In pursuit of a panacea: mitigating human-baboon conflict in the Cape Peninsula, South Africa

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In Pursuit of a Panacea: Mitigating Human-Wildlife Conflict in the Cape Peninsula, South Africa.

ABSTRACT With its unparalleled growth and distribution, the human species is increasingly conflicting with wildlife over crops, livestock and even human life as it infringes on natural habitat. In the Cape Peninsula, South Africa, urbanisation has simultaneously reduced the availability of productive low-lying natural land and provided plentiful high-caloric anthropogenic food items within urban, rural and tourist areas. The chacma baboons that occur in the Cape Peninsula have adapted to exploit this anthropogenic food, bringing them into direct conflict with humans. Despite the use of a costly management strategy (baboon monitors/herders), conflict between the two species persists in the form of property damage and stress to local residents and injury and mortality to baboons. The primary aim of this thesis was to explore new approaches for mitigating human-baboon conflict by experimentally manipulating various facets of the cost-benefit ratio to baboons entering human environments. Initially, I tested the efficacy of three deterrents, namely light prisms, bear bangers and electric fencing in raising the costs of entering human environments and therefore reducing baboon use of those environments. Light prisms were completely ineffective in achieving this end, while bear bangers and electric fencing showed prolonged success with no evidence of habituation. An alternative to raising the cost to baboons of entering human environments (deterrents) is to increase the relative benefits of remaining in natural areas, through provisioning food. Indeed, by manipulating the despotic leadership present in chacma baboons through a feeding patch, I was able to affect a shift in a troop's ranging pattern away from human environments. However, this shift was only significant where access to food in the human environment was restricted. Guided by this finding, I then tested the efficacy of baboon-proof waste bins in excluding baboon access and thereby reducing the benefit of human environments. While the bins were highly effective, their success was contingent on proper use and cooperation by residents. In this vein – to aid collaborative management of the baboon population – I conducted a survey of Cape Peninsula residents concerning various aspects of human-baboon conflict. Primarily, residents indicated a considerable tolerance for baboons despite the generally negative baboon-experience profiles. Further, residents had a poor understanding of baboon management structures as well as baboon conservation status, a finding that requires urgent attention where debates around baboon management are nuanced and emotive. I propose the use of two-way communication platforms (online social networks) that will help to minimise ever-present human-human conflicts. Ultimately, human-wildlife conflict is the combination of constraints imposed by cost, socio-ecological values and animal welfare and arguably it can only be ameliorated through multi-stakeholder engagements; the success of which is contingent on sound scientific data.

Dedication

To my grandmother, Bubbles, who taught me so much, but most of all, that courage is not bravado; it is facing the dark moments and enduring them, whatever their veracity, and remembering to laugh again once they have passed.

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“It is only when we reach primates that this soul of individual causal memory takes the predominant share in fashioning the behaviour of the animal in relation to its environment, and it is here that its real place in the scheme of mental evolution becomes clear.”

Eugene Marais

The Soul of the Ape 1969

Chapter 1:

HUMAN-WILDLIFE CONFLICT REVIEW

Introduction

The adaptability, intelligence and the means to alter environments has resulted in prolific growth of the human population and an unparalleled global distribution (Holdren & Ehrlich, 1974; Meyer & Turner, 1992). A consequence of this success is the indirect and direct competition between humans and wildlife for limited resources (Heydon, Wilson & Tew, 2010) where frequently the latter is outcompeted by the former (Woodroffe et al. 2005). In this chapter, I review the literature on human-wildlife conflict, beginning with the root causes of conflict (Sillero-Zubiri, Sukumar & Treves, 2007). I choose to define human-wildlife conflict in this thesis as the interactions occurring between wildlife and humans where negative consequences are incurred by either one or both parties.

Invariably the causes of human-wildlife conflict are viewed from an anthropocentric perspective ('human-wildlife impacts', see Redpath et al. 2012) and consequently are translated into costs incurred by humans through various wildlife behaviour (Aust *et al.*, 2009; Barua, Bhagwat & Jadhav, 2013). In response, humans typically employ a range of strategies to moderate the costs that they incur. These strategies range from the exclusion of wildlife from human environments (Bomford & O'Brien 1990; Marker et al. 2005; Reidy et al. 2008) to their complete removal using lethal methods (Ward *et al.*, 1979; Treves & Naughton-Treves, 2005; Katsvanga, Mudyiwa & Gwenzi, 2006).

The successes of different strategies are typically measured by the extent to which they reduce the costs to humans (Belant et al. 1998; Geisser & Reyer 2004; Hill & Wallace 2012), although their overall acceptability may be influenced by local religious and cultural norms (Enck & Decker, 1997; Neff, 2012). Indeed, the influence of socio-cultural factors on human-wildlife conflict cannot be overestimated and is a vital component to consider when mitigating human-wildlife conflict (Thirgood & Redpath 2008; Baruch-Mordo et al. 2009; Dickman 2010; Young et al. 2010).

In this review, I choose to use a number of examples of human-wildlife conflict scenarios to explicitly illustrate the various approaches and challenges associated with this conservation challenge. Through these examples, the variety across human-wildlife conflict scenarios becomes apparent (e.g. Lamarque et al. 2008). This variety may prove challenging to professionals seeking to mitigate this conflict (e.g. Madden 2004) by drawing conclusions from general trends. Therefore, as an aid to these professionals, and based on my review, I propose a generalised human-wildlife conflict framework (Fig. 1.1). After establishing the broader context of human-wildlife conflict, I conclude this review with a focus on human-primate conflict (Lee & Priston 2005; Estrada 2006; Hockings et al. 2009; Wallace & Hill 2012) with special reference to the subject of this thesis, the chacma baboon (*Papio ursinus*), a member of the Papio genus that rivals human distribution in Africa and whose adaptability and generalist diet (Swedell 2011a) has earned it a reputation as a pest (Hill 2000a; Strum 2010; Warren et al. 2011) across the length and breadth of the continent.

The roots of conflict

Crop raiders

The advent of agriculture and the ability to grow (and store) a food source, i.e. crops, has allowed humans to sustain a large, stationary population (Diamond, 2002). Crops present a high-density and predictable source of food, the quality of which has been further enhanced relative to natural fruits, tubers and bulbs through artificial selection (Schwanitz 1957). Consequently, human crop-fields provide easily accessible, concentrated, high-caloric food sources while natural areas bordering these fields contain food with more fibre, more protection (thorns, shells etc.), that require more handling time (searching, digging, removing protection) and are more dispersed. In addition, through fertilisers and irrigation, crops also may fare better than natural plants in times of environmental stress.

Considering the discrepancy in caloric yield between crop fields and natural vegetation, it is not surprising that wild species choose to forage in crop fields. Compounding the problem is the inescapable fact that farmers have had to clear and transform large tracts of natural habitat (e.g. Stoate et al. 2001; Luoto et al. 2003; Vandermeer & Perfecto 2007). For example, in Sumatra, large-scale deforestation to service agriculture has left only small forest remnants to act as wildlife refuges (Kinnaird *et al.*, 2003). Subsequently, several wild species have adapted by supplementing their diet with crops. Through semi-structured interviews in East Kalimatan, Sumatra, Marchal & Hill (2009) found that 13 vertebrate species were reported to feed on crops, and the respondents report crop-raiding by these species as the single most important determinant of crop yield (Marchal & Hill 2009).

Indeed, many wildlife species are faced with declining habitat availability in areas directly adjacent to energetically-abundant crop-fields and appropriately the crop-field has become one of the primary stages for human-wildlife conflict, worldwide. Depletion of crops is associated with a myriad of species including a range of invertebrates (Savary & Willocquet 2000), birds (Bruggers & Elliot 1989), rodents (Odhiambo et al. 2005), badgers (Moore et al. 1994), wild pigs (Kagoro-Rugunda 2004; Schley et al. 2008), deer (Putman & Moore 1998), bears (Fredriksson 2005), elephants (Fernando et al. 2005; Sitati et al. 2005) and a range of primates (Naughton-Treves 1998; Marchal & Hill 2009).

While the success of agriculture has impacted negatively on many wildlife species, a select few have proliferated as proficient crop-raiders (through conservation efforts or natural factors) and may even threaten the sustainability of local farming communities. For example In the east Caprivi, Namibia between 1991 and 1995, there was coincident growth of both the local human and elephant (*Loxodonta africana*) populations (Rodwell et al. 1995). During this period, the number of villages experiencing elephant damages increased and accounted for almost half of all reported wildlife conflicts in the region (O'Connell-Rodwell et al. 2000). The successful conservation of elephants in this region has led to increased conflict with humans and ultimately threatens their long-term persistence (see a further example for wolves below).

Livestock depredation

Equally problematic to crop raiding, is the success with which predators incorporate livestock into their diet. For humans, this livestock (largely cattle, sheep, chickens and goats) represents a source of food (subsistence) and profit (commercial). While livestock farmers stand to incur financial losses in the face of chronic livestock depredation (Butler 2000; Woodroffe et al. 2005a), depredation may further be costly where subsistence farmers and pastoralists ascribe an additional cultural value to livestock (Gandini & Villa 2003).

In comparison to wild herbivores, livestock exhibit consistent spatial patterns, are typically slow and docile (sometimes confined to small areas), and may lack defensive adaptations (e.g. large antlers), making them appealing prey items (Zohary, Tchernov & Horwitz 1998). As with their crops, humans have selectively bred livestock species to enhance the caloric return on farming effort. Domestic animals can be herded, maintained at high density and easily harvested compared to their wild counterparts (Clutton-Brock 1999; Price 1999) but this also makes them easier for predators to locate and consume them. Consequently human-wildlife conflict on the borders between conserved areas and livestock farms is as common as it is difficult to mitigate.

Conflict between livestock farmers and predators presumably date back to the onset of animal domestication and the juxtaposition of an abundant prey source with predators produces a predictable pattern of conflict. A recent example of this conflict comes from the Amazonian rain forest, specifically the Alta Floresta region in northern Mato Grosso, Brazil, where cattle-ranching has recently become widespread. A dramatic increase in cattle numbers (from 200 000 in 1990 to 1.7million in 2003: IBGE 2004) was synonymous with the clearing of extensive areas of primary forest, resulting in a landscape where small and fragmented forest patches lie adjacent to large tracts of grazing land. Two large felids, namely the puma (*Panthera onca*) and jaguar (*Puma concolor*) have included cattle in their diet and are thus conflicting with ranchers. Michalski et al. (2006) quantified the extent of this conflict by conducting detailed interviews with long-term residents, cattle managers and land owners. These data were ground-truthed by presence and abundance sampling of puma and jaguar using both line-transect censuses and camera-traps. Over a 24-month period, both puma and jaguar were found to prey on cattle but the latter accounted for the majority of predation events (72%), targeting young cattle (<15 months) almost exclusively. Unsurprisingly, farms closer to the forest edge sustained the greatest loss of cattle. Peak predations also correlated positively with monthly calving rates and negatively with monthly rainfall. While this conflict might be relatively recent, efforts to further understand it and to generate predictions may benefit through drawing comparisons with similar conflicts elsewhere.

In much of North America, commercial livestock farming is well established and so too is the conflict between ranchers and the gray wolf (*Canis lupus*). The severity of this conflict was such that the wolf was extirpated from entire states (Young & Goldman 1944). Since then and thanks to coordinated conservation efforts, it has been successfully reintroduced in many areas (Fritts et al. 1997; Bangs et al. 1998). However, with this reintroduction, the behaviour for which it was persecuted, namely livestock predation, has resumed.

To determine the extent of this depredation, Musiani et al. (2003) reviewed records for Idaho, Montana and Wyoming (U.S.A) and Alberta (Canada) over two separate 14-year periods. In the U.S.A., wolves killed 728 domestic animals, mostly sheep (68%) and cattle (26%) between 1987 and 2001. In Canada, between 1982 and 1996, wolves accounted for 2086 domestic animal depredations, largely cattle (78%) but also dogs (9%), horses (5%) and sheep (5%). In this conflict and the previous example from the Alta Floresta region (above), the cost imposed by predators on farmers jeopardises efforts to conserve them. Arguably however, it may be possible to advocate the persistence of these predators if the cost of depredation can be offset by a value provided by that species (e.g. tourism). This does not however assist the farmer nor provide security for a burgeoning human population and hence it is extremely difficult, if possible at all, to estimate and therefore offset the costs imposed by wildlife when the latter are responding ‘naturally’ to the loss of natural habitat on the one hand and the simultaneous introduction of an abundant, catchable and palatable food.

Human mortality

Crop-raiding and livestock depredation are arguably the primary drivers of human-wildlife conflict. However, humans themselves are not immune to attacks by wildlife. Spatial overlap between wildlife and humans increases the probability of humans encountering wildlife and a resultant defensive or deliberate attack. As an example, near central India, in the forests of Madhya Pradhesh, the sloth-bear (*Melursus ursinus*) has received notoriety for injuring and killing people from nearby villages (a combination of pastoralists, agriculturalists and gatherers). To quantify the extent of this conflict over a five-year period (April 1989 – March 1994), Rajpurohit & Krausman (2000) reviewed Forest Department records and conducted interviews with the chief wildlife warden, local wildlife officials and a sample of affected villages. 735 incidents of human casualties were attributed to the sloth-bear (67% of all wildlife-inflicted casualties), 48 of which resulted in death. Incursions of humans into ‘wildlife areas’ and vice versa was reflected in the fact that sloth-bear incidents occurred in both crop-fields and indigenous forests. While none of the incidents were classified as predation (human mortalities were likely a result of chance encounters between humans and sloth-bears), deliberate hunting of humans by other wildlife species does occur.

In the Junagadh district of Saurashtra, in north-western India, is the Gir lion (*Panthera leo persica*) which occurs in the Gir forest - a protected area. The forest is surrounded by a multitude of villages that are subject to both non-fatal and fatal lion attacks. Saberwal et al.

(1994) investigated the nature of these attacks between 1977 and 1991. Through interviews in 56 villages, 193 lion attacks were reported; 28 of which resulted in human mortality and 7 of these were attributed to deliberate hunting on the part of the lions. In contrast to Madhya Pradesh (above), the majority of these encounters occurred outside of protected areas and inside human habitat. Further complicating this scenario is that the Gir forest is the last natural home of the Gir lion (estimated at 285 animals in 1990: Gujarat Forest Department, unpubl. data). Arguably, this conflict – between a species on the brink of extinction and impoverished human communities dependent on natural resources – represents the pinnacle of human-wildlife conflict.

In summary the root causes of conflict for humans with wildlife include crop-raiding, livestock depredation and mortality. For wildlife, conflict with humans is characterised by hunting, destruction of natural habitat and the introduction of high-quality, predictable food sources into the environment. In response to such conflict humans have developed a diverse range of strategies primarily geared towards reducing the costs imposed by wildlife and in the next section I explore the rationale and efficacy of these different strategies.

The human response to conflict

In defence of livestock, crops and their own lives, humans have developed a diverse array of techniques that vary in their levels of sophistication, efficacy, welfare, environmental impact, duration and cost (Treves et al. 2009; Fig. 6.1). Most deterrents aim to reduce the spatial overlap between humans and wildlife. Lethal deterrents either specifically target individual problem animals, e.g. habitual crop-raiders, or target the population as a whole by reducing numbers through culling (population control). Generally, non-lethal deterrents are used when the means to administer lethal control are lacking or when the problem species is protected (by cultural or legal requirement) (Haber 1996; Shivik, Treves & Callahan 2003) or communities oppose the use of such methods (Treves & Karanth 2003; Martínez-Espiñeira 2006). Often, these strategies are applied without any attempt to quantify their efficacy which may allow an unsuccessful strategy to persist or provide little opportunity to introduce novel more effective strategies. This lack of data collection further limits an objective assessment of the relative costs and benefits of different strategies. Below I review a selection of the most commonly used lethal and non-lethal strategies and those that may be relevant in the context of the Cape Peninsula and I discuss their characteristics, success and shortcomings.

Non-lethal strategies

Disruptive deterrents

The most simple deterrents, such as hand-clapping, chasing and making loud noises (e.g. Hill 1997) are used against crop-raiding wildlife and operate under the implicit assumption that loud noises will scare animals away. These types of deterrents continue to be used, with varying degrees of sophistication and through devices that are able to generate louder noises with greater frequency and sometimes without the need for a human agent (Gilsdorf et al. 2002). Noise aversion can be classified as a 'Disruptive deterrent' or 'Primary repellent' described by Shivik et al. (2003) as those that 'disrupt (a species') actions through a number of mechanisms such as neophobia, irritation, or pain.'

Gas exploders produce very loud noises (e.g. 130dB at 75m) and 'Electronic guards' pair sirens with strobe lights (combination of light and noise aversion) and illustrate how technology can aid disruptive deterrents. These devices are prevalent in North America where crop depredation by white-tailed deer (*Odocoileus virginianus*) results in considerable financial damage (approximately $4.5 billion per annum: [Conover 2001]). Gilsdorf et al. (2004) tested the efficacy of propane gas exploders and electronic guards in deterring white-tailed deer from cornfields in the Missouri River valley, Nebraska during the corn's silking-tasseling stage, (late June/early July) when deer use of cornfields is most frequent and where corn is most susceptible to damage (Hygnstrom et al. 1992). Over an 18-day period, the study showed no difference between control cornfields and those 'protected' by electronic guards and propane exploders in terms of track-count indices, mean-use of areas, damage rates or corn yields. The authors suggest that the lower rate of increase in track-count indices in protected fields compared with control fields indicates that the devices were initially effective, but that this success declined over a short period of time. Thus, technological advances may not be necessarily synonymous with improved deterrent efficacy.

Fladry, brightly-coloured pieces of cloth tied at intervals along a fence, is an example of a simple disruptive deterrent that was adapted from historical techniques. Originally used to direct the movements of wolves in order to catch them (Okarma & Jędrzejewski 1997), fladry is now employed by ranchers to defend their pastures against livestock depredation by wolves. Interestingly, while no studies have provided convincing evidence to explain its mechanism, the success of fladry has been demonstrated in captivity and on free-ranging wolves (Musiani & Visalberghi 2001; Musiani et al. 2003) and is therefore regarded as a useful wolf deterrent. Once again this usefulness, is restricted to a finite period (1-60 days) following which wolves become accustomed to its presence and start to cross fladry lines that initially deterred them (Musiani et al. 2003).

Both fladry and gas exploders/electronic guards demonstrate the major characteristics of disruptive deterrents namely, rapid implementation, immediate success and financial sustainability. They also reveal the major shortcoming of disruptive deterrents viz. habituation of the target species to the deterrents' stimuli where, after time the target species' normal behavioural patterns resume (Frings & Frings 1963; Boudreau 1972). This is particularly prevalent where a deterrent poses no actual threat (versus e.g. electric fencing, see below). This is not problematic when the deterrent action is only required for brief periods of time (e.g. crop harvesting or calving) but habituation can prove highly problematic where chronic human-wildlife conflict occurs. Rotating deterrent strategies (multiple stimuli used in various combinations at irregular intervals: Koehler et al. 1990) or developing deterrents according to the target species' biology, i.e. using a predator model or playing back target species' distress calls (Conover 1984; Belant et al. 1998) are two ways in which habituation might be delayed. However, in the absence of the target animal forming a strong association between the deterrent stimulus (no matter how successful initially) and a particular behaviour it is likely that habituation will occur eventually, and ultimately lead to the failure of the stimulus to deter the target species.

Aversive deterrents

Shivik et al. (2003) classify 'Aversive deterrents' or 'Secondary repellents' as those that deliver a (negative) stimulus in synchrony with a target species' particular behaviour with such regularity that that species learns to associate its behaviour with the stimulus (negative outcome). Aversive deterrents have a higher specificity than disruptive deterrents and unlike disruptive deterrents, after a successful conditioning period, the animal avoids the problematic behaviour without the deterrent's presence. In contrast to disruptive deterrents that typically require continuous application, aversive deterrents require an initial, brief (sometimes intensive) application period with long-term deterrent effects.

Conditioned taste aversion (CTA) is a typical example of such a deterrent and relies on the theory that an animal that feels nauseous will develop a predisposition to avoid a recently-ingested food (Garcia et al. 1955; Garcia et al. 1974); the so-called 'gut defence' system (Garcia et al. 1972). Thus, treating an animal with an undetectable nauseating agent has the potential to change the diet of that animal. In laboratory experiments, nausea was originally induced in animals through gamma radiation, but subsequently the use of chemicals, either injected into the animal or mixed into food, has become prevalent (Riley & Tuck 1985). Studies have also shown CTA to be effective in a wide range of species (Lubow 2009) including coyotes (Ellins, Catalano & Schechinger 1977), crows (Nicolaus et al. 1983) and raccoons (Semel & Nicolaus 1992). The relevance for CTA in mitigating conflict between humans and wildlife has been explored for a number of species, with some clear particularly compelling successes including the work on badgers (*Meles meles*) in the United Kingdom (Baker et al. 2005; Baker et al. 2007)

Badgers frequently forage in both agricultural and residential human environments, utilising a range of food sources and this leads to the perception of badgers as a pest species (Moore et al. 1994). As badgers forage on the interface between agriculture and natural habitat they are an ideal candidate for CTA, which generates a highly-specific response and conditions an animal against a single food type. Thus, it is well suited to protecting monocrops from a crop-raiding species while allowing that species to range freely and access non-commercial food items (i.e. natural forage) interspersed with or adjacent to those crops. Baker et al. (2005) showed that bait items treated with ziram (organic zinc salt traditionally used as a fungicide) produced an aversive response in badgers that were allowed free access to the bait. Importantly however, the authors suggest that the badgers were able to detect ziram in the bait and in the days following initial consumption, preferentially chose alternative baits (control, capsaicin, cinnamamide in that order). Badgers were thus able to discriminate between treated and untreated bait. In a follow-up study, Baker et al. (2007) found that pairing an (unrelated) odour cue with ziram-treated bait produced an aversion to food treated with the odour cue alone (i.e. without ziram). Thus aversion to untreated food could be elicited in badgers, without the classic end-point of CTA, i.e. where food aversive behaviour occurs despite the absence of an aversive stimulus

The practical application of CTA to human-wildlife conflict scenarios can be difficult. Traditionally in CTA, the target is injected immediately prior to food consumption. This approach is prohibitively labour intensive for free-ranging wildlife populations whose presence at a feeding site is unpredictable. Alternatively, emetics used to treat food (e.g. Lithium Chloride) are more easily detected by the target species and may thus be avoided. In order to accommodate the emetic, treated foods also tend to differ qualitatively to non-treated foods (e.g crushed/peeled and/or placed in containers). These factors increase the likelihood an animal will distinguish treated items from non-treated items and develop an aversion to treated foods only. Also, while CTA may be effective at 'protecting' a single food type, many species involved in human-wildlife conflict tend to forage on multiple food types (e.g. on multi-crop farms or processed food in residential areas). Indeed, Ternent & Garshelis (1999) tested the efficacy of thiabendazole (an agricultural fungicide) in producing aversive behaviour in black bears to ready-to-eat meals (accessed from a military camp in central Minnesota). While the study showed positive results for the deterrent capacity of thiabendazole (bears avoided ready-to-eat meals more after the treatment period), the bears continued to forage on other items obtained from the same areas within the camp. Thus despite its efficacy in principle, CTA is of limited use to species with broad dietary niches that include a variety of human derived foods. Approaches that explore various modifications to typical CTA experiments, e.g. pairing an odour cue (Baker et al. 2007) with an aversive chemical are required for CTA to become a widespread, practical tool for mitigating human-wildlife conflict. Alternatively, the development of emetic chemicals that are both odourless and tasteless and have no detrimental effects on animal health would greatly increase the scope for the application of CTA as a wildlife deterrent.

Shock collars – where disruptive and aversive deterrents meet, succeed and fail

While a conceptual distinction does exist between disruptive and aversive deterrent strategies, electric shock collars arguably combine aspects of both. In principle, a collar is fitted to an animal and programmed (or remotely controlled) to deliver an electric shock when that animal engages in a particular behaviour or transgresses a particular spatial cue.

Adapting concepts used in electric shock aversion behaviour (Krane & Wagner 1975), Linhart et al. (1976) first tested shock collars on coyotes, determining whether aversion to a prey colour (i.e. black or white rabbits) could develop and if these aversions persisted after the collars were removed. Only four coyotes were tested, and three learnt to avoid preying on black rabbits: a response that persisted (without shocking) for between three and 9 months. This pioneer study led to a number of follow-up experiments (Christiansen et al. 2001; Shivik et al. 2003; Schilder & van der Borg 2004; Schultz et al. 2005). More recently Hawley et al. (2009) found that shock collars could successfully deter wolves from an area and that this deterrence persisted even once collars were removed; treated animals avoided the 'shock zone.' This conditioned aversion however, is limited in duration (to a maximum of several months). That the deterrent's stimulus actively disturbs or disrupts the animal and that its efficacy declines over time is typical of disruptive deterrents.

That shock collars do not appear to be effective as aversive deterrents (i.e. they are subject to habituation) in altering ranging patterns, may be due to its failure to manipulate the target animal's instinctive tendencies. That is, while CTA manipulates the way animals' foraging behaviour has evolved to avoid naturally occurring toxic compounds, there is no valid evolutionary rule for avoiding arbitrary spatial boundaries. Rather, avoidance of a threat (e.g. a neighbouring wolf pack) manifests in the avoidance of the area where that threat is likely to occur (inferred from scent and a variety of other cues). Furthermore, even in the presence of such a threat, an animal may periodically inspect and assess the different regions within its range as natural risks and threats are dynamic.

In the same way that Baker et al. (2007) adapted the basic principles of CTA and introduced an odour cue with a nauseating compound, so Schultz et al. (2005) have adapted the shock collar by pairing it with a sound cue (beeping as the treated animal approaches the perimeter). While this approach holds more promise in effecting long-term aversion, success has yet to be demonstrated experimentally. Thus, in principle, the shock collar is an aversive deterrent, but its assumptions regarding ranging behaviour appear flawed. This example illustrates the importance of understanding how deterrents interact with evolutionarily derived sensory systems and behavioural characteristics of target species. Indeed, an understanding of the physiology and behaviour of any target species is crucial when addressing unexpected deterrent failures. Often however, practical challenges complicate the application of deterrents and mitigation strategies that, on the surface, appear suitable.

Electric fencing: an old favourite

For decades, electric fencing has been applied as a wildlife deterrent (Storer et al. 1938; Mcatee 1939; Gard 1971), providing a strong delineator between human populations and wildlife. Strictly speaking, it is a disruptive deterrent and a direct obstacle to an animal's normal behaviour, i.e. crossing a certain boundary. While there is obvious overlap in the sensory basis of aversion for both electric fencing and shock collars, traditional electric fencing approaches do not call for the removal of the deterrent stimulus with any confidence that the previously-shocked animal will continue to avoid the area. Rather, its stimulus remains indefinitely, as per disruptive deterrents. However, unlike many other disruptive deterrents that rely largely on bluff, well-maintained electric fencing delivers a consistent and painful stimulus. Thus habituation is far less likely, occurring only if the target animal habituates to pain.

Black bears in North America (*Ursus americanus*) and Japan (*Ursus thibetanus*) enter suburban and agricultural environments to forage – behaviour that is often mitigated by electric fencing with varying degrees of success. In Okefenokee Swamp in southeast Georgia, bears' success in raiding bee-yards was contingent on a fence failure (through depleted batteries) and bear tracks were seen to follow the lines of successful fences (Clark et al. 2005), suggesting that bears approach fences but are deterred by an electric shock – a finding common with other studies (Maehr & Brady 1982; McKillop & Sibly 1988). Further, when bears did cross disconnected electric fences, they consistently did so only a few days after battery depletion, suggesting that they 'check' fences regularly. As the use of electric fencing is often a trade-off between costs and benefits, in the case of Okefenokee bee yards, the authors recommend its application (where proper maintenance prevents battery depletion) where the cost of a solar charger was approximately equivalent to cost of replacing one hive.

In Japan, black bears cross into human environments abutting natural forests and damage a variety of crops, fish farms and residential areas (e.g. Oka et al. 2004). The landscape of human-bear conflict differs from that of bee-yard raiding in Georgia (above), in that it occurs along an extensive front and not in small, isolated patches. Investigating the efficacy of electric fencing in reducing this conflict, Huygens & Hyashi (1999) found local villagers' attempts at electric fencing to be unsuccessful, largely through obvious construction failures such as poor grounding, incorrectly spaced wires and pregnable corner posts. When the authors constructed their own electric fences, they found them to be highly effective in deterring bears. Interestingly however, the authors cautioned against the widespread application of electric fencing as it may simply divert the bears (and human-bear conflict) to neighbouring, non-electrified agricultural areas. Instead of relying only on fencing, the authors suggested increasing local awareness of bears and providing financial incentive for protecting crops (Huygens et al. 2004).

These examples illustrate how, although electric fencing can be a very effective deterrent, various practical factors can hinder or sometimes prohibit their effective use. A further cautionary point with regards to electric fencing is that on occasion, even working, well-constructed fences do not guarantee exclusion of all problem species. The African elephant is renowned for its ability to breach working fences, through a variety of methods, including pushing over fence poles, breaking wires using their tusks and even breaking directly through 7kV wires when the incentive was sufficient (Thouless & Sakwa 1995). As a final point, the impact of electric fencing on ecosystems and species' evolutionary potential must be considered before its introduction to an area (Hayward & Kerley 2009). Indeed, the environmental impact of any deterrent strategy should be considered before its application, but this is especially important in the case of electric fencing, where an impermeable barrier is established, sometimes over large distances.

Provisioning

The above-mentioned non-lethal methods (deterrents) are similar in that they attempt to increase the cost to wildlife of either performing an undesirable behaviour (e.g. eating crops) or violating a spatial 'rule' (i.e. crossing into human environments). A successful deterrent should consistently make this cost sufficiently high to override any benefit that wildlife accrues from entering human environments and/or consuming human foods (Strum 2010). Taking this cost-benefit ratio and attempting to manipulate not the cost, but the relative benefit of entering human environments and/or eating human food may also achieve the end-goals of deterrents, without the potential negative by-products of deterrents (e.g.

injury or stress). Specifically, the two examples that follow show how increasing the benefits to wildlife of remaining in natural areas or eating food other than that 'owned' by humans can be achieved through food provisioning.

In Langholm Moor, Scotland, human 'ownership' takes the form of the red grouse (*Lagopus lagopus scoticus*) - a game bird that is highly prized for purposes of recreational shooting. The hen harrier (*Circus cyaneus*) preys on red grouse chicks and in combination with other predators can reduce the availability of grouses for shooting (Redpath & Thirgood 1999; Thirgood et al. 2000). Redpath et al. (2001) investigated the efficacy of provisioning (white rats and day-old poultry chicks) on reducing hen harrier predation on red grouse and found that harriers that had access to feeding stations preyed on significantly fewer grouse chicks (0.5/100h vs. 3.7/100h) than harriers that had no access to feeding stations**.** While this particular conflict remains complex for a number of reasons (Redpath et al. 2004; Thirgood & Redpath 2008), the outcome of the provisioning experiment provides scope for the hen harrier (a protected species) to remain in the moorland and continue to service its ecological niche, while reducing its impact on the grouse population and therefore conflict with recreational hunting organisations.

Unlike the above example, provisioning can also look to draw a target species out of a particular area that holds a valued resource. In the case of cervids, provisioning (or supplemental feeding) has been conducted for a number of reasons including to increase the number, fecundity or survival of a particular species or to reduce foraging-related damage to natural and commercial vegetation (Putman & Staines 2004). In a long-term study on moose (*Alces alces*) in Hedmark County, Norway, van Beest et al. (2010) examined whether provisioning stations were able to change spatiotemporal browsing pressure (i.e. reduce browsing pressure on species located far away from feeding stations) on both commercial and non-commercial tree species. Their findings showed an initial (5-10 years) positive relationship between tree proximity to feeding station and browsing pressure. However over time (15-20 years), the relationship between browsing pressure and tree distance from feeding station became more complex as moose no longer restricted their browsing efforts to areas around feeding stations. Through their data, the authors were able to show that while provisioning was able to reduce damage in certain areas, its efficacy was not assured over extended periods. Thus, provisioning is a tool that can be used to manipulate the cost-benefit ratio of wildlife behaving in certain ways (the relative benefit to hen harriers of consuming red grouse declined when presented with easily procured rats and poultry-chicks) or entering certain areas (the relative benefit to moose of entering non-feeding station areas was lower than remaining in feeding station areas).

Compensation schemes

Where wildlife damage cannot be prevented through deterrents or provisioning, the impact of that damage on local human communities can be moderated through compensation schemes; a strategy that seeks to increase the tolerance of local communities to wildlife-associated damage. It is employed in a variety of scenarios, with compensation manifesting in varying forms and originating from a number of sources, including governmental bodies and conservation groups (see Nyhus et al. 2003). Superficially, this approach is straightforward. The end-goal of compensations is to remove any negative impact that wildlife might have on the profit margins (whether on a subsistence or commercial basis) of people living on the periphery of natural areas and/or subject to wildlife damage. Conceptually therefore, these communities would persist as if there were no wildlife damage at all and those sponsoring the compensations would expect to minimise retaliatory action towards wildlife. However, when these compensation schemes are applied fundamental weaknesses become apparent.

Bulte & Rondeau (2005) cite a variety of factors that inhibit successfully administering a compensation scheme: poor administrative structures; dependence on outside funding which may be finite; difficulty in verifying claims; difficulty in making claims; apathy in local farmers who lose incentive to improve crop defences and livestock husbandry practices, opting instead to claim for damages (although some schemes demand proof of mitigation efforts before claims can be made). These factors tend to be typical of compensation programmes rather than idiosyncratic (Nyhus et al. 2003). However, even in the event that a compensation scheme can be implemented and maintained successfully, Bulte and Rondeau (2005) propose three outcomes that would counteract any positive effects that the scheme has on human-wildlife conflict. The first is that while compensation will reduce (retaliatory) hunting, it will simultaneously increase the consistency of crop-farming profits. As farming becomes more appealing, so incentive is provided for more land to be farmed by more people and for farming efforts to intensify. For wildlife, this loss of natural habitat will increase the benefit/cost ratio of raiding and in the absence of deterrents raiding should increase and place considerable strain on compensation scheme budgets without producing more food. Lastly, where herd sizes may have been limited by predation risk, compensation will allow pastoralists to maintain larger herds (as losses would be insured), increasing foraging competition with natural herbivores in areas outside of fenced parks which in turn might reduce the natural prey base. With fewer natural prey items, it is only inevitable that an increase in human-wildlife conflict follows – in complete opposition to compensation's primary objective. In light of these possible side-effects, the authors suggested that compensation (motivated by conservation) should be more closely linked to positive outcomes for wildlife, such as actual species numbers as opposed to "ambiguous incentives" where in essence, farmers and pastoralists are financially rewarded for damage caused and not for mitigating conflict.

Population control: playing the numbers game

An alternative to strategies enforcing the separation of wildlife and humans is the numerical reduction of wildlife populations. The implicit assumption of this approach is that fewer population members equates to fewer incidents of damage/depredation. This numerical control can be either non-lethal (where one or more animals are moved away from the area e.g. translocation) or lethal, where 'problem individuals' or large numbers of a particular population are extirpated. A number of factors dictate whether population control is lethal or non-lethal control, including cost (which can be high for translocation), species' protection status, potential disease/gene transfers, third party involvement and cultural/religious attitudes (Linnell et al. 1997; Treves & Naughton-Treves 2005; Martínez-Espiñeira 2006). Fertility control, where an animal's reproduction is artificially interrupted, either temporarily (e.g. contraceptive implants) or permanently (e.g. vasectomy or castration) can be considered a non-lethal method of mitigating conflict through slowing population growth. However, due to the length of time required for fertility control to affect changes in population size as well as its relatively experimental nature (Hobbs, Bowden & Baker 2000; Cowan, Pech & Curtis 2003), in this review, I consider only translocation under non-lethal methods of population control.

Translocation

Translocation (where a species is moved to an area where it occurs naturally) is used to resolve human-wildlife conflict, to restock game populations and for conservation of endangered species and is carried out almost exclusively by wildlife managers and authorities. While translocation has proved successful at restocking game populations and conserving species, its success at reducing human-wildlife conflict has been questionable (Fischer & Lindenmayer 2000). Translocation's success in human-wildlife conflict mitigation (and species conservation and game restocking) is dependent on animals establishing themselves at the release site and breeding successfully and it is unsurprising that two primary characteristics of failed translocations (Fischer & Lindenmayer 2000) are the inability of relocated animals to establish a territory, survive and breed (e.g. Pietsch 1994; Jones & Witham 1990; Wimberger et al. 2009; Wimberger et al. 2010) and extensive post-relocation movements, which include homing behaviour (e.g. Walsh & Whitehead 1993; Stuwe et al. 1998). In many cases, Linnell et al. (1997) found that post-release monitoring was poor, with available data showing mortality to be high and further, that very few animals remained at their release site, some moving as far as 500km (bears: Rodgers & Carr 1998; cougars: Ruth et al. 1995; Ruth et al. 1998) back to their capture sites. Further, even if homing behaviour does not occur, conflict mitigation at the capture site is not always assured. This is illustrated by an example where golden eagles were translocated and non-territorial conspecifics were observed to take their places (within 3 days in some cases: [Andelt et al. 1999]).

Two major reviews of translocation (Linnell et al. 1997; Fischer & Lindenmayer 2000) cited similar causal factors of failure: hard releases (where an animal(s) is transported and released immediately as opposed to a soft release where animals are placed in holding areas to allow for habituation to the release site); proximity of original problematic factors to the release site (e.g. livestock or crops); injuries sustained during capture/transport; conflict with territorial animals at the release site. Further improving translocation efforts can be challenging where poor monitoring post-release and publication of those results (providing no guiding information to future translocation efforts) and the lack of standard criteria for evaluating the success of translocation.

Clearly translocation can be a risky endeavour and as such, potentially detrimental where the translocated species is endangered. Therefore, experiments with non-threatened, but closely-related species can inform translocation models, improving the chances of success when attempts to move endangered species are made. An example of such an experiment was the translocation of two olive baboon (*Papio anubis*) troops in Kenya from a farming area to a private game reserve on the Laikipia Plateau (Strum 2005). Critically, the release site was carefully chosen with regards to the presence of conspecifics and lack of conflict-inducing factors. In addition, a soft release (provisioned for a brief, initial period) was paired with careful and continuous monitoring of a number of factors. The strength of this study lies in the extensive observation periods before (12 years) and after (18 years) translocation. The extent of these observational periods allowed for factors such as inter-birth interval, birth rates, mortality patterns and survivorship, intestinal parasites and group size to be compared before and after translocation. Strum (2005) posits that translocation success should be measured according to two criteria: whether animals show an improvement in the above indices, post-translocation (criterion 1) and whether the translocated animals perform equally or better than conspecifics which occur/occurred at the release site (criterion 2). The translocation of both troops in Strum's (2005) study satisfied both criteria and importantly showed a decline in the proportion of human conflict-induced mortalities.

Thus, the outcomes of translocation can vary greatly. In some cases, translocation is not viable for logistical or financial reasons and its scope in mitigating human-wildlife conflict may be more limited than is commonly perceived. However, in some cases, translocation can be successful. Ultimately, the applicability of translocation must be assessed on a case-by-case basis and crucially, any translocation attempts should monitor a number of demographic and behavioural indices over at least a generation before and after translocation to adequately inform the literature.

Lethal strategies

Where animals are removed from the population through lethal means, there is less complexity in measuring efficacy than with translocation. Lethal control ranges from extirpation (removal of all members of a species from a specific range: Young & Goldman 1944) to selective removal (where perceived 'problem animals' are removed individually: Linnell et al. 1999). Removing large numbers of a particular species theoretically reduces the impact that a species has on its collective environment, including agriculture and livestock.

Thus, the short-term effects of this type of removal may be favourable for those suffering losses related to the species in question. However, the long-term implications of this strategy are not always predictable. In Kruger National Park, South Africa, high elephant densities were thought to be causing considerable damage to vegetation and to combat this, authorities instigated a culling programme in 1967 (Joubert 1986) that persisted until 1996. While culling reduced the number of elephants, it generated a self-reinforcing process where density-dependent reproductive rates were maximised as the population was reduced below the carrying capacity. High growth rates meant that the population had to be culled regularly over this period and, unwittingly, culling increased the need for further culling and there was only limited evidence that this continued culling actually reduced pressure on the vegetation (van Aarde et al. 1999).

In a comprehensive review of the role that lethal control plays in human-wildlife conflict, Treves & Naughton-Treves (2005) stress that while removal of animals is a potentially useful tool, its application should be carefully deliberated where long-term consequences are not fully understood. For example, the removal of apex predators (and livestock depredators) can lead to the proliferation of meso-predators(e.g. Greenwood et al. 1995). Another unexpected consequence of removal occurs where a territorial animal is euthanized and a neighbouring conspecific takes its place, often exhibiting similar behaviour and rendering the initial removal pointless. In response to livestock depredations by wolves in the Greater Yellowstone Area, 10 wolf packs were removed. In seven of these instances, new packs re-colonized the vacant home ranges and livestock depredation resumed in six of the original ranges (Bradley 2004; Rutledge et al. 2010).

As an alternative to the complexity and unpredictability involved in removing large numbers, Treves & Naughton-Treves (2005) proposed the selective removal of ‘problem individuals’. There are two crucial points to consider when taking this approach. The first is that correct identification of individual problem animals (or even species) is not always feasible and identity can usually only be inferred from an animal’s temporal and spatial proximity to any raiding/predation incident. The second point is that negative perceptions of wildlife in local communities are not necessarily mollified by selective removals and Treves & Naughton-Treves (2005) caution against removal as a knee-jerk reaction to public dissatisfaction. Instead, removals should be part of a goal-driven strategy to reduce depredation of livestock or crops without having to remove excessive numbers of animals. Crucially, Treves & Naughton-Treves (2005) advocate a holistic approach in which non-lethal methods are applied in conjunction with removals, and efforts to improve crop protection and livestock husbandry to proactively prevent the emergence of new problem animals. Thus, translocation and lethal control may seem both simple and powerful means to reduce human-wildlife conflict, but there are myriad factors that influence their use and success.

Where conflict gets complicated

The simplicity of the factors that drive wild animals into conflict with humans starkly contrasts with the complexity of factors that are involved in the human perspective of such conflict. The latter factors will exert a strong influence on the outcome of human-wildlife conflict, but are not always thoroughly explored. The influential factors for both directly affected parties (i.e. communities interfacing with wildlife and incurring crop losses, livestock depredation and/or human mortality) and third parties (not directly affected by wildlife behaviour but having a vested interest in the outcomes of human-wildlife conflicts) are important to understand for successful human-wildlife conflict mitigation (Dickman 2010; Redpath et al. 2012). While the behaviour and influential factors of directly affected parties may seem simple (e.g. protecting crops), there are often factors complicating their interactions with wildlife. This also holds true for third parties where human-human conflicts are often at play (Young et al. 2005; Redpath et al. 2012).

In a comprehensive review of the social factors influencing human-wildlife conflict, Dickman (2010) went as far as to suggest that human-wildlife conflict is sometimes a manifestation of underlying conflicts between directly affected parties and third parties. Critically, Dickman (2010) also proposes an instinctive thought process that those attempting to mitigate conflict, often adopt. These are that (1) conflict levels accurately reflect the damage caused by wildlife, (2) the response to the conflict is proportional to the level of conflict and (3) the greater the manipulation of the response to conflict, the greater the conservation effects. Although logical, these assumptions are often flawed and the efficacy of conservation efforts will be much improved by accepting that a variety of factors influence human-wildlife conflict at various junctures.

Dickman (2010) classified these factors into three broad categories, namely perceptions of risk (where actual risk is poorly understood or measured), disproportionate responses (where negligible damage might elicit harsh responses) and social influence (e.g. religion or culture). In order to appreciate the importance of these factors, I use two iconic conflict species as illustrative examples of how social influences might lead to cross-cultural variation in the perceptions of a single species (wolves); or precipitate conflict between third party organisations and communities directly affected by human-wildlife conflict (tigers).

