Movement

Day journey length was not significantly different on high- (5.6 ± 2.3 km, mean = 5.57 ± 2.30 km) versus low- (3.8 ± 1.3 km) herding days (Mann–Whitney *U* test, $Z = 0.93$, $p = 0.34$; $N_{high} = 10$, $N_{low} = 10$). The hourly travel speed was significantly higher on high-herding days compared to low-herding days (linear regression, $Z = 3.35$, $p < .001$).

4 | DISCUSSION

It is widely accepted that for monitors to be successful, the costs to baboons of raiding must outweigh the nutritional benefits given the high caloric content of human-derived foods (Forthman Quick & Demment, 1988; Lee & Priston, 2005; Naughton-Treves, Treves, Chapman, & Wrangham, 1998; Strum, 2010). Our results suggest that Cape Town's monitors achieved this goal, as reflected by the significantly reduced time that baboons spent in urban areas when they are present. This success is mirrored in a dietary shift with baboons eating less human-derived foods, more invasive plant seeds (primarily *Acacia cyclops* seeds within the leaf litter) in addition to significantly more indigenous fynbos vegetation when monitors are present.

Although the general presence of monitors did not cause significant changes in activity budgets, high-herding days were associated with an average of 103 min less time spent foraging and a substantially lower mean percentage of time allocated to feeding (14%) compared to both low-herding days (32%) and the mean for the troop in the same season (27%). The fact that it is an increase in herding intensity, but not the mere presence of herding, that changes baboon activity budgets is not surprising given that these troops are habituated to the presence of monitors. Thus, the baboons only change their behavior when the monitors throw projectiles, whistle, and drive the baboons to another part of their home range. The low percentage of time allocated to feeding on high-herding days is atypical for baboons and has been documented only in troops that have unrestricted access to human-derived foods (Altmann & Muruthi, 1988; Bronikowski & Altmann, 1996; Forthman Quick & Demment, 1988). Other troops on the Cape Peninsula that also live on the urban edge and have access to human-derived foods allocate a much higher percentage of their time to feeding compared to our study troops: 41% in summer and 37% in winter for the Plateau Road troop (van Doorn, 2009; van Doorn et al., 2010) and 28% in summer and 31% in winter for the Tokai troops MT1 and JT (Chowdhury, 2018; Chowdhury & Swedell, 2018). Given that raided food consumption was similar on low- and high-herding days, we interpret this finding as evidence that baboons are being herded to areas convenient for management success but that have limited food availability, resulting in reduced time spent foraging by the troop.

The baboons spent significantly more time socializing (mainly allo-grooming) and, to a lesser extent, resting on high-herding days. This increase in social effort is unexpected as baboons that can afford to reduce foraging time typically use the extra time for resting with a small increase only in socializing (Bronikowski & Altmann, 1996; Forthman Quick & Demment, 1988; Weingrill, Gray, Barrett, & Henzi, 2004). Grooming is recognized as an important coping strategy to reduce stress and anxiety in primates (Cheney & Seyfarth, 2009; Shutt, MacLarnon, Heistermann, & Semple, 2007; Wittig et al., 2008). It is, thus, possible that a high level of herding induces anxiety in troop members which, in turn, elicits high levels of grooming. The stress of herding may, thus, be a consequence of the aggressive behavior of the monitors on high-herding days which included throwing stones, sticks, shouting, and whistling.

Our observations revealed that monitors regularly acted outside of the management protocol and often herded the troop while foraging in natural habitat, even at an acceptable distance from urban areas. During herding events the troop would be forced to travel quickly and once in a desirable location (from the monitors' perspective) they would then be held there for a prolonged period. The absence of a link between herding behavior and the number of raided food items consumed suggests that the intensity of herding decisions are largely ad hoc. Once the monitors' shift had ended and they left the field in the late afternoon, the baboons would typically watch and wait for them to disappear before moving rapidly back to the urban edge. This pattern of management is reflected in the higher rates of travel in both the morning and the late afternoons. By contrast, on days without monitors and/or low-herding levels, the movement of the troop was more consistent throughout the day. The decision to move the troop appeared to be motivated by the BMTs service provider Baboon Matters, aiming to provide the residents of Da Gama Park with a prolonged period of “zero baboon raiding” (J. Trethowan [personal communication, February 2005]).

It is important to note that since the data in this study were collected, management has continued to use monitors as the primary nonlethal management tool for reducing spatial overlap between humans and baboons on the Cape Peninsula. In 2013, monitors were equipped with paintball markers which has greatly improved their deterrent ability and reduced raiding in urban areas to as little as 1.8% of total time active (Fehlmann et al., 2017). Education, baboon-proofing of waste, electric fencing, and the inclusion of baboon home ranges within the cities' spatial development framework are all also part of the current management plan. However, none of these approaches on their own, or even in combination, offer a solution across all regions of the city that are adjacent to baboon home ranges. Thus, though electric fences are extremely successful at preventing baboons from accessing residential areas, they have only been deployed in select high-value suburbs that have the financial means to construct and maintain such fences (O'Riain & Hoffman, 2010; Kaplan, 2013). Similarly, baboon-proofing of waste can greatly reduce incentives for baboons to enter urban areas (Kaplan et al., 2011) but because success requires cooperation at the level of each individual household, compliance varies widely.

In summary, this study provides evidence that monitors are a successful nonlethal management strategy for the reduction of raiding by baboons in urban areas and thus may effectively reduce human–baboon conflict in the Cape Peninsula. In the absence of monitors, both troops spent more than 70% of their total time within the urban edge and fed predominantly on human-derived food items. Importantly the City of Cape Town can continue to resource this nonlethal monitor program through the municipal taxes levied on individual properties throughout the city. Rural communities and small towns are unlikely to be able to afford such a sustained program given the economies of scale but this program does provide a sustainable and effective management approach for most other cities in sub-Saharan Africa.

The success of the monitor program is, however, tempered by the finding that monitors do impact on the behavior of the baboons when they engage in persistent herding techniques often associated with the forced relocation of the troop. We recommend that monitors desist from aggressive and unpredictable bouts of herding specifically for the purposes of the forced relocation of the troop within the natural part of their home range. If the troop is outside the urban edge then it is imperative that the monitors assume a passive monitoring role and do not actively herd the baboons because this may prevent them from tracking subtle seasonal and annual variation in the availability of desirable food, water, and sleeping site resources within their home range.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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