Wolves

Within a single country, the perceptions of a species may vary according to a number of factors. This scenario is typified by attitudes towards the gray wolf in Sweden – a species that has reappeared and increased dramatically in numbers since 1991 (Wabakken et al. 2001). Ericsson & Heberlein (2003) investigated the attitudes towards wolves of four, mutually-exclusive sectors of the Swedish population, namely: urban non-hunters; rural non-hunters; urban hunters; rural hunters. The authors found that rural hunters (who had the most knowledge and experience of wolves) held the most negative view towards wolves. In contrast, the group with the greatest predisposition to wolves, urban non-hunters, had the least experience and knowledge of wolves. Further, once knowledge and experience were controlled for, data showed that rural inhabitants still held a more negative view of wolves than their urban counterparts. The authors suggested that a complex interplay of factors determine the perceptions of people towards wolves. That the wolf occurs in rural areas is contrary to the will of the rural population, and its persistence is symbolic of how the will of the majority urban population (i.e. favourable toward the wolf) has prevailed.

The attitudes of rural inhabitants are not necessarily preserved across cultures. Indeed, shifting focus to North America, the attitudes of indigenous rural inhabitants towards wolves contradict those of Swedish rural inhabitants. There exists a cultural component that influences the perspectives of members of the Bad River Band of the Lake Superior Tribe of Ojibwe Indians (Johnston 1990). Broadly the wolf is seen as part of the natural system which is treated with reverence, accepted as inexorably linked to the survival of man and endowed with qualities such as determination and guardianship (Johnston 1990). It is largely for these reasons that, when questioned about their perceptions of wolves, respondents from the Bad

River Band were significantly more positive and showed more opposition to wolf population control than non-tribal respondents living on wolf-traversed land (Shelley 2010). The contrast in these attitudes shows how factors rooted in cultural views can fundamentally influence the perspectives on wildlife species.

Tigers

Human-wildlife conflict in developing countries is characterised by human populations that experience resource paucity and directly conflict with wildlife. Often these populations are involved in resource harvesting on the periphery of deteriorating natural refuges. To add complexity, several of the species involved in these conflicts are endangered (e.g. Gir lion, snow leopard and tiger) and this can draw the attention of multinational conservation organisations. In these scenarios, where the survival of both humans and wildlife are precarious, social factors influencing and underlying these conflicts can become more pronounced. Across Asia, e.g. Laos PDR (Johnson et al. 2006), Sumatra (Nyhus & Tilson 2004), Bhutan (Sangay & Vernes 2008), Myanmar (Lynam, Khaing & Zaw 2006) and India (Madhusudan, 2003), human-tiger conflicts typify situations in which these social factors precipitate. Conventional (and arguably outdated) conservation strategies placed the interests of such wildlife species before those of local human populations; a logical premise, but one that may ultimately prove detrimental to those species.

To illustrate this trend, Norchi & Bolze (1995) compiled a strategy document on behalf of the Wildlife Conservation Society in which they highlighted the major challenges facing wild tigers and suggested actions to overcome these challenges. While the document was arguably appropriate in addressing the needs of tigers, Saberwal (1997) asserted that the best interests of local communities were not considered adequately. By failing to do this, Saberwal suggested that the policy itself was fundamentally flawed. Any attempts at an education campaign (a primary recommendation of the strategy document), he argued, would fail if the needs of local communities were neglected, particularly in areas with widely-held negative views of tiger conservation. Insensitivity to these perceptions and the local lifestyle where villagers struggle to survive and sometimes lose relatives to tigers would thus threaten the success of any conservation strategy.

Further, Norchi & Bolze (1995) urged that options to relocate locals and livestock out of tiger habitat should be explored; an approach that, Saberwal (1997) argued, failed to appreciate the consequences of social fragmentation and disturbance which emerge following these relocations. Furthermore any strategy placing the needs of an animal above the local community risks isolating and antagonizing that community. Ultimately, Saberwal (1997) proposed that long-term success in conservation projects would only be feasible if local communities are not only involved, but given custodianship of local resources and their conservation. This example illustrates how conflict between locals and wildlife can be overlaid by the conflict existing between third parties. Resolution of both levels of conflict is fundamental if human-wildlife conflict is to be mitigated sustainably. In addition, it should be noted that Saberwal (1997) was writing from a biologist's perspective and not that of a human rights' advocate. Conflict between third parties could easily intensify should human interest groups become involved. Ultimately, when human-wildlife conflict reaches this kind of multi-layered complexity, the need for a platform for dialogue becomes clear. This dialogue should consider the interests of, and ideally receive representation from, all directly-affected parties.

Thus, while human-wildlife conflict may have simple origins that are characterised by competition between humans and wildlife over resources, the complexity that contemporary conflict exhibits far exceeds this simple interaction. Understanding the prevailing cultural, religious and economic factors that influence these conflicts is crucial. In precarious conflicts, i.e. where the livelihoods of people are pitted against the survival of endangered species, understanding the perspectives of those people will minimise the risk of isolating and excluding local communities from decision-making processes. While each party taking part in this dialogue may have to accept a compromise on their initial aims, sustainable solutions can never be reached where disproportionate costs are borne by a single party.

Although diverse, the studies I have discussed above represent only a small proportion of human-wildlife conflict worldwide. I have selected them to illustrate that an understanding of human-wildlife conflict demands that both biological and social aspects must be addressed. It can also be seen that mitigation strategies should be site-specific and may require simple techniques like fencing or innovative and resourceful approaches like constructing beehive fencing as an elephant deterrent (King et al. 2009) in combination with audience-appropriate education campaigns. I have summarised the literature presented above into a generalised theoretical framework of ‘the process of human-wildlife conflict’ (Fig. 1.1). The ultimate causes or roots of conflict are species’ loss of habitat and food, often in close proximity to desirable human food sources. Proximally conflict occurs where wildlife species ‘transgress’ by eating crops, livestock or causing human mortalities. These ‘transgressions’ result in loss of livelihood or profit to humans (directly affected parties) and provokes emotions such as fear (human mortality) or anger. Consequently these affected parties might respond by using non-lethal or lethal methods of deterrence. This response will be influenced by both social factors (e.g. religious or culture beliefs) and by third parties (government, NGOs, researchers etc.). Conflict species will be affected by this response in various ways, including injury or mortality, further loss of habitat or occasionally are left undisturbed where affected parties benefit from conflict species (e.g. ecotourism). These consequences for wildlife then feedback into third party responses and social factors. From this point, two broad outcomes are then possible. Conflict can end through species’ removal (deterrence or lethal control) or symbiosis between affected parties and conflict species. Alternatively, conflict continues and/or escalates as wildlife species continue to ‘transgress.’ Continued conflict may result in feedback to third parties or social factors that will then moderate the conflict process over the next cycle. While this framework may not encompass all human-wildlife conflict scenarios it should aid a variety of parties seeking to mitigate these conflict scenarios. In the final sections of this review, I focus on human-primate conflict in general and human-baboon conflict in particular, where high niche overlap between humans and primates arguably results in the most intensive conflicts and ones that hold great evolutionary significance.

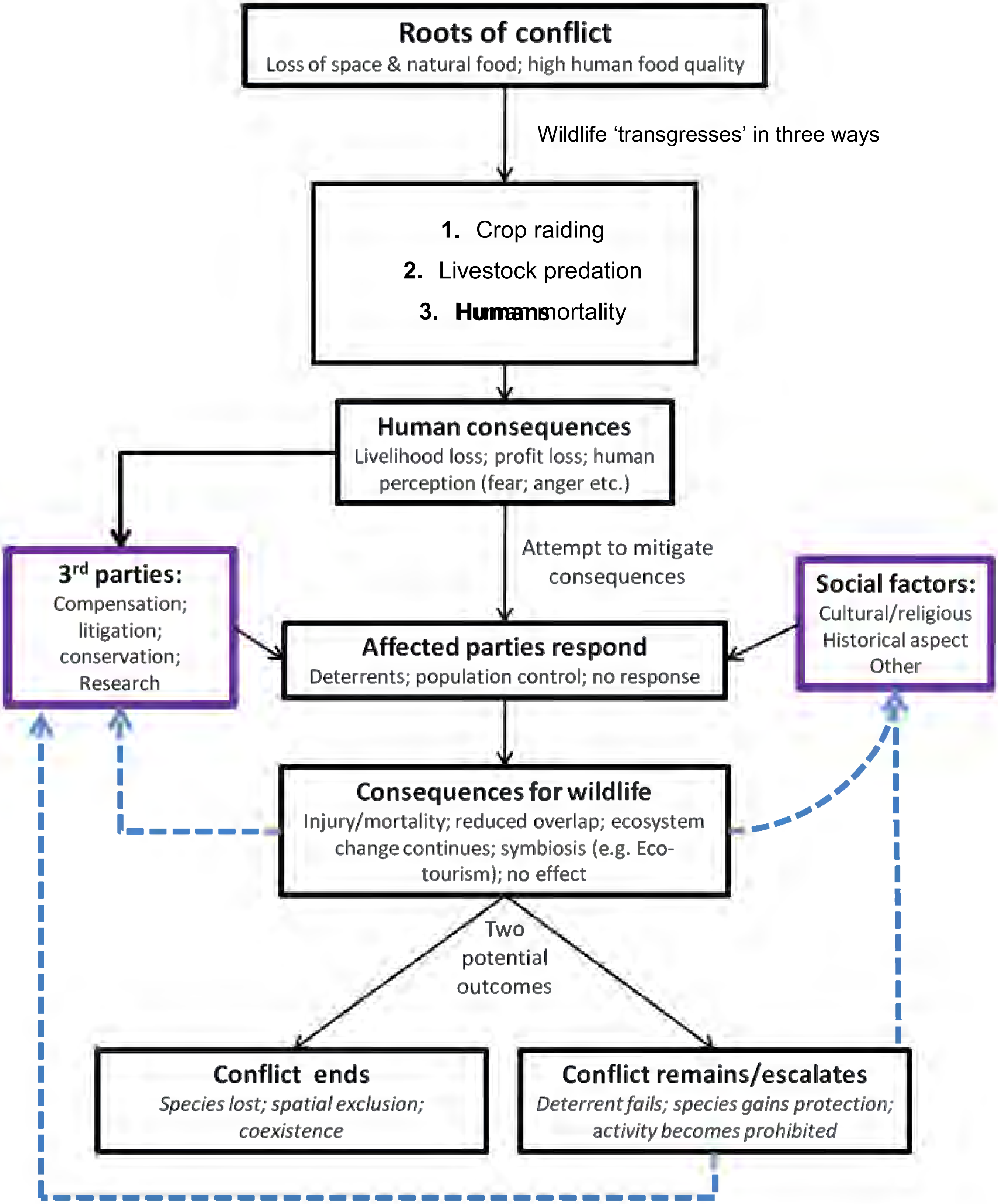


Figure 1.1. Proposed schematic of the process of human-wildlife conflict based on a review of the literature that includes sequential steps from the roots of conflict to the conclusion as well as a variety of influential factors (purple boxes) and feedback mechanisms (blue dashed lines).

Close to home: human-primate conflict

Conflict between humans and primates originates almost entirely from primate crop-raiding behaviour (see above) and includes nearly all primate families (Lee & Priston 2005). In particular, the genera *Cercopithecus*, *Macaca* and *Papio* are ideally suited to raiding as they are dietary generalists, dexterous and have the locomotory ability to move from forest edges to crop land (Chivers 1986; Gautier & Biquand 1994). Mitigation strategies and retributive actions often follow primate raiding and the matter is made more complex by a variety of social factors and the involvement of third parties.

Human-primate conflict is receiving progressively more attention due to its importance in both species conservation and the costs experienced by human populations (e.g. Gumert & Fuentes 2011). The factors that distinguish human-primate conflict from human-wildlife conflict in general, are akin to those that provoke intense debate and emotive responses regarding the use of primates in biomedical research (e.g. Goodman & Check 2002), i.e. the close phylogenetic relationship and overall phenotypic similarity between humans and primates. While physiological and anatomical similarities are of importance in biomedical research, similarities in dietary requirements and habitat preferences have resulted in pervasive conflict between humans and primates.

In a review of the ethics of conserving primate populations that live in close proximity to human communities, Hill (2002) proposed that the scientific, ecological, moral/cultural & economic value of primates should be weighed against the costs that primates incur to neighbouring human communities. These costs are largely in the form of crop losses but include disease transmission (Woodford, Butynski & Karesh 2002). That these costs are generally borne by 'disadvantaged and economically-vulnerable people' raises the question of how much capital and effort should be allocated to primate conservation, particularly if no benefit accrues to these local communities. Any successful mitigation of human-primate conflict requires local community cooperation, particularly if end-goals are to reduce habitat destruction and hunting. Where these communities bear the costs of protected areas, but receive no benefit (Bell 1984), their perceptions may prohibit any such mitigation efforts.

Lee & Priston (2005) reviewed studies involving local human perceptions of primates, finding them to vary with religious and cultural context. Across Asia, for example, primates are variously revered, respected and/or endowed with anthropogenic qualities such as cunning and deviousness (e.g. Burton 2002; Gautier &Biquand 1994). Ultimately however, while cultural structures may dictate initial attitudes towards primates, they do not maintain tolerance in the face of chronic damage. For example, primates that are revered and fed in temples are readily persecuted for raiding in neighbouring crop fields (Eudey 1994; Knight 1999). In some instances, cultural influence may prompt aggressive behaviour towards primates, e.g. in Madagascar, where the aye-aye (*Daubentonia madagascariensis*) was seen as an evil omen and persecuted as a result (Fitter 1974).

Cultural values and behaviour towards primates may vary over time within a single cultural context. Sprague & Iwasaki (2006) illustrate this by exploring the fluctuations in human-primate coexistence in Japan. Between the early 1970’s and 2001, monkeys were hunted on a regular basis in response to their detrimental impact to crops and as many as 10 000 were being removed per year. Then, in 2005 in contrast to this trend, the Prime Minister of Japan used the word *kyosei*, meaning harmonious and mutually-beneficial coexistence between humans and nature, at the closing ceremony of the Aichi World Exposition. This was possibly a naively optimistic forecast given the high costs of monkey raids to farms that overlapped with monkey home ranges. Consequently government education programmes have made the subtle but significant shift from *kyosei* to the *kyozon,* which means simply to co-exist or a ‘common presence in space and time’. This is typified by recommendations that farmers reduce raiding incentive and increase protection around their farms, sometimes urging the use of electric fencing. Thus, while large-scale lethal control programmes may be undesirable, so too is spatial overlap between humans and primates.

Throughout Asia, the genus *Macaca* is renowned for its ability to live in close proximity to humans and to exploit human-derived food items; a most unlikely candidate for *kyosei*. The rhesus macaque is arguably the most prominent raider within the genus but is by no means the only macaque involved in conflict. The long-tailed macaque (*Macaca fascicularis:* North Sumatra), the Buton macaque (*Macaca ochreata brunnescens*: Buton) and the Tonkean macaque (*Macaca tonkeana*: Buton, Sulawesi) are prominent crop raiders in Indonesia (Marchal & Hill 2009; Riley & Priston 2010). In interviews, villagers rated these primates as the most destructive of wildlife species, citing their preference for fruit as highly problematic (Marchal & Hill 2009). Further, the long-tailed macaque was reported to be the most destructive of all the primates and was the species most frequently killed by hunters (the frequency was likely under-reported due to the protected status of some of the macaques).

Damage is also disproportionately attributed to larger mammal species such as monkeys further biasing negative perception to them. Crop damage reports from the Lindu highlands in Sulawesi suggest that the Tonkean macaque is believed to be the species responsible for the majority of damage, but quantified surveys of the damage revealed significantly more damage is caused by forest rats (Riley 2006). Riley & Priston (2010) suggest that while crop-raiding may have been a problem historically, the recent advent of commercial cacao farming effectively increased the costs of macaque raids to farmers as their crop value increased. Further, Tonkean macaques actually show a preference for cacao, irrespective of natural fruit availability, resulting in a scenario highly conducive to human-primate conflict (Riley 2007).

Primate species may differ in their proficiency to source anthropogenic food. Pirta et al. (1997) investigated the Hanuman langur and rhesus macaque populations in the state of Himachal Pradesh, northern India. The species co-occur and while both are seen to crop raid, rhesus macaques did so significantly more than Hanuman langurs (83% of farmers reported macaque damage while only 44% did so for langurs) and showed bolder behaviour, i.e. were willing to snatch food directly from people. Further, in contrast to the absence of Hanuman langurs, 17 rhesus macaque troops were recorded at temples in the sample area. Consequently, interview respondents expressed more negative attitudes towards the rhesus macaques than towards the Hanuman langurs, despite the revered status of rhesus macaques as the reincarnation of the Hindi god Hanuman (Jolly 1985; Pirta et al. 1997; Choudhury 2008).

While conflict around religious temples is only a small part of the conflict between rhesus macaques and humans, it is critical in eliciting some of the contradictions of human behaviour and perceptions. Other primates, e.g. rhesus, Assamese macaques and golden- and capped langurs in Northern India (e.g. Medhi et al. 2007) also use these temples, either as temporary or permanent refuges. Typically, these ‘temple primates’ are not harassed, and often semi-provisioned. In some cases, these populations expand spatially (either when provisioned food is reduced, or if the population grows) and encounter other human environments where they may not be protected. Raiding behaviour used to obtain food to which the primates have become accustomed, often leads to harassment and retributive actions by humans. This disparity in human behaviour was elicited in a study of temple primates (Medhi et al. 2007) in which the authors surveyed human temple visitors and found that the same respondent might express a desire for the temple primates to be removed, while admitting to feeding primates at temples.

Education about primate behaviour and the consequence of feeding primates may prove crucial where transient human populations (i.e. visitors) are in frequent proximity to primates. Recreational visitors to the Parque Nacional de Brasília in Brazil are often at close quarters with tufted capuchins and provide a useful platform for understanding this particular facet of human-primate interactions (Sabbatini et al. 2006). In their study, Sabbatini et al. (2006) observed human-capuchin interactions discretely and subsequently interviewed visitors. Observations showed that visitors regularly fed capuchins at close proximity, initiating 47% of interactions, with the majority (80%) involving human food. When interviewed, respondents contradicted these observations, with the majority (84%) denying that they provided food, although interestingly reporting that they had seen others feeding the capuchins 70% of the time. The authors posit that the respondents provided socially-acceptable answers, (as dictated by signage) without accurate substantiation, suggesting that visitors knew not to feed capuchins, but not why and hence continued to do so. Currently, levels of capuchin aggression are low (pursuit or threats in only 17% of interactions and a complete absence of overt aggression), but they could escalate (e.g. Zhao & Deng 1992; Chauhan & Pirta 2010) if preventative measures like education and enforcement are not implemented and the problematic feeding is allowed to persist.

Human-baboon conflict: the problem with Papio

The concluding section of this review centres on the primate genera arguably most renowned for conflict with humans - *Papio*, the baboons. The genus as a whole has the greatest distribution of all non-human primates and generally, they are intelligent, social, agile, dexterous, have a high dietary flexibility and wide habitat tolerance (Else 1991; Swedell 2011). As a result of these attributes, baboons are highly adaptable and have learnt to incorporate human food into their diet from a number of sources. Indeed, baboons can prove so adept at raiding human food sources, that they can impose greater costs to farmers than any other wildlife species (Naughton-Treves 1996). It is primarily this raiding behaviour that leads to conflict with humans.

Hill (2000) explored human-baboon (*Papio hamadryas anubis*) conflict on the southern edge of Budongo Forest Reserve in Uganda, where the impacts of wildlife-associated crop damage can be crippling (over half of respondents reported being entirely dependent on agriculture for subsistence). Hill (2000) sampled five adjacent regions in the study, assessing crop damage, farmer perceptions and the wildlife species responsible for damage (using bite marks and spoor). Baboons raided crops more often than any other species, causing 70% of all wildlife-induced crop damage. Farms on the forest edge, and those without neighbouring farms to buffer the forest edge incurred greater crop damage, indicating baboon preference for crop fields closer to natural refuges. Local villagers relied mostly on crop guarding and chasing and although men were known to be more effective chasers and guards, alternative activities (school, trading and non-farming employment) resulted in their presence only being recorded one third of the time. In the face of the considerable nutritional reward of crops, inconsistent guarding will invariably fail as baboons are able to reduce overall foraging times and allocate time to waiting for raiding opportunities (Oyaro & Strum 1984; Forthman-Quick & Demment 1988). Resulting crop losses contributed to perceptions of baboons as vindictive and 'organised like the army.'

Another aspect to consider is baboon movements and behaviour in relation to crop-raiding. For example, adolescent male baboons (*Papio anubis*) are the age class showing the greatest raiding frequency (Forthman-Quick 1986; Oyaro& Strum 1984; Strum 1994). Beyond the individual level, Warren (2008) assessed the behaviour of a crop-raiding baboon (*Papio anubis*) troop near the south-western border of Gashaka Gumti National Park, Nigeria. Impressively, 69% of raids were successful, despite the presence of vigilant farmers during 32% of successful raids. Baboons exhibited a clear surveillance regime before entering crop fields, and assumed elevated positions within 50m of the fields. While the time actually spent in crop fields was minimal, baboons maximised yield by transporting raided items in their cheek pouches, mouths and hands by resorting to bipedal locomotion.

Despite perceptions that baboons exhibit tactical deception or military organisation (see above), Warren (2008) suggests rather, that group splits while raiding are perhaps a consequence of lower-ranking individuals avoiding competition with dominant individuals when close to high quality food items (see Chapter 3). Researchers recorded some crop-guarding by farmers but this was not consistent: guards were only present for 54% of raids in the dry season and for 44% of raids in the wet season. Where raiding efforts are rewarded more often than not with nutritionally-rich crops, baboons should be expected to maintain raiding behaviour.

The emergence of commercial farming ventures in Africa has introduced an additional dimension to conflict. A primary example of this is in pine plantations, where bark-stripping behaviour by baboons results in mortality, deformation and stunted growth of pine trees (Bigalke & van Hensbergen 1990; Fergusson 2005; Katsvanga et al. 2006). This behaviour is not unique to baboons (Barbary macaques: Ciani et al. 2001; Sika deer: Akashi & Nakashizuka 1999; grey squirrel: Kenward & Parish 1986) and results in considerable losses to farmers and subsequent conflict between humans and baboons. The motivation for bark-stripping in baboons is not yet clear, but pine seeds (stored in cones) feature in their diet and may serve as an attractant to pine plantations (Katsvanga et al. 2009). Attempts to reduce bark-stripping almost entirely focus on numerically reducing baboon populations, through hunting, trapping and shooting (Fergusson 2005), but quantification of the success of this approach is scarce.

Katsvanga et al. (2006) assessed the impact of chemical control (treating baited maize within plantations with Papiol, a rodenticide) on baboon numbers and bark-stripping. Poisoning resulted in an immediate, significant decline in the baboon population (mean troop size declined from 72 to 20) and bark-stripping was significantly reduced in the two months following the poisoning. However, after this period, bark-stripping levels increased to pre-poisoning levels and several baboons joined the three focal troops from surrounding areas. Thus, poisoning as a means to reduce bark-stripping had failed to produce a long-term solution. Henzi et al. (2011) argue that indiscriminate eradication programmes that are not informed by data on the local baboon population structure, behaviour and diet are unlikely to succeed in the long-term. Thus, in the same vein that Warren (2008) advocates a better understanding of raiding behaviour, so Henzi et al. (2011) advocate an understanding of broad population knowledge, baboon habitat use, ranging patterns and behaviour within and adjacent to plantations as a starting point in mitigating such damage.

The growing interface between humans and baboons, coupled with the success that baboons exhibit in human-modified environments justifies the need to understand their biology and behaviour in this context (Strum & Western 1982; Strum 1987). The findings of such investigations are relevant not only to the biological sciences but conservation and management as well. In a unique study, Strum (2010) assessed how and why crop-raiding behaviour develops in baboons (*Papio anubis*) and what the consequences of this raiding are. The “Pumphouse Gang” or PHG was a non-raiding troop at the Gilgil study site, Kekopey. In 1979, farming efforts began in the area at the same time a fission troop “Wabaya” or WBY was beginning to separate from PHG. Progressively, WBY began to exploit crops; behaviour that persisted throughout the study (by 1984, human food consistently comprised between 40% and 50% of WBY’s diet). In contrast, PHG showed raiding behaviour at a very low frequency and the troop never became regular crop-raiders (human food never comprised more than 10% of PHG’s diet). The attraction of human food (as discussed above for other species) lies in its nutritional superiority reduced handling time, easier digestion and spatial predictability.

While baboon preference for human food is well-documented (Altmann & Alberts 1987; Altmann & Muruthi 1988; Altmann et al. 1993; Biquand et al. 1994; Boug et al. 1994; Bronikowski & Altmann 1996; Forthman 1986; Hill 2000b; Kemnitz et al. 2002; Naughton-Treves 1998; Naughton-Treves et al. 1998; Tarara et al. 1985; Warren et al. 2007; Hoffman & O’Riain 2010; van Doorn et al. 2010; Chapters 2 & 3) the long-term implications of raiding behaviour and the acquisition of human food are not as well understood. With the benefit of a long-term dataset, Strum (2010) was able to assess this impact on activity budget, ranging behaviour, inter-birth interval, injury and mortality. These indices proved useful in assessing the relative costs and benefits of raiding. Raiders (male and female) exhibited higher growth rates, reached maximum weight sooner and achieved heavier final weights than non-raiding individuals (Strum 1991). Further, raiders showed a decreased inter-birth interval (433d vs. 645d), lower range of percentage time spent feeding (24%-38% vs. 38%-61%) and more time spent resting and socialising. There was also the suggestion that raiding females were younger at first birth, but this was complicated by a period of higher biomass of natural food prior to the onset of raiding.

While there are expected to be costs associated with raiding, they have rarely been quantified (Tarara et al. 1985). Strum found the presence of human settlements to increase mortality for both the raiding and non-raiding troop, with human-related mortalities slightly higher in the raiding troop. However, over the four-year study period, there was no significant difference in injuries, mortality or infant survival between the two troops. Thus, the benefits of raiding to baboons seemed to offset the costs incurred through humans crop-guarding, chasing and hunting. Consequently, Strum (2010) argues that the only way to reduce raiding frequency is to make raiding a more costly behaviour.

The above examples illustrate the pervasiveness and variation of human-baboon conflict. In South Africa, the Cape Peninsula exhibits arguably the greatest diversity of human-baboon (*Papio ursinus*) conflict in a single geographic region. The region consists of a multitude of land-use areas including a pine plantation, vineyard, a protected area (Table Mountain National Park) with tourist nodes and high- and low-density urban areas. Historically, chacma baboons were able to move from the Cape Peninsula across the Cape flats to the nearest neighbouring populations in the Limietberg mountains to the east. However, urban sprawl has effectively created a physical barrier and isolated the local baboon population from their nearest neighbours for at least 100 years.

Currently, 16 troops, and a total population of 501 baboons (Beamish 2012, unpubl. data) range in the 470km^2 area that comprises the Cape Peninsula. In South Africa, this is the only baboon population outside of a National Park that is legally protected from hunting (Western Cape Nature Conservation 2000). Nevertheless, although conflict between Peninsula residents and baboons may have been reduced by these laws, residents continue to sustain property damage, stress and injuries to domestic animals (NCC and HWS monthly reports*), and baboons are still injured and killed by a range of causes (e.g. shooting, cars, electric shocks, dogs, poisoning) within urban areas (Beamish 2009). The conflict also extends to the involvement of a number of third parties. Three authorities are directly or indirectly responsible for baboon management in the Cape Peninsula. SANParks (South African National Parks) is mandated to manage various parks within the Cape Peninsula and therefore the several troops that range in these parks. Cape Nature is the provincial authority mandated to manage wildlife (therefore baboons) outside of national parks in the Western Cape. The City of Cape Town is the municipal authority mandated to maintain a safe living environment for residents which can be compromised by aggressive baboons. A baboon management service provider (NCC/HWS) is contracted to manage conflict troops, generally through coordinating baboon monitors/field rangers (see below). The SPCA (Society for the Prevention of Cruelty to Animals) is generally mandated to protect domestic/caged animals but has historically been involved in baboon management debates. Baboon Matters is a charity organisation that advocates for the rights of Cape Peninsula baboons and was once responsible for running the baboon monitor programme. Finally, the Baboon Liaison Group (BLG) is a group of elected civil representatives that interface with baboon management authorities, researchers and the general public. Chapter 6 explores in depth, the human-human conflict that has occurred between these various organisations.

*NCC (NCC Environmental Services) and HWS (Human-Wildlife Services) are private companies that were contracted to run the monitor programme between 2009 and the present time. Both organisations produce monthly reports of various aspects of the day-to-day occurrences of baboon management (NCC: http://www.ncc-group.co.za/case-studies/managing-baboon-human-conflict-city-cape-town; HWS: http://www.hwsolutions.org/data-and-reports.php).

Conflict between Cape Peninsula residents and baboons revolves largely around raiding behaviour, where baboons have learnt to source food from a variety of human environments (van Doorn 2009; Hoffman & O'Riain 2010), in preference to natural food items found in Fynbos - the predominant vegetation type which is characteristically species-rich but nutrient-poor (Cowling, MacDonald & Simmons 1996). Reducing this conflict is highly desirable and currently, the primary method of human-baboon conflict mitigation is the baboon monitor programme (van Doorn et al 2010), where teams of predominantly men are assigned to commensal troops and tasked with keeping baboons away from urban areas (van Doorn 2009). The method looks to increase the actual and perceived costs of raiding by interrupting raiding bouts – a strategy recommended by researchers working in other parts of Africa (Hill 2000; Strum 2010). However, since the baboons are legally protected from hunting in the Cape Peninsula, monitors have largely been restricted to posturing and threatening without actually ever delivering a systematic cost (e.g., pain or the threat of pain from a projectile). Consequently the baboons have learnt that the costs imposed by monitors are far outweighed by the benefits of human environments (where food obtained includes fruit, bread, eggs, vegetables and sugar). Thus raiding levels have remained very high for monitored troops most of which are now comprised almost entirely of habitual raiders with little to no fear of humans including the monitors employed to deter their raiding efforts. In 2012, a change in monitoring techniques and permission to use new deterrents (e.g. paintball markers) has reduced raiding by increasing monitor efficacy (Hoarau unpubl. data, HWS reports) and reduced human-induced baboon injury and mortality (Beamish 2012, Beamish unpubl. data). While these outcomes are positive, monitors do not completely exclude baboons from human environments and raiding, particularly by lone males, continues. Further baboon population growth (ironically through improved conflict mitigation) may render baboon management in the Cape Peninsula unsustainable in light of the already considerable costs associated with this management (13.9 million ZAR: van Zyl & Barbour 2013) and therefore alternative solutions are required.

In light of the current human-baboon conflict in the Cape Peninsula and findings gleaned from this literature review, in the remainder of this thesis I will explore various methods that may augment or replace the current mitigation approach (i.e. baboon monitors). Various options described above do not appear viable in most conflict scenarios. Although future variations may still be tested (e.g. Schultz et al. 2005), the use of shock collars to deter wildlife from particular areas has not yet exhibited long-term efficacy (Hawley et al. 2009). Similarly, while arguments can be made for its application in alternative forms, traditional compensation schemes have been shown to be highly flawed (Nyhus & Tilson 2004). Some of the successful human-wildlife conflict mitigation tools described above are not applicable to the Cape Peninsula context. Conditioned taste aversion, while potentially effective in single-crop fields, will face similar challenges to those encountered when it was applied experimentally against bears foraging on ready-to-eat meals (Ternent & Garshelis 1999, see above), i.e. Cape Peninsula baboons enjoy a wide range of food types inside human environments and aversion to a single food is unlikely to render these environments unappealing. Translocation of baboons (and the associated damage) away from the Cape Peninsula is not considered to be a viable management option with conservation authorities citing the genetic paucity of the population (Bishop et al. *in prep*), risks of disease transfer (Drewe et al. 2012; Ravasi et al. 2012), the raiding habits of the Cape Peninsula baboons (van Doorn et al. 2010; Hoffman & O'Riain 2012b) and the shortage of appropriate release sites and resources for adequate post-release monitoring (see Strum 2010) as strong counter arguments to this management option. Lastly, reducing the population and the damages associated with its collective behaviour through lethal means (culling) is improbable due to the baboons' legally protected status and the potential public objection to such an approach (although single problem baboons are euthanized when they are considered to be a danger to public health and safety).

Therefore, given the current management scenario and research conducted to date on the Cape Peninsula population (Beamish 2009; van Doorn et al. 2010; Hoffman & O'Riain 2011; Hoffman & O'Riain 2012; Hoffman & O'Riain 2012a; Hoffman & O'Riain 2012b), I will attempt to mitigate conflict between humans and baboons principally by minimising (and eliminating, if possible) spatial overlap between humans and baboons, conducting studies on various Cape Peninsula troops (Fig. 1.2). In Chapter 2, I test the efficacy of three non-lethal, disruptive deterrent strategies, namely reflective light prisms, bear bangers and electric fencing in excluding commensal troops from human environments. While these three deterrents differ in the stimuli they deliver (prisms: light aversion; bear bangers: noise aversion; electric fencing: pain aversion), they all seek to increase the cost (actual or perceived) to baboons entering human environments. In Chapter 3, I explore an alternative to increasing the costs to baboons of entering human environments by increasing the benefit of remaining in natural environments through provisioned food and manipulating the leadership structure in chacma baboons (King et al. 2008). The relative benefit of ranging in natural areas (versus entering human environments) might also be increased by reducing the availability of anthropogenic food in human environments; a proportion of which is freely available in ubiquitous refuse containers. Therefore in Chapter 4, I test the ability of modified residential waste bins to exclude baboon access. Finally, in lieu of a collaborative effort between baboon managers and the local human population, it is unlikely that any approach to mitigate this conflict will succeed. In order to aid this collaborative effort, in Chapter 5, I conduct a survey of Cape Peninsula residents to determine their understanding of baboon management, their experience of baboons, their attitudes towards a range of non-lethal and lethal management approaches and their use of various media. Based on my combined findings, I evaluate the current management structure and make recommendations of methods that are most likely to mitigate human-baboon conflict in the Cape Peninsula.

Figure 1.2. Cape Peninsula map showing the locations of the five study troops. Urban development in the northeast Peninsula prevents natural dispersal and immigration. A boxed map in the top left corner indicates the location of the Peninsula in South Africa.

Chapter 2

DETERRENTS

Introduction

Disruptive deterrents aim to startle or frighten target species either by exhibiting surprising or atypical stimuli (Musiani & Elisabetta Visalberghi 2001; Beringer et al. 2003; Gilsdorf et al. 2002; Davidson-Nelson & Gehring 2010) or by imitating natural, fear-inducing stimuli such as conspecific warnings (Bender 2005; Ramp et al. 2011), predator stimuli (Belant et al. 1998) or both (Conover 1994). While deterrent stimuli that tend towards the extremity of their spectra (e.g. excessively loud noise) may be effective, they pose an ethical concern with regards to the effect they produce in the target species, beyond simply deterring them (e.g. inducing stress; causing injury or inhibiting survival and reproduction) and may not be appropriate in the case of suburban wildlife (Holevinski, Curtis & Malecki 2007). A more subtle stimulus (e.g. fladry: page 8, Chapter 1; Okarma & Jędrzejewski 1997) may circumvent these ethical concerns and further, minimise disturbance to non-target wild, and domestic, species and humans. However subtle stimuli are not always effective (e.g. Belant & Ickes 1997) and thus a balance between a deterrent's ethical and local socio-cultural acceptance and its effectiveness in deterring the target species remains a major challenge for this approach to conflict mitigation (Enck & Decker 1997).

Deterrents that rely on surprising but non-harmful stimuli are also subject to habituation, which, to quote Rankin et al. (2009) is defined as "a behavioural response decrement that results from repeated stimulation and that does not involve sensory adaptation/sensory fatigue or motor fatigue." Deterrent stimuli that fail to evoke a threat are thus at risk of losing efficacy over time. In contrast, those that impose an actual and repeated cost to the target animal (e.g. pain: Solomon & Turner 1962) are more likely to result in a behavioural change but present both ethical and socio-cultural challenges.

Deterrents clearly differ in their cost (start-up and maintenance), efficacy (initial and long-term), and welfare implications to both target and non-target species. Consequently Treves et al. (2009) propose three categories in which to evaluate deterrents for the purpose of choosing the most appropriate deterrent for a particular conflict situation, namely, "cost-effective design, wildlife specificity and selectivity and socio-political acceptability." The cost of a deterrent entails "the resources, time, and expertise needed to install and maintain the intervention in its most effective form" (Treves et al. 2009). Further, the value of the resource to be protected (e.g. crops) must exceed the cost of a deterrent. Indeed, a costly deterrent can be difficult to justify where its use depletes common funds that may be servicing other causes central to the needs of the affected community or other wildlife conservation initiatives.

A deterrent's efficacy "must be evaluated against the goal, which is either to reduce the frequency or severity of encounters between wildlife and people or raise tolerance among people for wildlife encounters" (Treves et al. 2009). Implicit assumptions of a deterrent action should also be quantified as a deterrent's primary goal can be conflated with secondary outcomes (i.e. primary goal: reduce spatial overlap; secondary outcome: reduced crop raiding). Linked to a deterrent's efficacy is its habituation susceptibility, or its likelihood of losing efficacy over time. This is a particularly important characteristic to be considered when using disruptive deterrents (e.g. Bomford & O'Brien 1990).

I chose to define as ethical, deterrents that do not cause permanent injury, do not inflict pain that the animal cannot retreat from/avoid, do not inflict chronic stress and do not interrupt foraging, reproduction or ranging behaviour within natural areas. These criteria should not only be applicable to the target species, but to any affected non-target species as well. Finally, a deterrent's socio-political acceptability is generally the "tolerance for the installation, maintenance, and consequences of the intervention among affected individuals and households, more remote interest groups, and the broader populace." Indeed, the public acceptability or even desirability of management actions or deterrent strategies may be influential in determining whether they are implemented (Mehta & S. Kellert 1998; Borrini-Feyerabend et al. 2004; Neff 2012).

For the greater part, the conflict that occurs between humans and baboons in the Cape Peninsula is contingent on proximity and indeed, overlap between various types of human environments* and baboon home ranges (Hoffman & O'Riain 2012b). Therefore, arguably the most direct way to mitigate conflict is to prevent or minimise this overlap. In this chapter, I aim to quantify the relative success of three disruptive deterrents (Shivik et al. 2003) in preventing baboon incursions into human environments. Two of these deterrents relied on non-harmful stimuli, one in the form of light (reflective prisms) and one in the form of noise (bear bangers) while the third relied on a painful/aversive barrier (electric fencing). Both bear bangers were initiated and subsequently managed by civic organisations in consultation with a number of baboon researchers and subject to approval by local baboon management authorities while the third (light prisms) was designed exclusively as a research project following consultation with local communities and following approval from UCT ethics and baboon management authorities. Consequently only the latter included detailed direct behavioural observation of the baboons and other wildlife before and after the use of the deterrent. For both the noise aversion (bear bangers) and aversive barrier (electric fencing) deterrents I had to rely on remote sensing of troop movements through GPS tracking collars that were affixed to troop members before and after the deployment of the intervention. For comparison, I predicted that each deterrent (light prisms: prediction one; bear bangers: prediction two; electric fencing: prediction three) would significantly reduce the target troop's spatial overlap with specific human environments. This chapter will serve, not only as a test of the relative success of the three deterrents to reduce the spatial overlap between baboons and humans, but also to illustrate differences in levels of assessment of deterrents which have to represent a compromise between the rigour of a research focussed approach with a limited budget (e.g. light prisms) and the practical needs of communities suffering from chronic levels of conflict that need immediate solutions and have the means to deploy expensive deterrents (e.g. electric fencing).

*In the context of the Cape Peninsula, I use 'human environment' as a term inclusive of residential, suburban and urban environments as well as areas where baboons raid anthropogenic food sources.

Methods

A: Prisms: a low-cost, non-harmful deterrent

Study site and troop

Simon's Town (34°11'39.62"S; 18°25'55.44"E) is located on the eastern coast of the Cape Peninsula, South Africa and is a composite of residential areas, a naval barracks and a homeless shelter (Fig. 2.1). 'Natural' land on the periphery of the town is composed of a mixture of indigenous Fynbos (shrub-like community of plants, i.e. Proteaceae, Ericaceae, and Restionaceae: Cowling et al. 1996) and alien vegetation which includes a small Eucalyptus thicket and alien grasses. Ranging in these areas, the relatively small Waterfall Troop ("WT") is comprised of 21 individuals (Beamish 2009). The baboons were already habituated to the close proximity of observers, presumably through their prolonged exposure to humans. That is, the troop sleeps in natural land on cliffs outside the urban edge but typically descends into the low lying urban areas on a daily basis to forage for human derived food items. This troop was the only routinely raiding Cape Peninsula troop that was not assigned a team of monitors (at the time of the experiment) and residents in the area have expressed on-going distress at the frequent troop incursions and the resultant damage to property and loss of food.

Baseline protocol

I conducted baseline observations over a period of ten days (28/10/2009-07/11/2009) and during daylight hours (06h00 to 18h00). Numerous physical barriers (e.g., fences and walls) in the urban area confounded continuous troop follows on foot. Therefore, I assumed a remote observation post on a ridge overlooking the troop's range area in Simon's Town (Fig. 2.1). From here and using binoculars, I conducted scans every five minutes, recording: perceived geometric troop centre; the mutually-exclusive behavioural category (locomote, forage, groom, rest, play) of each visible troop member; the head orientation (if visible) of individual baboons, using muzzle direction to infer gaze orientation (Fig. 2.3) to the nearest 45° compass point, i.e. North, Northeast, East, Southeast etc.). At 15-minute intervals, I recorded the total number of red-winged starlings (*Onychognathus morio*), sacred ibises (*Bostrychia hagedash*) and rock hyraxes (*Procavia capensis*) that were the most common wildlife species within 200m of the 'prism line'. I also maintained an *ad libitum* record of raided food items (RFIs below). for the troop as a collective since individual identification was not consistently possible from the vantage point, sometimes at a distance of 600m

Raided food items (RFI)

I chose to define one raided food item (or RFI) as a single movement of anthropogenic food from hand to mouth. I was able to identify this feeding behaviour at the maximal range of observation (600m), but this was not true for individual identification of raiding baboons. I therefore found measurement of the troop's collective raiding success to be more meaningful. Where clear identification of a food item was possible, its quantity was recorded but where it was not, the RFI was scored as one unit. Although this method provided only a rough estimate of the troop's total RFI intake, a consistent approach allowed for meaningful comparison between baseline and experimental periods.

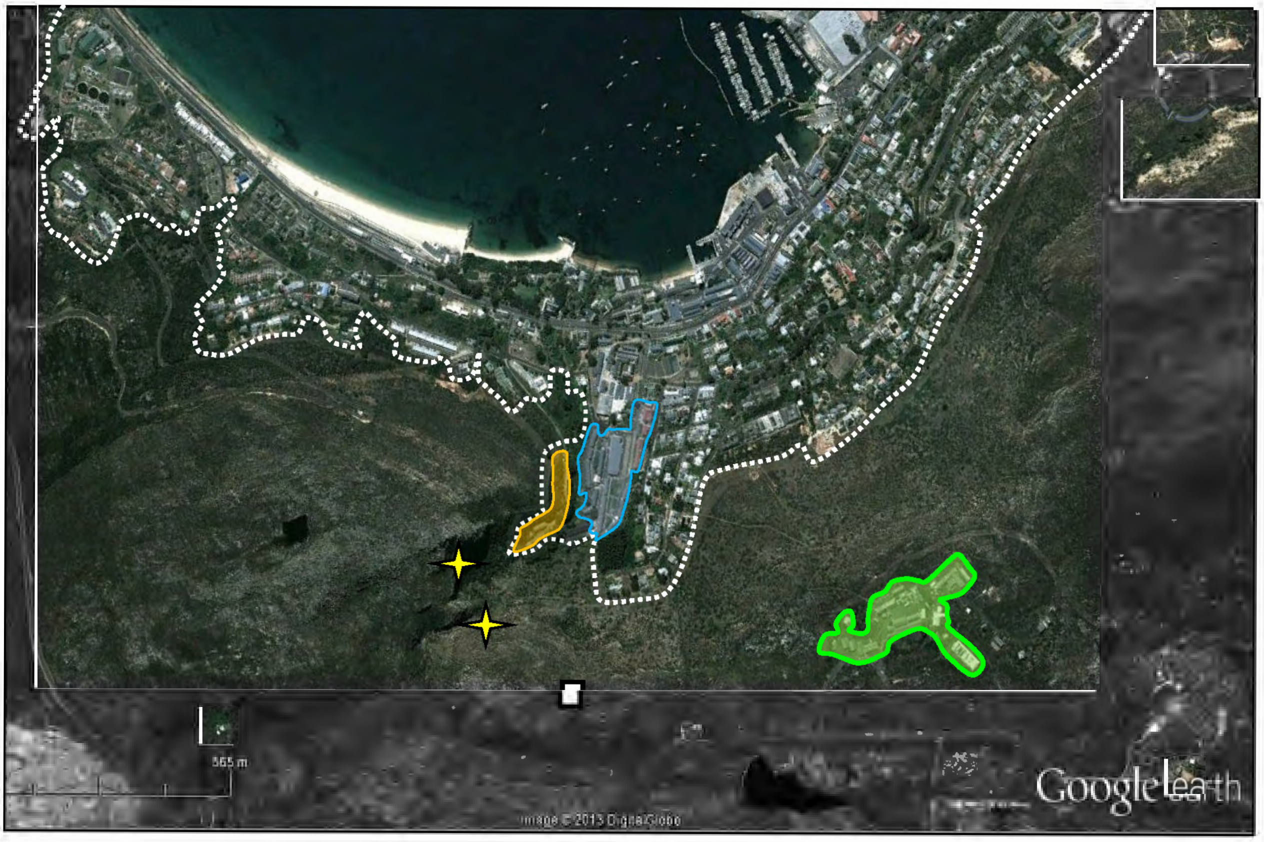


Figure 2.1. Satellite image of WT's home range area. Yellow stars indicate the troop's sleeping sites at the time of the study. Simon's Town urban boundary is indicated with white dots and contains two major raiding sites – Happy Valley (orange polygon) and Navy Barracks (blue polygon). The green polygon indicates the troop's third primary raiding site, Signal School. The terrain is angled sharply downhill from the sleeping sites and Signal School towards the urban boundary. My observation point is marked with a solid white square.

Experimental protocol

On the first clear day after the end of the baseline period (eight consecutive days of cloud/rain intervened between baseline and experimental period), I erected four reflective, rotating prisms (SunGunOne, © W. Eckermans, Innoventek; Fig. 2.2). The basic premise of this deterrent is that reflected sunlight from an unexpected source will startle any approaching baboons, causing them to stop and/or divert their movement path. The deterrent is cost-effective (US$190/300m or US$0.63/m), easy to install with no maintenance costs. Each prism (dimensions: 19x17x16cm) was constructed from fibreglass and covered on three sides with mirrors (14x14x12cm). One of these mirrors was coated in red plastic. The prism base was fitted to a rotating motor (8vDC servo-motor) powered by a (34x25cm) solar panel. On each prism, the solar panel powered the motor which rotated the prism, reflecting light at observers positioned above the prisms. Every third flash appears red due to the red panel. The prisms were mounted on wooden poles so that the prism base was horizontal with its mid-point, 2.25m off the ground. The solar panel was oriented North-Northeast to maximise sun exposure during the austral winter. I selected prism locations to both maximise light reflected at the troop and to ensure that their access to the town could either be achieved by passing directly past the prisms (Fig. 2.10) or taking an atypical and lengthy path to circumvent them. The prism deterrent range was reported to be 300m (W. Eckermans, pers. comm.) and consequently I positioned each prism no further than 200m from its nearest neighbour. Thus, the four prisms formed a continuous line of deterrence (a virtual 'fence') between the troops sleeping site and the urban areas below.

On the day after I had erected the prisms, I began a second observation period (16/11/2009-25/11/2009) of ten days. The period was to be extended if any evidence emerged to suggest the prisms were altering the troop's ranging pattern to assess habituation to the deterrent. During this time I conducted scans and *ad libitum* observations as per the baseline period but in addition to this, I recorded light intensity (using a portable photometer with its receptor oriented directly upwards) every 15 minutes (Appendix 2.1).

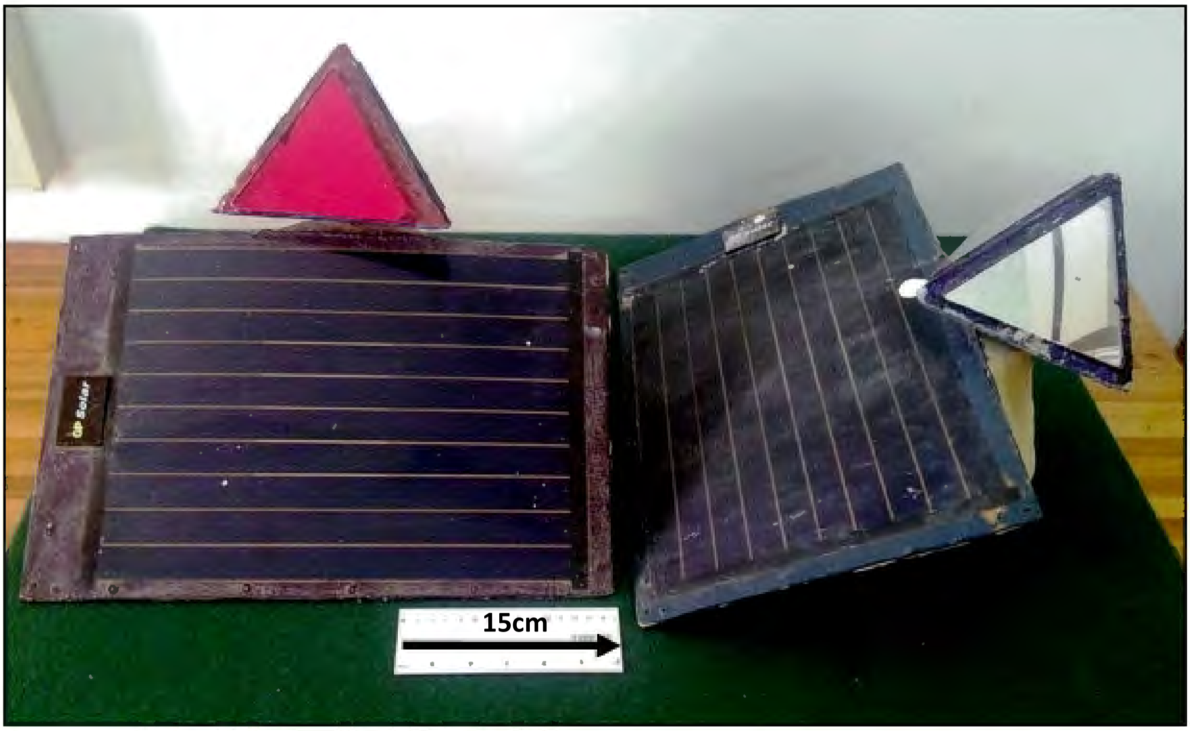


Figure 2.2. Two reflective prisms that were tested in the experiment. A motor below the prism base is powered by the solar panel which causes the prism to rotate. All three of the prism's sides are mirrored with one side being covered with a red plastic film (on left). The prisms are fitted to poles, 2.25m off the ground with their bases level with the ground below. A 15cm white plastic ruler provides a scale.

Analyses

I compared percentage of troop locations recorded in human environment within the "prism zone" (i.e. human environment that the baboons can only reach by moving across or around the prism 'fence') before and after prisms were erected. I also developed fixed kernel estimates (ArcView 3.3 Home Range Extension: Rodgers & Carr 1998) based on troop locations recorded every 5-minutes during active hours. Active use areas were delineated within the 95% probability contour, while the core use area was delineated within the 50% probability contour. I compared the average proportion of individuals in each scan that were performing one of five mutually exclusive behavioural categories (locomote, forage, rest, groom and play). I tested for any differences between the baseline and experimental phase activity budgets using one-way ANOVAs in R. I considered daily RFIs for the troop as a collective and tested for differences between baseline and experimental phases using a Mann-Whitney U test in R. For each scan, I recorded the number of baboons gazing a) in the same direction (to the nearest 45° compass point) and b) no more than one 45° compass point away from other troop members. I considered scans of type b), where no ‘gaps’ existed between troop members’ gaze direction in a given scan (i.e. the gaze direction of individual baboons formed a continuous arc) as having gaze synchrony (Fig. 2.3). I did this to infer whether a certain object/event (e.g. the light prism) may be biasing the troop’s collective gaze direction. I used a Mann-Whitney U test in R to compare the number of gaze synchrony scans in baseline with those occurring when prisms were present. I also sub-sampled the 3 hours directly following sunrise, when the troop was moving off their sleeping site and most exposed to the prism’s reflected light. Across the non-target species (ibis, hyrax and starling) I compared two indices. The first was the total number of each species I counted every day. The second was the percentage of scans in which I record each species within 200m of the ‘prism line’. I then tested for differences in these species’ indices between the baseline and experimental phases using Man-Whitney U tests in R.

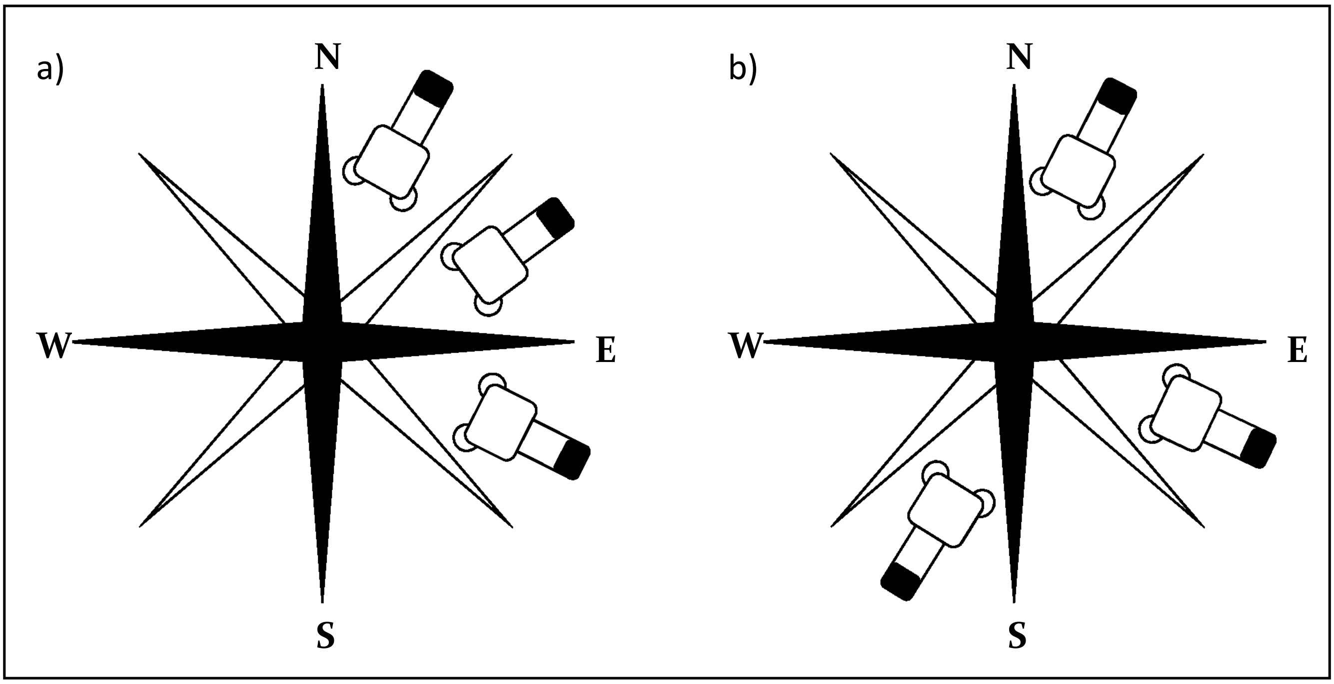


Figure 2.3. Example of head orientation scans of three baboons with gaze synchrony (a) and without gaze synchrony (b). Gaze synchrony can only be said to occur if two or more baboons are observed and their head orientations (as inferred by muzzle direction) do not differ by more than 45°.

B: Bear bangers: a moderate-cost, non-harmful deterrent.

Study site and troop

The Smitswinkel Bay troop (SWB, n=23: Beamish 2012, unpubl. data) ranges (Fig. 2.4) in the south-eastern section of the Cape Peninsula, more specifically from the southern end of Simon's Town to the northern edge of the Cape of Good Hope Section of Table Mountain National Park (Fig. 2.4; Hoffman & O'Riain 2012). Their range incorporates alien vegetation, coastline, indigenous Fynbos and various human-modified habitats including both dense and sparse residential areas, Navy buildings, a picnic area, restaurants, tourist viewpoints and a boat-launching site (34°11'39.62"S; 18°25'55.44"E). The troop frequently entered these dense residential areas moving from property to property looking for raiding opportunities within gardens, refuse bins and houses. There were no baboon monitors or any other form of management by the baboon management authorities during the baseline period.

Figure 2.4. Satellite image of SWB's home range area. Yellow stars indicate sleeping sites used by the troop during the baseline period. The white polygon indicates the urban boundary of Simon's Town (ST) which signifies a high density residential area, the orange polygon indicates a combination of Miller's Point picnic site, boat-launching area and The Black Marlin restaurant (Miller/Marlin) and the blue polygon indicates a series of viewpoint areas where tourists frequently stop their vehicles for sightseeing (VP). The red rectangle indicates the proposed bear banger border south (left) of which are also low density residential units.

Baseline

A GPS collar had been fitted to a sub-adult male in the troop as part of long term research to determine the home range use and habitat preferences of Cape Peninsula baboons (Hoffman & O'Riain 2012). This study coincided with the local community's decision to employ a resident to follow the troop and deploy bear bangers in an effort to initially displace them out of the dense residential areas and subsequently deter them from crossing the southern buffer zone to the south of the Simon's town residential area. As such I was able to use the GPS data to provide ranging data before (baseline) and after (experimental) the deployment of a noise aversion deterrent (bear bangers) on a habitual raiding troop. The decision to deploy bear bangers was done following consultation with the Baboon Research Unit and the baboon management civic authorities who, at the time, lacked the financial resources to assist the community with the deployment of baboon monitors. The rugged terrain, dense exotic vegetation and numerous large private properties south of Simon's Town prevent troop follows. These factors have always prevented researchers from recording behavioural observations on this troop in natural areas and for the same reason the individual responsible for deploying the bear bangers was restricted to a designated area (the buffer zone) which had good visibility (indigenous plants and grasses) and provided easy access on foot from the main road below and hence a rapid response by the monitor when the troop approached the buffer zone.

I used the GPS collar data to compare the movement patterns of the SWB troop for 10 months before (baseline) and 10 months after (experimental) the initial deployment of bear bangers on the 1st of June 2009. The collar recorded 1666 GPS locations (mean 5.48 readings/day) in the baseline period and 998 locations (mean 3.28 readings/day) during the experimental phase.

Experiment

The topography within which the troop's home range was located included steep terrain (peak of 620 m.a.s.l.) to the east and coastline to the west, effectively constraining the home range into a linear shape with abundant natural land to the south and dense residential areas (Simon's Town) in the north (Hoffman 2011). The civic association, in consultation with researchers and civic authorities delineated a buffer area south of Simon's Town that they proposed to defend with the use of bear bangers and so condition the SWB troop to avoid this area, effectively stopping incursions into the residential areas (Fig. 2.4). Initially one, and then two field monitors tracked the troop's movements (either visually or via the sub-adult male's GPS/VHF collar). If the troop came within 500m of the bear banger border, these monitors would approach the troop, dressed in visible and distinct clothing (luminous hats and vests), shouting to draw attention to them. If the troop continued to approach, the monitors would deploy one 12g rim-fire bear banger. Originally designed a s bear deterrents for hikers, bear bangers (Fig. 2.5) are thumb-sized cartridges (see a cartridge disassembled: http://www.youtube.com/watch?v=OOjlNT17S7M) that are propelled by pen-sized launchers into the air (approximately 30m from the ground). The initial launch makes an audible pop and is followed a few seconds later by a loud bang (115 decibels) of short duration (the launch causes combustion in the cartridge, leading a build-up of pressure, forcing out the cartridge base; see a demonstration of a bear banger deployment: http://www.youtube.com/watch?v=Mgv9t5fU6T4). While easy to use, they can be dangerous if used improperly and their incendiary properties pose a potential fire risk. The costs for a single launcher and cartridge are moderate (launcher: 15 – 22 US$; cartridge: 3 – 7 US$), but depend on deployment frequency which may or may not decline over time. The rationale behind this strategy was that the troop would learn to avoid the deterrent (a visible monitor pointing towards them and discharging a loud noise followed by a second louder bang often directly above troop and not associated with the monitor) whenever they attempted to cross the 'border' from natural habitat into a residential area. To complement this approach, the bear banger team made no effort* to chase baboons away from any areas to the south of the bear banger border. This approach looked to create a contrast between the troop's southern range where they were left undisturbed and the northern range, from which they were actively deterred.

*While this was the verbally expressed approach, anecdotal reports suggest that the bear banger team would sometimes move the border to the south of the Black Marlin Restaurant. For the purpose of analyses, I have included this extended buffer zone.

Analyses

Figure 2.5. Examples of bear banger cartridges and pen launchers. The cartridge bases are fitted to the broad end of the launcher. When the launcher's trigger is released, it initiates a primer (initial 'pop' sound) in the cartridge as well as a delay pellet. The primer causes the pellet to launch, while oxidisation of the flashpowder in the delay pellet results in a loud bang a few seconds later (and 20-30m from the ground if aimed correctly).

I analysed the troop's ranging patterns in relation to three 'urban zones' (Fig. 2.4). Simon's Town (ST) the dense residential area to the north of the bear banger border and the area to be 'defended' by the bear bangers. Miller/Marlin (MM) is a combination of a popular boat-launching area, adjacent campsite (Miller's Point) and restaurant (Black Marlin). Viewpoints (VP) is a series of viewing points located on a 1.5km stretch of the main coastal road where tourists typically stop their vehicles and disembark to take scenic photographs, providing baboons with an opportunity to raid them and their cars. Both Miller/Marlin and Viewpoints are located south of the bear banger border. I opted to include all three zones in the analyses as they are spatially discrete, frequently raided (E. Jordaan pers. comm.) and account for the majority of human-modified habitat within the troop's home range.

I divided both the baseline and experimental periods (10 months each) into five consecutive two-month periods and developed fixed kernel estimates for each time interval (ArcView 3.3 Home Range Extension: Rodgers & Carr 1998) based on troop locations recorded by the GPS collar. Hoffman & O'Riain (2012b) found the locations recorded from a GPS collar affixed to a single troop member as an accurate proxy for the troop's perceived centre and therefore an accurate method to determine a troop's home range and habitat composition. The troop's active use areas were delineated within the 95% probability contour, while the core use area was delineated within the 50% probability contour. I then determined spatial overlap between these kernels and the three urban zones, testing for differences between the baseline and experimental periods for each zone using Mann-Whitney-Wilcoxon tests in R. Using the same time intervals as described for the kernels above, I compared the proportion of total GPS points in each zone and tested for differences between baseline and experimental values using Mann-Whitney-Wilcoxon tests in R. After this, I used the same comparisons, but corrected for the size of each urban zone. This compensated for the discrepancy in size between the urban zones (ST: 2.89km^2; MM: 0.131km^2; VP: 0.133km^2) and illustrated the relative importance (use) of each urban zone. I tested for differences across zones in the baseline and experimental periods, respectively, using Mann-Whitney-Wilcoxon tests in R.

C: Electric fencing: a high-cost, painful deterrent

Study site and troop

The John Travolta (JT) troop, ranges on the western edge of the Tokai plantation predominantly within Table Mountain National Park (34° 3'44.86"S; 18°24'48.26"E; “TMNP”) and is a fission troop from the original Tokai troop (Hoffman & O’Riain 2011). The troop comprises 26 individuals (Beamish 2012 unpubl. data) and raids the residential suburb adjacent to the Tokai plantation on an almost daily basis (Fig. 2.6). Their home range thus includes pine plantations, picnic areas and indigenous vegetation within Tokai plantation, and a residential suburb and youth development academy (Chrysalis Academy or ‘Chrysalis’) within urban areas adjacent to Tokai plantation. The troop uses large exotic trees in the plantation, picnic site and Zwaanswyk suburb (‘Zwaanswyk’) as sleeping sites (Hoffman & O’Riain 2011)

Zwaanswyk is situated within the southern end of the troop’s home range and is comprised predominantly of upmarket homes sited on large plots, many of which have domestic animals (e.g. horses, dogs and fowl) with associated feeds, fruit trees and vegetable patches. Properties within this suburb include a variety of urban perimeter barriers (e.g. wire mesh fencing, vibracrete and brick walls) that vary in both height and security specifications, including electrified wire strands. Adjacent to Zwaanswyk and bordering the southern edge of the troop’s home range is the Steenberg Golf Estate (an upmarket security and lifestyle estate which includes vineyards and a golf course). Steenberg is surrounded by a fence exceeding 2.5m in height (Fig. 2.8) and including upright metal bars with 12 electrified wire strands on the exterior surface, and 24 electrified strands lining the interior surface of the fence. The Steenberg fence was designed specifically to deter human intruders but has proved to be an effective baboon deterrent despite the obvious attractants within (O'Riain & Hoffman 2010). The only reports of baboons occurring within Steenberg have been linked to a failure to clear vegetation or following the building of a solid structure (e.g. pole) outside the fence that has provided baboons with a temporary bridge into the property. There was also one instance when a lone adult male walked in through the main security entrance for vehicles.

Baseline

A GPS collar was fitted to a sub-adult male in the JT troop to allow for remote tracking of the troop's movement. Much like the collar used to monitor the SWB troop (above), the

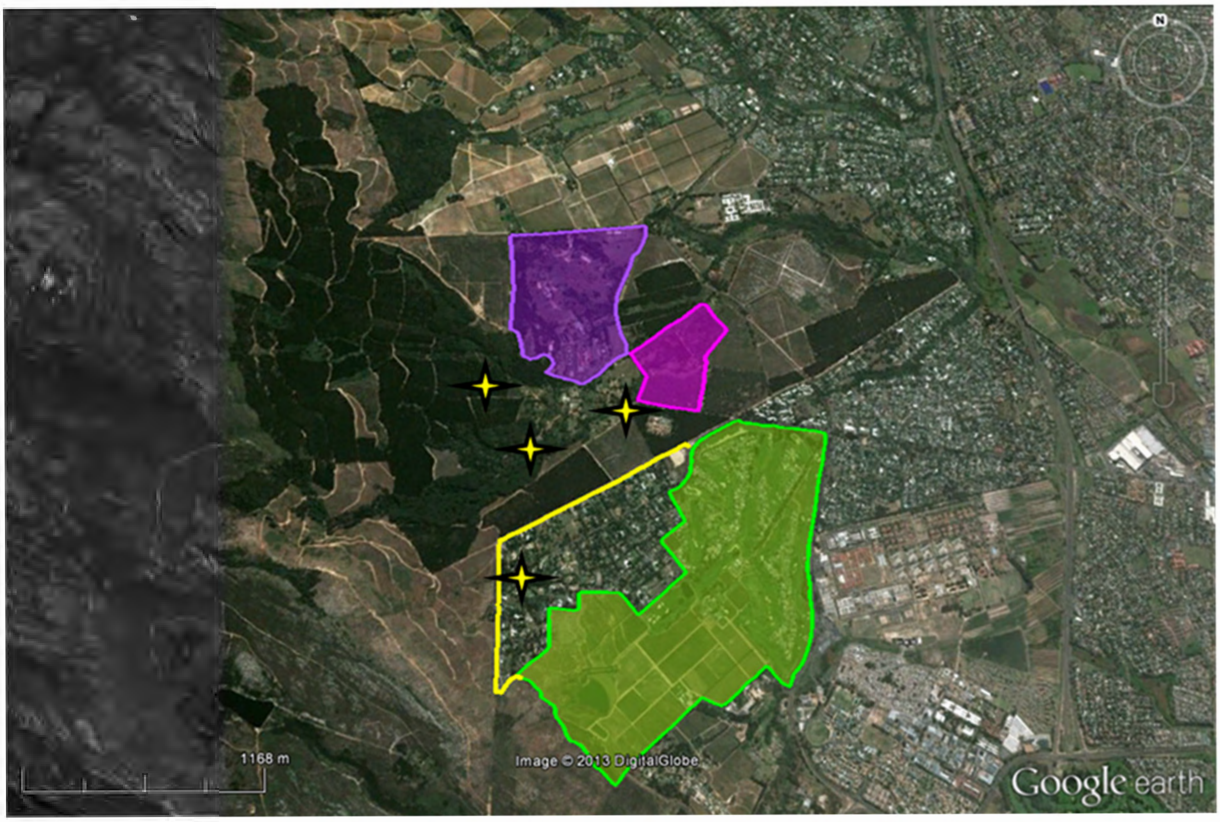


Figure 2.6. Satellite image of JT's home range area. Sleeping sites recorded during the baseline period are marked with yellow stars. The green polygon indicates Steenberg estate (golf course, vineyards and residential estate) and the yellow line indicates where the electric fence was built around Zwaanswyk. The purple polygon indicates Chrysalis Academy and the pink polygon indicates the picnic site which was also enclosed by an electric fence of a different design to the Zwaanswyk fence.

recording interval was variable. Over the 143-day (11/02/2012 – 02/07/2012) baseline period before the fence was constructed, the collar recorded 568 points, with an average of 3.97 readings per day. During the 143-day (14/11/2012 – 05/04/2013) experimental period, after the Zwaanswyk fence was completed, the collar recorded 887 points at an average of 6.2 readings per day. Unlike the bear banger experiment, the baseline and experimental periods were not controlled for season. Since raiding behaviour has been shown to be independent of season (van Doorn 2009; Hoffman & O'Riain 2012a), this comparison (i.e. measuring the reduction in the use of human environments) is still valid. During the baseline period, the John Travolta troop was unimpeded by physical barriers in accessing Zwaanswyk suburb, Chrysalis and the Picnic Site. Baboon monitors were active in the area and attempted to deter the troop from entering Zwaanswyk using loud shouts and whistles. The presence of monitors did not prevent raiding (Figs. 2.22; 2.23) but is assumed to have reduced the physical extent and duration of raiding efforts by the troop. Thus the baseline period for this deterrent already included aversive conditioning to raiding unlike the baseline for either light prisms or bear bangers. While this does confound the baseline period it does not prevent the validity of a before and after approach using a GPS collar as monitors were present in both periods.

Experiment

Following a prolonged public participation process, consultation with baboon researchers and approval from the baboon management team the Zwaanswyk residents took the decision to erect an electrified fence on the boundary between their suburb and TMNP. The fence is approximately 2.3km in length and at its eastern end, it linked with the existing electrified fence of the Steenberg Estate. At the south-western end, a small gap of approximately 15m was necessary to accommodate the access road to the suburb. The fence is 2.4m in height, has 15 electrified strands (80 000V) on the exterior surface with the lowest strand at 0.015m above the ground and the highest at 2.4m. The top 4 strands formed a 45^{o} overhang towards TMNP land (the side from which baboons approach the fence) which served as an additional anti-climb device. In addition to the electrified wire strands the fence includes a 10x10cm wire mesh (Bonnox®) on the residential side which provides a physical barrier through which baboons cannot pass. This mesh fence was dug below ground level to prevent animals including baboons from digging under the fence. The total length of the fence is 2.1km and includes both pedestrian and horse access gates for accessing TMNP land. The fence cost approximately R1.3million to install but has since been upgraded to include a number of anti-crime features (Fig. 2.7). The experimental period that I used was primarily a test of the efficacy of the Zwaanswyk fence. However, the results I obtained can be used to assess the efficacy of the Picnic Site fence in the same way. A period of ‘fine-tuning’ the Zwaanswyk fence, which included closing a gap along a water course and removing some large overhanging branches that the baboons used to cross the fence, was required before the experimental period commenced. Due to this fine-tuning and the actual fence-building period, the baseline and experimental periods included a four month interval.

Within the Tokai plantation which is part of the TMNP, there is another ‘raiding hotspot’, namely the picnic site which is used by large numbers of recreational visitors on public holidays and weekends. The predominant vegetation type within the picnic site is large pine trees that the troop occasionally uses as a sleeping site and includes waste bins that adult individuals can open (‘Picnic Site’, Fig. 2.6). A combination of pine trees, waste and the availability (willingly or unwillingly through picnickers) of human derived food, makes this an attractive area to the troop. In response to the raiding, TMNP authorities agreed to fence off the Picnic Site using a combination of fine mesh (5x5cm holes) fencing to a height of 1.8m and topped with 6 strands of electric wires placed at a 45^{O} angle to the vertical pointing towards the natural land outside of the picnic area. This served as an anti-climb structure for baboons (Fig. 2.9).

Figure 2.7. Photograph of the Zwaanswyk electric fence from within the residential area looking towards TMNP. The 2.4m high fence has 15 electrified strands (80 000V), with a four-strand overhang The fence also includes fine wire mesh to prevent baboons from forcing their way through the strands.

Figure 2.8. Photograph of the 2.5m high Steenberg electric security fence. It includes upright metal bars with 12 electrified wire strands on the exterior surface, and 24 electrified strands lining the interior surface of the fence.

Figure 2.9. Photograph of the picnic site electric fence which used a combination of fine mesh (5x5cm holes) fencing to a height of 1.8m, topped with 6-strand overhang of electric wires.

Analyses

I analysed the troop's ranging patterns in relation to three 'urban zones' (Fig. 2.6), namely Zwaanswyk suburb (before and after the installation of a high specification electrical fence), the TMNP Picnic Site and Chrysalis Academy (a control site which received no fence)). I divided the baseline and experimental periods (5 months each) into five consecutive one-month periods. For the full baseline, full experimental period and their respective one-month component periods, I developed fixed kernel estimates (ArcView 3.3 Home Range Extension: Rodgers & Carr 1998) based on troop locations recorded by the GPS collar. Active use areas were delineated within the 95% probability contour, while the core use area was delineated within the 50% probability contour. I then determined spatial overlap between these kernels and the three urban zones, testing for differences between the baseline and experimental periods for each zone using Mann-Whitney-Wilcoxon tests in R. Using the same time periods as described for the kernels above, I compared the percentage of GPS locations recorded in each zone, testing for differences using Mann-Whitney-Wilcoxon tests in R. After this, I used the same percentage comparisons, but corrected for the size of each urban zone (Zwaanswyk: 0.71km^2; Chrysalis: 0.62km^2; Picnic Site: 0.06km^2) allowing for an assessment of the relative importance (use) of each urban zone and whether this changed with the presence of fencing. I used Mann-Whitney-Wilcoxon tests in R to test for differences between zones in the baseline and bear banger periods, respectively.

Results

A: Prisms

Habitat use, activity budget and raiding success

The kernels I developed for the baseline and experimental phase (Fig. 2.10) were similar in size in both general (baseline: 0.25km^2; experimental: 0.26km^2) and core use (baseline: 0.05km^2; experimental: 0.04km^2) areas and show little variation in where they were located. I found no change in the troop's use of non-urban, i.e. indigenous and alien vegetation habitat ($W = 53$, p-value = 0.3) or human environment 'behind' the prism line ($W = 30$, p-value = 0.38) before and after the prisms were erected (Fig. 2.11).

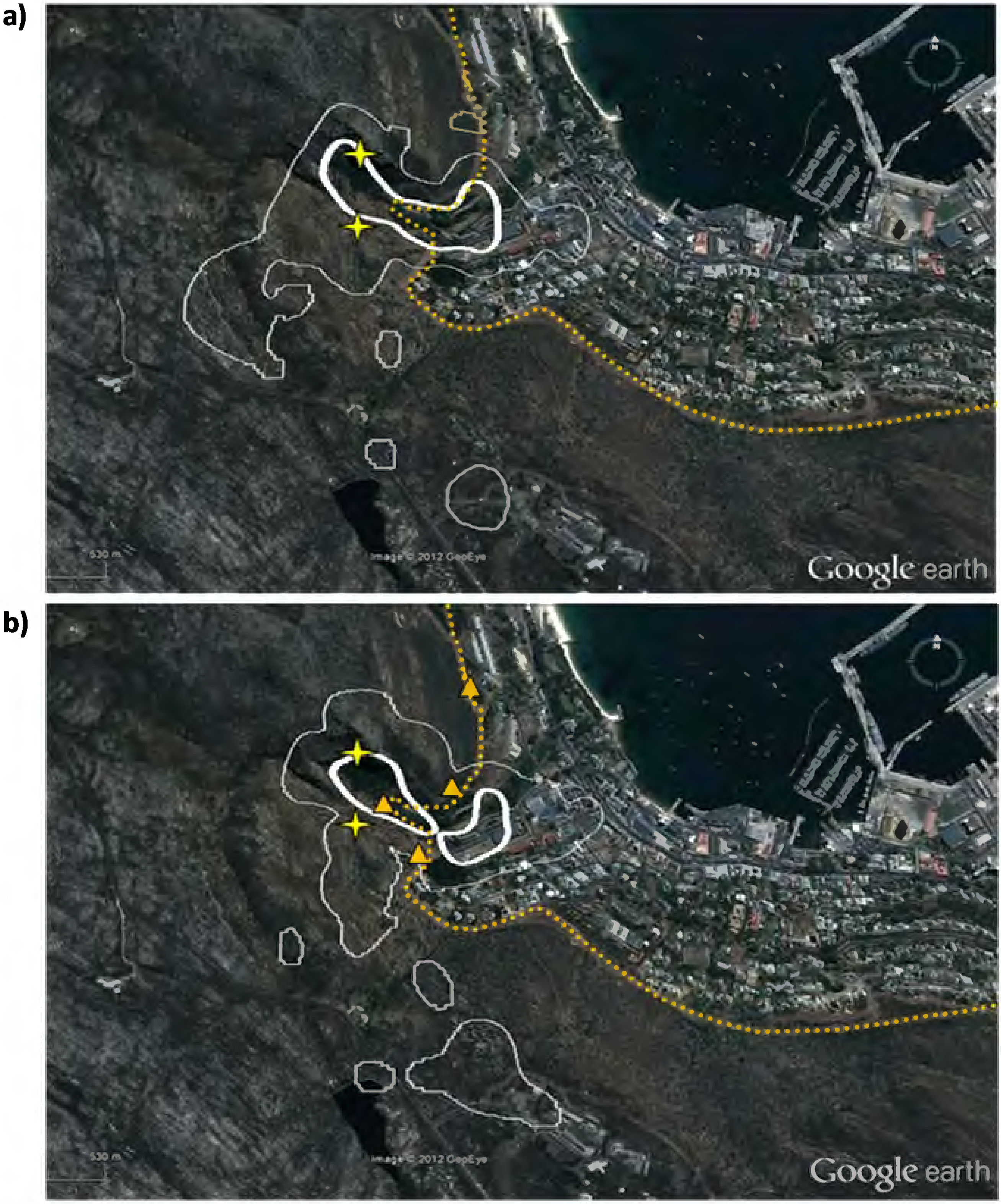


Figure 2.10. Satellite image of WT's home range area overlaid with kernel density estimates during the baseline (a) and experimental (b) period. The images show urban habitat boundary (dotted orange line), sleeping sites (yellow stars), prism locations (b: orange triangles) and the troop's active (95% probability contour: thin white line) and core use areas (50% probability contour: thick white line).

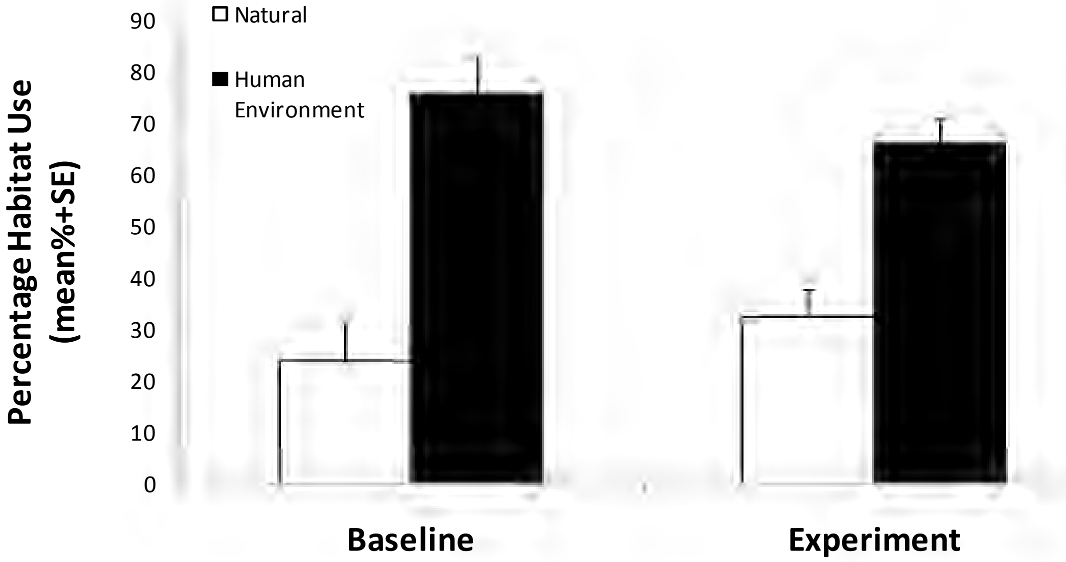


Figure 2.11. WT's daily percentage use of 'natural' (alien & indigenous vegetation) and human environments located behind the prism 'fence' during the baseline (white bars) and experimental phases (black bars). The troop showed no difference in their use of either habitat type.

The troop exhibited similar activity budgets before and after the prisms were erected (Fig. 2.12) with no difference emerging between locomotion (16.43±0.88% vs. 15.56±0.88%; F1,1847=0.47, p=0.5), foraging (22.75±0.98% vs. 21.81±0.92%; F1,1847=0.49, p=0.49), playing (6.5±0.47% vs. 6.71±0.49%; F1,1847= 0.09, p=0.76) and grooming (16.82±0.82 vs. 15.05±0.73; F1,1847=2.59, p=0.11). Only in the resting category, was there a small but significant increase after the prisms were erected (37.53±1.06 vs. 40.88±1; F1,1847=5.24, p=0.02).

Daily RFI yield was slightly higher in the experimental phase (RFI=29.11±5.4) compared to the baseline (RF=24.22±6.63) but this difference was not significant (W=29.5, p=0.35) (Fig. 2.13).

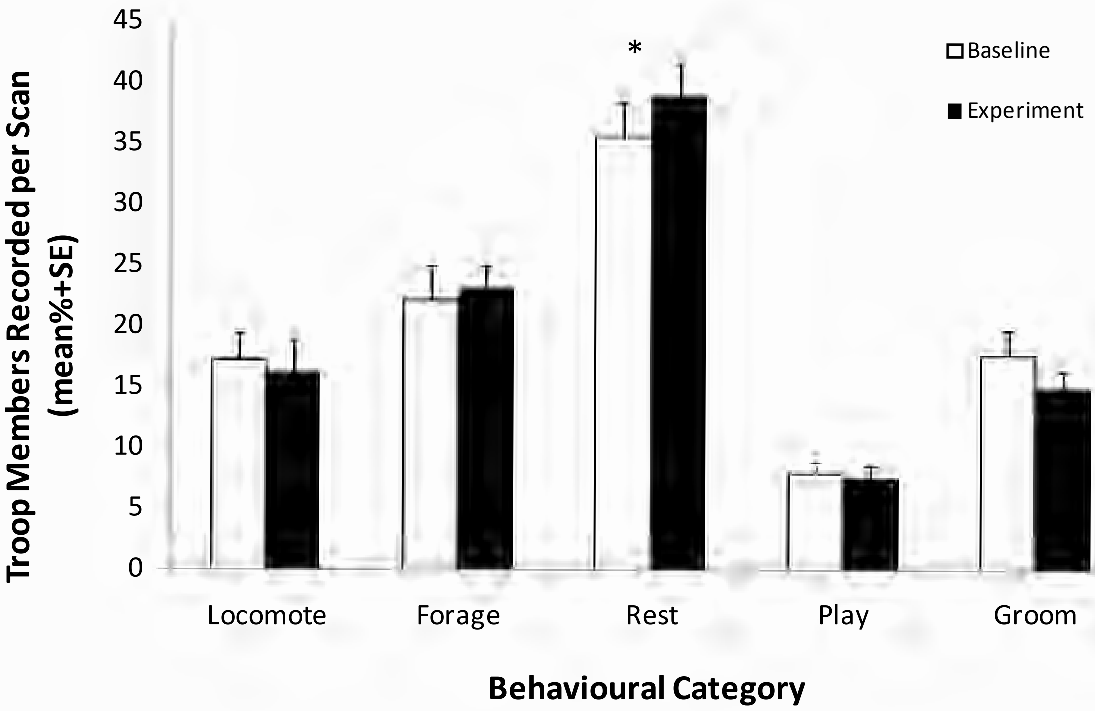


Figure 2.12. Activity budget of WT during the baseline (white bars) and the experimental phase (black bars). The values were compiled by taking the mean percentage of individuals engaged in each behavioural category in each scan. Significant differences are marked with '*'

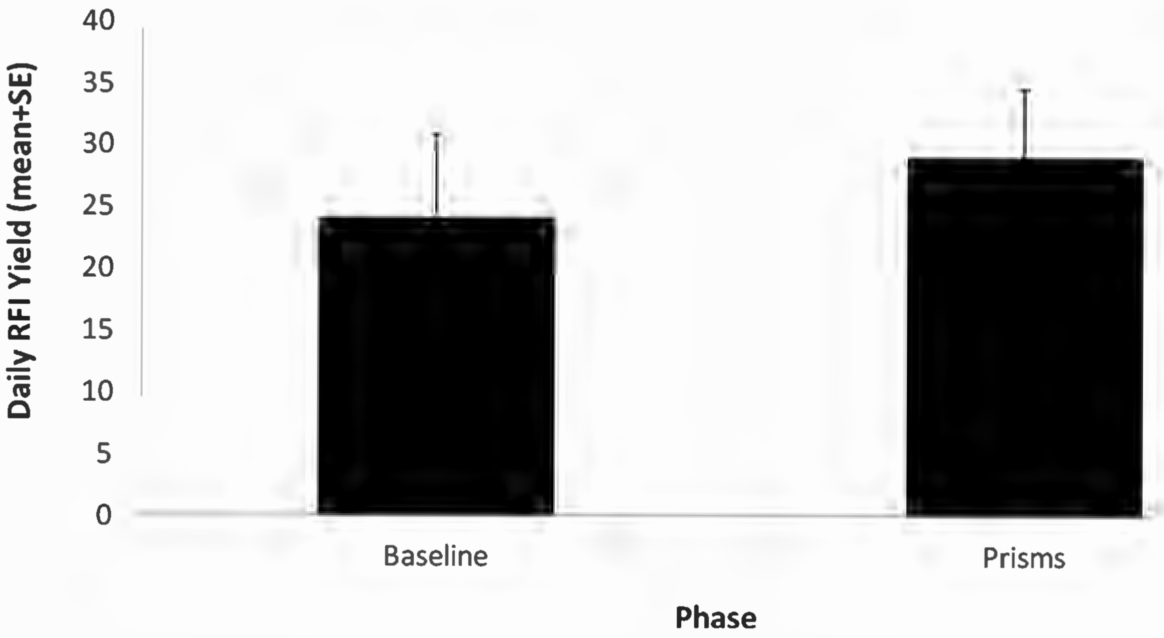


Figure 2.13. Raiding success of the WT in the baseline period and experimental period as measured by the troop's collective RFI (raided food item) yield.

Gaze orientation

In total, I conducted 783 gaze orientation scans in the baseline and 745 in the experimental phase. Of these, I had a clear view of more than one baboon in 438 scans (285: 2 baboons; 116: 3 baboons; 34: 4 baboons; 2: 5 baboons; 1: 6 baboons) in the baseline and 441 scans (278: 2 baboons; 129: 3 baboons; 34: 4 baboons) in the experimental phase (Fig. 2.14). There was no difference (W=95649, p=0.46) in the frequency of gaze synchrony between the baseline, 30.59% (n=134scans) and experimental phase (33.33%, n=147 scans)(Fig. 2.15). In addition, sub-sampling the first three hours of the day, I found gaze synchrony (27.88% of scans) in the baseline and experimental phases (32.08%) to be similar (W=5228, p=0.42).

Non-target species

The total number (Fig. 2.16) of hyrax and starling observed decreased after the prisms were erected, i.e. hyrax: 15 vs. 0 (average per scan: 0.11±0.02 vs. 0; W=16987.5, p<0.001) and starlings 241 vs. 150 (average per scan: 1.53±0.15 vs. 0.67±0.08; W=22543.5, p<0.001). In contrast, the number of ibis recorded increased after the prisms were erected from 24 to 69 (average per scan 0.16±0.05 vs. 0.31±0.06; W=15586, p=0.03).

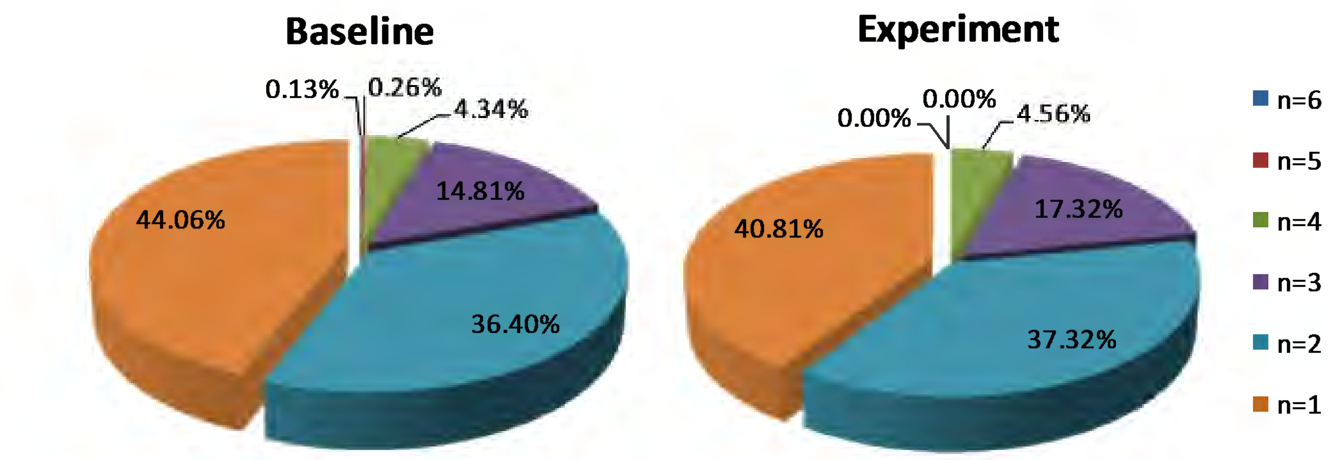


Figure 2.14. Percentage of scans during which Ian observer was able to record the gaze orientation of a varying number of baboons (1, 2, 3, 4, 5 & 6) in WT during the baseline and experimental periods.

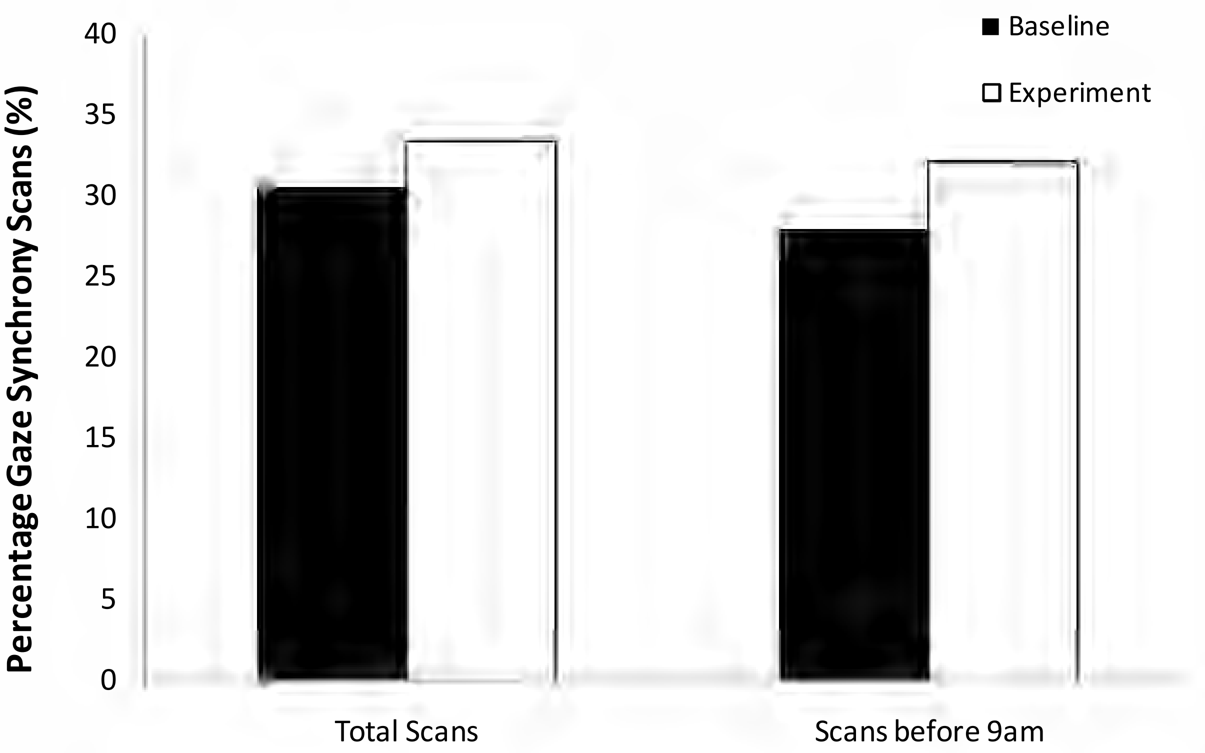


Figure 2.15. Percentage of scans (total and before 9am) in which an observer recorded gaze synchrony in the WT during the baseline and experimental periods.

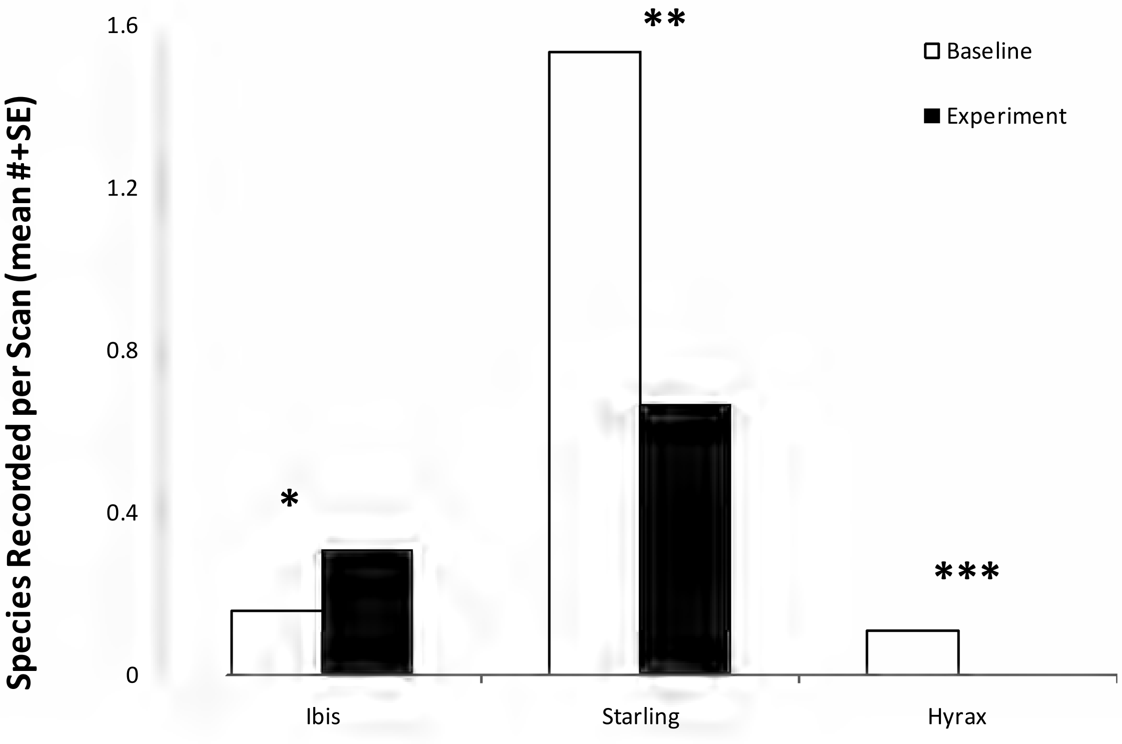


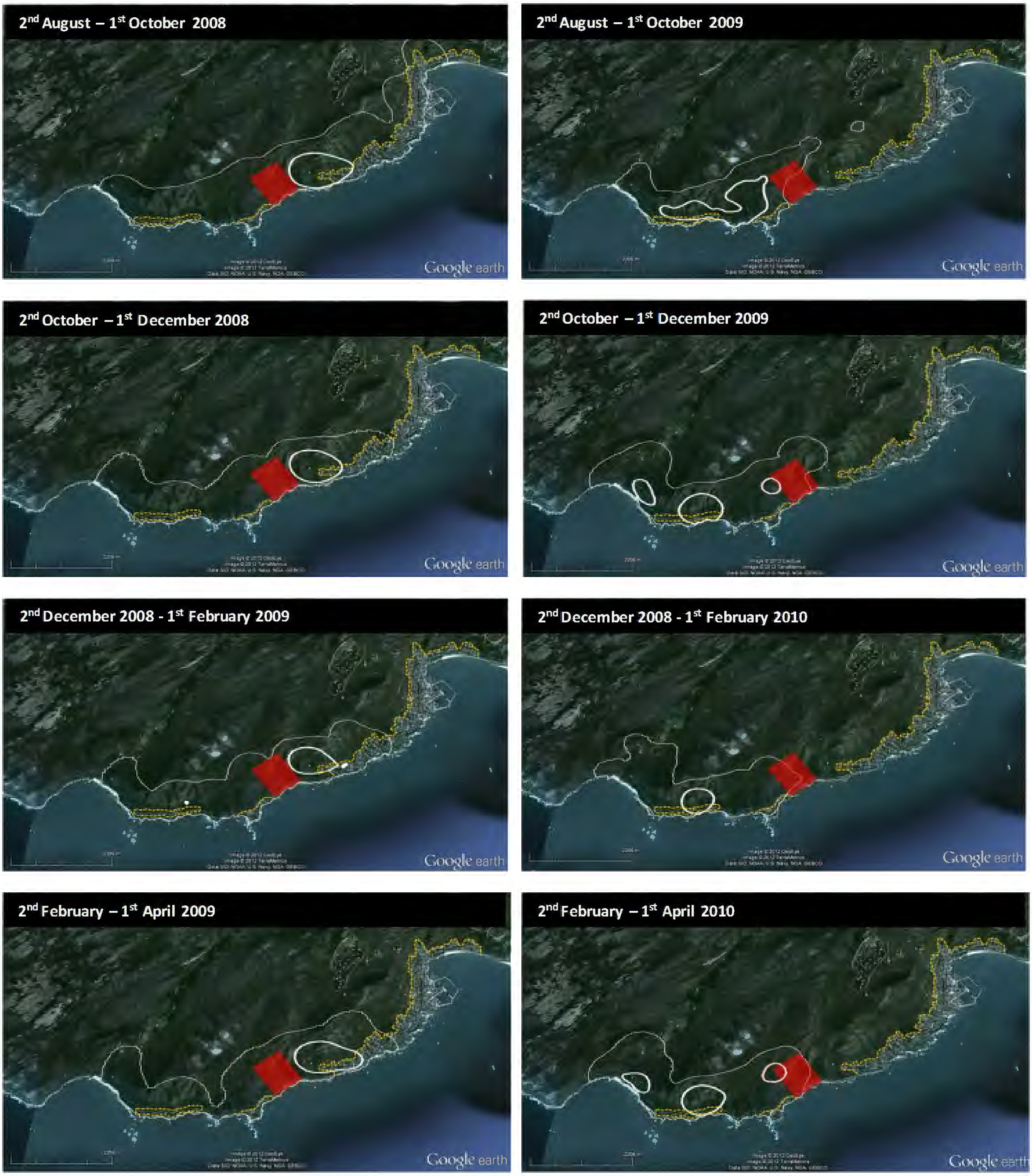
Figure 2.16. Mean number of each species recorded per scan during the baseline (white bars) and experimental periods (black bars). Significant differences are marked with '*', '**' or '***'.

B: Bear bangers

Kernel density estimates

Over the baseline period, the troop showed a consistent pattern in habitat use (Fig. 2.17, 2.18 Appendix 2.2) with the core area almost always (barring occasional isolated fragments) located north of the buffer zone and overlapping (0.17±0.04km^2) within the ST residential area. The general use area reached into the north of ST, overlapping with a considerable section of the town (1.11±04km^2), and extended south to the Cape of Good Nature Reserve boundary – a total distance of approximately 10.5km.

In the experimental phase, neither core (W=25, p=0.007) nor general (W=25, p=0.007) use areas overlapped with ST (Table 2.1) and were restricted to areas south of the bear banger border. While core use area size remained similar (1.06km^2 vs. 1.46km^2; W=13, p=1), the size of the troop's general use area almost halved (11.47km^2 vs. 6.16km^2; W=25, p=0.008) and I did not record a shift in the southern extreme of their range (Fig. 2.18). In addition, they utilised four new sleeping sites towards the southern end of their range, two of which were the most southerly sleeping sites recorded during the entire 20-month observation period. The troop's core use area did not overlap significantly less with MM once bear bangers were introduced, although their general use area overlap with MM did decline significantly (Fig. 2.19; Table 2.1; W=25, p=0.01; Appendix 2.2). Conversely, the troop's general use area overlap with VP did not change after the introduction of bear bangers, while their core use area overlap increased significantly (Fig. 2.19; Table 2.1; W=0, p=0.007; Appendix 2.2).



2nd August – 1st October 2008

2nd August – 1st October 2009

2nd October – 1st December 2008

2nd October – 1st December 2009

2nd December 2008 - 1st February 2009

2nd December 2008 - 1st February 2010

2nd February – 1st April 2009

2nd February – 1st April 2010

Figure 2.17. Kernel density estimates (bold white: 50% contour/core use area: thin white: 95% contour/general area use) of SWB for four, two-month periods during the baseline (left column) and when bear bangers were in operation (right column). Each two-month period shown for the baseline has an equivalent period (i.e. exactly one year later) when bear bangers were used. Orange dashed lines delineate the three urban zones (in each image, from right to left: Simon's Town "ST", Miller/Marlin "MM" and Viewpoints "VP") and the red band indicates the area in which bear bangers were deployed (bear banger border).

Figure 2.18. Kernel density estimates of SWB (bold white: 50% contour/core use area: thin white: 95% contour/general use area) for consecutive 10-month periods of baseline (a: 3rd August 2009 – 1st June 2010) and experimental behaviour (b: 2nd June 2010 – 1st April 2011). Dashed lines delineate the three urban zones (orange: Simon's Town/ST; blue: Miller/Marlin/MM; green: Viewpoints/VP) and the red band indicates the area in which bear bangers were deployed. Stars indicate sleeping sites used by the troop (yellow: used in both phases; white: used in [a] but not [b]; red: used in [b] but not [a]).

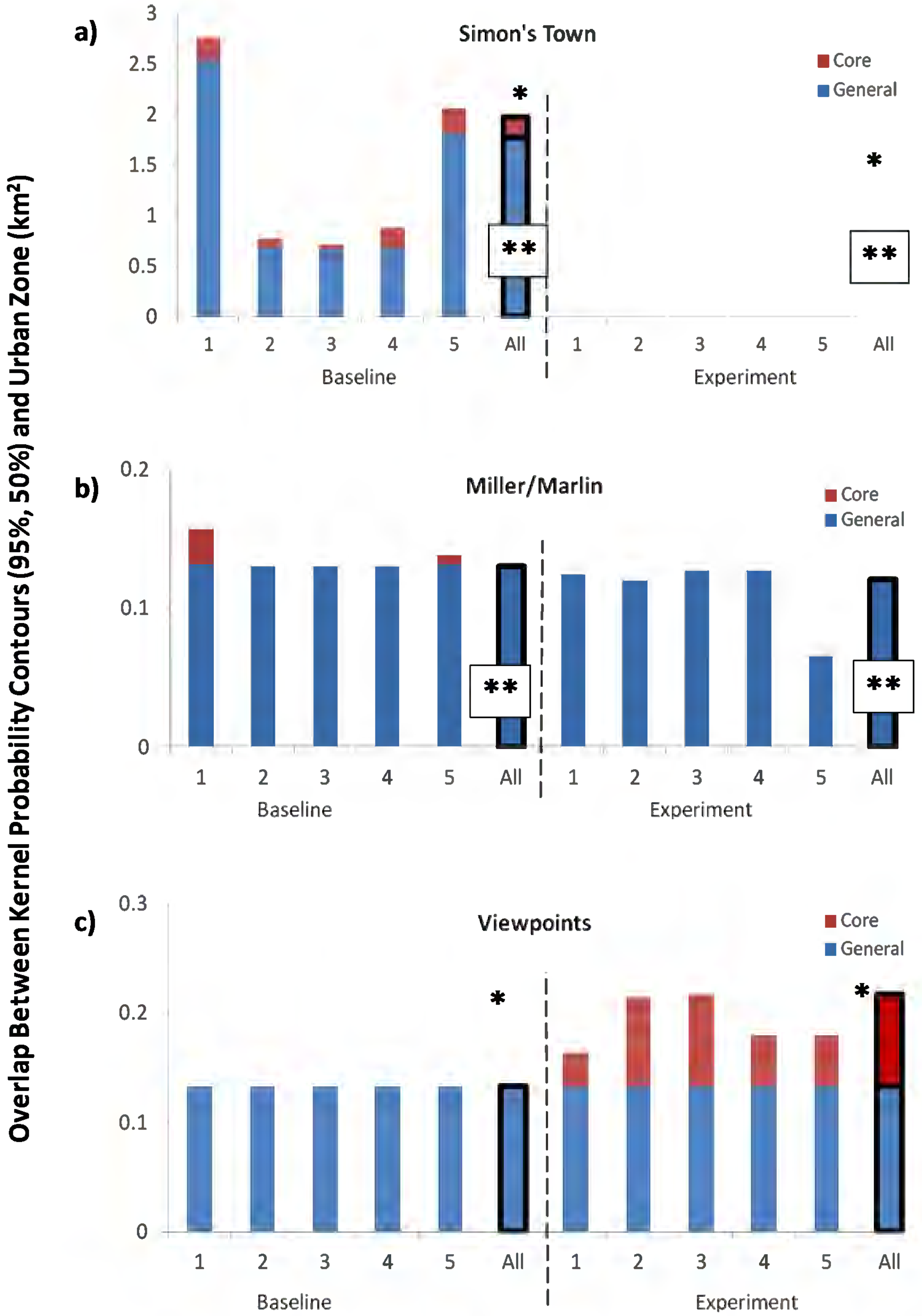


Figure 2.19. Spatial overlap (km²) between six kernel density estimates (50% contour/core use area: red and 95% contour/general use area: blue) of SWB troop and three urban zones (a: Simon's Town, b: Miller/Marlin and c: Viewpoints) before ('Baseline') and after ('Experiment') bear bangers were deployed. For both the baseline and experiment, the kernels were developed for five, two-month periods (1, 2, 3, 4 & 5) as well as a ten month period ('All': outlined in black) which incorporated all of these two-month periods. For ease of reading, the baseline and experiment are separated by a dashed line. Significant differences between baseline and experimental values are marked with '*' for core use area or '**' for general use area.

Table 2.1. Overlap of home range kernels (95% probability contour: general use area; 50% probability contour: core use area) of SWB with three urban zones contained within the troop's home range (Simon's Town, Miller/Marlin and Viewpoints) during a ten-month baseline period and immediately following a ten-month period when bear bangers were used (experiment).

Urban Zone	**Baseline**		**Experiment**		**Baseline vs. Experiment**
	Mean (km^2)	Std. Err.	Mean (km^2)	Std. Err.	
General Use Area					**Mann-Whitney-Wilcoxon**
Simon's Town	1.11	0.36	0	0	W=25; p=0.007*
Miller/Marlin	0.13	0.00	0.11	0.01	W=25, p=0.01*
Viewpoints	0.13	0	0.13	0	W=17.5, p=0.18
Core Use Area					
Simon's Town	0.17	0.04	0	0	W=25, p=0.007*
Miller/Marlin	0.01	0.01	0	0	W=17, p=0.18
Viewpoints	0.13	0	0.08	0.01	W=0, p=0.007*

Percentage use of urban zones

In terms of absolute percentage, the troop's mean use of ST declined when bear bangers were present from 19.31±1.73% to 0.04±0.04% (W=25, p=0.009) and they also showed a significant decline in their use of Miller/Marlin (W=25, p=0.008), while conversely, their use of VP increased significantly (W=2, p=0.03) as compared with the baseline (Fig. 2.20; Table 2.2; Appendix 2.3).

When percentage was corrected for the area of each zone, during the baseline period, MM was used most intensively (mean= 28.61±4.55%/km^2) and significantly more than VP (W=23, p=0.03) which was in turn used significantly more than ST (W=1, p=0.01). In the experimental phase, ST remained the least intensively used zone (0.07%/km^2), exceeded significantly more by the intensity of use of MM (W=0, p=0.01) which in turn was exceeded significantly by the intensity of use of VP (mean: 54.75±13.12%/km^2, W=0, p=0.008) (Fig. 2.21; Table 2.2; Appendix 2.4).

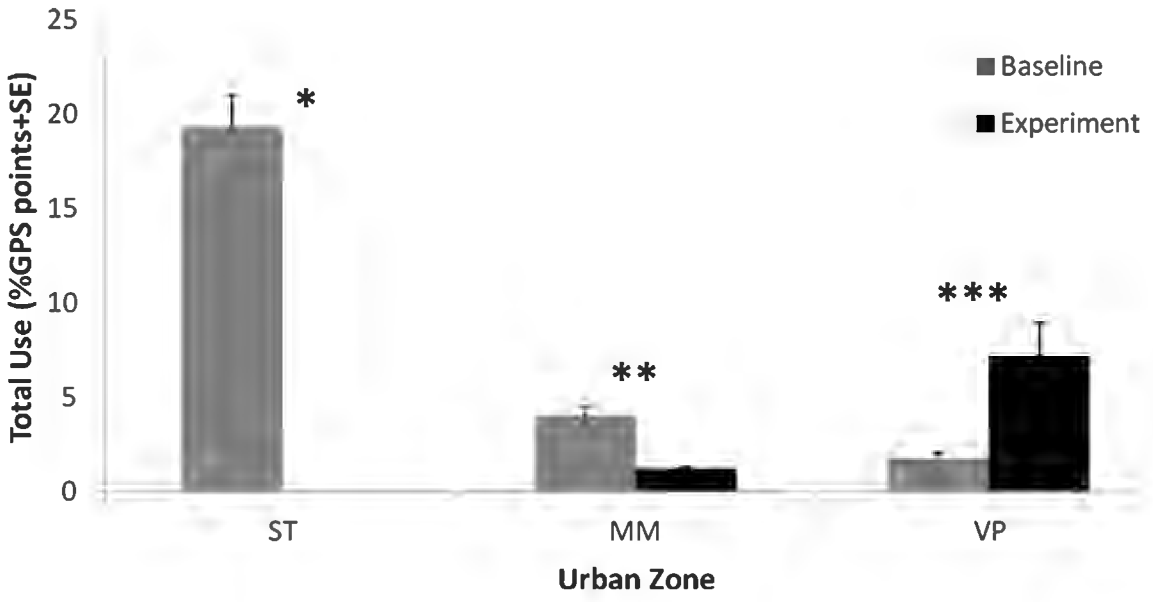


Figure 2.20. Percentage of GPS coordinates recorded for SWB in each urban zone (Simon's Town, Miller/Marlin, Viewpoints) in the baseline (grey bars) and experimental (black bars) periods. The baseline and experimental periods were composed of five consecutive, two-month periods. Significant differences are marked with '*', '**' or '***'.

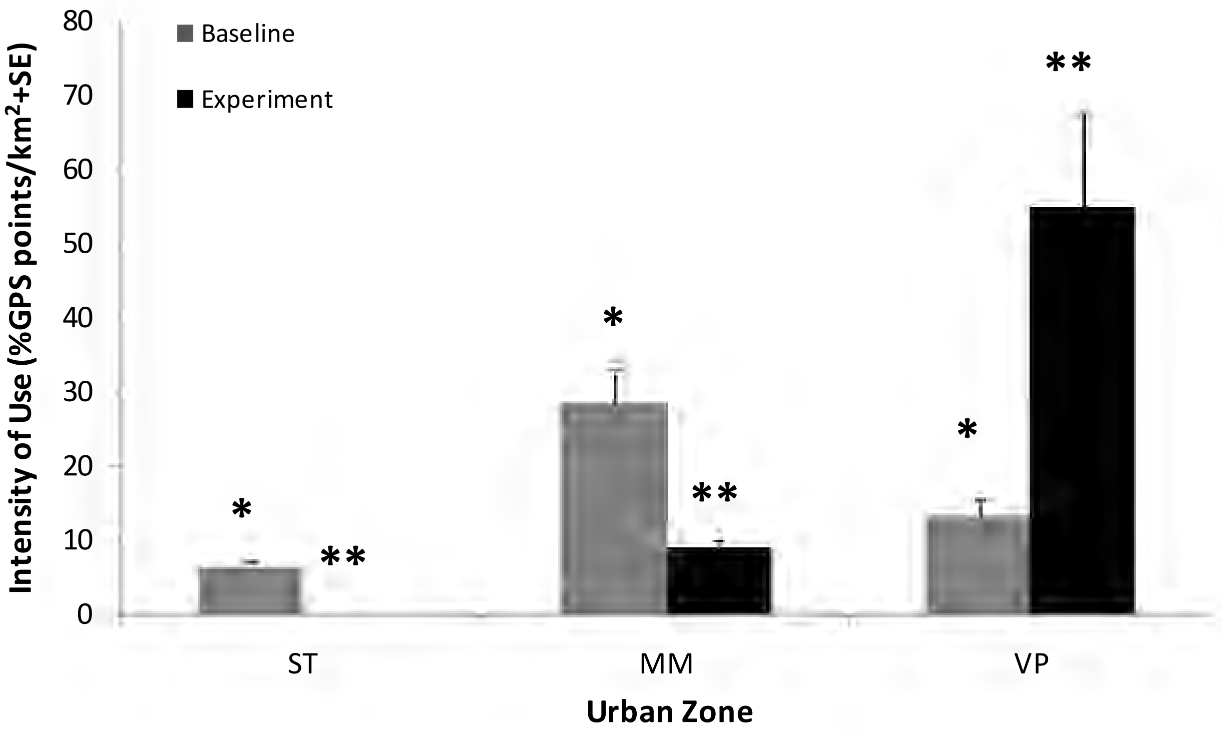


Figure 2.21. Percentage of GPS coordinates recorded for SWB in each urban zone (ST: Simon's Town, MM: Miller/Marlin, VP: Viewpoints), corrected for the area of the zone in (a) the baseline period and (b) experimental period when bear bangers were being used. The baseline and experimental periods were composed of five consecutive, two-month periods. Significant differences are marked with '*' or '**'.

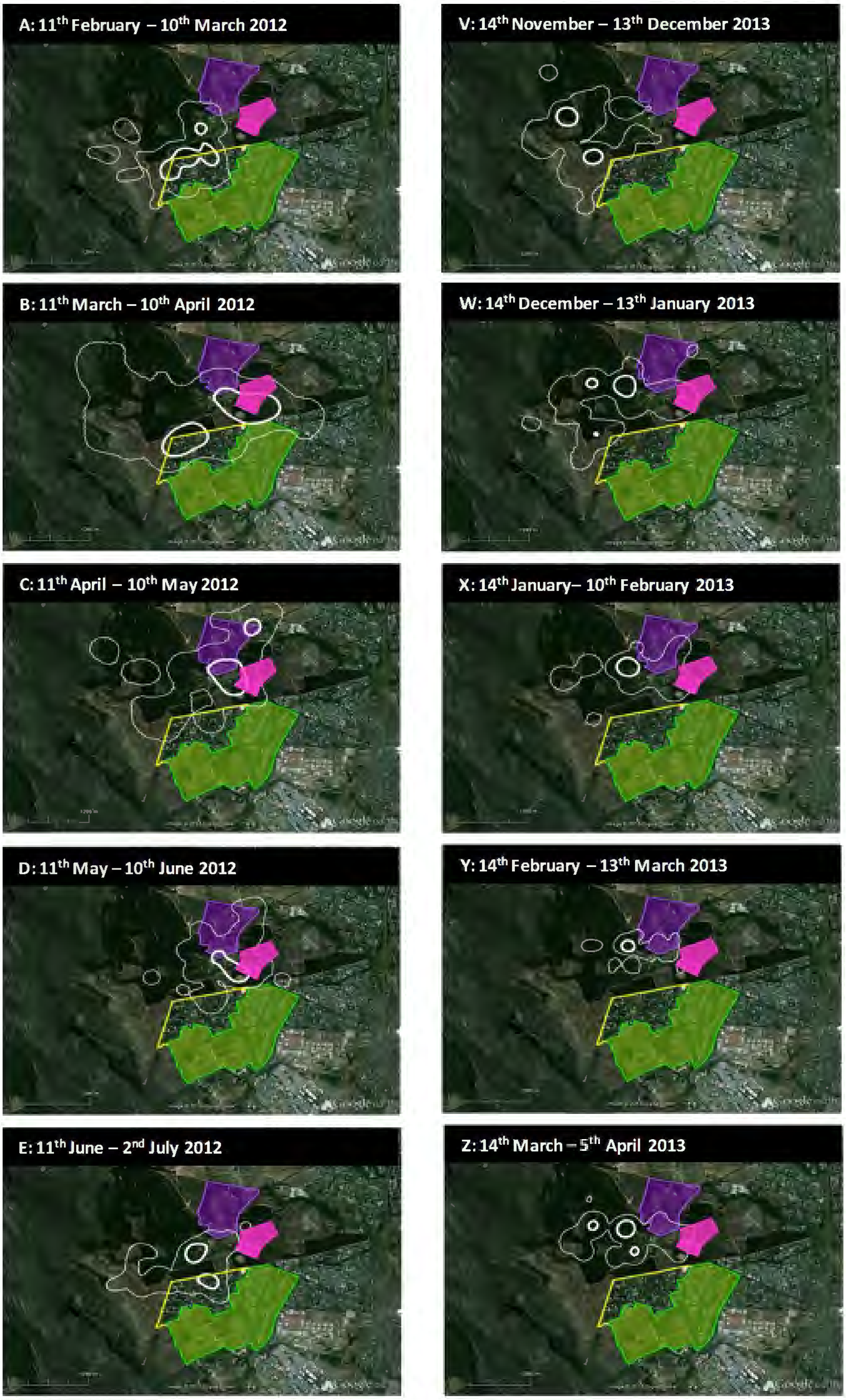
Table 2.2. Percentage of GPS locations (absolute value: 'percentage'; controlled for size of urban zone: 'percentage/km^2') of SWB inside three urban zones contained within the troop's home range (Simon's Town, Miller/Marlin and Viewpoints) during a ten-month baseline period and immediately following a ten-month period when bear bangers were used (experiment).

Urban Zone	**Baseline**		**Experiment**		**Baseline vs. Experiment**
Percentage	Mean (%)	Std. Err.	Mean (%)	Std. Err.	**Mann-Whitney-Wilcoxon**
Simon's Town	19.31	1.73	0.04	0.04	W=25, p=0.009*
Miller/Marlin	4.09	0.49	1.23	0.11	W=25, p=0.008*
Viewpoints	1.79	0.29	7.26	1.75	W=2, p=0.03*
Percentage/km^2	Mean (%/km^2)	Std. Err.	Mean (%/km^2)	Std. Err.	
Simon's Town	6.68	0.6	0.02	0.02	W=25, p=0.009*
Miller/Marlin	28.61	4.55	9.29	0.87	W=25, p=0.008*
Viewpoints	13.5	2.2	54.75	13.12	W=2, p=0.03*

C: Electric fencing

Kernel density estimates

In the baseline period, the troop's general use area consistently overlapped with Zwaanswyk (0.7km^2±0.25km^2), while the core use did so in only some component periods (0.1±0.04km^2). Once fencing was erected was around Zwaanswyk, the troop's core use area did not overlap with Zwaanswyk at all and general use area overlap declined significantly to 0.01±0.01km^2 (W=25, p=0.01) (Fig. 2.22, Fig. 2.23; Table 2.3, Appendix 2.5). The troop's general use area overlapped with both Chrysalis and the Picnic Site in the baseline period and this did not change significantly in the experimental period, despite a decrease in the overall size of the troop's general use area (Fig. 2.24; 1.24km^2 vs. 1.21km^2; W = 19, p-value=0.22). In the experimental period, the troop's core use area did not overlap with Chrysalis and the Picnic site, consistent with a decrease in the overall size of the troop's core use area (0.54km^2 vs. 0.05km^2; W = 25, p-value<0.01) (Fig. 23, 24; Table 2.3; Appendix 2.5).



A: 11th February – 10th March 2012

V: 14th November – 13th December 2013

B: 11th March – 10th April 2012

W: 14th December – 13th January 2013

C: 11th April – 10th May 2012

X: 14th January– 10th February 2013

D: 11th May – 10th June 2012

Y: 14th February – 13th March 2013

E: 11th June – 2nd July 2012

Z: 14th March – 5th April 2013

Figure 2.22. Kernel density estimates (bold white: 50% contour/core use area: thin white: 95% contour/general area use) for the JT for five, one-month periods during the baseline (left column: A-E) and experimental periods when electric fencing (yellow line) surrounded Zwaanswyk (right column: V-Z). The green polygon indicates Steenberg estate (golf course, vineyards and residential estate), the purple polygon indicates Chrysalis Academy and the pink polygon indicates the picnic site which was also enclosed by an electric fence during part of the experimental period

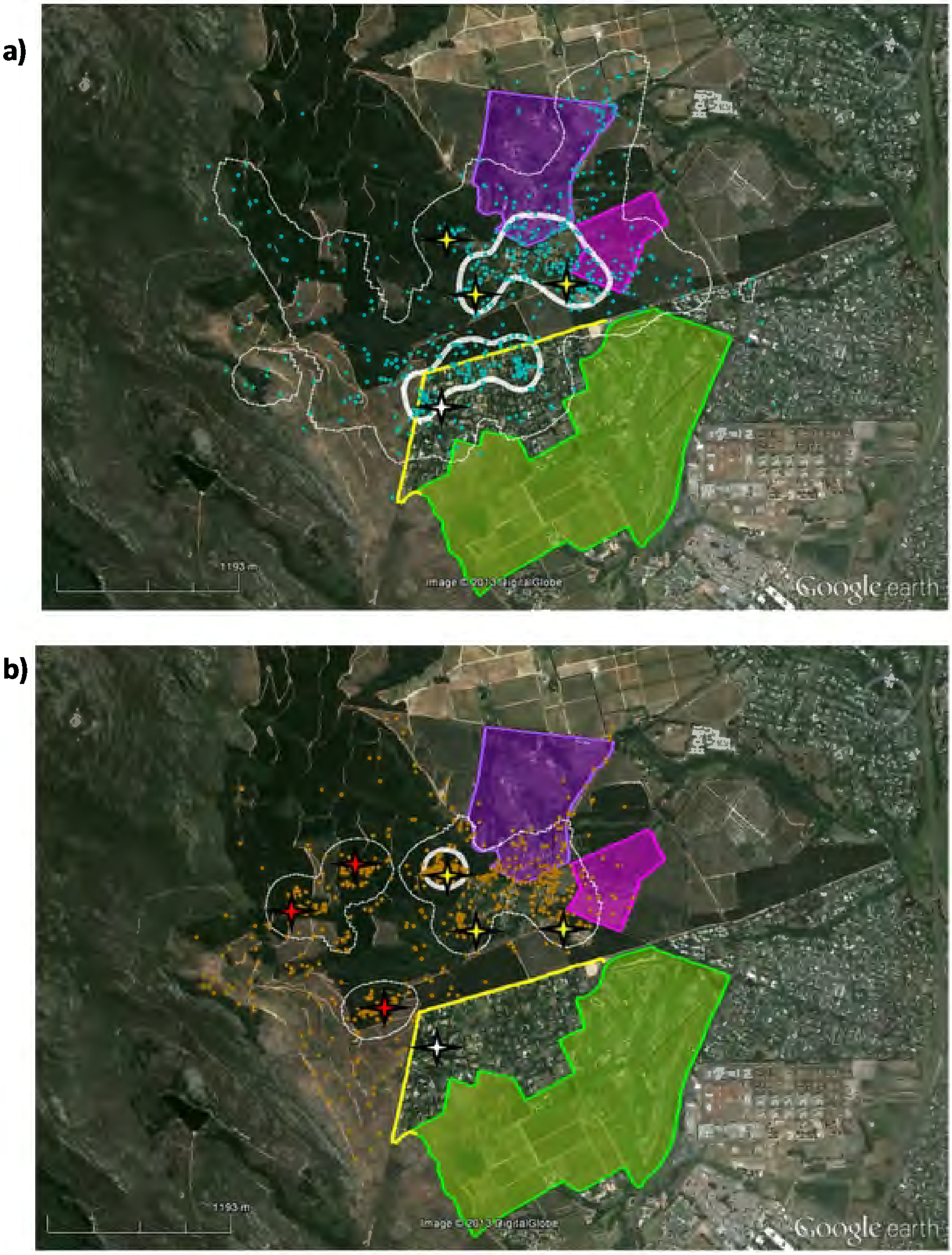


Figure 2.23. Kernel density estimates (bold white: 50% probability contour/core use area; thin white: 95% probability contour/general use area) compiled for JT for two, five-month periods (11th February 2012 – 2nd July 2012; 14th November 2012 – 5th April 2013). The first period shows GPS coordinates recorded as a baseline measure (a: blue dots) and the second (b: orange dots) shows points recorded while Zwaanswyk was surrounded by electric fencing (yellow line). Stars indicate sleeping sites used by the troop (yellow: used in both phases; white: used in [a] but not [b]; red: used in [b] but not [a]). The green polygon indicates Steenberg estate (golf course, vineyards and residential estate), the purple polygon indicates Chrysalis Academy and the pink polygon indicates the picnic site which was also enclosed by a permeable electric fence during part of the experimental period.

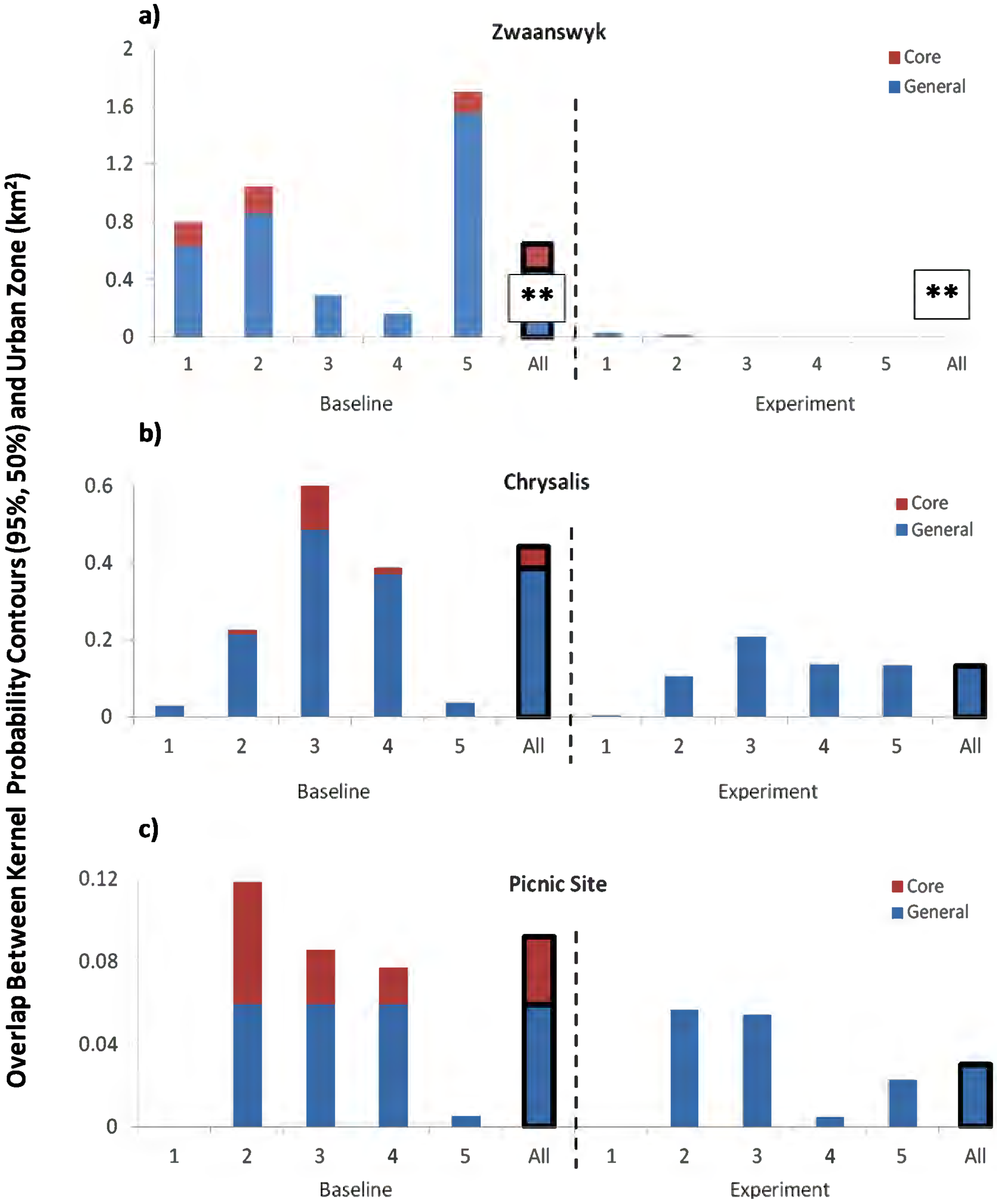


Figure 2.24. Spatial overlap (km^2) between six kernel density estimates (50% contour/core use area: red and 95% contour/general use area: blue) of JT and three urban zones (a: Zwaanswyk, b: Chrysalis and c: Picnic Site) before ('Baseline') and after ('Experiment') electric fencing was erected around Zwaanswyk. For both the baseline and experiment, the kernels were developed for five, one-month periods (1, 2, 3, 4 & 5) as well as a five-month period ('All': outlined in black) which incorporated all of these two-month periods. For ease of reading, the baseline and experiment are separated by a dashed line. Significant differences between baseline and experimental values are marked with '**' for general use.

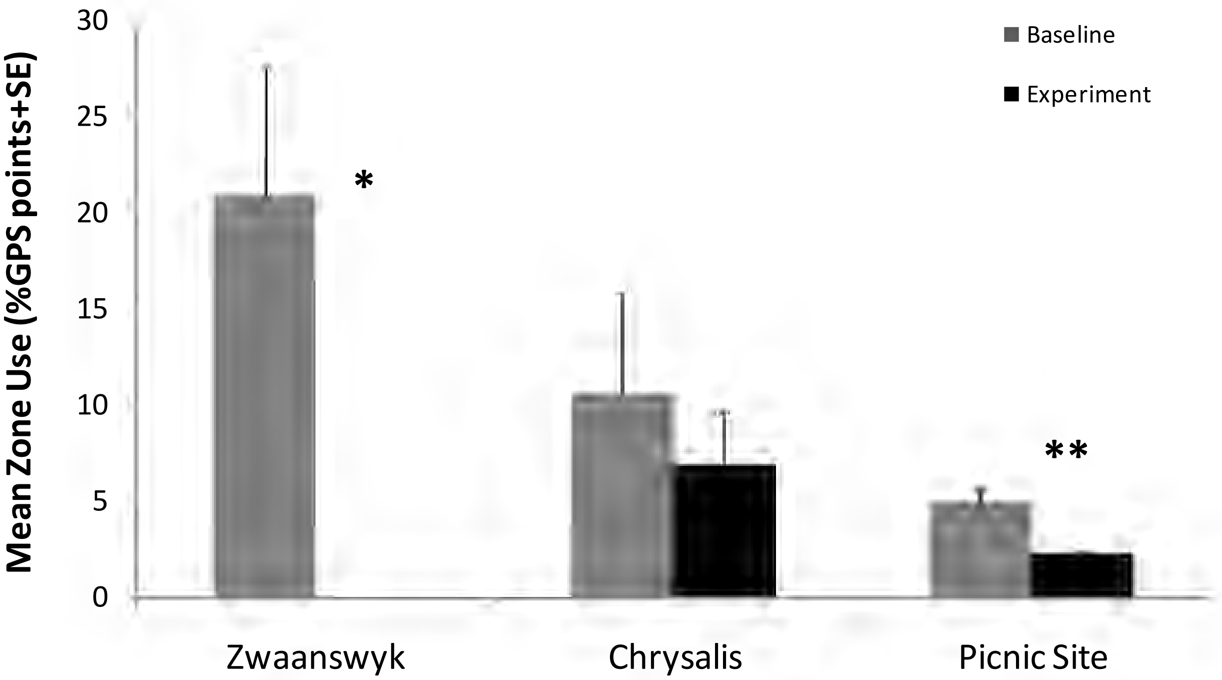


Figure 2.25. Percentage of GPS coordinates recorded for JT in each urban zone (Zwwanswyk, Chrysalis, Picnic Site) in the baseline (grey bars) and experimental periods (black bars). The baseline and experimental periods were composed of five consecutive, one-month periods. Significant differences are marked with '*' or '**'.

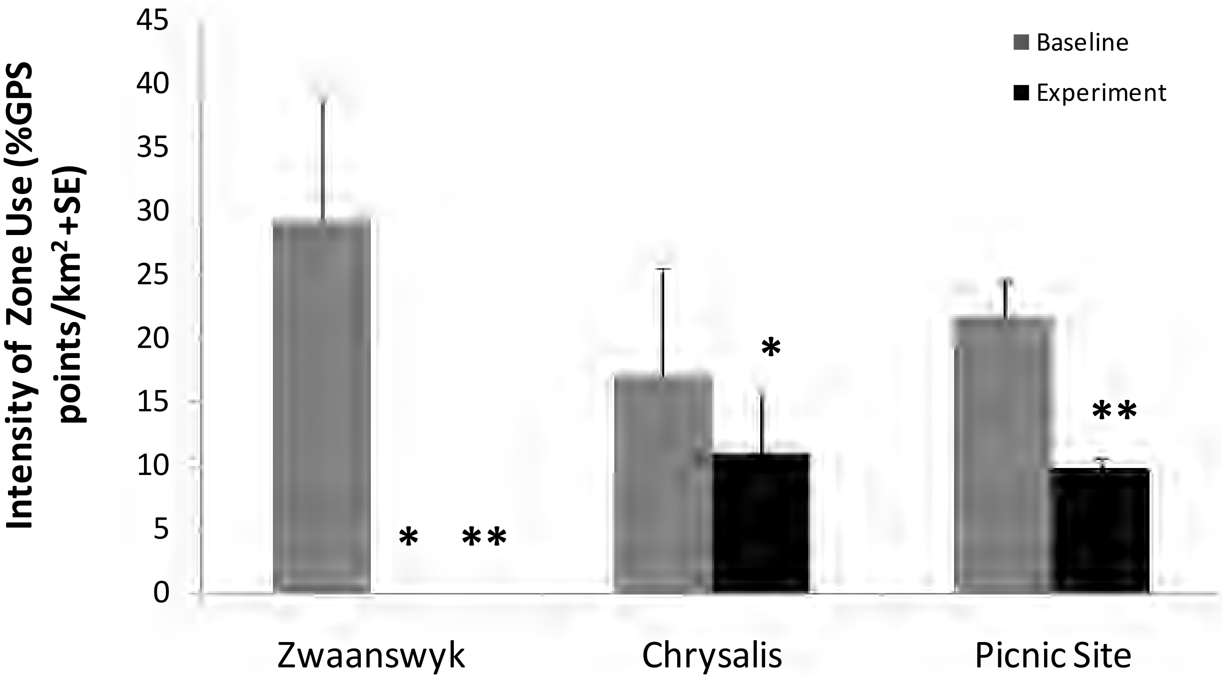


Figure 2.26. Percentage of GPS coordinates recorded for the JT in each urban zone (Zwwanswyk, Chrysalis, Picnic Site) corrected for the area of each zone in the baseline (grey bars) and experimental periods (black bars). The baseline and experimental periods were composed of five consecutive, one-month periods. **Significant differences are marked with '*' or '**'.**

Table 2.3. Overlap of home range kernels (95% probability contour: general use area; 50% probability contour: core use area) of JT with three urban zones contained within the troop's home range (Zwaanswyk, Chrysalis and Picnic Site) during a five-month baseline period and a five-month period when electric fencing was present around Zwaanswyk (experiment). The complete absence of overlap with urban zones and the troop's core use area in the experimental phase rendered statistical tests invalid.

Urban Zone	**Baseline**		**Experiment**		**Baseline vs. Experiment**
	Mean (km^2)	Std. Err.	Mean (km^2)	Std. Err.	
General Use Area					**Mann-Whitney-Wilcoxon**
Zwaanswyk	0.70	0.25	0.01	0.01	W=25, p=0.01*
Chrysalis	0.23	0.09	0.12	0.03	W=17, p=0.42
Picnic Site	0.09	0.04	0.07	0.03	W=16.5, p=0.46
Core Use Area					
Zwaanswyk	0.10	0.04	0.00	0.00	N/A
Chrysalis	0.03	0.02	0.00	0.00	N/A
Picnic Site	0.03	0.02	0.00	0.00	N/A

Percentage use of urban zones

In terms of absolute percentage, in the troop's use of both Zwaanswyk (20.9±6.68% to 0%; W=25, p=0.007) and the Picnic Site (5±0.7% to 2.26±0.19%; W=24, p=0.02) decreased significantly in the experimental period, while their use of Chrysalis was no different in the experimental period as compared with the baseline period (Fig 2.25; Table 2.4; Appendix 2.6)

When using the percentage use values, controlled for by the area (Table 2.4; Appendix 2.7), I found the troop to use Zwaanswyk most intensively in the baseline (20.9±6.68%/km^2), followed by the Picnic Site and then Chrysalis, although these differences were not significant (Fig. 2.26). In the experimental period, the troop Chrysalis most intensively (10.96±4.57%/km^2), followed by the Picnic Site and then Zwaanswyk, which was used significantly less than both Chrysalis (W=0; p=0.007) and the Picnic Site (W=0; p=0.007) (Fig. 2.26).

Table 2.4. Percentage of GPS locations (absolute value: 'percentage'; controlled for size of urban zone: 'percentage/km^2') of JT inside three urban zones contained within the troop's home range (Zwaanswyk, Chrysalis and Picnic Site) during a five-month baseline period and a five-month period when electric fencing was present around Zwaanswyk (experiment).

Urban Zone	**Baseline**		**Experiment**		**Baseline vs. Experiment**
Percentage	Mean (%)	Std. Err.	Mean (%)	Std. Err.	**Mann-Whitney-Wilcoxon**
Zwaanswyk	20.9	6.68	0	0	W=25, p=0.007*
Chrysalis	10.65	5.27	6.85	2.85	W=13, p=1
Picnic Site	5	0.7	2.26	0.19	W=24, p=0.02*
Percentage/km^2	Mean (%/km^2)	Std. Err.	Mean (%/km^2)	Std. Err.	
Zwaanswyk	29.34	9.38	0	0	W=25, p=0.007*
Chrysalis	17.04	8.43	10.96	4.57	W=13, p=1
Picnic Site	21.72	3.05	9.81	0.83	W=24, p=0.02*

Discussion

Light prisms – lessons from an empty threat

With the exception of a slight increase in resting (which may be accounted for by increased raiding success), the WT members showed no change in either activity budget or range use (prediction one) in response to the presence of light prisms. In addition, I did not observe an increase in gaze synchrony when the prisms were present, suggesting that the prisms did not even draw greater visual attention than the ambient environmental events in the baseline. I expected that the novelty of the prisms would elicit a measurable decrease in the troop's approaches to the urban edge, even if this response waned over time through habituation. The lack of response in the baboons may be due to the fact that the troop ranges inside residential areas on a near-daily basis and are frequently exposed to a range of visual stimuli including reflective windows, mirrors and bright lights. Together these stimuli may have 'inoculated' them against reflected light as a deterrent, i.e. habituation had already occurred.

The prisms did negatively influence the presence of two other native wildlife species (hyrax and red-winged starlings) suggesting that they were relatively naive to flashing, reflective stimuli (light prisms) or as prey species, more susceptible to novel stimuli in their environment. Thus while light prisms may reduce the presence of certain wildlife species along the urban edge they had no impact on baboons in the waterfall troop possibly due to prior habituation to reflective surfaces within urban areas and in the absence of a clear threat or cost to the baboons in approaching these passive devices.

Bear bangers – success through dynamic, conditional stimuli

The results of the bear bangers provide convincing evidence that this deterrent strategy was effective in realising its primary goal - to deter the SWB troop from entering the residential area of Simon's Town (prediction two). Success was realised immediately and showed no evidence of decline over a ten-month period. The lack of habituation to noise aversion is surprising given the examples in the literature showing that habituation to noise was likely (e.g. Conover 1984, Koehler et al. 1990; Belant et al. 1996; Gilsdorf et al. 2002). It is possible that habituation did not occur here because the bear bangers were paired with a human presence and thus their spatial and temporal deployment within the buffer zone was unpredictable. Secondly bear bangers produce two noises - the first associated directly with the person ejecting the cartridge from the launcher and the second loud bang approximately 20-30m from that person and often directly above the troop. Thus, the range at which a person can affect a noise and the spatial unpredictability of this noise (dependant on the direction and flight path of the cartridge) may increase the efficacy of this deterrent relative to a static noise or one associated exclusively with a person (e.g. blanks from a firearm). Future work could explore this by comparing the effects of bear bangers with those produced by a device delivering a single, immediate bang. Lastly it is possible that bear banger efficacy was in part, due to the history of conflict between the troop and local residents. That is, in the past, raiding baboons from this troop have been shot at to deter them. This was illustrated by an autopsy conducted on the alpha male of this troop in 2011 which revealed 70 individual foreign metal objects (including buckshot from a shot gun and pellets from an air rifle) distributed throughout his body. Arguably the pain inflicted, and therefore associated with, the loud bang of a rifle or shot gun contributed to the troop's aversion to bear bangers (see Pearce & Bouton 2001).

It is regrettable that it was not possible to follow the troop on foot and assess the behavioural changes before and after the deployment of bear bangers. Direct observations may also have yielded more tangible reasons for the success of this noise aversion method relative to other more static forms and baboon monitors without bear bangers (van Doorn 2009). However the efficacy of this deterrent in reducing the troop's spatial overlap with Simon's Town is unequivocal. This separation between human and baboon habitat has corresponded with a decline in human-induced death (from five baboons to zero) in the two years preceding and following the deployment of the bear bangers (E. Beamish pers. comm.).

In summary bear bangers proved to be a remarkably successful deterrent for defending a narrow boundary (topographically constrained) adjacent to a residential area. It was however necessary to create a large buffer zone (approx. 800m) and the troop was prevented from accessing all the natural land to the west of Simons Town. Restricting the troop's access to the residential area did correspond with an increase in their use of other areas (e.g. viewing points) in their home range where they continued to raid both cars and people, despite the availability of excess natural habitat to the south and west (Hoffman, 2011). This points to the need to manage conflict troops across their entire interface with human environments as successful deterrents in one area may increase raiding pressure on another. In this case, the few, dispersed residences in the southern end of the troop's range could not be defended by bear bangers due to the nature of the terrain. Residents in these areas were urged by the City of Cape Town to baboon proof their houses and gardens to minimise conflict with the troop.

The simple efficacy of electric fencing

Similar to bear bangers the Zwaanswyk fence significantly reduced the JT troop's overlap with the residential area (prediction three). The success of the Zwaanswyk fence was reflected in a comparison of the call volume to the baboon management service provider – before fencing was erected (5-month period: 88 reports/complaints of baboons, ranging between 8 and 24 calls per month) and after fencing was erected (5-month period: 11 reports/complaints in total, ten of which were in one month, prior to the removal of overhanging vegetation that provided two males with a bridge into the residential area). The fencing was further appealing as, unlike the bear bangers, no buffer zone was required, therefore affording the troop maximal access to their natural land within their home range. While select troop members did manage to enter Zwaanswyk on occasion by leaping from the branches of large trees on either side of the fence, the removal of these branches quickly solved this problem (G. Chapman, pers. comm.). Prior to the fence's activation, two adult males also began to access the residential area via the entry road, necessitating the recruitment of a single monitor to guard the entrance during daylight hours (see paintball markers below). That both the Steenberg and Zwaanswyk fences are capable of preventing baboon entry suggests that certain electric fence designs can be 100% 'baboon-proof'. Cases of electric fences failing can often be attributed to an ineffective design (e.g. too few electric strands: Reidy et al. 2008) and improper implementation and/or maintenance (e.g. Kioko et al. 2008) and seldom lies with a failure of the actual electric shock to act as a suitable deterrent. The Zwaanswyk fence has a very high specification because it serves the dual purpose of deterring baboons by day and humans by night. While this raised the cost of the fence it has ensured that the level of deterrence (80 000V), in addition to levels of maintenance, are sufficient to preclude baboons discovering weak points or overcoming low voltage sections. This contrasted with the design of the Picnic Site fence, which through poor maintenance and design flaws, afforded baboons multiple access points into the Picnic Site

(L. Swedell, pers. comm.) and was reflected by their continued use of the Picnic Site throughout the observation period. That the troop did not compensate for the loss of access to Zwaaswyk's residential food resources by increasing their home range size was unexpected. It is possible that this is largely a seasonal effect as troops in this region of the Cape Peninsula have smaller home range sizes during the summer months (which corresponded with the experimental phase) (Hoffman & O'Riain 2011).

As a minimum in deterrent trials, the target animal/s should be monitored spatially and a comparison made between their use of a target area before and after a deterrent's deployment. From a manager's perspective, this data should prove sufficient, provided the target species still have access to suitable habitat, equal to or surplus to requirement. The influence of stochastic or sporadic events/factors (sometimes accompanying the deterrent itself (e.g. increased aggression from landowners) on a target animal's ranging patterns may obscure some results in deterrent trials. These factors can only be discounted or controlled for by frequent observations (similar to those used in the prism experiment). Managers will need to weigh the clarity of evidence against the potential of influential factors to decide whether more detailed observations are required. These frequent observations may be of relevance when the target species, like baboons, live in large, complex groups that are subject to a variety of social and ecological influences (e.g. Cowlishaw 1997; Henzi et al. 1997; Noser & Byrne 2007; King et al. 2011; Hoffman & O'Riain 2012). Further, evaluating the stress induced by more invasive deterrents on target and non-target species can only be achieved by close behavioural monitoring.

Implications of findings for the use of deterrents in the Cape Peninsula

Mitigating human-wildlife conflict through deterrents will typically manifest as a trade-off between cost and efficacy. Where resources are scarce, thorough and quantified trials of a given deterrent can be one of the first aspects of management objectives to be sacrificed. However, the long-term benefit of objectively monitoring deterrent success and indices of human-wildlife conflict will temper, or even offset, the costs of labour and expertise through the informed decisions that follow well-planned trials (Hill & Wallace 2012; Wallace & Hill 2012). Further, if the results (whether successful or not) of these trials are made available in a centralised database it would not only allow for successful deterrent strategies to be propagated but also prevent the repeated and sometimes costly application of ineffective deterrents. I have included an example (Table 6.1) of how such reports might appear for the above three experiments (and management methods from Chapters 3 and 4) in Chapter 6. An important caveat for these trials, and for those presented above, is that they will generally be of a brief duration and have small sample sizes. Managers, therefore, will need to treat conclusions inferred from these trials with some degree of caution and should not assume that the results presented will occur indefinitely and in any scenario to which they are applied.

The exclusion of troops from densely populated, residential areas remains the Cape Peninsula baboon managers' highest priority and it is encouraging that two of the three methods tested here provided possible solutions. The success of bear bangers and electric fencing was contingent on a suite of unique factors that included levels of urgency in mitigating conflict, topography, cost, perceived efficacy and support firstly from the local civic organisations and subsequent approval by local and provincial conservation authorities. Remote sensing with GPS collars allowed for a long-term assessment period (five months or more) for both deterrents – an important consideration given the high frequency of habituation by wildlife in general and baboons in particular to most conflict mitigation methods. Bear bangers have now proved successful in deterring the SWB troop from Simons Town for almost four years but single raiding males have continued to raid this suburb as they are seldom detected leaving the troop and limited baboon monitor numbers prevents the management of individual raiding baboons using bear bangers. By contrast the Zwaanswyk fence has enjoyed 100% efficacy for both the troop and single raiding males in the last six months.

In the event that a long-term deterrent annexes large sections of natural habitat, the impact on the target species' ecology, social structure and reproduction should be monitored. Bear bangers, significantly decreased the SWB troop's home range size (core and general area) and denied the troop access to the buffer zone and large tracts of natural land to the west of the residential area including four sleeping sites. Fortunately the ranges of both SWB and JT troops are adjacent to large tracts of unused natural land, devoid of other troops and thus both troops were able to compensate for any deterrent-induced habitat loss. That neither troop increased their range into these available areas in response to the deterrents, suggests that they are not food stressed. This is an important outcome as reduced resource availability may drive troop fissions, resulting in a greater number of troops that require management and excessive resource loss may bring animal rights activists into direct conflict with managers.

A recent development in the Cape Peninsula is the use of paintball markers by field rangers (previously 'baboon monitors') primarily in areas where the deployment of bear bangers is not considered appropriate because the noise disturbs both domestic animals and residents living near the edge of human environments. Initial results (http://www.hwsolutions.org/data-and-reports.php) suggest that these paintball markers are effective in reducing the spatial overlap between baboon troops and urban areas (up to 95% of a troop's total active hours). Unlike bear bangers, paintball markers make little noise and can therefore be used in close proximity to urban/suburban areas without causing disturbance to residents and domestic animals. However, the relatively short range of paintball markers (approx. 30m) has meant that when the baboons are at the boundaries of human environments, they will run through the monitor line often using dense vegetation for cover against the paintball markers. Consequently the success of paintball markers, similar to bear bangers is contingent on the establishment of large buffer zones around residential areas with the baboons being herded to areas where they can be more easily contained. Thus, while effective, both noise aversion using bear bangers and pain aversion using paintball markers are environmentally costly over the long-term as their frequent deployment (up to five field rangers per troop) within a national park will disturb other fauna and the need for monitors to walk off path poses the risk of trampling to an area with high levels of plant endemism and many rare and endangered species. Furthermore the management strategy of herding a wild animal within a national park to mitigate conflict(van Doorn 2009), effectively denies that animal the ability to decide where within natural land they wish to complete essential components of their life history (e.g. sleeping site selection and feeding) and thus brings into question the ecological role/value of retaining that species within the system given the impacts on other more threatened biodiversity.

These drawbacks do not preclude the use of such deterrents but together suggest that they may be more suited to augmenting other less environmentally costly strategies (e.g. electrified fencing), as opposed to being the primary conflict mitigation tool that is used constantly. In light of the findings presented here, the Baboon Technical Team (the combined authority body mandated to manage Cape Peninsula baboons) has concluded that baboon-proof electric fencing is the best long-term solution for preventing the incursions of baboons into human environments in the Cape Peninsula.

At their centre, the principle of deterrent strategies is universal, i.e. to inflate the cost (or perceived cost) of performing a behaviour beyond the benefit accrued from that behaviour. That bear bangers and electric fencing achieved this goal does not simply equate to solving the challenge of human-baboon conflict; it is a long and varied task. Thus, while the first instinct of humans in conflict with wildlife is to deter, there is considerable merit in exploring other avenues of conflict mitigation. Indeed, practical challenges may slow (the Zwaanswyk fence was only possible through resident sponsorship) or prevent (the linearity of SWB's home range coupled with the separation of human and natural areas is not characteristic of Cape Peninsula troops: Hoffman & O'Riain, 2012a) the implementation of these tools in the Cape Peninsula. Further, in other human-baboon conflict (and indeed other human-wildlife conflict) scenarios, various impediments may similarly prevent the use of bear bangers or electric fencing. Therefore, in the following two chapters I will address the converse of the deterrent strategy. That is, I explore methods of manipulating the relative benefits associated with using human environments.

Chapter 3

PROVISIONING

Introduction

The energetic contrast between naturally-occurring Fynbos in the Cape Peninsula, which is characteristically nutrient-poor (Cowling et al. 1996) and human environments, where calorie-rich foods are ubiquitous (fruit, vegetables, sugar, eggs and bread) has contributed to baboon preference for these human environments (Hoffman & O'Riain 2012). This preference, coupled with baboons' intelligence, social cooperation, communication, agility, manual dexterity and behavioural flexibility (Else 1991; Hill 2000b; Strum 2010; Swedell 2011b) can make human environments highly beneficial habitats. Successful deterrents in the Cape Peninsula therefore would need to impose costs on baboons entering these human environments that are equal to or exceed the benefits thereof. In some cases, the cost required to achieve this will impinge on baboon welfare. Therefore, it is instructive for managers to consider alternative means of manipulating this cost-to-benefit equation.

That is, the incentive to enter human environments can be reduced without having to manipulate costs. Essentially, by increasing the benefit of (remaining in) natural areas, the relative benefit of human environments (and the incentive to enter them) is reduced. Specifically, provisioning food in natural environments could possibly reduce the time baboons spend in human environments. This approach, of supplementary feeding, is more commonplace in the management of wild ungulates where its application is intended to reduce browsing pressure on natural and commercial forests (Putman & Staines 2004). While the approach has had mixed success – moose, for example using feeding stations cause excessive damage to surrounding natural vegetation (van Beest et al. 2010) - the feeding stations' appeal can increase the use of habitat around feeding stations and thereby affect a herd/species' ranging patterns (Sahlsten et al. 2010; Jerina 2012). The use of provisioned feeding sites has also been applied outside of wild ungulate management but their success in effecting ranging pattern changes has been varied (e.g. Lopez-Bao et al. 2008; Fersterer et al. 2001). Despite these varied results, the appeal of diversionary feeding in the Cape Peninsula remains high, where its relatively benign nature compares favourably with deterrents and lethal control.

Altering ranging patterns is only a by-product of provisioning, whose primary goal is to increase the nutritional intake of target animals. Unsurprisingly, therefore provisioning of wild species has been found to increase body mass (olive baboons: Altmann & Alberts 2005; black bears: Partridge et al. 2001; red deer: Rodriguez-Hidalgo et al. 2010; mountain hares: Newey et al. 2010), fecundity (olive baboons: Warren et al. 2011; red deer: Rodriguez-Hidalgo et al. 2010), offspring survival (olive baboons: Warren et al. 2011; red deer: Schmidt & Hoi 2002; eagles: Margalida et al. 2007; mountain hares: Newey et al. 2010) and overall population size (eagles: Mccollough et al. 1994). In a critically endangered species, supplementary feeding can be a valuable conservation tool and has been proposed for the long-term conservation of primates (Asquith 1989). However, in the Cape Peninsula, where baboons are not endangered and where the local population is growing (Beamish 2009), increased growth rates or fecundity could exacerbate human-baboon conflict by increasing the space required by extant troops.

Of relevance to human-baboon conflict in the Cape Peninsula is a specific provisioning methodology (King et al. 2008) that has been shown to [a] influence the movement patterns of baboon troops whilst [b] minimising potential for increased growth rates and fecundity. The study in question examined movement decisions in chacma baboon troops in a desert environment (Tsaobis Nature Reserve, Namibia) that experiences no human-baboon conflict. When presented with a high-quality, dense food patch, dominant males led the whole troop to the patch and then monopolised the limited resources thereon. Thus incentive to the troop leader influenced the movement patterns of the whole troop, despite very few troop members receiving any nutritional incentive to follow the dominant animals to the food patches (and suffering 'consensus costs': Conradt & Roper 2003; Conradt & Roper 2005). Despite these consensus costs to subordinates, troop fission was observed rarely, only occurring on 6/80 occasions and always in the largest troop that was studied. Arguably, the appropriate (i.e. provisioning outside human environments) application of this methodology in the Cape Peninsula may prove to be a powerful tool in changing the ranging patterns of conflict troops.

Firstly, I tested the hypothesis that implementing King et al.'s (2008) provisioning strategy will reduce spatial overlap (and thus conflict) between a troop (WT) and the neighbouring human environment (Simon's Town) in the Cape Peninsula. Based on the appeal of a reliable food resource and King et al.'s (2008) findings, I predicted that after finding an introduced feeding patch, the troop would continue to visit that patch (prediction one), led by dominant individuals (prediction two) who would monopolise that patch (prediction three). I further predicted that these visits would reduce the time the troop spends in the urban* environment (by virtue of the patch's placement in natural land: prediction four). However, in contrast to Namibia, where baboons' alternative to a provisioned food source was natural forage, Cape Peninsula baboons have access to human food items, such as bread, fruit, vegetables, cereals, eggs and even sugar (typically superior in nutritional value, and protein and/or fat contents than a uniform provisioned food, i.e. corn). These items are acquired from sources such as waste bins (where baboons often consume discarded food), human hand-outs, shops and kitchens and could potentially moderate (lower) a troop leader's incentive to visit an experimental feeding patch. Therefore in addition to presenting the experimental patch, I identified those urban food sources being raided by the baboons and secured them with barriers that prevented baboon access. After this modification, I predicted that the time baboons spent in the urban space would be further reduced (prediction five). Finally, given that the baboons under investigation are already heavily reliant on localised, high-energy food sources in the urban space, I predicted the troop's activity budge would not change despite any changes in movement.

Methods

Study site and subjects

Simon's Town (34°11'39.62"S; 18°25'55.44"E) is located on the eastern coast of the Cape Peninsula, South Africa and is a composite of residential areas, a naval barracks and a homeless shelter. 'Natural' land on the periphery of the town is composed of a mixture of indigenous Fynbos (shrub-like community of plants, i.e. Proteaceae, Ericaceae, and Restionaceae: Cowling et al. 1996) and alien vegetation which includes a small Eucalyptus thicket and alien grasses. Ranging in these areas, the relatively small Waterfall Troop ("WT") is comprised of 21 individuals (September 2009: one adult male, one sub-adult male, nine adult females, ten juveniles and one infant). I compiled identikits for all adult individuals in this study and found the baboons already habituated to the close proximity of observers, presumably through their prolonged exposure to humans. That is, the troop sleeps in natural land on cliffs outside the urban edge but typically descends into the low lying urban areas on a daily basis to forage for human derived food items. This troop was the only routinely raiding

Cape Peninsula troop that was not assigned a team of monitors (at the time of the experiment) and residents in the area have expressed on-going distress at the frequent troop incursions and the resultant damage to property and loss of food.

Experimental procedure

I divided the experiment (13/08/2009 - 11/09/2009) into three, consecutive phases (A=10 days, B=9 days and C=9 days). I collected baseline data of activity budget and movement patterns in phase A while in phase B I introduced a spatially discrete 10x10m supplementary food patch on natural land within the troop's home range *sensu* King et al. (2008). Patch location (34° 11' 36.45'' S, 18° 25' 09.08'' E) was a trade-off between distance from the urban edge and proximity to the core of the troop's home range (Figure 3.4). I provisioned the patch daily before sunrise with 880g (80g/adult member) of dry corn kernels. This amount of food and the patch size made our experiments comparable to the high-contest patches tested by King et al. (2008). I distributed kernels evenly (approximately 26 kernels/m^2) throughout the patch by scattering a handful at one metre intervals and collected any remaining kernels after sunset. Importantly, corn also provides a means to quantify foraging bite rate as baboons characteristically transfer individual kernels from the ground to their mouths. In phase C, I retained the experimental patch, but increased the incentive to use it by restricting troop access (using wire-mesh fencing) to the three major urban waste sites identified in the baseline phase.

Data Collection

I commenced observations at sunrise (07h00) and ended them at sunset (18h00). Numerous physical barriers (e.g., fences and walls) in the urban area confounded continuous troop follows on foot. While this was not problematic in Chapter 2, in this experiment, I wished to increase the confidence in identifying the troop's raiding targets and to include focal data to determine grooming relationships between individual baboons. Therefore, I instituted a paired-observer (I was assisted by a biology student) approach. One observer (O1) was positioned at an elevated observation post on a ridge overlooking the urban space (see Fig. 3.4). From this location O1 could observe and accurately plot the troop's movement throughout the urban area (see 'Scans' below). Using two way radios O1 directed a second observer (O2) who followed the troop on foot. O1 thus recorded all spatial data, scans and instances of raiding whilst O2 recorded focal behavioural data. Data collected on days with sustained heavy rainfall (phase A: 3 days; phase B: 2 days; phase C: 1 day) were discarded as these conditions have been shown to substantially reduce range use in Cape Peninsula baboons (Hoffman & O'Riain 2011) and because troop visibility to the elevated observer was greatly limited.

Focals

On average, O2 conducted N = 42.36±0.7 (range = 16-49) 10-minute continuous focal watches on randomly selected adult troop members throughout the day. Each focal recorded habitat type, time spent foraging (actively searching for, manipulating and ingesting food); grooming (affiliative manipulation of recipient's pelage by groomer); locomoting (movement resulting in a shift in space while not engaged in foraging) and resting (sedentary position without foraging or grooming).

Scans

Instantaneous scan samples (Altmann 1974) were recorded at 15-minute intervals throughout the day during all phases. Each scan recorded the number of individuals foraging, locomoting, resting, and grooming as defined in the focal protocol (above) and plotted the location of the estimated troop centre on an aerial photograph. The clear delineation of land types (Fig. 3.4) within the troop's home range allowed O1 to consistently plot locations with a high degree of accuracy, further improved by continuous communication with O2 at ground level.

Habitat Use

To determine the troop's active and core areas of use in each phase, I developed fixed kernel estimates (ArcView 3.3, Home Range Extension: Rodgers & Carr 1998) based on troop locations collected every 15 minutes during active hours (scans: above). The area of active use was delineated within the 95% probability contour, while the core use area was delineated within the 50% probability contour. Due to the importance of understanding raiding 'targets' for setting up phase C (see below), I divided the human environment of Simon's Town at a much finer scale (Fig. 3.4) than in Chapter 2.

Raided food items (RFI)

During phase A, observers obtained data (where and when) on the raiding behaviour of the troop. RFI intake (see Chapter 2; Prisms) was then systematically quantified for the troop during Phase B and C. As with Chapter 2, individual identification was not always possible, therefore, I chose to compare the troop's collective raiding success. Where clear identification of a food item was possible, its quantity was recorded but where it was not (N=253/816 cases), the RFI was scored as one unit. Although this method provided only a rough estimate of the troop's total RFI intake, a consistent approach allowed for meaningful comparisons across phases.

Dominance

I recorded the number and direction of agonistic events *ad libitum* throughout the study (*sensu* King et al. 2008) and compiled actor-recipient matrices from active supplants and displacements. I used Matman software (de Vries et al. 1993) to determine whether the dominance hierarchy was linear

Experimental patch protocol

When the troop entered the patch, normal observations were suspended. O1 relocated to the patch's periphery immediately prior to the first baboon arriving, while O2 followed the troop to the patch. Continuous video recordings taken by a video camcorder (Canon ZR700) mounted on a tripod, 10m from the patch supplemented all patch observations. The arrival order of adults to the patch were recorded as well as the identity of all individuals within the patch at one minute-scans (mean=41.67±1.14 scans per visit; N=250). The foraging bite rates of all adults on the patch (one bite is measured as a baboon moving one corn kernel from the ground to its mouth) were sampled at random (15.5±1.45 bite rates per patch visit; N=93). This allowed me to estimate mean individual foraging benefits to visiting the patch (mean bite rate*mean time spent on the provisioned patch) which was equivalent to the average corn intake of that individual per day. I could not measure accurately individual consensus costs (Conradt & Roper 2005; King et al. 2008) incurred as a result of visiting the experimental patch, that is, lost foraging opportunities on urban food sources. Therefore I examined relative differences in RFIs (see above) between phases B and C to assess whether the troop's incentive to visit the patch may have been increased by restricting access to urban food sources.

Analyses

I used Wilcoxon-matched pairs tests (Statistica ver. 8.0) to assess differences in behaviour and habitat use between the three phases of the study and a Mann-Whitney U test (Statistica ver. 8.0) to test for differences in the number of RFIs obtained between phase B and C. I used standard binomial statistics to test whether any individual led the troop to the patch significantly more than others and whether arrival order was random. A one-way, single factor ANOVA (and Tukey HSD Post-hoc test) was used to examine differences in corn consumption across individuals. Arrival orders were analyzed using a Linear Mixed Model (LMM) conducted in MLwiN version 2.18 (Rasbash et al. 2004), which included individual dominance rank, grooming relationship to the individual who arrived first, experimental phase (B, C), and sex (male, female) as fixed effects. All two-way interactions were tested, but none were found to be significant. ‘‘Experimental day’’ and ‘‘individual ID’’ were incorporated as random effects in order to control for non-independence of repeated observations of individuals over experimental days. Backward elimination was used in selecting the minimal adequate model and included only those factors that contributed significantly ($p<0.05$) to the explanatory power (Akaike 1974). The significance of fixed terms is presented as Wald statistics evaluated against the Chi-square distribution.

Results

(i) Patch Use and Dominance

Four days elapsed between placing the supplementary food patch and its discovery by the troop and the data from these days were not used in analyses. After they had discovered the patch, the troop visited its location significantly more in phases B (5/9 days) and C (7/9 days) than in phase A (0/10 days), (Fisher exact test: $p_{AvsB} = 0.0108$; $p_{AvsC} < 0.0001$) supporting my first prediction.

I found the troop’s dominance hierarchy to be linear ($h=0.76$, $N=189$, $p<0.001$). I found that individual arrival order to the patch was predicted by dominance rank (LMM: $X^2=31.73$, df=1, p<0.001; Table 3.1; Figure 3.1); with either the alpha male or sub-adult male (ranked second) leading the troop to the patch on all but two occasions (supporting prediction two). Also, individual grooming relationships with the alpha male determined follower behaviour, and this was a non-linear effect. That is, the stronger the grooming relationship with the dominant male the sooner the individual arrived on the patch (LMM: $X^2=19.08$, df=2, $p<0.001$; Table 3.1). Once the troop was at the patch, foraging benefit differed significantly across individuals (ANOVA: $F_{(10, 55)}=50.093$, $p<0.001$) with the alpha male and female consuming the most (Tukey HSD Post-hoc test: M1: $p<0.001$; F2: $p<0.001$) (Figure 3.2: supporting prediction three). Two mid-ranked (3rd and 4th) adult females attended the patch but did not remain for long periods, as reflected in their low corn yield (Fig. 3.2). Although we only recorded data for adults in detail, I consistently observed several juveniles (mean number=5.79±0.57) present on the patch while food was present, i.e. from first adult arrival until the corn was completely depleted (mean=33.6±9.8min).

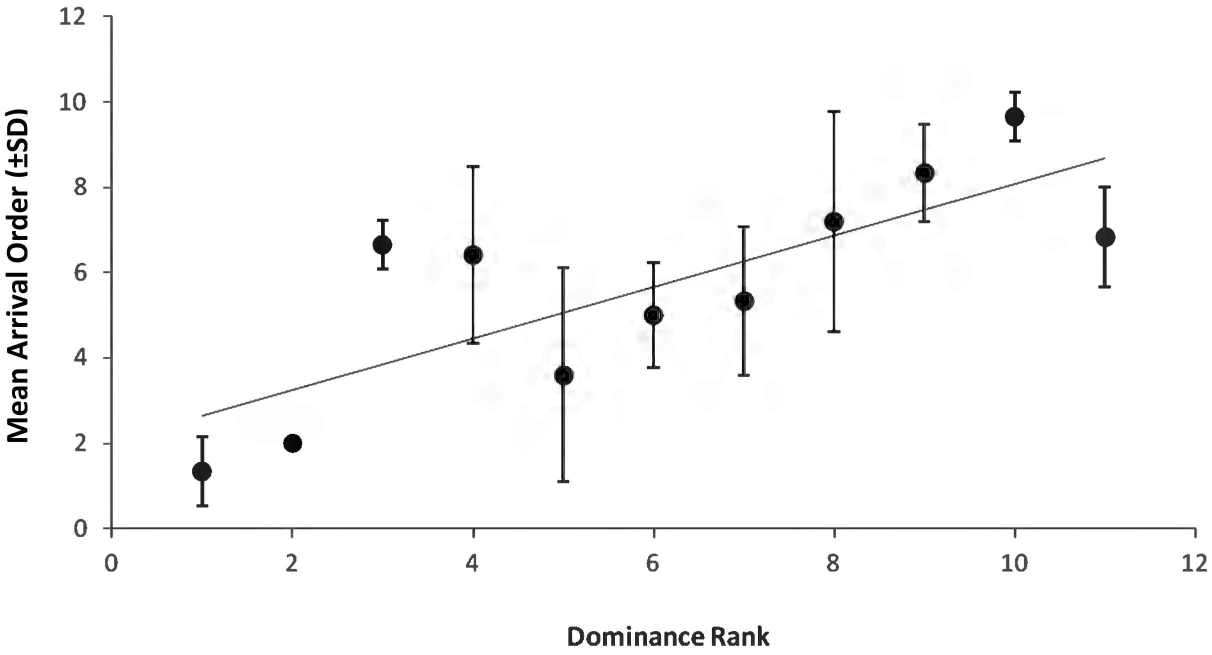


Figure 3.1. Arrival orders of individual WT members to the supplementary patch during phases B and C, compared with dominance rank. The trend shows the tendency of more dominant animals to arrive early.

Table 3.1. Linear mixed model analysis with a normal error structure, controlling for repeated observations on individual focal animals across days (both entered as random effects). Parameter estimates (Estimate), Standard Error (SE) and associated p values, evaluated against a chi-squared distribution are provided. Values for non-significant terms (here, only sex) were obtained from fitting terms individually to the minimal model, and there were no significant two-way interactions.

Fixed Effects	**Estimate**	**SE**	**Wald**	**p**
Dominance rank	0.615	0.124	31.73	<0.001
Social affiliation to leader	2.237	0.515	18.91	<0.001
Social affiliation to leader* Social affiliation to leader	-0.310	0.076	16.49	<0.001
Experimental condition (phase B, phase C)	-0.894	0.409	4.76	0.029
Sex (female, male)	-1.463	0.796	3.37	0.067
Constant	3.644	0.826		
Random Effects	**Estimate**	**SE**		
Individual	0.000	0.000		
Observation day	4.278	0.585		

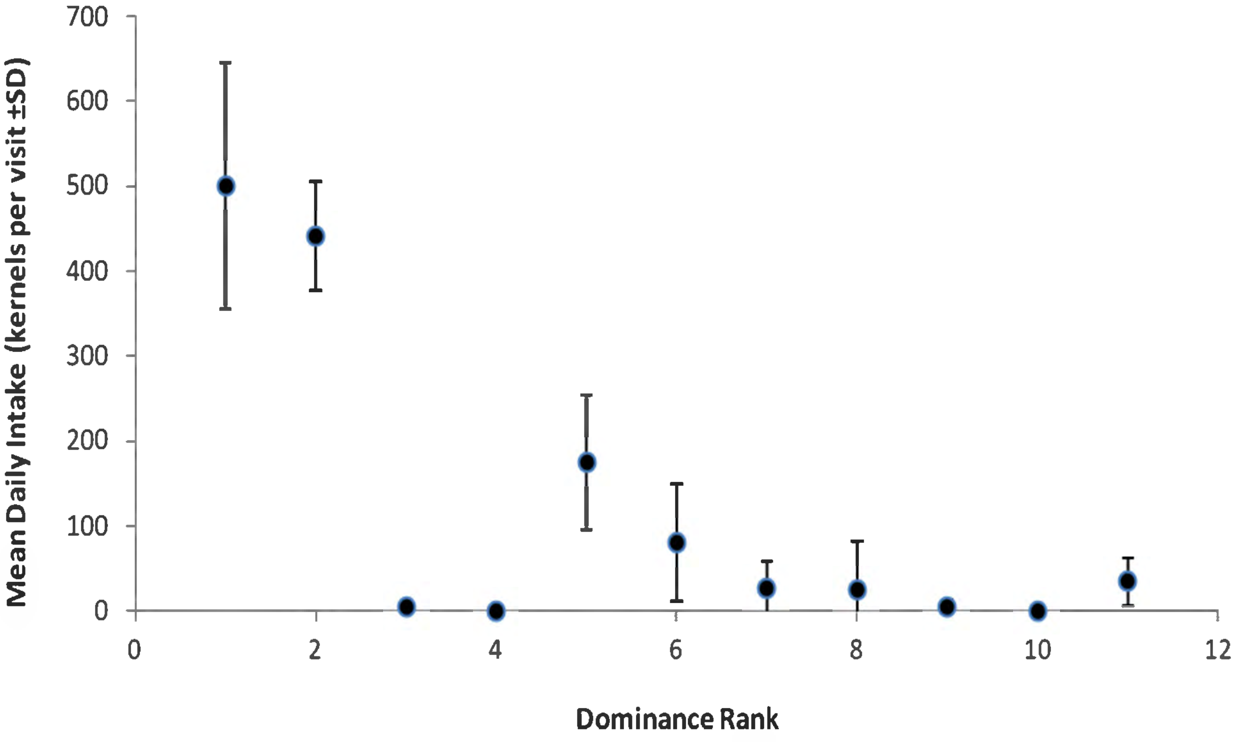


Figure 3.2. Mean daily corn intake of WT members plotted against dominance rank shows a clear monopoly by the two dominant troop members over phases B and C.

(ii) Habitat Use

After introducing the patch in phase B, the troop’s average daily use of the human environment decreased from 40% (±5.39) to 29.68% (±7.64) (N = 9; Z = 1.13; p=0.26), although this change was not significant (i.e. I found no support for prediction 4). After restricting access to urban food items in phase C, the troop’s average daily use of the human environment decreased to only 12% (±2.78), significantly less than in phase A (N=9; Z= 2.310161; p=0.001), supporting prediction five (Fig. 3.3).

Fixed kernel estimates showed a clear difference between troop range use in each phase (Figure 3.4). During phase A the troop showed core area use of the navy barracks and Happy Valley home. In phase B, core area use extended to incorporate the patch and the Signal School, reflected in the increase seen in mean daily use of the Signal School from phase A (mean=6±11%) to phase B (11±15%) and an increase in the troop’s core area size from phase A (0.04km^2) to phase B (0.13km^2). In phase C, restricted baboon access to the Signal School, Happy Valley home and navy barracks resulted in a reduction in the core use area (0.06km^2) with focus shifting to natural habitat, reflected in the mean daily use of natural habitat increasing from phase B (70.32±17.04%) to phase C (88.06±8.34%).

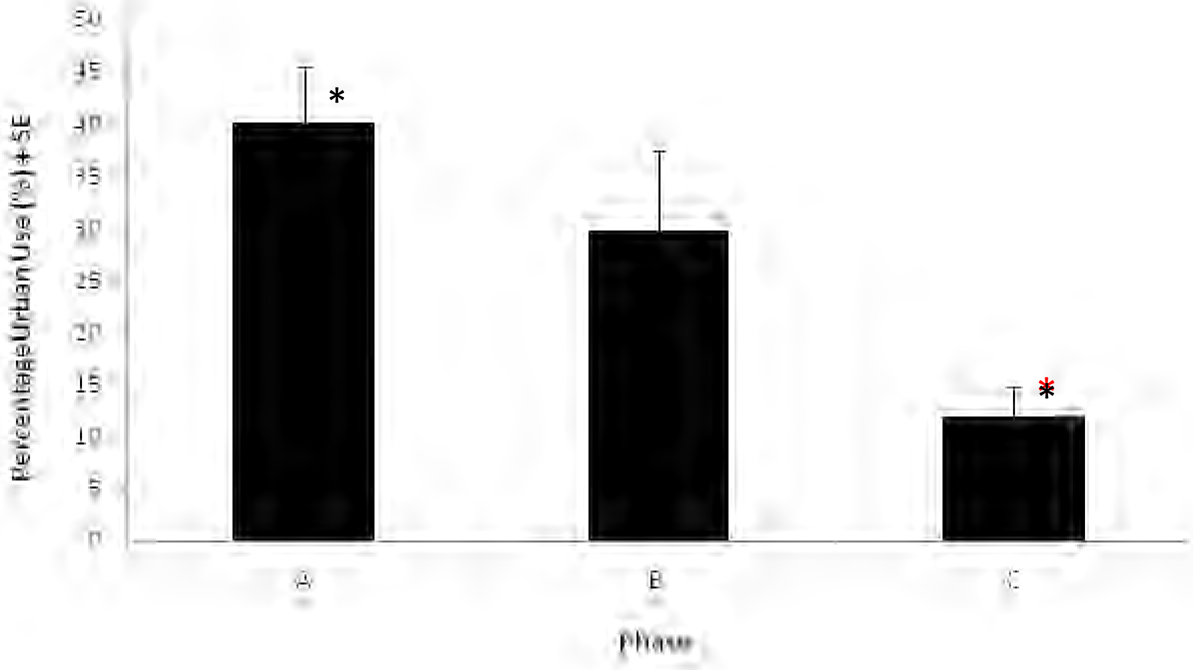


Figure 3.3. Mean daily percentage time WT spent in the human environment during the three different phases of the experiment. A: baseline; B: provisioned patch and C: provisioned patch plus removal of main urban food sources. Significant difference (Wilcoxon-matched pairs: p< 0.05) is indicated with “*”.

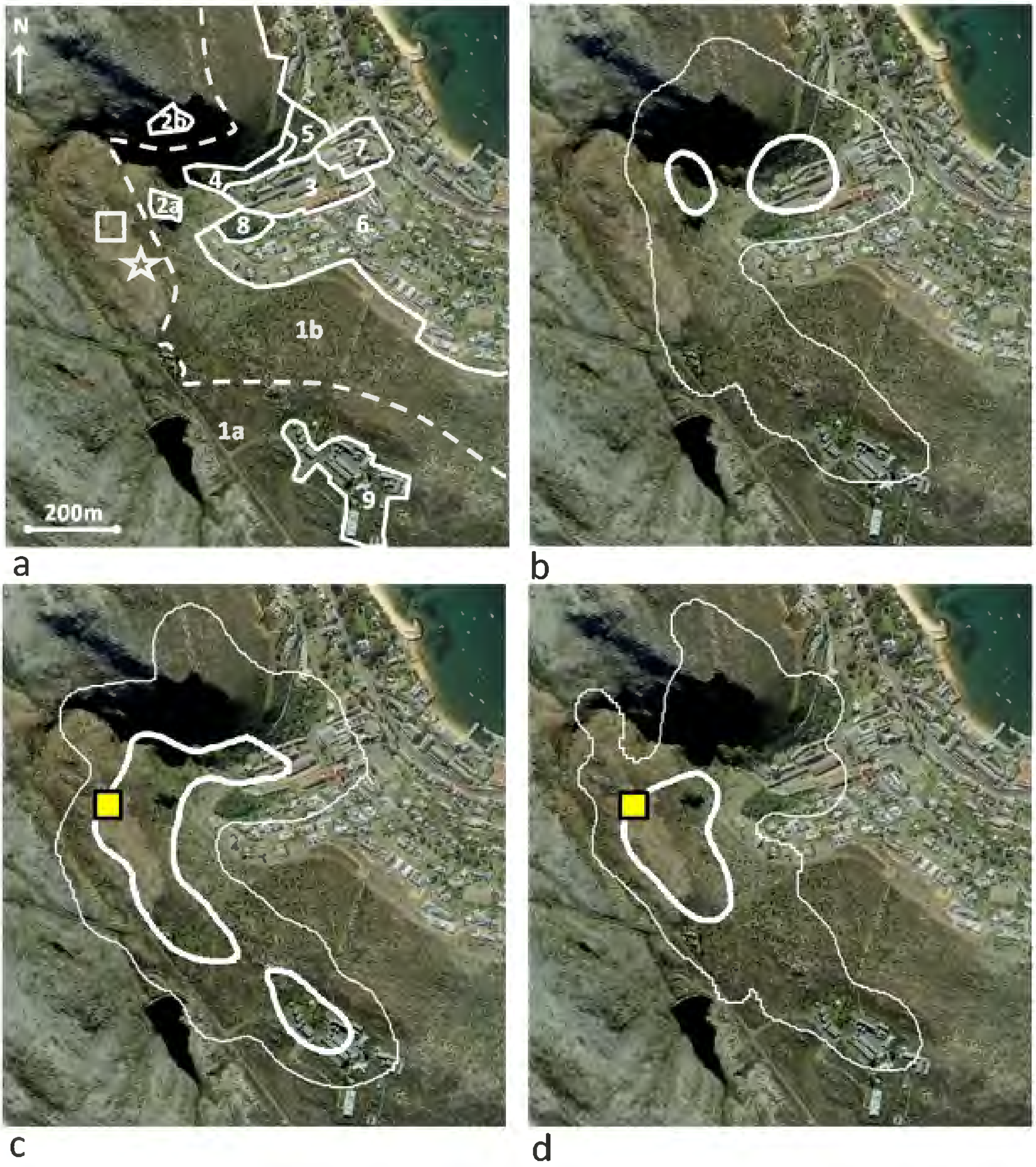


Figure 3.4. [a] Habitat composition of the study site: 1a) Fynbos; 1b) mixture of alien vegetation and Fynbos; 2a) sleep site one; 2b) sleep site two; 3) navy barracks; 4) Happy Valley home; 5) wetland; 6) residential zone; 7) procurement centre; 8) Eucalyptus thicket; 9) Signal School. Sites 3, 4 and 9 are raiding 'hotspots' as indicated by the frequency raided food items (all have large, accessible kitchens and waste areas). The star indicates the position of O1. The hollow square denotes the position (not size) of the supplementary patch. b, c & d) Fixed kernel estimates of the troop's range use (narrow white: 95% probability contour; bold white: 50% probability contour): [b] phase A – baseline; [c] phase B – location of introduced supplementary patch marked with a solid square; [d] phase C – supplementary patch plus restriction of urban food availability.

(iii) RFIs and activity patterns

Following identification of raiding locations in phase A, I subsequently recorded a significant decrease in mean RFIs obtained per day from phase B to phase C (Z=2.2; N=6; p<0.001; Fig. 3.5).

Despite reductions in human environment use and RFIs obtained, scan data showed no significant differences (Wilcoxon matched-pairs) in the mean daily time spent in any behavioural category during phase A (baseline) and phase B (foraging: Z=0.77, N=9, p=0.44; locomotion: Z=1.36, N=11, p=0.17; resting: Z=0.42; N=11, p=0.68; grooming: Z=0.42, N=11, p=0.68), supporting prediction six. These values remained approximately constant in phase C, except for reduced locomotion from 20.55% (±4.17%) in phase B to 15.66% (±4.58%) in phase C (Z=2.55, N= 9, p=0.01).

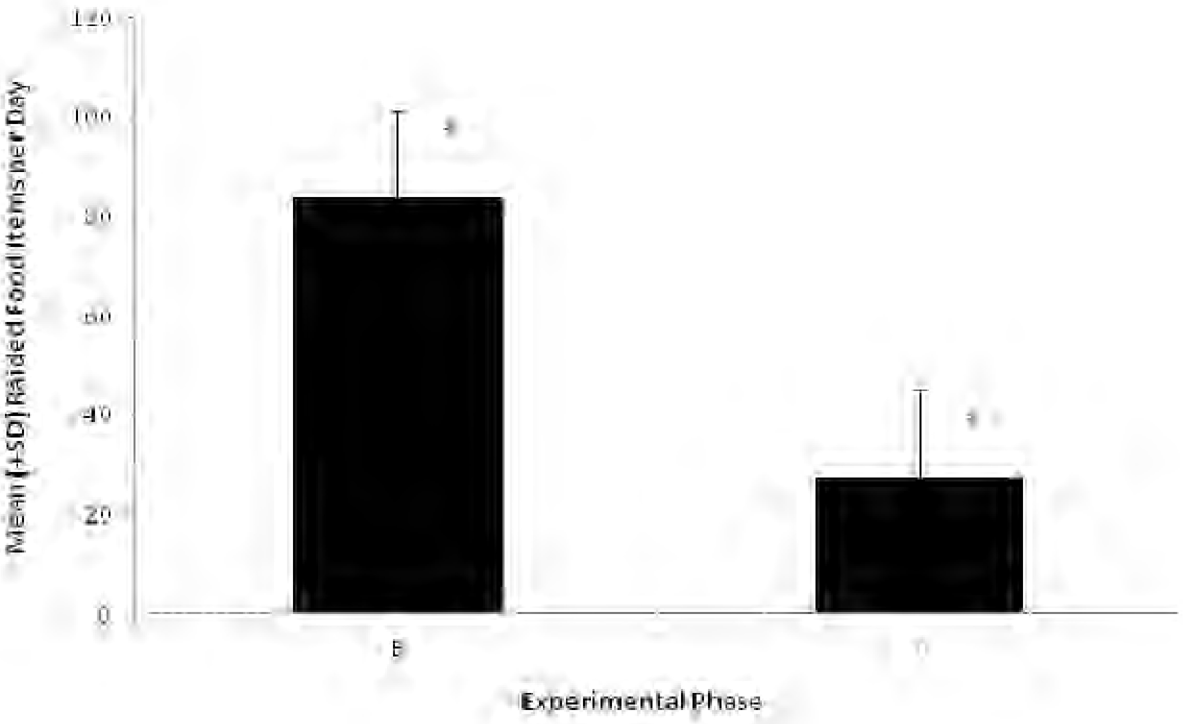


Figure 3.5. The mean number of raided food items (RFI) accessed per day by WT during phase B and C of the experiment. Significant differences are indicated with "*".

Discussion

The data support the findings of (King et al. 2008). That is, following its discovery, the troop visited the supplementary food patch regularly (prediction one), with the dominant male consistently arriving first at the patch (prediction two) and grooming relationships with the dominant male predicting the subsequent arrival order of other troop members. Moreover, foraging benefits were highly skewed in favour of the most dominant troop members (i.e., the dominant male and female: prediction three). Due to their high social rank, dominant troop members have priority of access to human food sources, a high yield of raided food items and relatively high reproductive potential (Strum 2010). Thus, the skewed foraging benefits observed on the patch were likely to have had a negligible impact on these dominant animals' fecundity. Crucially, as a test of a management tool, deliberate placement of the supplementary food patch, within a raiding baboon troop's home range, but as far from the urban edge as possible, attracted that troop and subsequently induced multiple visits over a period of 20 days. While this reduced the time the troop spent in urban areas, the reduction was not significant, contrary to prediction four.

Following the placement of the supplementary patch, the troop (more specifically, its leader/s) was given an incentive to visit an area in their home range that consistently provided a nutritional benefit. This caused a change in ranging pattern and habitat use with their core range use shifting to include the natural areas around the patch. However, there was no significant change in the troop's use of the urban area. Furthermore, the proximity of the patch to one of the main raiding sites beyond the urban edge (viz. Signal school) resulted in an undesirable increase in use of that area from phase A to phase B and its inclusion into the troop's core range use area. Conceptually, the urban space represents a collection of variable, but potentially lucrative (e.g. whole loaves of bread or packets of fruit) food patches. The corn-supplemented patch was therefore only an incremental improvement to an already-profitable foraging environment, and while appealing, it was insufficient to persuade the dominant male to forego foraging in the urban space. Thus, I restricted access to the three urban waste areas frequented by the troop during the first two phases of the experiment. In essence this increased the profitability of our patch, relative to the baboons' collective foraging environment, thus raising its appeal to the dominant male. Only once I had taken this step, did I record a significant decline in raided food items in the troop's diet, coupled with a significant decline in use of the urban space (prediction five) and a shift in the troop's core range use to include only the natural environment. It is evident that successfully reducing the baboons' incentive for the urban space was achieved by simultaneously reducing the appeal of the urban area while increasing the appeal for natural habitat.

The presence of the patch alone (phase B) did not alter the study troop's activity budget (supporting prediction six). This is unsurprising as the study troop was already unintentionally provisioned by concentrated human food sources. The patch effected only a marginal improvement on the troop's collective foraging environment, offering only one additional food type and thus had a negligible impact on the baboons' activity budget; already typical of a food-supplemented troop (i.e. reduced locomotion and foraging and increased socialising and resting) (Bronikowski & Altmann 1996; Altmann & Alberts 2003; van Doorn et al. 2010). Interestingly, restricting access to key urban foraging sites (phase C) also had no impact on the troop's activity budget. While the dominant male may have received sufficient nutritional benefit from the patch to maintain his activity budget through to phase C, this was not true of the majority of the troop. Arguably, the length of phase C was insufficient to force a change in the troop's collective activity budget. Extension of phase C may result in increased locomotion and foraging (except for a minority of dominant individuals), and this may drive temporary fission events (see below). Indeed, restricting the amount of provisioned food to baboons has been shown to increase daily range size, the number and diversity of sleep sites and the proportion of natural items in their diet (Boug et al. 1994).

Thus, a diversionary feeding approach is able to alter the range of a baboon troop in conflict with humans. That it also circumvents concerns of increased growth and fecundity (see introduction), makes it a strong candidate for consideration as a primary management tool for the Cape Peninsula baboon population. However, two considerable concerns remain. Firstly, local ecosystem changes can occur as species (target and non-target alike) aggregate around provisioned food, resulting for example, in overuse of natural vegetation (Cooper et al. 2006; van Beest et al. 2010) and alterations in community composition (Casey & Hein 1983; Robb et al. 2008), both of which are highly undesirable in pristine areas of the Cape Peninsula – a component of the Cape Floristic Region, one of the world's 18 biodiversity hotspots and a UNESCO World Heritage Site. Secondly, the risk of troop sub-trooping or permanent fission, as observed in King et al's (2008) study, remains tangible where low-ranking individuals suffer high consensus costs when they follow their leader to a food patch where they do not benefit (while foregoing plentiful, if scattered, foraging opportunities in the human environment). Due to the lack of baboon predators in the Cape Peninsula, the costs associated with fissioning are lower and to counter this, low-ranking individuals would need access to supplemented food, necessitating an increase in the amount of provisioned food and for its distribution to be widened. Increasing the food quantity may increase the growth rates and/or fecundity of troop members (the majority of which enjoy neither priority of access at urban food sources nor high yields of RFIs), while increasing the patch size would undermine the dominant animals' ability to monopolise the food – arguably the reason the troop visits the patch so regularly. Both troop fissions and increased growth rates/fecundity would undermine baboon management efforts in the Cape Peninsula.

The effect produced by provisioning on the baboon troops' ranging patterns renders it difficult to ignore in the context of human-baboon conflict. While long-term applications may be ethically indefensible, scope exists for provisioning as an emergency measure over brief time periods, suited to situations in which usual management is suspended and in heavily transformed vegetation (minimising damage to natural vegetation). In the recent history of Cape Peninsula management, funding crises led to interruptions to the baboon monitor program for periods lasting between five and 20 days (J. O'Riain, pers. obs.). During these periods, commensal troops are afforded unlimited access to human environments and conflict between baboons and residents – who are invariably caught unaware in the absence of monitors – escalates rapidly. Additionally, periodic fires, typical of Fynbos ecosystems (Kruger & Bigalke 1984; Stock & Lewis 1986) may reduce natural food availability to baboons for a finite period. The loss of this natural food (for finite periods) may provoke troops ranging near to human environments to increase their raiding intensity. In situations similar to those mentioned above, provisioning provides a cost-effective and simple strategy that can be implemented at short notice and in a number of troop's home ranges, if necessary. The length of time for which provisioning will be feasible before inducing troop fusions or impacting local flora/fauna will depend on individual troops and their habitat, but managers should be mindful of both of these side-effects should they opt to provision troops in emergency scenarios.

Long-term management should also consider an anomaly I observed. That is, while competitive exclusion is expected when a hierarchical species feeds on a concentrated resource (e.g. López-Bao et al. 2009) exceptions are known to occur (e.g. Grenier et al. 1999) and did so in the experiment. The 'exception' took the form of juveniles being tolerated on the patch and collectively obtaining higher overall yield than any sub-adults and all but one of the adult females. Although I had no genetic data for this troop, only one adult male has been present in this troop over the previous three years. Thus, there is a strong probability that all infants and juveniles in the WT were sired by the current, lone, dominant male. Therefore, tolerance of juveniles may be expected to occur by direct fitness benefits alone (Hamilton, 1964). The short duration of the provisioning experiment (20 days) minimises any potential effect on the growth and ultimately fecundity of juvenile troop members, especially considering that these juveniles would have otherwise been foraging on high calorific urban food sources. Nevertheless, this observation has implications for raiding behaviour (i.e. tolerance of juveniles at concentrated human food sources and subsequent increased growth rates/decreased mortality and habituation and affiliation for human food) and should be explored further.

As the field of human-wildlife conflict mitigation advances, so the need for innovative approaches becomes apparent. This chapter demonstrates how specific knowledge of a species' behavioural ecology can be applied to aid mitigation efforts in the face of increasing urbanisation. That is, troop movements can be manipulated through the consistent leadership presented in chacma baboons. Providing an incentive to dominant individuals to enter natural habitat, reduced the amount of time the troop spent in the human environment. Furthermore, in short-term applications intended to augment primary management strategies (e.g. baboon monitors), many of the inherent problems associated with provisioning are largely negated. Pointedly, the most convincing result to emerge was that a significant change in the troop's movement pattern was achieved by reducing the incentive to forage in human environments, solely through proper waste management. Thus, while short-term provisioning emerges as a low-cost, low-maintenance strategy to reduce spatial overlap between humans and baboons, long-term approaches should focus on reducing baboons' incentive for human environments, principally by reducing food availability.

Chapter 4

WASTE MANAGEMENT

Introduction

Across the globe, access to waste food is a driver of conflict for a diverse range of wildlife species that exhibit considerable opportunism in the face of anthropogenic change (e.g. badgers, *Meles meles*: Cresswell & Harris 1988; coyotes, *Canis latrans*: Fedriani et al. 2001; foxes, *Vulpes vulpes*: Contesse et al. 2004; raccoons, *Procyon lotor*: Prange et al. 2004; macaques, *Macaca spp.*: Jones-Engel et al. 2006; hyaenas, *Crocuta crocutta*: Kolowski & Holekamp 2007; keas, *Nestor notabilis*: Gajdon et al. 2006; Huber & Gajdon 2006; black bears, *Ursus americanus*: Don Carlos et al. 2009; Makkay 2010). Consequently considerable effort has been focused on preventing wildlife from accessing waste while still ensuring efficient waste management services to the public. Human-baboon conflict in the Cape Peninsula is largely confined to human-modified environments where baboons access both natural and human-derived food items (Van Doorn et al. 2010; Hoffman & O'Riain 2012). The main source of accessible food in these urban areas is waste found in both private residential and municipal refuse bins.

In the previous chapter, I showed how a reduction in spatial overlap between humans and baboons can be achieved by raising the foraging benefits within natural areas (i.e. provisioning) while simultaneously reducing the benefits of foraging within human environments (i.e., restricting access to refuse). However given the concomitant problems of provisioning it is clear that reduced access to waste is a more logical long-term solution for reducing spatial overlap and ultimately human-baboon conflict. To this end the three local authorities, i.e. the City of Cape Town (local municipality), Cape Nature (provincial wildlife authority) and SANParks (national wildlife authority) have provided various forms of 'baboon-proof' bins in areas where baboons overlap spatially with humans. However the dexterity, physical strength and flexible behaviour of baboons, has thwarted the success of these baboon-proofing measures.

Here I briefly review aspects of innovation and social learning that are relevant to raiding by baboons in the Cape Peninsula. I then experimentally investigate the behavioural response of troops to high quality food items in refuse bins and through progressive bin modifications, assess whether and how baboons learn to innovate and whether this process is enhanced by social learning. Ultimately I hope to improve the understanding of learning and innovation in chacma baboons while simultaneously providing information relevant to improving the management of urban waste to mitigate conflict in a commensal population of primates.

Innovation

Experimental investigation into cognition across a range of species (see for example: Gallistel 1989; Thorndike 1998; Shettleworth 2001; Bekoff et al. 2002) enrich and sometimes challenge long-held views of cognitive abilities in animals (e.g. Lefebvre et al. 1997; Held et al. 2000; Bshary et al. 2002). What remains uncontroversial is that, relative to other orders in the animal kingdom, Primates, is one of the more cognitively complex (Byrne & Bates 2010; Whiten 2000; Steele et al. 2011; van de Waal & Ferrari 2012). The factors contributing to this complexity are numerous and sometimes contentious. Tomasello (2000) succinctly illustrates the predominant theories that account for this complexity stating: "These two sets of adaptive problems - foraging and social interaction - may thus present special difficulties for primates relative to other mammals. The result is an order of mammal with a relatively large brain relative to body size (with an expanded neocortex; Jerison 1973; Dunbar 1992) that learns much of what it needs to know during ontogeny and deploys that knowledge flexibly in all kinds of complex foraging and social situations."

In this chapter I will not discuss the evolution of primate cognition per se but rather one of the contemporary facets of this cognition, namely innovative behaviour (*sensu* Reader et al. 2011) initially defined as: "The invention of a new behaviour pattern or the modification of an old one in a novel context (Reader & Laland 2002)." It is not conditional that innovative behaviour should confer an advantage to an animal. However, when it does, it can have implications for how an animal performs relative to conspecifics or heterospecifics, particularly where niche overlap is high e.g. in social groups. Over the course of an individual's lifespan, advantageous innovative behaviour might result in increased direct fitness. While over longer time-scales, this behaviour becomes a candidate for Wilson's behavioural drive hypothesis (Wyles et al. 1983; Wilson 1985; Nicolakakis et al. 2003; Sol et al. 2005; Reader & Laland 2002). Here I focus on innovations that can be influential within an animal's own lifetime.

Just as some species may have a higher propensity to innovate, so some environmental conditions are more likely to produce innovation in a particular species. In their landmark paper on primate innovation, Kummer and Goodall (1985) suggest a sudden change in the environment or sufficient 'free time' (arising through either one of, or a combination of: ample food resources; a lack of predators; limited social 'obligation') and familiarity with the components of the situation may all facilitate innovation. In the Cape Peninsula two of these criteria are present, where an absence of natural predators and access to high quality, human-derived food greatly increases resting or 'free' time (van Doorn et al. 2010; Hoffman & O'Riain 2012). The Cape Peninsula thus provides a context where innovative behaviour may confer considerable advantages to baboons.

There are also a number of attributes within a species that may correlate with the probability of innovation, such as neophobia (negatively) and exploration (positively) (Greenberg & Mettke-Hofmann 2001). In an opportunistic raptor, the chimango caraca (*Milvago chimango*), Biondi et al. (2010) found that juveniles showed lower neophobia than adults and exhibited higher exploratory tendencies, shorter latency to feed and a higher success in problem solving. This highlights another important consideration: within a species, innovative tendencies may vary considerably according to environment, age, rank or sex, or simply individual identity. Within primates, in a review of approximately 1000 articles, Reader and Laland (2001) found that innovation was more likely to occur within a foraging context and that males and adults were more likely to innovate than females and non-adults, respectively.

Social learning

Here I use Fragaszy & Perry's (2008) definition of social learning: "Broadly defined, social learning is a change in the behaviour of one animal that results from paying attention to the behaviour of another." Social learning is a nuanced topic and the imposition of artificial categories on this behaviour arguably results in some overlap between categories. Three such categories are: 1) stimulus enhancement, where a model animal's interaction with an object increases an observer animal's likelihood of interacting without the observer making an association between the object and a reward (Thorpe 1963; Galef 1988; Campbell et al. 1999; Heyes 1994); 2) observational conditioning, where the observer makes a connection between the model, the object being interacted with and a reward (Cook et al. 1985; Heyes 1994); 3) imitation, where an observer observes what a model is doing, and actively repeats that action or sequences of actions (Whiten & Byrne 1988; Heyes 1998).

The phenomenon of social learning has been studied extensively in primates (e.g. Whiten 2000) and in those species, where social groups are maintained for extended periods, opportunities for model observation are abundant. In these instances, deliberate learners choose to regularly observe experienced or successful models (e.g. Biro et al. 2003; Ottoni et al. 2005) and consequently out-compete individuals that learn only through trial-and-error (Whiten et al. 2005; Caldwell & Whiten 2007; Burkart et al. 2009; van Schaik & Burkart 2011). In primate groups where this learning is robust, an innovative behaviour may propagate and persist through generations, arguably having become a tradition and eventually, after sufficient time, a culture (Ramsey et al. 2007). Culture in primates is best understood in chimpanzees, *Pan troglodytes* (e.g. Kummer & Goodall 1985; Boesch 1995; Whiten et al. 1999), orang-utans, *Pongo pygmaeus* (e.g. van Schaik et al. 2003) and capuchin monkeys, *Cebus capucinus (*e.g. Panger et al. 2002; Perry et al. 2003).

Importantly however, while an individual animal may innovate a particular behaviour that confers an advantage (social or ecological), it is not necessarily adopted into the behavioural repertoire of conspecifics (e.g. Nishida 1987; Goodall 1973; Kummer & Goodall 1985). That is to say, while social learning and innovation can be correlated (Reader and Laland 2002; Bouchard et al. 2007), socially-mediated learning is not a conditional consequence of innovation (e.g. Boyd & Richerson 1996; Giraldeau et al. 2002; Henrich & Mcelreath 2003; Kendal et al. 2005). As stated above a prerequisite of social learning is model observation (see Range et al. 2009 for a comparative study). Consequently, in a theoretical model, van Schaik et al. (1999) propose high inter-individual tolerance as one of three primary requirements for tool-use learning. In species characterised by aggression and despotism in the context of concentrated food resources (see Chapter 3), this inter-individual tolerance may be absent, moderating the probability that social learning will occur. The relevance of this in the context of raiding baboons in the Cape Peninsula lies in the fact that social learning or the emergence of a 'raiding culture' will exacerbate human-baboon conflict and hence hinder the prospects of long-term persistence of the Cape Peninsula population (see Donaldson et al. 2012). Thus, understanding how baboons innovate and whether social learning might occur in this population will aid managers in adapting current policy and protocols.

A caveat to the literature presented above is that the majority of findings have been gleaned from captive environments (e.g. Tomasello & Call 1997). While these conditions allow for social and environmental manipulation (pivotal to better understanding animal cognition), certain inescapable by-products also arise. Where animals are afforded excess free time, they may show a higher propensity to interact with novel objects (lowered neophobia) as compared to wild counterparts (Visalberghi et al. 2003; Day et al. 2003; Reader & Laland 2003). Certain facets of captive conditions may also create a bias towards an age class or gender (e.g. Box 1997). Of late, studies of cognition and social learning on free-ranging animals have become more prevalent (e.g. Halsey et al. 2006; van de Waal et al. 2010; van de Waal & Bshary 2010; Humle et al. 2009; Pesendorfer et al. 2009; Thornton & Samson 2012) providing a more natural setting with itinerant constraints (e.g. food, predators and time) that may influence social learning. In this study I investigate innovation and social learning with "baboon-proof" refuse bins in a population of free-ranging commensal primates. With limited natural predators, ample food resources and permanent social groups the potential for learning opportunities in this population is high.

Innovation and social learning using ''baboon-proof'' refuse bins

In the Cape Peninsula in 2006, suburbs that neighboured baboon home ranges and were subject to frequent raiding were issued with 'baboon-proof' refuse bins (the design was improved over time up to the current model: see Fig. 4.1) in place of normal municipal refuse bins. The design of these modified bins (Retief Krige: Binguard) includes a latching mechanism that could be readily opened by residents and which latched closed automatically when the lid was depressed. Eye-holes in the latches allow for the padlocks to be affixed, making the bins virtually inaccessible (Fig. 4.1). Importantly an override mechanism allowed for the collection and processing of residential bins using automated refuse trucks and thus the waste collection service was not adversely impacted by the need for further handling by waste operators.

These modified bins were however never formally tested on baboons (either captive or free-ranging) nor were the baboons' response to them ever quantified. Anecdotal reports have since emerged of baboons opening latched bins through a variety of means (e.g., by force, dexterity or a combination of both) but it is not known how individuals acquire the ability to innovate this behaviour and further whether latched bins that are padlocked are also pregnable.

In this study I explore the response of a bin-naive troop to standard and baboon-proof residential refuse bins. By varying the number of bins available to the troop and the type of food within the bins I was further able to explore how food availability and quality affects the responses of troop members to refuse bins. By determining the dominance status, sex, and age class of the troop members I was able to determine how individual level attributes affect access to bins and their contents in addition to the ability to innovate and/or engage in social learning. Lastly I repeated aspects of this experimental design on a habitual bin raiding troop to determine whether current high levels of bin raiding are a consequence of a design limitation of the bins, poor human management of the bins or a combination of both.

More specifically I tested the following predictions: baboons have a linear dominance hierarchy with more dominant individuals gaining priority of access to resources (Barton, 1989; Bulger, 1993; King et al. 2008; Kaplan et al. 2011), I thus predict that arrival order at refuse bins will correlate positively with dominance rank (prediction one). Further because dominance correlates positively with age of a baboon and males are typically dominant over females I predict that adult and male baboons will access the bins before sub-adult and female baboons respectively (prediction two, prediction three). Relative to most vertebrates, baboons are cognitively adept, have high dexterity and strength and can persist in varied environments (Bowlig 1961; Beck 1972; Hamilton, Buskirk & Buskirk 1975; Maple 1975; Else 1991; Engh et al. 2006; Noser & Byrne 2007; Fagot & Thompson 2011; Grainger et al. 2012). These attributes suggest that they will be good innovators. Thus, when presenting a naive troop with a range of waste bins (unmodified, latched and locked & latched), I predict that behaviour innovation will occur; specifically that at least one individual will learn to open a latched bin (prediction four). I also predict that the naive baboons that enjoy the greatest yield during the baseline phase will have the greatest incentive to open latched bins and are therefore the most likely to innovate this behaviour (prediction five). Lastly, while baboons maintain large and complex multi-generational groups and form strong social bonds (Bergman et al. 2003; Cheney, Dorothy & Seyfarth 2007; Crockford et al. 2007; Silk 2007), they also exhibit appreciable levels of competition with conspecifics around concentrated food resources (Barton & Whiten 1993; Barton et al. 1996). Therefore, I predict that the presence of bins will increase levels of aggression within the troop (prediction six) and further that despotic monopolisation of food resources will limit the opportunities for social learning by imitation (category 3, see above) but that opportunities for learning through observational conditioning and stimulus enhancement are likely (prediction seven).

Figure 4.1. Residential waste bins currently in use on the Cape Peninsula. Standard bins (a) are easily accessible. Baboon-proofing modifications have been added to some waste bins. When used correctly (b) these modifications should prevent baboons accessing the bins' contents. However, some residents reportedly fail to use these baboon-proofing modifications correctly, and leave the latches closed without locks (c).

Methods

Study sites & animals

Mountain troop: bin naive

The Mountain Troop (MT) is found approximately 13.5km north east of the Da Gama troop (see below) on the eastern slopes of the Constantiaberg (34° 2'21.62"S; 18°23'59.65"E). Their home range extends from the Tokai pine plantation in the South to the vineyards of Groot Constantia in the North. The troop sleeps exclusively in large exotic trees (primarily pine) and similar to adjacent troops, forages almost exclusively within human-modified habitats including plantations, vineyards and fields dominated by exotic annuals (Hoffman & O'Riain 2010) (Fig. 4.4). At the time of the study, incidences of house raiding were rare according to monthly reports provided by NCC (the company mandated with running with the monitor program) and thus the troop had only minimal prior association with standard waste bins before the study commenced. The troop comprised 42 individuals including six adult males, four sub-adult males, 12 adult females, two sub-adult females, 12 juveniles and six infants at the time of the study (Fig. 4.2; Beamish 2009).

MT	
'Bin naïve'	
Adult Male	6
Adult Female	12
Subadult Male	4
Subadult Female	2
Juvenile	12
Infant	6

Figure 4.2. MT's composition at the time of the study. The troop resides predominantly in a pine plantation (b & c) in Tokai and surrounding vineyards (a & d). At the time of the experiment, the troop was unfamiliar with baboon-proof bins.

Da Gama troop: bin experienced

The Da Gama troop (DG) is found in the vicinity of the Da Gama and Welcome Glen residential suburbs (34°9'17.73"S; 18°24'14.36"E). The troop has no access to agricultural land (i.e., plantations and vineyards) but frequents the neighbouring suburbs where they raid houses and gardens on a near daily basis (van Doorn 2009; Hoffman & O'Riain 2011). The troop sleeps either within (on the roof of an apartment block) or immediately adjacent (pine trees) to the urban edge (Fig. 4.5). The rest of the home range includes low-lying fields dominated by exotic annuals and low hills comprised predominantly of natural vegetation with both light and heavy infestations of exotic plants (e.g., acacia spp.).

Raiding within the suburbs is mitigated by a team of four baboon monitors, men employed specifically to keep the baboons away from the urban edge and failing that, minimising the damage caused to properties during raiding events (van Doorn 2010). Despite the presence of monitors the baboons regularly enter the urban area, affording them access to residential waste bins (240-litre capacity). These bins are either standard (unmodified: Fig. 4.1a) or modified (Fig. 4.1b, 4.1c). At the time of the study, DG comprised four adult males, four sub-adult males, 12 adult females, 10 juveniles and two infants (Fig. 4.3; Beamish 2009).

DG	
'Bin experienced'	
Adult Male	4
Adult Female	12
Subadult Male	4
Subadult Female	0
Juvenile	10
Infant	2

Figure 4.3. DG's composition at the time of the study. The troop resides predominantly in a residential area surrounded by natural vegetation. The troop is familiar with baboon-proof bins.

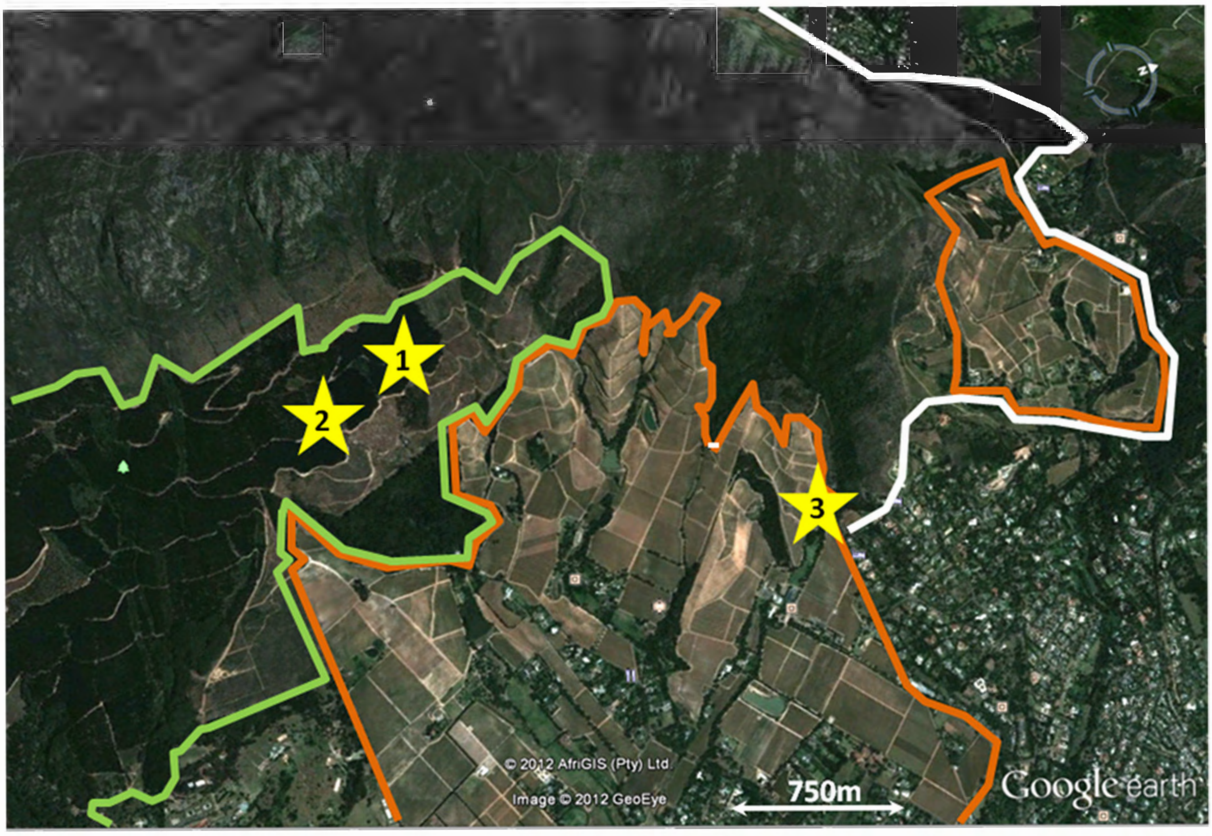


Figure 4.4. Satellite images of human environment contained within MT's home range. Suburbs are outlined in white, vineyards in orange and pine plantation in green. Areas not encircled are considered to be natural vegetation*. Sleeping sites are indicated with yellow stars. MT has access to suburban habitat but ranges predominantly in pine plantation and vineyard.

**Natural includes both indigenous Fynbos and exotic vegetation. I have grouped them since they are areas where conflict with humans does not occur, in contrast to pine, vineyards and suburb.*

Protocols

Baseline observations

Both troops were habituated to close behavioural observation and so baseline data collection commenced once my field assistant and I had established identikits for all adult baboons and could reliably identify all adults (100% independent agreement in identifying 15 adults, chosen at random). The baseline period comprised at least seven full (sunrise to sunset) days (MT: 29 Mar – 9 Apr; DG: 19 May – 27 May). I recorded affiliative and aggressive interactions on an *ad libitum* basis, noting the initiator, the recipient, the specific behaviour (displace, supplant, chase, attack, groom, mount, lip-smack, ear-pull) habitat type and time. Where applicable, I also maintained a record of copulation events (interactants and time).

Figure 4.5. Satellite image of human environment contained within DG's home range. Suburban areas are outlined in white. Areas not encircled are considered to be natural vegetation*. Sleeping sites are indicated with yellow stars. The dashed line separates two suburbs, Welcome Glen (northeast) and Da Gama Park (southwest). The troop uses suburban habitat extensively, raiding multiple times on a daily basis. The proximity of DG's sleeping sites to the suburban boundary is evident, particularly sleeping site 1 (the roof of a building).

**Natural includes both indigenous Fynbos and exotic vegetation. I have grouped them since they are areas where conflict with humans does not occur, in contrast to pine, vineyards and suburb.*

Experimental phase set-up

I transported a predetermined number of bins (1 or 4) to the centre of the troops' sleeping site at dawn. Bins were thus clearly visible to the troop and approximately equidistant to all troop members. I baited each bin with equal amounts of a combination of apples (high quality) and dried corn kernels (low quality; Tables 4.1 & 4.2) to ensure that the baboons were motivated to explore and open the bins. On the first two days, baiting of the bins was performed loudly and in clear view of the troop to ensure that even the naive troop knew that the bins contained food. In total, I used three bin types in the experiment, progressing from standard bins in the baseline phase to latched and finally locked (Fig. 4.1).

Naïve troop (MT) experiment

I installed a single standard bin, containing four apples and four handfuls of dried corn kernels, at the base of the sleeping site at dawn every day for a six day period (phase 1). I limited this time to prevent overfeeding and to minimise the reliance of the baboons on waste bins as a food source. In this time, I recorded priority of access to the bin and the duration that each troop member spent within 1m of a bin (i.e. on the bin). This was followed by a further six day period (phase 2) in which I increased the number of standard bins to four while keeping the total amount of food constant (i.e. each bin contained one apple and one handful of dried corn). The four-bin configuration was such that each bin represented the corner of a square with side length of 20m. Where the terrain prevented this, I ensured each bin was as close to 20m away from its neighbour as possible. This configuration looked to balance the area that could be covered reliably by two observers while making monopoly of the bins by a single baboon as difficult as possible. By increasing the number of bins, I was attempting to reduce competition to the food source and to assess whether this increased the number of individuals 'on the bin' and whether this resulted in the yield being more evenly distributed amongst troop members. I restricted the maximum number of bins to four as a concession to welfare and conservation management concerns associated with provisioning wild animals while acknowledging that an optimal design for exploring the potential of all troop members to innovate would include a bin for each troop member.

On days 13 – 22 (phase 3) I replaced the standard bins with four latched bins while keeping the food quantities constant. Here I was investigating whether the latches themselves make the bins baboon proof and if not, which troop members learn to open them. Once again welfare and conservation management considerations associated with provisioning limited the duration of the experiment which was terminated after 10 days.

Table 4.1. MT experimental protocol

Variable	Phase 1	Phase 2	Phase 3
Days	6 (13/04 -18/04)	6 (20/04 – 25/04)	10 (26/04 – 06/05)
Bin type	Standard	Standard	Latched
# Bins	1	4	4
Apples/bin	4	1	1
Corn handfuls/bin	4	1	1

Bin-raiding troop (DG) experiment

A different protocol was followed for this troop because at least some baboons were confirmed as being successful at opening latched bins (NCC pers. comm.). The baseline period days 1 – 6 (phase 1) was the same as for the naïve troop with a single standard bin, containing four apples and four handfuls of corn being used to record individual arrival order to bins, yield and time spent 'on the bin.' On Day 7 I introduced a single latched bin, containing four apples and four handfuls of corn. Following confirmation that the latches were not successful in preventing access to the bins for at least one baboon, I immediately moved onto the next phase of providing four latched bins, each containing one apple and one handful of dried corn kernels (days 8 –13; phase 2). While prolonging this phase would have been interesting from an academic perspective, I restricted it to prevent overfeeding and to minimise the baboons' reliance on waste bins. On days 14 – 19 (phase 3), I locked the latches of the four bins, in accordance with the design specifications and provided the same amount of food as in phase 2.

Table 4.2. DG experimental protocol

Variable	Phase 1	Phase 2	Phase 3	Phase 4
Days	6 (29/05 -04/06)	1 (05/06)	6 (06/06 – 11/06)	6 (13/06 – 18/06)
Bin type	Standard	Latched	Latched	Locked
# Bins	1	1	4	4
Apples/bin	4	4	1	1
Corn handfuls/bin	4	4	1	1

Experimental observations (both troops)

I employed the same data collection protocol for both troops, through all experimental phases. I recorded individual arrival order to bin/s and individual yield of apples and corn. Apple yield was scored as 1, 0.5 or 0.25 depending on whether approximately the whole, half or a quarter of the apple was consumed by a given individual. As corn was frequently consumed while the baboon was facing the inside of overturned bins I was not able to record corn yield accurately (as in Chapter 3). I thus estimated corn yield by recording the amount of corn depleted (%) from each bin by each individual (typically only one individual foraged at the bin entrance at any given time) following a foraging bout.

I conducted 'bin scans' at one-minute intervals, recording the identity of troop members within either 1m of a bin (zone 1, 'on a bin') or between 1- and 5m of a bin (zone 2, capable of close observation of conspecific in zone 1). I recorded all affiliative and aggressive interactions *ad-libitum* for all troop members (not only those active with bins). Once the apples and corn were depleted (i.e., when 'bin time' was adjudged to be over), I continued to record affiliative and aggressive interactions for a further two hours on an *ad-libitum* basis. Thus, I could compare baseline (no bins) aggression levels with aggression levels when bins were present and aggression levels in periods immediately following bin removals.

Analyses

Aggressive interactions

For each troop, I used Wilcoxon-Mann-Whitney tests in R to compare the rate of agonistic interactions (number of agonistic dyadic events per hour): on non-bin (baseline) days with experimental days when bins were present; on non-bin (baseline) days with experimental days when bins were absent (2-hour period after the troop had left the bin site); on experimental days when bins were present with experimental days when bins were absent (2-hour period after the troop had left the bin site).

Rank

I used David's Score method (David 1987; 1988) in R (steepness package: Leiva & de Vries 2011) to calculate a rank value for each individual (sub-adults and adults), based on the matrices generated from dyadic supplant/displace interactions. I normalised these David's Scores to assess hierarchy steepness and Landau's h-index in R (Csardi & Nepusz 2006) to assess linearity.

Arrival order

For males and females, I calculated mean corn and apple yields based on the daily yield of known individuals. Similarly, for males and females, I calculated mean arrival order based on the daily arrival order of individuals. I then tested for differences in yield and arrival order between males and females using Wilcoxon-Mann-Whitney tests in R.

To evaluate the factors influencing arrival order to bins, I conducted a linear-mixed model in R for each troop. Since the data (from either troop) were not normal, I used a Laplace approximation to fit each model. Using individual arrival order as the response term and individual ID as a random effect, I included individual rank, age (adult or sub-adult), sex and experimental phase (1, 2 or 3) as fixed effects. I allowed for interaction terms and used backward elimination to select the best model, based on the Akaike information criterion (AIC: Akaike 1974) value of each potential model. Model validity was assessed by plotting the residual values against the fitted values as well as assessing the normal, half-normal and histogram plots of the residual values of each candidate model.

Results

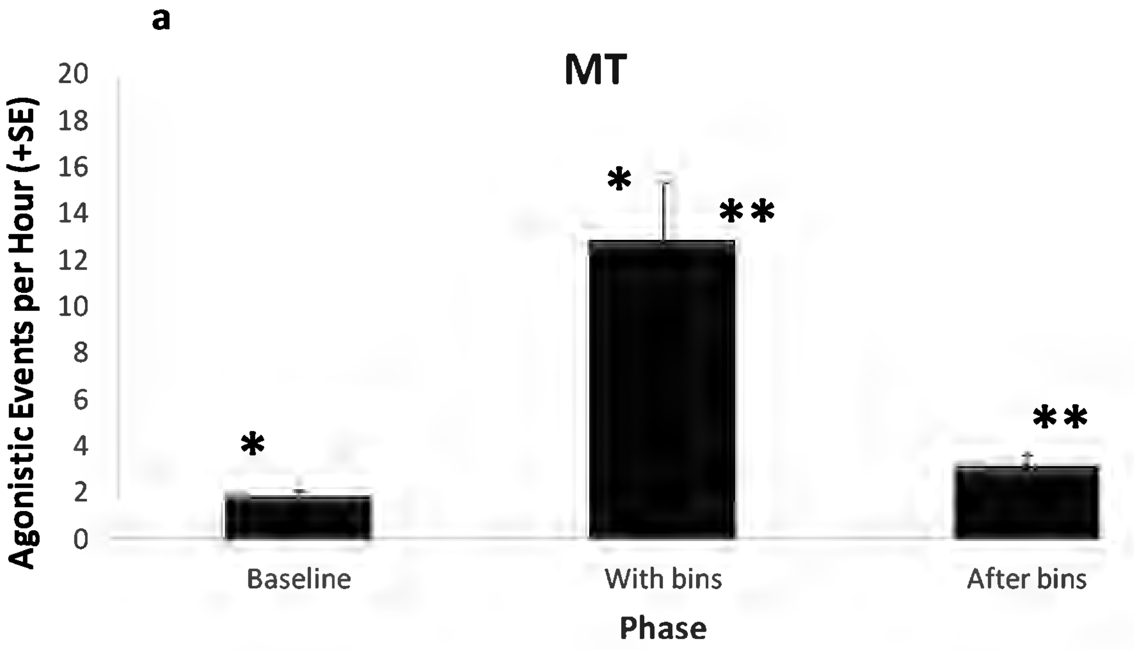
Dominance rank and levels of aggression

I recorded 379 dyadic supplant/displace interactions in the MT troop and 231 in the DG troop. Both troops had linear hierarchies according to their Landau's h' value (TK: 0.299, $p<0.001$; DG: 0.293, $p=0.01$) with MT's hierarchy emerging as steeper (normalised David's scores plotted against rank order) than that of DG (MT slope=0.135095, $p<0.001$; DG slope=0.107439, $p<0.001$). Of interest is that the dominance hierarchies I obtained for both troops ranked some adult females above adult males (Appendices 4.1, 4.2).

While the rate of agonistic interactions (events per hour) during the baseline period in DG (2.72±0.51) was on average, higher than in MT (1.83±0.19), these values were not significantly different ($U=3495$, $p=0.613$) (Fig. 4.6). For both troops, I divided the experimental phases into two sub-sets (bins present and bins absent). When bins were present, agonistic interactions were significantly more frequent for both MT (1.84±0.19 vs. 12.83±2.53; U=746, p<0.001) and DG (2.72±0.51 vs. 15.3±3.69; U=145, p<0.001) than in the baseline periods (Fig. 4.6). Once the troops moved away from the bins, I noted a significant decline in the frequency of agonistic interactions in both MT (12.83±2.53 vs. 3.12±0.51; U=407, p<0.001) and DG (15.3±3.69 vs. 1.66±0.37; U=746, p<0.001). The frequency of agonistic interactions in DG troop during the baseline and after the bins were removed periods were similar (U=1511.5, p=0.18).

Arrival order & yield

The mean arrival order for males was significantly lower (i.e., an earlier arrival) than that of females in both MT (males: 4.53±0.32 vs. females: 5.97±0.46; U=2463.5, p=0.006) and DG (males: 3.09±0.29; females: 4.61±0.29; U=796.5, p<0.001) (Fig. 4.7). Males, on average, obtained a significantly higher yield of corn (MT males: 7.68±1.18%vs MT females: 1.48±0.8%; U=8962, p<0.001; and DG males: 10.56±2.16% vs. DG females: 3.65±0.88%; U=9029.5, p=0.003) and apples (MT males: 7.9±1.36% vs. MT females: 1.4±0.62%; U=26247, p=0.03; DG males: 13.54±3.73% vs. DG females: 1.04±0.54%; U=4464.5, p<0.001) (Fig. 4.7). These male-female differences are arguably conservative as I excluded two non-arriving (with zero yields) females (with zero yields) from both troops.



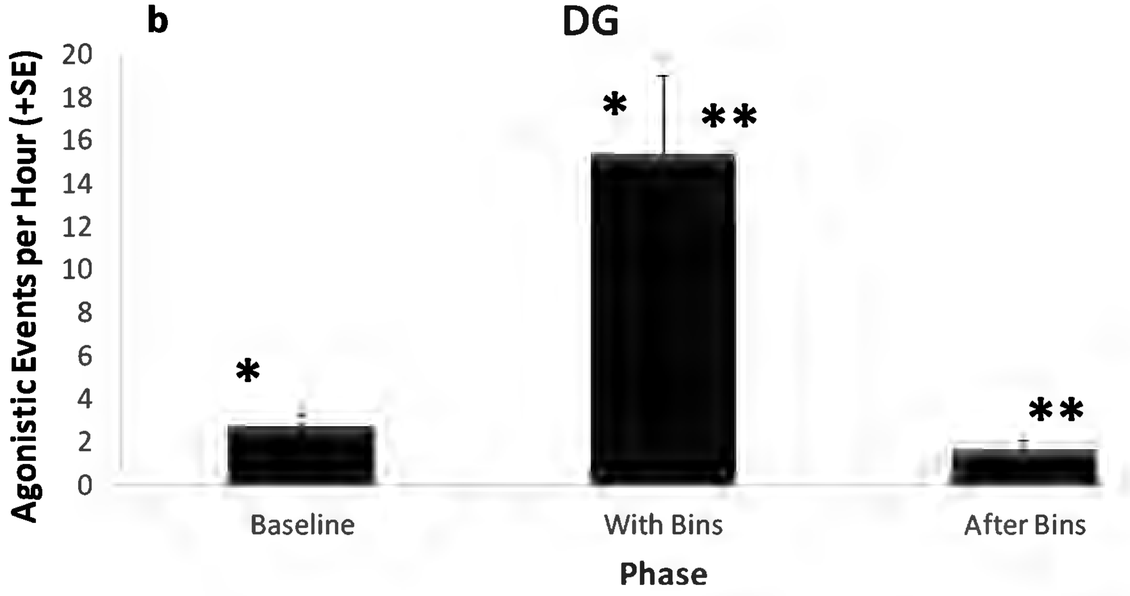


Figure 4.6. Graphs showing the rate of agonistic interactions (events per hour) of a) MT and b) DG. Experimental days were divided into two periods ('With bins' and 'After bins' i.e. two hours after bins were removed). MT and DG exhibit similar baseline agonism levels. Both troops show a significant increase in the frequency of agonistic interactions when bins were present. Also, when bins were removed, levels of agonism declined significantly as compared to levels recorded when bins were present. In DG, there was no significant difference between baseline levels of agonism and those recorded after bins were removed. It is worth noting that overall, the percentage of agonistic interactions in DG is higher than MT. Significant results ($p < 0.05$) are indicated with '*' or '**'.

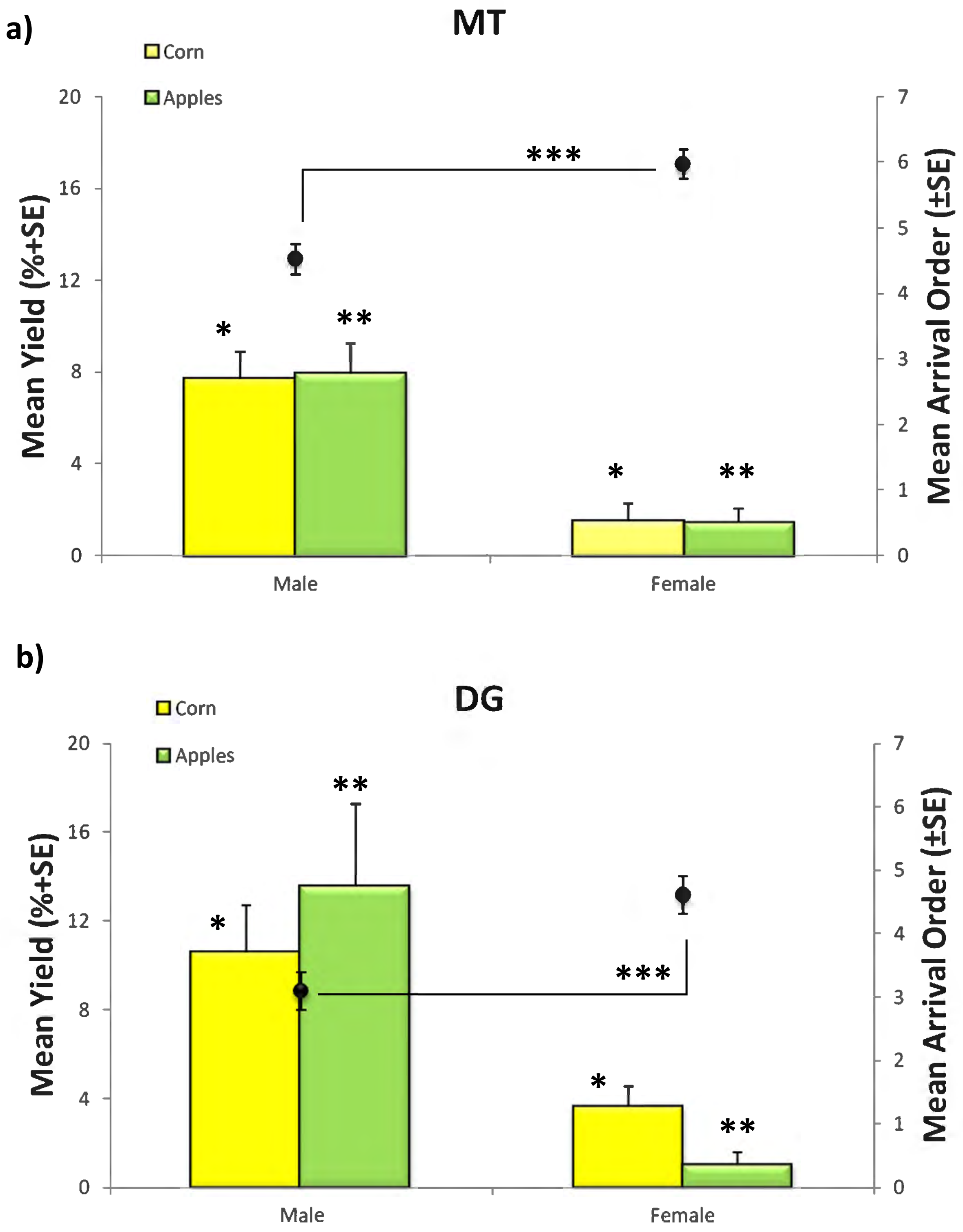


Figure 4.7. Graphs showing the contrast between males and females of MT (a) and DG (b) in terms of average arrival order (black dot) and average corn (yellow bars) and apple (green bars) yields. In both troops, males, on average, arrive earlier than females and enjoy a higher yield of both apples and corn. Significant results ($p < 0.05$) are indicated with '*' or '**'.

Arrival order: linear mixed model

For both troops, the model that provided the best fit of the data included rank and age as the fixed effects (Table 4.3). For the MT troop the model revealed that for every step up the dominance hierarchy, arrival order for an individual decreases, (i.e., the individual would arrive earlier) by a factor of 0.039. Similarly, increasing age from sub-adult to adult will decrease arrival order by 0.327. The AIC value of this model was 79.26. While neither of the fixed effects was significant, the p-value for rank does approach significance (0.0584). In the DG troop, a step up the dominance hierarchy, decreased arrival order by 0.04 and an increase in age (from sub-adult to adult) decreased arrival order by 0.55. The AIC value of the DG model was 97.15, and both fixed effects were significant (rank: p<0.003; age: p<0.001).

Table 4.3. Results of an LMM conducted on MT (a) and DG (b). The response term was arrival order to the bin/s on each experimental day. I included dominance rank, age, phase and sex as fixed effects and individual ID as a random effect. Parameter estimates (estimates), standard errors, log-likelihood- and p-values are shown for each fixed effect. For both troops, the minimal model included age and rank as fixed effects. To obtain values for phase and sex, these terms were added individually to the minimal model (rank and age as fixed effects). Significance (p < 0.05) is shown with an asterisk.

a) MT				
	Estimate	**Standard Error**	**Log Likelihood**	**p-value**
Fixed Effects				
Dominance Rank	0.039	0.021	-36.29	0.058
Age (Sub-adult, Adult)	-0.327	0.278	-37.16	0.24
Phase (1, 2, 3)	0.078	0.092	-35.28	0.399
Sex (male, female)	0.141	-0.285	-35.51	0.62
	Variance	**Standard Deviation**		
Random Effects				
Individual ID	0.108	0.329		
b) DG				
	Estimate	**Standard Error**	**Log Likelihood**	**p-value**
Fixed Effects				
Dominance Rank	0.048	0.014	-51.68	>0.001*
Age (Sub-adult, Adult)	-0.55	0.188	-52.51	=0.003*
Phase (1, 2, 3)	0.111	0.068	-46.92	0.104
Sex (male, female)	0.238	0.211	-47.64	0.26
	Variance	**Standard Deviation**		
Random Effects				
Individual ID	0.047	0.216		

Latch-opening

In the naive MT troop, 18 (out of 24) of the adults and sub-adults interacted at least once with latched bins but only five individuals, four of which were male (M1, F3, M5, M7, M10), spent more than 60 minutes with the bins and between them they consumed more than 88% of the corn and 100% of the apples. Of these five only the four males succeeded in opening the latched bins by the end of the ten-day period (Table 4.4). One of these males, (M5) was capable of opening the latched bins from first contact suggesting he had dispersed into this troop from an area where baboons have already been exposed to such bins and hence acquired this skill (e.g., the DG troop). M5 was thus excluded from the innovation analysis.

The alpha male (M1) spent less time per day (9±2.07 min/day) interacting with the bins than both the other males M7 (12±2.84 min/day) and M10 (16±1.98 min/day) but obtained a significantly higher corn yield (44.35±7.35 kernels/day) than both M10 (16.21±3.09 kernels/day; U=363.5, p=0.004) and M7 (5.84±1.99 kernels/day; U=416.5, p<0.001). M10, in turn, enjoyed a significantly higher yield than M7 (U=127, p=0.006) (Fig. 4.8).

Despite receiving the lowest yield of these three males M7 was the first member of this troop to successfully innovate the latches (day 5) followed two days later by M10 (day 7) while the alpha male did not succeed within the experimental period. Both individuals subsequently repeated the latch-opening behaviour (M7: 10 occasions; M10: 2 occasions). While all baboons engaging with the latched bins repeatedly attempted to open the lid using force, this was only achieved once by M1 on day 5 of the last phase.

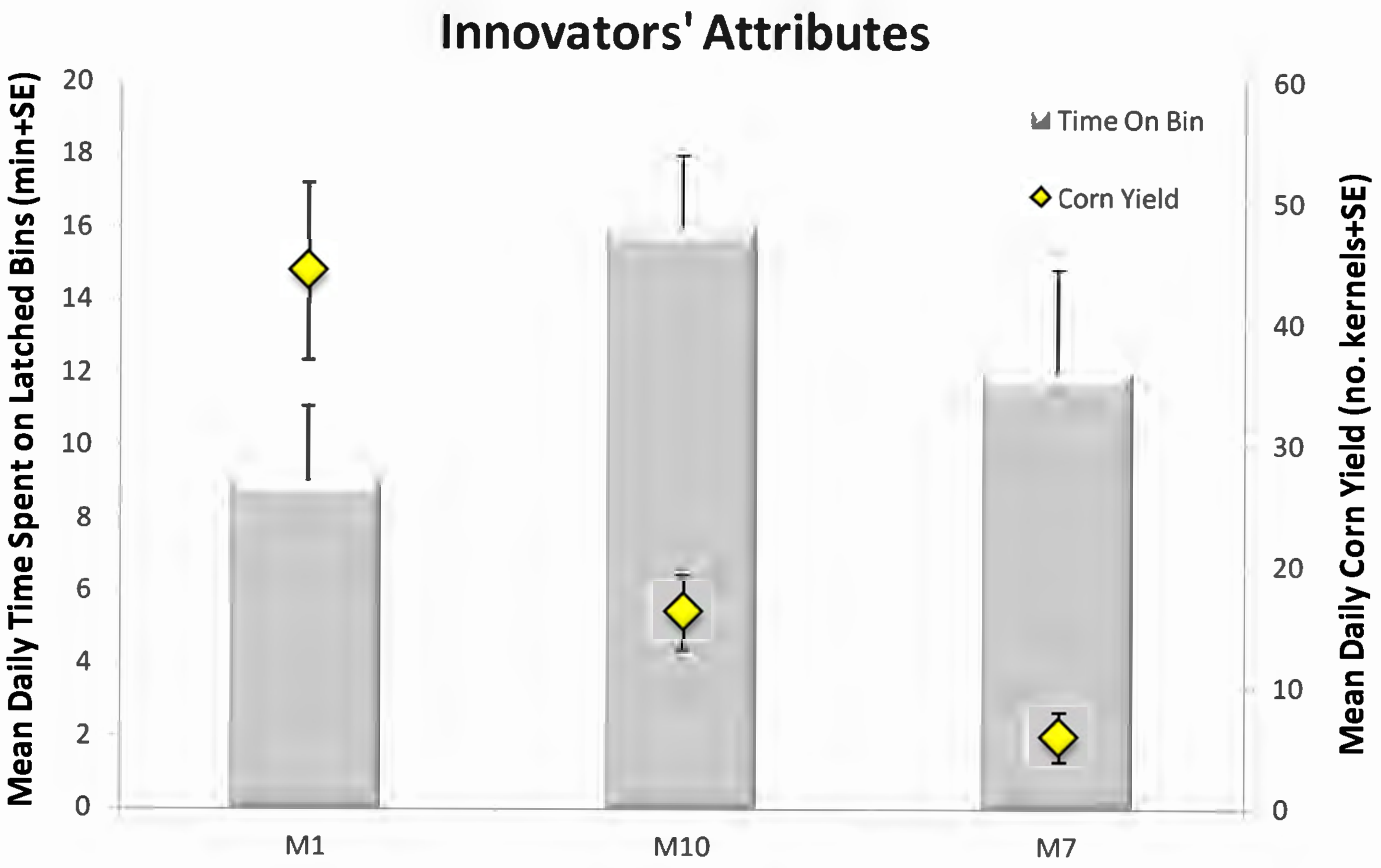


Figure 4.8. Graph showing daily mean time spent in zone 1 ('on a bin') and corn yield of the three* members of MT that were able to open latched bins in phase 3: M1, M10 & M7. M1, the dominant male, shows the highest ratio of time spent in zone 1 to corn yield, followed by M10 and then M7. The speed of acquiring latch-opening skills was inverse to this ratio, with M7 opening latches within 5 days, M10 within 7 days and M1 not succeeding in opening latches within the 10-day experimental period.

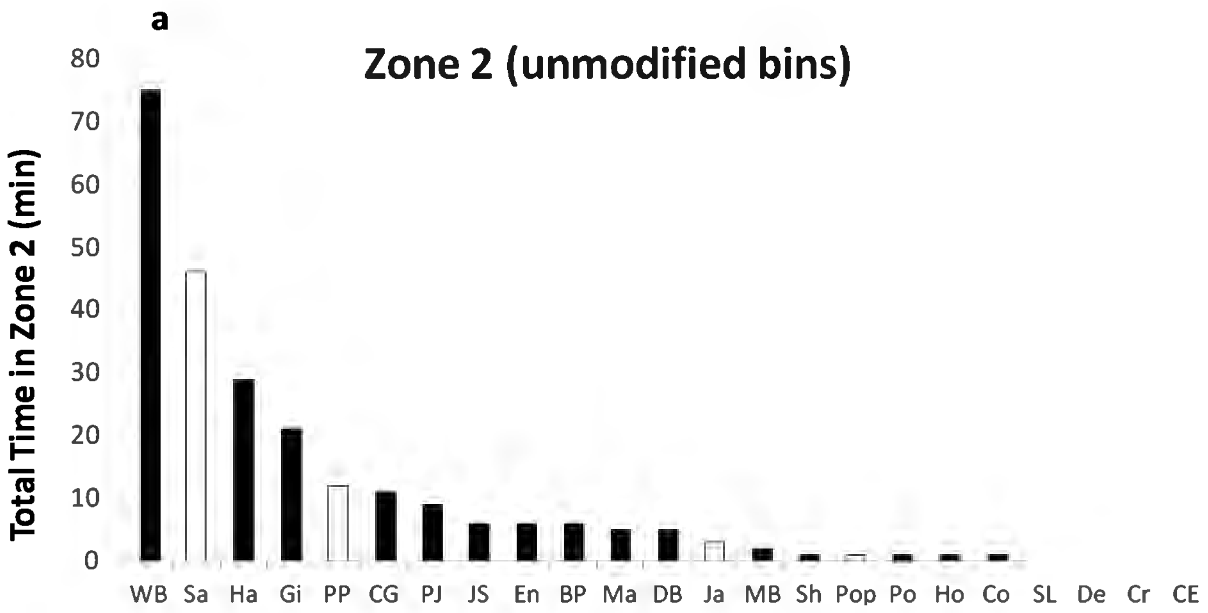
**The fourth member that was able to open bins, M5, was excluded as he likely already had this ability before the experiment began.*

Table 4.4. The latch-opening profiles of the four members of MT that were able to open latched bins. Day of first opening is marked with a '*'. Each bin where an individual was able to open one or two latches is scored as 1. M1 only opened one latch on a single occasion and was the only baboon that used force to break the mechanism.

Day	**M5**	**M7**	**M10**	**M1**
1	4*	0	0	0
2	4	0	0	0
3	4	0	0	0
4	4	0	0	0
5	1	1*	0	1*
6	2	2	0	0
7	2	1	1*	0
8	0	4	0	0
9	0	1	0	0
10	1	1	2	0
Total	**22**	**10**	**3**	**1**

Zone 2: an opportunity for social learning in the naïve troop

In the first two phases the dominant female (F3) spent the greatest total time in zone 2 (75min), followed by three sub-adults (two males: 46min; 21min, one female: 29min). The two individuals that opened latches most successfully spent virtually no time (M7: 3min; M5: 1min) in zone 2 during these phases. In phase 3, the three most successful latch-openers spent the most time in zone 2 (M5: 25min; M7: 23min; M10: 23min). None of the juveniles (male and female) spent any time in zone 2 and (with the exception of the alpha, F3: 16min) adult females spent a negligible time in zone 2 (F11: 1min; F12: 1min; F22: 2min; F23: 5min) (Fig. 4.9).



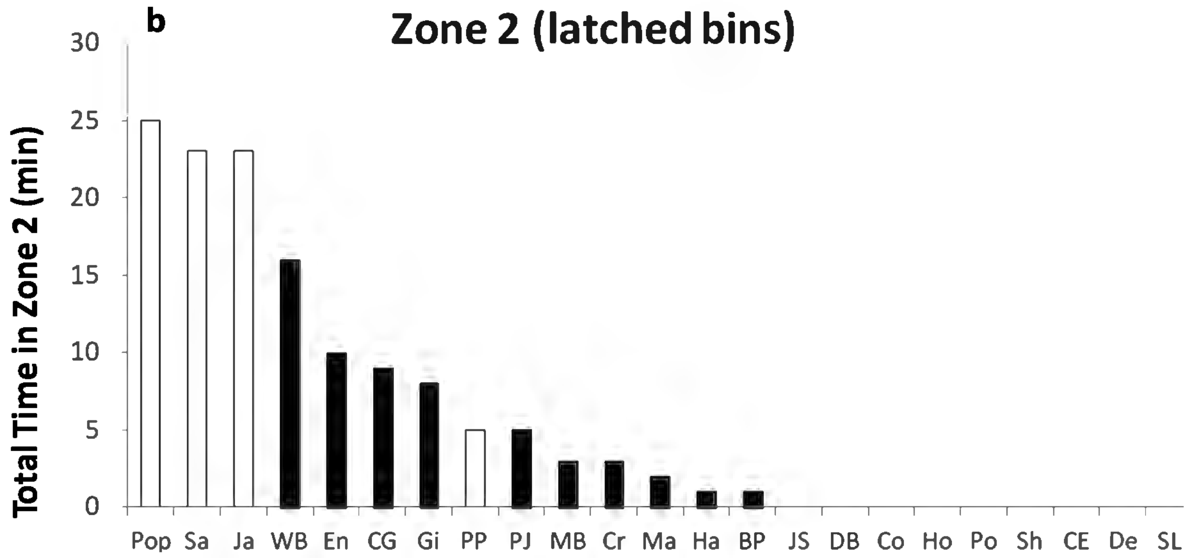


Figure 4.9. Graphs showing the time spent in zone 2 ('near a bin') of individual members of the bin-naive MT during (a) phases 1 & 2 (1 unmodified bin; 4 unmodified bins) and (b) phase 3 (four latched bins). Hollow bars indicate individuals that were able to open latches during phase 3.

Consortships

In MT only one female (F23) was observed consorting with five different males (M18; M10; M5; M4 & M2) during the experimental phases. In DG, two females (F4 & F19) consorted with two different males (M10 & M1) and one male M18 consorted with F19 only. Wilcoxon tests in R showed no difference between the arrival orders of males on days when consorting compared to days when no consorting was observed. The duration of the experiments did not allow for comparisons to be made between individual female arrival order and yield when in consortships and their arrival order and yield when not in consortships.

Discussion

Priority of access to and yield from refuse bins

The models I developed for both troops revealed that rank (prediction one), and to a lesser extent, age (prediction three) were the best predictors of arrival order and yield from refuse bins in both troops. These results are similar to those for other primates foraging in natural environments (capuchin monkeys *Cebus apella*: Janson 1985; Vogel 2005; vervet monkeys, *Chlorocebus aethiops*: Pruetz & Isbell 2000) and further support the findings presented in Chapter 3 of a strong dominance effect around concentrated artificial food resources. Both rank and age were stronger predictors of arrival order in DG, possibly because this troop had extensive experience with refuse bins prior to these experiments and thus a more stable and defined hierarchy associated with competition for this high quality resource. Contrary to my prediction, sex (prediction two) did not have a significant effect on arrival order in either troop. This is arguably due to a minority of females that arrived early and a majority that because they never arrived at all were excluded from the analyses thus skewing the results.

Innovation

Baboons in DG were observed opening latched bins prior to the onset of the study and this ability was confirmed during the second phase of the experiment when the alpha male first pulled the bin over so that it lay horizontally and then manually lifted each latch before opening the lid. By contrast the alpha male of the MT troop was incapable of opening the latched bins for the duration of the experiment. Only a minority of the MT troop persisted in investigating the latched bins and at the end of the experiment (day 10) the two mid-ranked sub-adult males that had spent the most time in contact with the bins had acquired the skill of opening latches (prediction four). This persistence of sub-adult males and subsequent success makes for an interesting comparison in olive baboons (*Papio anubis*), where adolescent males are the demographic showing the greatest raiding frequency (Forthman-Quick 1986; Oyaro& Strum 1984; Strum 1994).

One anomaly in the MT troop was the discovery that a relatively low-ranking adult male knew exactly how to open the latched bins despite having spent only a minimal amount of time in contact with them. Indeed he opened both latches effortlessly the first time he had contact with the bins. Rather than assume that this individual has extraordinary innovation skills I propose that he has dispersed into the Tokai area from a habitual bin-raiding troop such as DG and retained this skill despite the complete absence of latched bins in Tokai. Of relevance to this anomaly was that this individual never opened the latched bins in the presence of other more dominant adult male troop members. Rather he waited until the alpha male and other more dominant males had tired of the bins and moved off with the troop before he approached the bins. This suggests that he was actively avoiding a potentially high conflict situation, only opening the bins with lower ranking troop members present or when alone.

Despite receiving a lower yield than the alpha male (generally arriving after corn was depleted), the sub-adult males spent the most time on the bins; somewhat contradicting my prediction that reward would predict innovation (prediction five). This low-reward persistence was also observed in subordinate olive baboons using experimental puzzles (Laidre 2008) and in young chimpanzees that attempt nut-cracking behaviour for a number of years without actually succeeding (Matsuzawa et al. 2001). Arguably, the exploratory tendencies of baboon sub-adult males (Bergman & Kitchen 2009) is a trait that aids innovative behaviour (Schuck-Paim et al. 2009). In this experiment, the combination of exploratory tendencies, moderate food rewards and alpha male tolerance of their ‘play’ with latched bins (not afforded to adult males) provided sub-adults with the necessary conditions and ‘free time’ (Kummer & Goodall 1985) to acquire the latch-opening skill. That no other baboons succeeded in opening latched bins in MT may simply be a function of the limited opportunities (time) afforded to them.

Consistent with other primates foraging on high-quality food items (Shopland 1987; Johnson 1989; Hanya 2009; Robbins 2008), there were elevated levels of aggression associated with the bins (prediction six) and in particular when they contained food, suggesting that the experimental design may have excluded many subordinate baboons from proximity or access to the refuse bins. Attempts to increase the number of bins from one to four did not increase accessibility to the bins of these lower ranking individuals as the alpha male was capable of dominating all four bins despite their being spaced some 20m metres apart. Sigg (1980) suggests that social constraints on peripheral females in hamadryas baboon (*Papio hamadryas*) one-male units reduced the amount of attention those females could allocate to tasks (relative to central females). Similar social obligations in female chacma baboons (e.g. Silk 2003, 2010) may reduce the time available for problem-solving tasks (relative to sub-adult males). While male social obligations may occur in the form of mate-guarding and copulation (Alberts et al. 1996), this constraint was not evident during these experiments. Halsey et al. (2006) suggested that vigilance behaviour impeded the ability of common marmosets to improve their success over time in parallel-strings tasks. However the absence of natural predators in the Cape Peninsula and the abundance of refugia in the Tokai plantation make predator vigilance an unlikely factor in these experiments.

Social learning

In this study, my prediction that baboons would not show evidence of social learning (prediction seven) was not answered conclusively. The combination of a steep dominance hierarchy and the despotic monopolisation of limited food resources (Deutsch & Lee 1991; Wittig & Boesch 2003; King et al. 2010; Kaplan et al. 2011) greatly reduces the opportunities for social learning. Only one baboon (M5) could open the latched bins from the first encounter, thus limiting reliable conspecific models available to the MT troop. Further, because this individual was a relatively low ranking adult male, he was denied access to the bins by other higher ranking individuals when the troop was present and typically only opened the bins when alone. Van Schaik et al. (1999) proposed a theoretical model for tool use learning and one of the three primary requirements is a high inter-individual tolerance to allow for such close observation.

In chimpanzees, Matsuzawa et al. (2001) describe the relationship between observers and models as ‘Education by master-apprenticeship’ where models show prolonged and appreciable tolerance for observers. In tufted capuchin monkeys, almost 25% of all nut-cracking events were watched by other troop members (Resende & Ottoni 2002). However, the baboons in my experiment showed little or no tolerance of individuals in close proximity to them when in the presence of bins and such situations were associated with increased the mean levels of agonistic interactions, particularly in MT troop. Thus as a tentative conclusion, social learning through imitation in chacma baboons does not seem to be occurring, but the brief duration of the study limits the confidence of this conclusion. Future studies should look to better explore social learning in chacma baboons in the form stimulus enhancement, observational conditioning and imitation.

Arguably tolerance would increase in certain circumstances such as when females are sexually receptive (Dubuc et al. 2012) but this variable was not explored in the study. Further, while females may have been more suitable models than dominant or sub-adult males (e.g. van de Waal et al. 2010), a lack of females interacting with latched bins for extended periods did not allow for this theory to be tested. Tolerance may also be higher where direct fitness benefits (Hamilton 1964) are accrued to the dominant individuals that monopolise resources (see Chapter 3). That MT troop is a multi-male troop (as compared to the WT that had only one dominant male for several years), reduces the dominant male’s probability of having sired juveniles and may explain the comparative lack of tolerance shown to juveniles. Furthermore the cost-benefit ratio of defending a food patch of widely dispersed corn versus corn and apples within a discrete container may explain the higher levels of aggression of the alpha male to juveniles in this experiment relative to Chapter 3.

Management findings

Even baboons with limited spatial overlap with urban areas (MT) quickly learnt to associate bins with food rewards. Naïve troops could not open latched bins when first presented with them but were able to solve the challenge through trial and error within five days. At least some individuals in troops that have had prolonged exposure to latched bins

(DG) were able to open these latches effortlessly and males dispersing from such troops appear to retain these skills when they disperse into new areas.

In my experiment, baboons did not appear to engage in deliberate social learning and thus raiding skills are presumably acquired if individuals have sufficient time for trial and error. Arguably, social learning would exacerbate conflict by increasing the number of technically adept raiders (e.g. Donaldson et al. 2012). Thus excluding baboons from human environments serves the dual purpose of reducing the potential for human-baboon conflict and impeding the acquisition of raiding skills. Bins that are latched and locked are capable of excluding even habitual bin raiders. Since the locked latch mechanism is effective and still allows for automated refuse collection by specially modified waste trucks, there is no reason why the current design needs to be altered. Rather it is the behaviour of the residents that needs to change to ensure that the latches are always locked. In an unannounced survey on one bin collection day in Da Gama (16th June 2010), I sampled 273 bins in total, 67% of which had latches but only 27% of which were locked and thus baboon-proofed. Consequently, a raiding baboon could potentially access the contents of three out of every four bins.

Thus, my first recommendation would be to ensure that residents 1) have access to baboon-proof bins (approximately one third of bins sampled were unmodified), 2) understand the correct way to use their bins and 3) are penalised/rewarded for a failure/competency to adequately baboon-proof their bins following a prolonged education and awareness campaign in the affected areas. This is an important component of the overall goal of reducing raiding incentives in residential areas which has a measurable impact on the spatial overlap with urban areas (Chapter 3).

Secondly, management methods should not consider troops in isolation. M5 made it evident that behaviour can be transferred between troops through male dispersal (although not necessarily disseminated between baboons through social learning). A similar outcome was observed in Bossou chimpanzees, where a female (Yo) showed immediate proficiency at cracking coula-nuts (introduced by researchers) in sharp contrast to her group members (Biro et al. 2003). And in the Cape Peninsula, an array of raiding innovations may emerge, such as adult male baboons in Smitswinkel Bay opening car doors to gain access to the food within (Hurn 2011). Thus human environment buffering baboon habitat should be prepared for the possibility that raiders with a range of 'specialities' may emerge, irrespective of how naive the resident troop is. Lastly, there is evidence to suggest that primates can improve their performance at problem-solving tasks when exposed to environmental conditions that offer enrichment (Whiten & van Schaik 2007). Generally these conditions are only present in captivity. However, with the frequent interaction that Cape Peninsula baboons are having with man-made structures, there is reason to expect that raiding proficiency may actually improve over time (van de Waal & Bshary 2010). Thus means of limiting, if not completely preventing, baboon interaction with human environments should be a priority for current management.

Limitations of the study

While the rigour of laboratory experiments can provide equal problem-solving opportunities to all demographics of a social group, the environmental and social constraints in free-ranging conditions can be considerable (e.g. Shopland 1987; Johnson 1989; Alberts et al. 1996; Laidre 2008). In this study, the majority of adult males and females were prevented from accessing the bins by a minority of dominant animals. Thus, it was not possible to assess the relative problem-solving ability of individuals of different rank, age and sex. Arguably, in this free-ranging environment, there is also the unavoidable conflation of persistence with innovation. That is, the animal that solves a task may not be a better innovator than those that don't, but rather a more persistent animal. Without being able to control the length of time allotted to each individual to solve a task, this conflation is difficult to disentangle.

Importantly, I am not critiquing problem-solving behaviours in the context of evolutionarily specific tasks (i.e. bins are highly artificial) and acknowledge that more natural tasks (see Laidre 2008) might have obtained different results. However, in the context of raiding baboons in the Cape Peninsula, I would argue that this data is highly relevant. That is, in an environment where food resources are concentrated and access is not always easy (obstructed by windows, door, locks etc.), certain individuals will emerge as more successful raiders by virtue of the same characteristics that were evident in this experiment (i.e. rank, age and willingness to explore). Understanding this process is of significance to baboon managers.

While I employed scan sampling during bin observations, future work may benefit from using focal follows of each individual. The scans may have overlooked some fine-scale detail and differences between individuals. Activity budget, social affiliation, social attention and aggression should all be included in these focal observations. If possible, the number of bins should be increased (to maximise access for lower-ranking animals) and the experimental period lengthened. Out of ethical concerns of overfeeding baboons and encouraging habituation to refuse in this managed population, I limited the experimental period as much as possible.

Chapter 5

CAPE PENINSULA RESIDENT SURVEY

Introduction

Most human-wildlife conflict scenarios are accompanied by equally challenging human-human conflicts. Rarely in these conflict scenarios do communities, managers, authorities and third parties reach consensus in assigning accountability for damage, responsibility for managing damage-causing animals and selecting appropriate methods for carrying out this management (Treves et al. 2009; Dickman 2010). In Chapters 3 and 4 I show that while there is value in reducing the quantity of anthropogenic food available to baboons and adequate means to achieve this, it is a largely flawed strategy because it depends on consistent and responsible human behaviour. In Chapter 2, I assessed the efficacy of various deterrents – the success of which determines whether or not a manager should consider their use. However, I also argue that when applying a deterrent, a manager must consider a variety of factors other than efficacy, one of which is a deterrent's cultural acceptability. Indeed, without the support of local communities, management interventions are unlikely to endure, particularly where that deterrent is costly or controversial (Mehta & Kellert 1998; Borrini-Feyerabend et al. 2004).

Defining the 'human' side of human-wildlife conflict can be problematic. Helpfully, Redpath et al. (2012) delineate two major categories, namely 'human-human conflicts' and 'human-wildlife impacts.' The latter is defined as "centre(ing) on human interactions between those seeking to conserve species and those with other goals" (Redpath et al. 2012). While I acknowledge the significance of human-human conflict (see Chapter 6) in the Cape Peninsula, in this chapter I continue to focus on 'human-wildlife impacts' defined by Redpath et al. (2012) as those that "deal with the direct interactions between humans and other species." For humans, these impacts include damage to properties, loss of crops, stress and injury to humans and their domestic animals and health risks associated with pathogens and parasites transmitted from baboons (Drewe et al. 2012; Ravasi et al. 2012b). I conducted a survey in an attempt to understand how these impacts affect the way in which Cape Peninsula residents perceive baboons and their management. Surveys can be conducted in a number of ways and be guided by various theoretical paradigms. Here, I distinguish between two general methods, namely qualitative research and quantitative research (see Cresswell [2003] for a comparison of methodologies).

Qualitative research can take a number of forms, namely ethnographies (LeCompte & Schensul 1999), grounded theory (Strauss & Corbin 1990), case studies (Stake 1995), phenomenological research (Nieswiadomy 1993; Moustakas 1994), or narrative research

(Connelly & Clandinin 2000).These investigations may use a single iconic event to illustrate the various social and cultural influences that shape human-wildlife interactions (e.g. Luther 2013) or study historical media to elicit how perception of a species evolves over time (Jerolmack 2006). However, arguably the qualitative research that is most informative to human-wildlife conflict mitigation is that which makes use of in-depth, open-ended interviews conducted by a neutral researcher who may spend prolonged periods integrated in a community (e.g. Hampshire, Bell, Wallace, & Stepukonis 2004; Hurn 2008; Paolisso 2002). While valuable, such investigations are problematic in an area like the Cape Peninsula where communities affected by baboon conflict are not necessarily culturally or socially homogenous. Further my identity as a biologist in the Baboon Research Unit may influence the answers that respondents will provide (or make them reticent to provide certain answers) in such interviews. In light of these factors I decided to adopt a quantitative approach to understanding human-baboon conflict for Cape Peninsula residents, using brief surveys that allowed the identity/affiliation of the investigator to remain anonymous and as neutral as possible.

Quantitative surveys make use of structured questions, sometimes requiring respondents to answer within a pre-defined range (Babbie 1990). Although this may limit the scope in which respondents think or restrict the answers they would otherwise give (compared to those provided in open questions), it allows investigators to target specific topics and to compare answers across respondents and how these perspectives or fears might vary with respondent attributes such as age, level of education (Prokop, Fancovicova & Kubiatko 2009), place of residence (Røskaft et al. 2003) or perceived damage inflicted by wildlife species (Hill 1997; Siex & Struhsaker 1999). These quantitative surveys are also useful in measuring whether these opinions change over time, or whether a significant event (e.g. mass media ‘campaigns’; human injury caused by wildlife) causes a change in these opinions (Gore & Knuth 2009; Neff & Yang 2012) and for general predictions to be made regarding respondent characteristics (e.g. gender: Herzog 2007). These studies also allow for results to be comparable across a range of studies and wildlife species that cause damage or evoke particularly emotive responses (e.g. the wolf, *Canis lupus*: Ericsson & Heberlein 2003). Lastly, the data resulting from quantitative studies are more comfortably accommodated within this thesis and the general epistemological framework of the natural sciences.

Only one formal social survey focusing on human-baboon conflict in the Cape Peninsula has been conducted to date (Kansky & Gaynor 2000). However much has changed since then, including an increase in both the number of people and baboons as well as changes in management decision structures. How Cape Peninsula residents, as directly-affected parties in this conflict, perceive the current human-baboon interface is unknown and I therefore chose to focus on two basic aspects that would prove informative to managers and third parties and to help guide future surveys of a similar nature. The first aspect was to test several predictions about how respondent demography and baboon experience were associated with perceptions of baboons and the acceptability of both non-lethal (e.g field rangers to keep baboons out of urban areas) and lethal (removing habitual raiders) methods for their management. The culling of habitually raiding troops was last carried out in 1998 and met with strong public resistance. Despite this, culling remains a management option for a geographically isolated population with no natural predators that is experiencing high levels of conflict with humans. I thus included culling (through humane procedures) as a potential management method in my survey.

Arguably, a lack of agreement with either non-lethal or lethal management methods may limit or even prevent their implementation. I predict that respondent support for lethal management techniques (euthanasia and culling) will be greater for respondents living inside baboon conflict areas and for respondents having predominantly negative experiences of baboons, i.e. those having a negative impression of baboons. Further, I predict that male (Herzog 2007), less educated (Bjerke, Reitan & Kellert, 1998) and non-vegetarian/vegan (Pacelle, 1998) respondents will be more accepting of lethal management techniques than female, more educated and vegetarian/vegan respondents, respectively. The second aspect of this chapter will quantify some of the broad patterns of conflict and baboon management from a Cape Peninsula resident's perspective. These findings will hopefully provide relevant insight to managers looking to mitigate this human-baboon conflict.

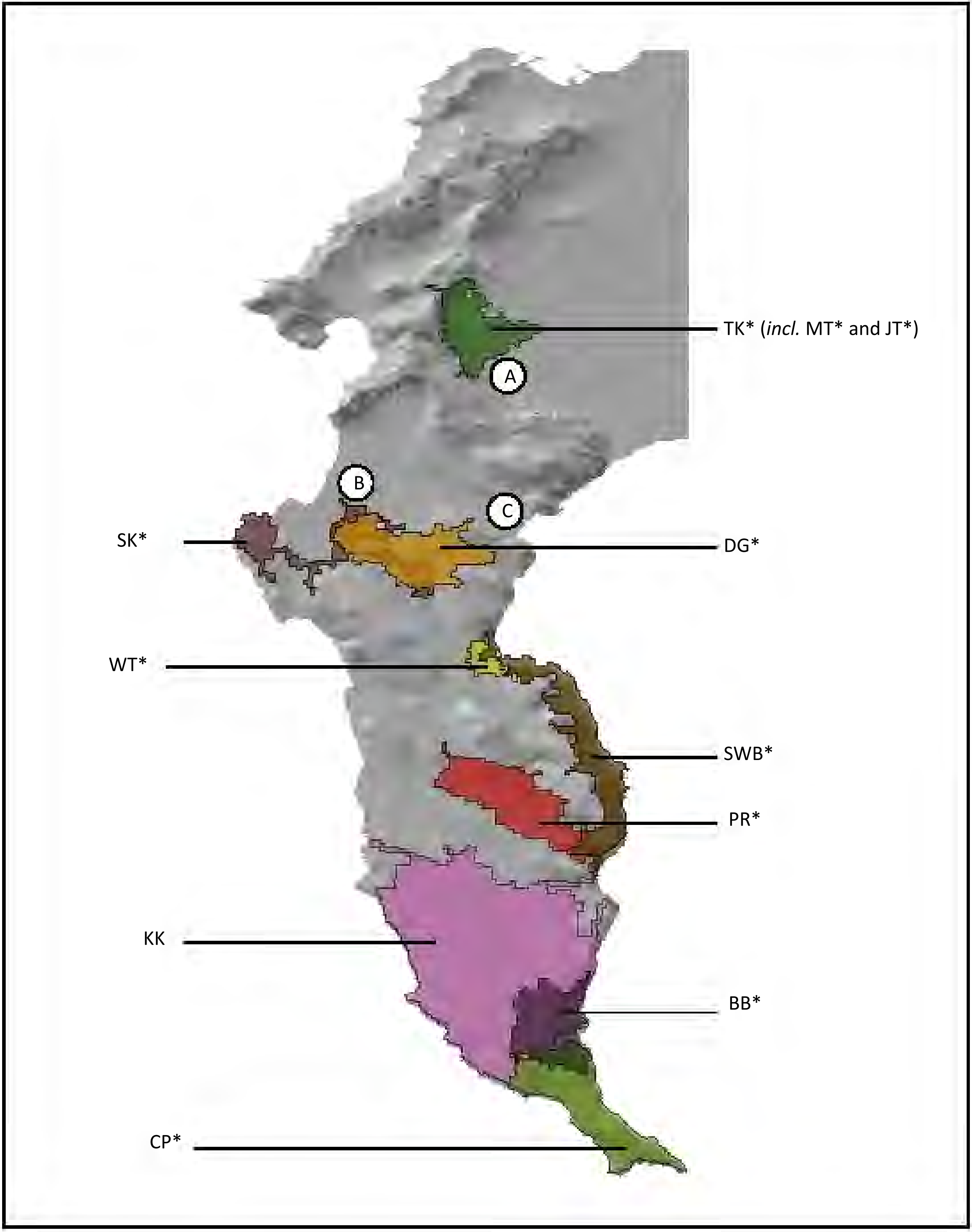


Figure 5.1. A map of the Cape Peninsula showing the home ranges of extant baboon troops (Hoffman 2011; used with permission). Commensal troops are marked with an asterisk. Survey sites are denoted by solid circles (Tokai Rd., Tokai (A); Main Rd., Fish Hoek (B); Long Beach Mall, Noordhoek (C).

Methods

Survey sites

I selected primary shopping areas (i.e. shopping malls/centres containing banks and stores selling groceries, hardware, clothing, books and pet supplies) within residential suburbs as my survey sites (Fig. 5.1). These areas attract residents from a diverse array of residential suburbs and encompass the full spectrum of human-baboon conflict areas from none (e.g. Kirstenhoff) to chronic (e.g. Scarborough) and thus provided the variation necessary to test my predictions. While it may appear that a bias exists in sampling sites being towards the northern half of the Cape Peninsula, no sample sites with the required characteristics were located further south.

Survey procedure

Six field assistants (female university students, ages ranging between 21 and 32) conducted the surveys (see Appendix 5.1). While there may be some influence of interviewer gender on responses, examples in the literature suggest this does not occur unequivocally, but rather where gender-specific topics such as sexuality or views on feminism are concerned (e.g. Catania et al., 1996; Huddy et al., 1997; Flores-Macias & Lawson, 2008). It is possible that respondents may have shown more support for moderate/baboon-friendly techniques to female interviewers than to male interviewers, but the use of female interviewers exclusively allows for comparisons across respondent categories. All surveyors were English-speaking and at the time of the surveys, lived in the Cape Peninsula. I briefed each assistant on the survey structure and explained aspects of human-baboon conflict and management that were relevant to the survey. Before the onset of surveys, all assistants conducted a number (between five and fifteen) of ‘practice’ surveys to refine their method and to clarify any misunderstandings they might have. The data from these surveys were not used in the analyses.

Surveys were conducted between March 2012 and January 2013 and during working hours (9am – 5pm) on weekdays. I chose these times to limit contact with non-Peninsula tourists. While this may have restricted the number of working professionals, the diversity of stores at the three sites ensured that at least some professionals were sampled while purchasing business supplies/materials or dining. I made no concerted effort to restrict the overall sampling period as I was not interested in temporally specific events or a change in a particular variable over time. No more than three surveyors were active simultaneously. Surveyors wore peak caps with the

University of Cape Town logos and lanyards around their neck displaying their student identification. Surveyors either located themselves at the entrances of shopping centres or on common pedestrian routes towards these centres. Surveyors identified themselves as students from the University of Cape Town and respondents were asked if they would be prepared to answer a five-minute survey about baboons.

Respondents were assured their identity would be kept anonymous and asked to answer a series of questions as honestly as possible. Each question was explained thoroughly and the respondent had to express their understanding before answering. Surveyors stood alongside respondents while transcribing answers to allow respondents the option of reading questions as they were asked. Respondents were not pressed to provide answers to questions if they were reticent to answer. If respondents requested the ‘correct’ answer to a question, this was done once the survey was complete. Respondents consented for the data from their surveys to be used by providing a signature next to their survey number.

Survey content

For each respondent, the following characteristics were recorded: age* (to the nearest 10 years e.g. 10-19; 20-29 etc; inferred by the surveyor), highest level of education, suburb (and street if possible) of residence, whether they identify as vegan/vegetarian.

Respondents were asked to describe a baboon and those that were unable to do this were not considered in the analyses. Respondents were then asked: if the chacma baboon (if necessary, surveyors explained that the chacma baboon is the same species as the one occurring locally) was endangered (yes or no); whether their most recent experience of baboons occurred in the last month (recent experience), more than a month ago (dated experience) or whether they had never experienced baboons. If they had an experience with baboons, they were asked to provide the locations of all of these experiences and to briefly describe their two most memorable experiences of baboons (respondents were prompted to include where the experience occurred, what the respondent was doing at the time and what the baboon/s were doing at the time).

Respondents were then provided with a list of human actions (feeding baboons; chasing baboons; shooting a paintball marker at baboons; shooting a rifle/pellet gun at baboons; spraying baboons with water; driving into baboons with a vehicle; throwing sticks/stones at baboons; watching baboons from a distance; making loud noises/bangs to scare baboons; closing and locking their car/house doors/windows to keep baboons out; approaching baboons or trying to interact with them) and for each action asked i) if they had witnessed any person performing the action and ii) if it would be acceptable for an authority to perform the action. Respondents were asked to indicate which groups or organisations (SANParks, City of Cape Town Municipality, NCC (organisation responsible for managing the baboon monitor programme between June 2009 and June 2012), Cape Nature, SPCA, researchers, Baboon Matters (charity organisation that was responsible for managing the baboon monitor programme prior to 2009), Human-Wildlife Solutions (organisation responsible for managing the baboon monitor programme from August 2012 until the current time), Baboon Monitors or other [space to add a group]) were responsible for baboon management on the Cape Peninsula.

Surveyors provided the statement that single baboons that repeatedly threaten public health and safety, despite intensive management efforts, are humanely put down/euthanized. On a 7-point Likert-type scale respondents were asked to rank their view on this approach (1: disagree completely, 2: disagree, 3: disagree somewhat, 4: neutral, 5: agree somewhat; 6: agree, 7: agree completely) and justify their answer. Immediately following this, respondents were asked if it would ever be acceptable to euthanize (while I use the word ‘culling’ in this chapter, it was avoided in surveys as respondents may have had associated it with inhumane euthanasia) whole troops of baboons in order to control baboon numbers (yes or no). Surveyors stressed the difference between these two management actions before allowing respondents to answer.

Respondents were asked to indicate their sources of information regarding baboons (multiple answers possible) choosing from: newspaper; public talks; internet; school; TV; pamphlets; signs; their own experience; or other (space to add source). In addition, they were asked to rank the following media, in terms of their general use from most frequently to least frequently: television; magazines; radio; newspaper; internet.

Analyses

After the surveys were complete, I coded each respondent’s memorable experiences of baboons as either positive, neutral or negative. Due to the subjective nature and individual variation that may occur between respondents (e.g. respondents may differ on whether to interpret baboons foraging on fruit trees in their garden as positive or negative), I coded experiences within a baboon management context where negative experiences were those that increased the habituation of baboons to humans; where baboons profited from being in human environments; where humans were at risk of stress/injury by baboons and vice versa. This would include any instances where baboons raided, behaved aggressively towards respondents, or where respondents behaved aggressively towards baboons. Positive experiences were those where baboons were observed in non-residential, semi-natural or natural environments (e.g. Tokai plantation) and where baboon behaviour was not described as aggressive (e.g. ‘they were playing’). Neutral experiences I defined as observing baboons in habitat that is neither natural, nor heavily developed human environments (e.g. along road-sides in semi-natural environments) and where respondents offered no emotive description of the experience. Thus a respondent could be classified into one of a possible 13 groups based on their two memorable baboon experiences and the order in which they were recalled. That is, where, P=Positive, N=Negative, Z=Neutral and O=No experience recalled, the possible combinations were PP (positive, then positive), PO (positive, no second recollection) etc. (PZ, ZP, ZO, ZZ, ZN, NZ, NO, NN, OO, PN, NP). When I analysed the coded data I excluded respondents that had one positive and one negative experience. After this and for the purpose of analysis, I allocated respondents into one of four experience categories, i.e. positive overall (PZ, ZP, PP, PO), neutral overall (ZZ, ZO), negative overall (NN, NZ, ZN, NO), and no experience (OO).

Initially I treated the 7 points on the Likert-type scale independently and found no trends. Therefore, I conducted a simplified analysis and grouped respondents according to their view of euthanasia of single baboons (1: strongly disagree; 2: disagree; 3: somewhat disagree; 4: neutral; 5: somewhat agree; 6: agree; 7: strongly agree) into either ‘disagree’ (scale values: 1-3) or ‘agree’ (scale values: 5-7) and excluded those with neutral (scale value: 4) views. Respondent suburb was designated either ‘in-conflict’ (suburb raided by baboon troop) or ‘out-conflict’ (suburb not raided by baboon troop; suburbs occasionally entered by dispersing males only were not considered as in-conflict).

I tested for associations between i) suburb (in-conflict/out-conflict) and baboon experience (positive/neutral/negative), and ii) view of euthanasia (agree/disagree) and culling (yes/no), using Pearson’s chi-square test. I also used Pearson’s chi-square test to test whether differences in suburb (conflict/non-conflict), experience (positive/neutral/negative), respondent gender (male/female), education (pre-tertiary vs. tertiary) and diet (vegetarian/vegan vs. not vegetarian/vegan) were associated with differences in view on euthanasia (agree/disagree) and culling (yes/no), respectively. Finally, combining the independent variables relevant to management (suburb, respondent gender, experience), I performed two binary logistic regressions with culling approval and view of euthanasia as the response terms, respectively.

Questions for which respondents were able to provide multiple answers were not amenable to statistical tests. However, the findings from these questions are of value to Cape Peninsula baboon managers. To this end, I investigated (a) respondent support of more invasive, sub-lethal management techniques (paintball markers; pellet rifles; spraying water; throwing sticks/stones; making loud bangs/noises) and (b) whether respondents had witnessed any of these techniques in use. I then investigated whether (a) or (b) varied with respondent demographic (i.e. gender, suburb, experience). I also compared the frequency of baboon experiences between various locations in the Cape Peninsula. Respondent knowledge of baboons was tested in a Pearson's chi-square test by comparing i) suburb (in-conflict/out-conflict) and ii) education level to respondents' answer to the question "Is the chacma baboon endangered?" Respondent knowledge of the baboon management structure was tested in a multiple-answer question. Finally, I made qualitative comparisons of respondents' use of various media and their sources of baboon information.

Results

Respondent demography

In total, 226 surveys were conducted. 102 respondents were male and 124 were female; 127 respondents lived outside conflict suburbs and 99 lived inside conflict suburbs; age class counts were as follows: 10-19yr:1, 20-29yr:53, 30-39yr:56, 40-49yr:46, 50-59yr:35, 60-69yr: 22, 70-79yr: 6, unknown: 7. Only 26 respondents identified as vegetarian or vegan, 35 respondents had not finished high-school, 93 had completed high school and 89 had received tertiary education (9 respondents declined to disclose their education level).

Human-baboon interface

Respondent experiences with baboons on the Cape Peninsula (Fig. 5.2) were predominantly negative. The total number of respondents that I classified as having overall positive experiences with baboons (positive+positive=4; positive+nothing=9; positive+neutral=7; neutral+positive=1) was 21, compared to the 28 respondents I classified as having overall neutral experiences (neutral+nothing=24; neutral+neutral=4) and the 116 I classified as having overall negative experiences (neutral+negative=12; negative+neutral=18; negative+nothing=44; negative+negative=42). The locations of baboon experiences (Fig. 5.3) are also indicative of the prevalent conflict in the Cape Peninsula, where respondent sightings of baboons in areas associated with people in urban or recreational areas numbered 202 (house=75; garden=64; picnic area=63) compared to the 168 sightings of baboons in natural or semi-natural settings (Tokai plantation [northern section of Table Mountain National park] =83; Cape Point [Good Hope Section of Table Mountain National Park] =85) and the 113 times baboons were seen on/alongside the road.

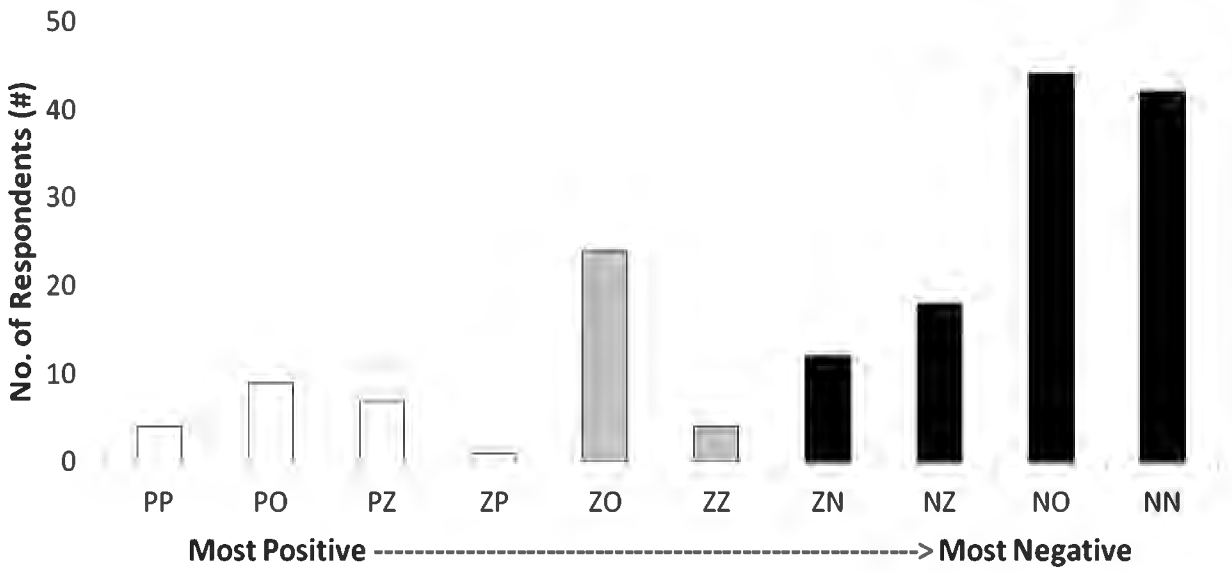


Figure 5.2. The total number of reported experiences between respondents and baboons in the Cape Peninsula. Four types of experience were recorded: P = positive (white bars); N = negative (black bars); Z = neutral (grey bars); O = no experience.

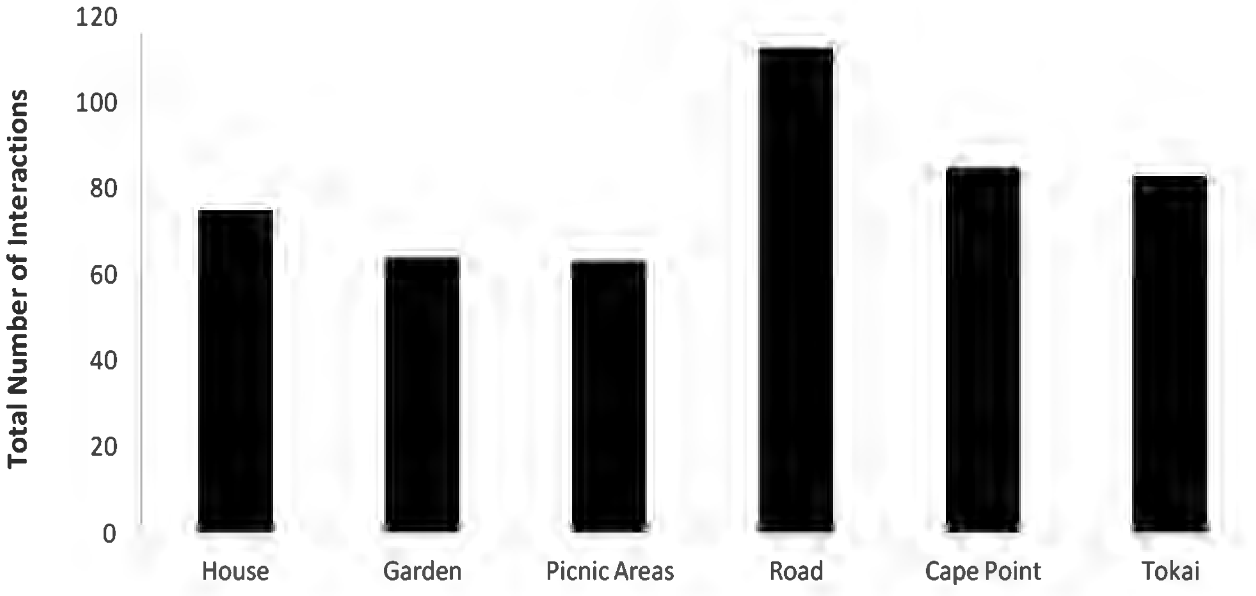


Figure 5.3. Total number of human-baboon experiences within urban (house, garden), recreational (picnic areas), road-side and Table Mountain National Park (Cape Point and Tokai) areas of the Cape Peninsula. Experiences with baboons in 'houses', 'gardens' and 'picnic areas' are considered to be undesirable.

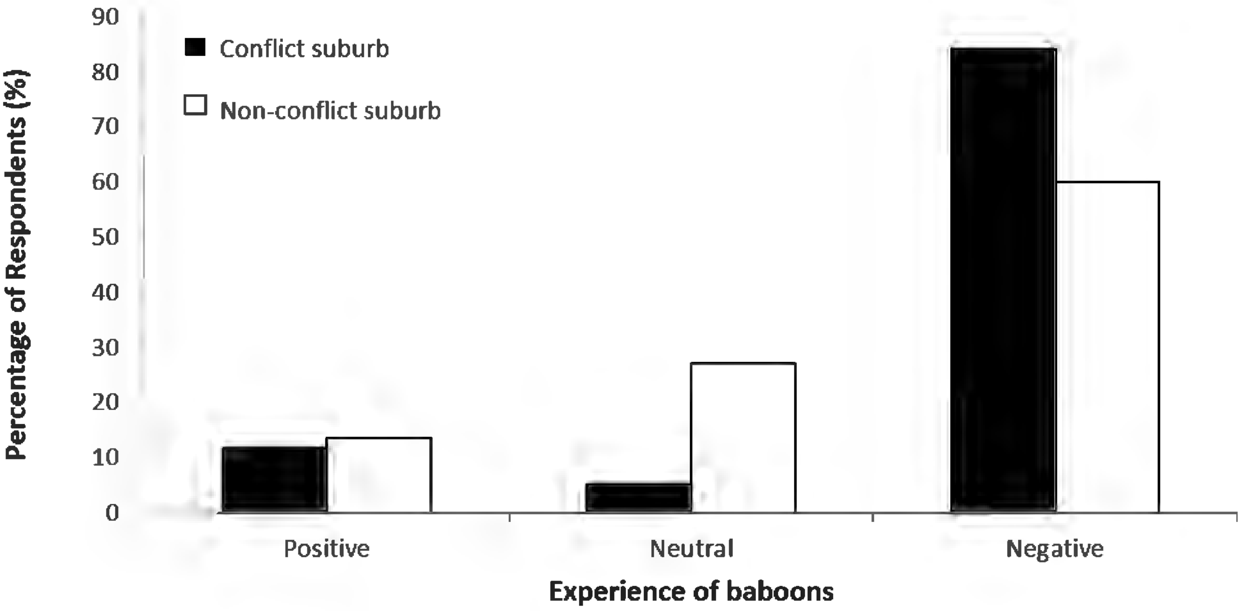


Figure 5.4. Percentage of respondents living either in suburbs with baboon conflict (black) or with no baboon conflict (white) and the percentage of their positive, neutral or negative experiences.

Lethal methods

Respondents living within baboon conflict suburbs had significantly more negative experiences and fewer positive and neutral experiences than respondents living outside conflict suburbs (X^2=14.643, df=2, p<0.001) (Fig. 5.4). I found no significant difference between suburb (X^2=1.087, df=1, p=0.297; Fig. 5.5), experience (X^2=0.326, df=2, p=0.85; Fig. 5.6) and respondent gender (X^2=1.112, df=1, p=0.292; Fig. 5.7) and respondent agreement with euthanasia. Similarly, suburb (X^2=0.178, df=1, p=0.673; Fig. 5.5), experience (X^2=1.886, df=1, p=0.17; Fig. 5.6) and respondent gender (X^2=0.964, df=1, p=0.326; Fig. 5.7) were not associated with respondents finding culling to be acceptable. Further, binary logistic regressions that included all three respondent characteristics as independent variables, found none to be significant predictors of either views on euthanasia or culling (Table 5.1). However, respondent agreement with euthanasia was significantly associated with respondents finding culling to be acceptable (X^2=24.356, df=1, p<0.001) (Figs. 5.8, 5.9). While vegetarians/vegans did not find culling to be unacceptable more often than non-vegetarians/vegans (X^2=0.211, df=1, p=0.646; Fisher exact test=0.774), they were significantly less likely to agree with euthanasia (X^2=4.182, df=1, p=0.03). Finally, respondents with a tertiary education were significantly more likely to support both culling (X^2=10.900, df=1, p<0.001) and euthanasia (X^2=10.641, df=1, p<0.05) than those with only pre-tertiary educations (matric or junior school).

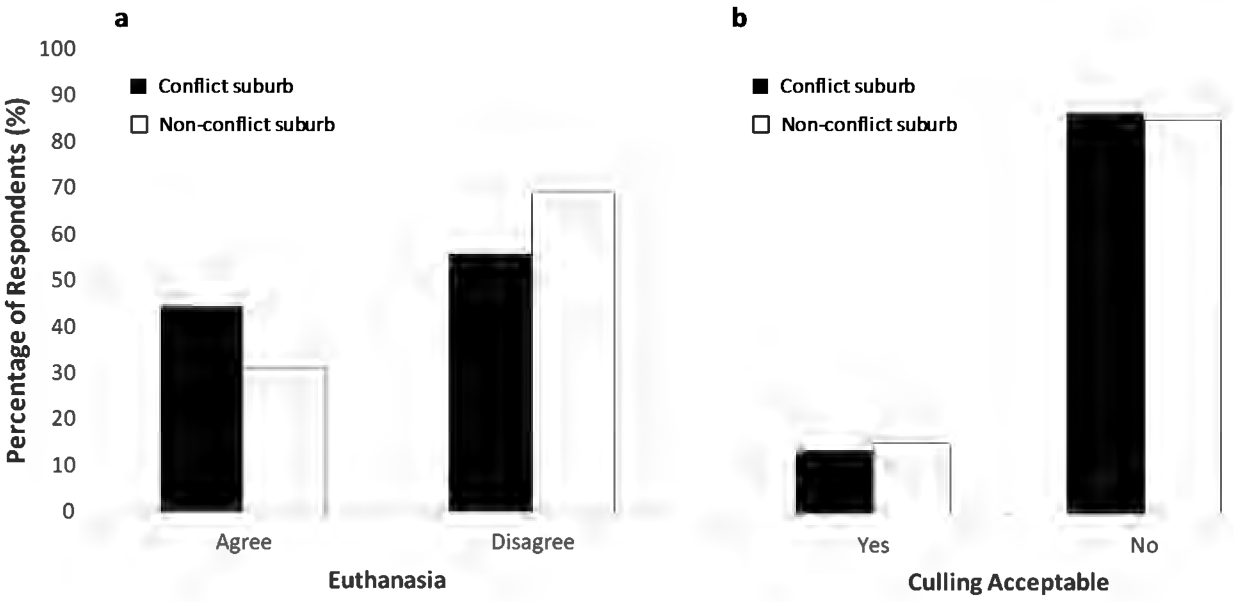


Figure 5.5. Percentage of respondents living either within (black) or outside (white) suburbs with human-baboon conflict that indicated on a Likert-type scale their disagreement (1-3) or agreement (5-7) with a) euthanasia of single baboons that pose a risk to public health and safety through habitual raiding and b) whether they agreed or not with the culling of troops of Cape Peninsula baboons in order to regulate this baboon population. Respondents that reported feeling neutral (scale value: 4) were excluded.

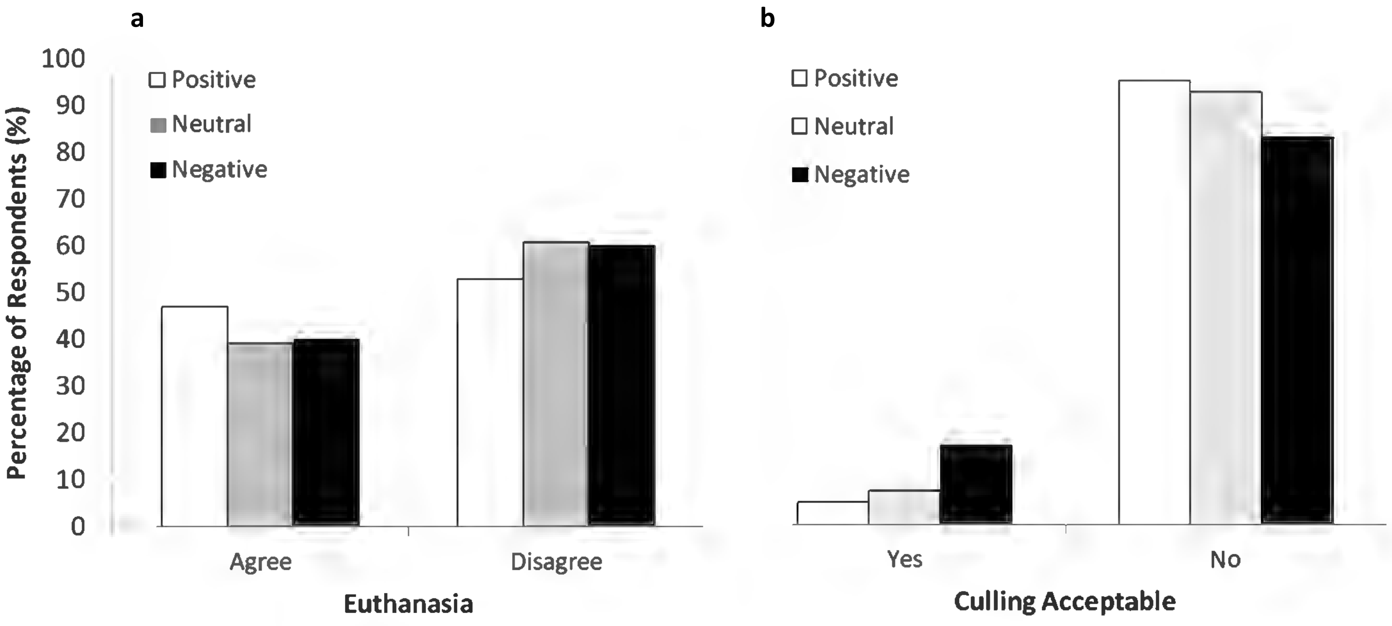


Figure 5.6. Percentage of respondents having positive (white), neutral (grey) or negative (black) experiences with baboons that indicated a) on a Likert-type scale their disagreement (1-3) or agreement (5-7) euthanasia (a) of single baboons that pose a risk to public health and safety and culling troops (b) of Cape Peninsula baboons in order to regulate this baboon population. Respondents that reported feeling neutral (scale value: 4) were excluded.

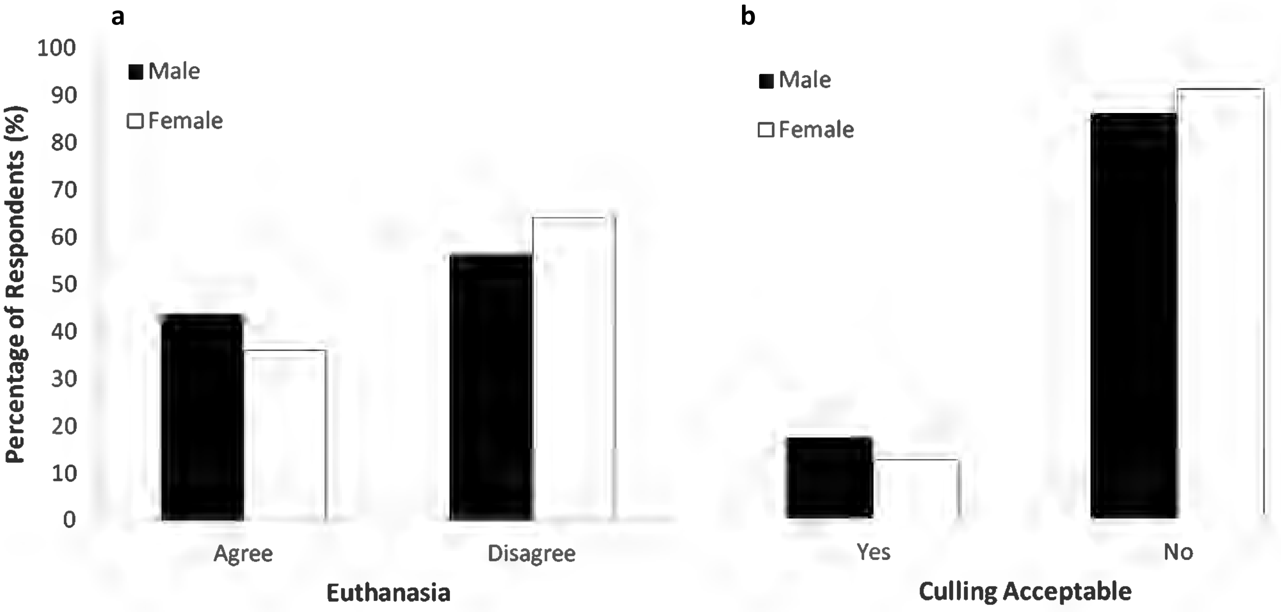


Figure 5.7. Percentage of male (black) and female (white) respondents that indicated on a Likert-type scale their disagreement (1-3) or agreement (5-7) with euthanasia (a) of single baboons that pose a risk to public health and safety and culling troops (b) of Peninsula baboons in order to regulate the Cape Peninsula baboon population. Respondents that reported feeling neutral (scale value: 4) were excluded.

Table 5.1. Binary logistic regressions conducted to determine whether respondent experiences of baboons (positive/negative), gender (male/female) or suburb (in-conflict/out-conflict) were able to predict respondent agreement with euthanasia of problem baboons or culling of troops. No predictors in either regression were significant.

	Predictor	B	Wald X^2	p	Odds Ratio
Euthanasia					
	Experience	-1.316	1.515	.218	.268
	Gender	.645	1.443	.230	1.905
	Conflict	-.021	.002	.968	.979
	Constant	-1.981	15.737	.000	.138
Culling					
	Gender	.470	1.272	.259	1.600
	Conflict	.521	1.469	.226	1.683
	Experience	-.273	.220	.639	.761
	Constant	-.717	1.446	.229	.488

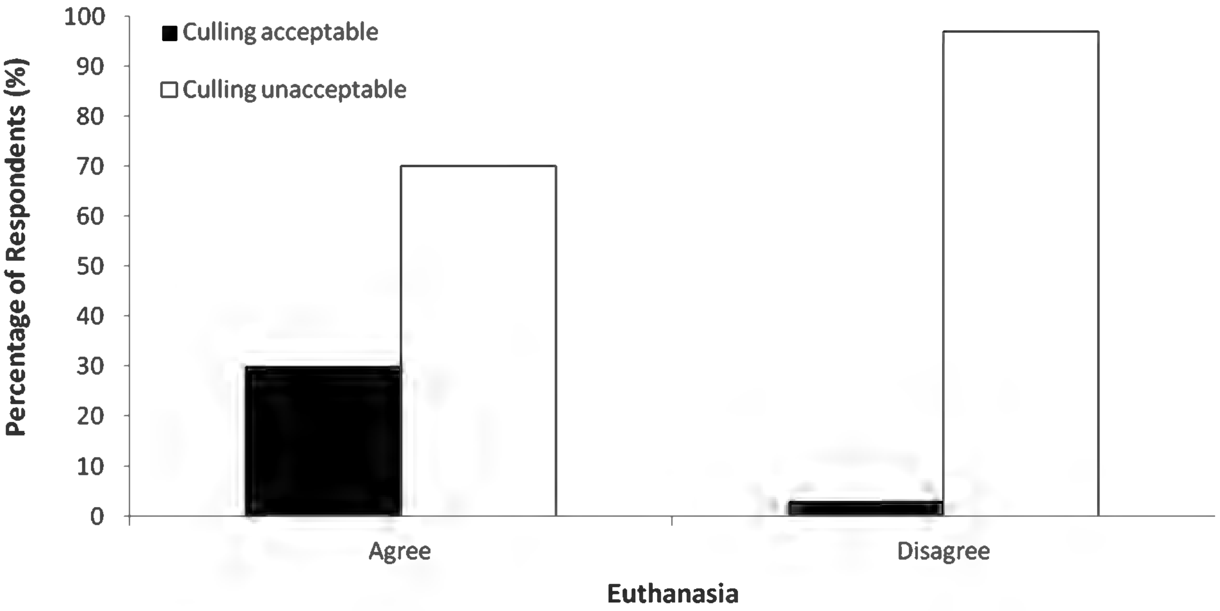


Figure 5.8. Percentage of respondents that indicated on a Likert-type scale either their disagreement (scale values: 1-3) or agreement (scale values 5-7) with euthanasia of single baboons that pose a risk to public health and safety and whether they found culling whole troops acceptable (culling acceptable: black; culling unacceptable: white) as a means to regulate the Cape Peninsula baboon population.

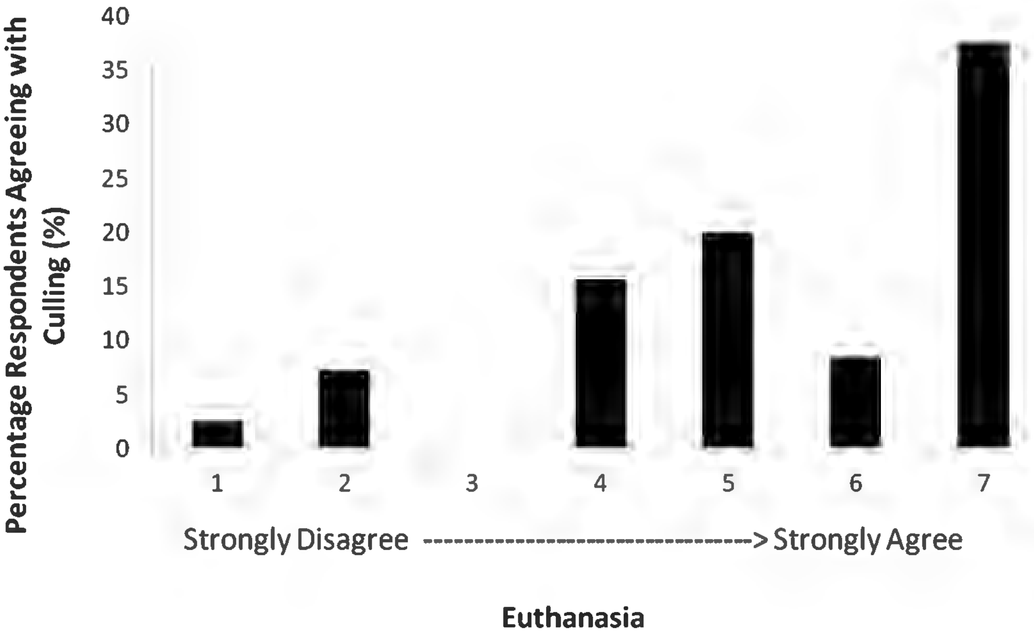


Figure 5.9. Percentage of respondents that found culling to be acceptable as a means to control the population of Cape Peninsula baboons according to how, on a 7-point Likert-type scale, they felt (1: strongly disagree; 2: disagree; 3: somewhat disagree; 4: neutral; 5: somewhat agree; 6: agree; 7: strongly agree) about euthanasia as a way to manage single baboons that threaten public health and safety.

Non-lethal deterrents

Of the five non-lethal methods used by humans to deter baboons from raiding, pellet guns were the least acceptable (15.49%); followed by throwing sticks/stones (23%); paintball marker (24.34%); spraying water (44.24%) and loud bang/noise (50.44%)(Fig. 5.10). Respondents also reported witnessing these methods from order of least frequent to most frequent: pellet gun (6.67%); paintball marker (11.56%); spraying water (25.22%); throwing sticks/stones (34.51%); loud bang/noise (49.12%) (Fig. 5.10). Thus, barring throwing sticks/stones, respondents witnessed the least acceptable human behaviour most infrequently and vice versa for the most acceptable behaviour. I found males and respondents living in conflict suburbs to be marginally more accepting of all five categories than females (with the exception of females accepting loud bangs/noises) and respondents living outside conflict suburbs, respectively. The relationship between experience (positive/negative) and the acceptability of the human behavioural categories was far more variable (Fig. 5.11).

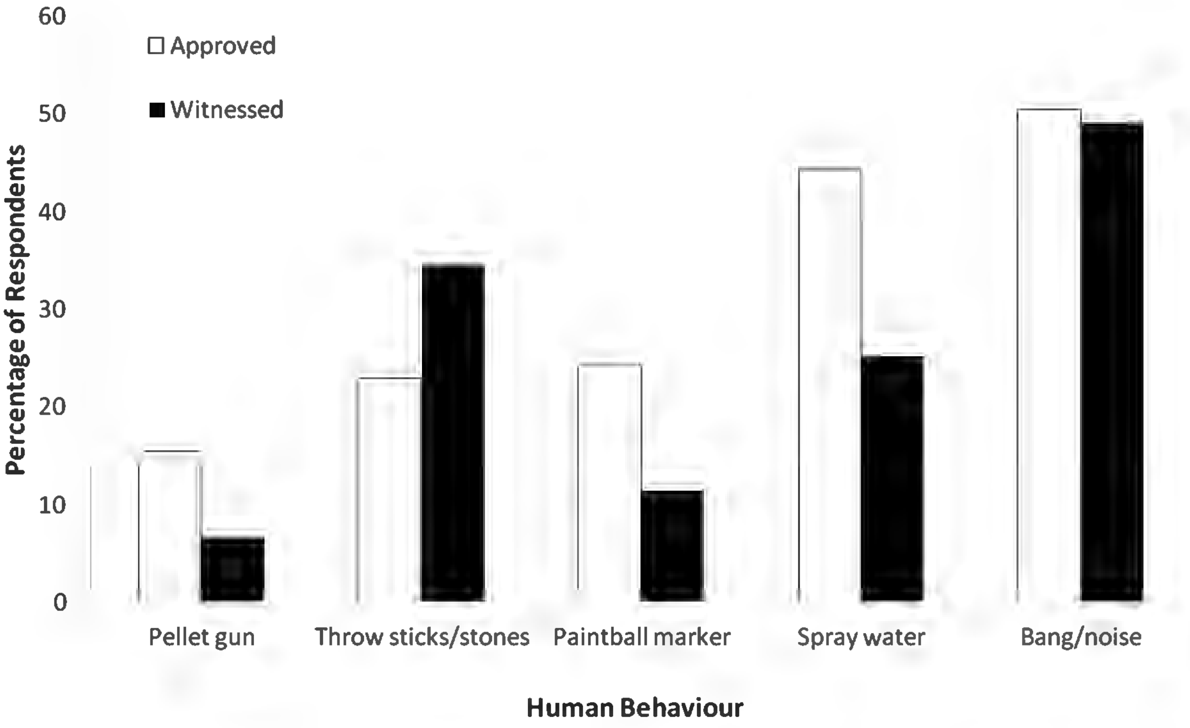


Figure 5.10. **P**ercentage of respondents that approve of the various non-lethal methods that managers and residents administer to deter baboons (white) and how often they witnessed the use (black) of these deterrents (pellet gun; throwing sticks/stones; paintball markers; spraying water; loud bang/noise).

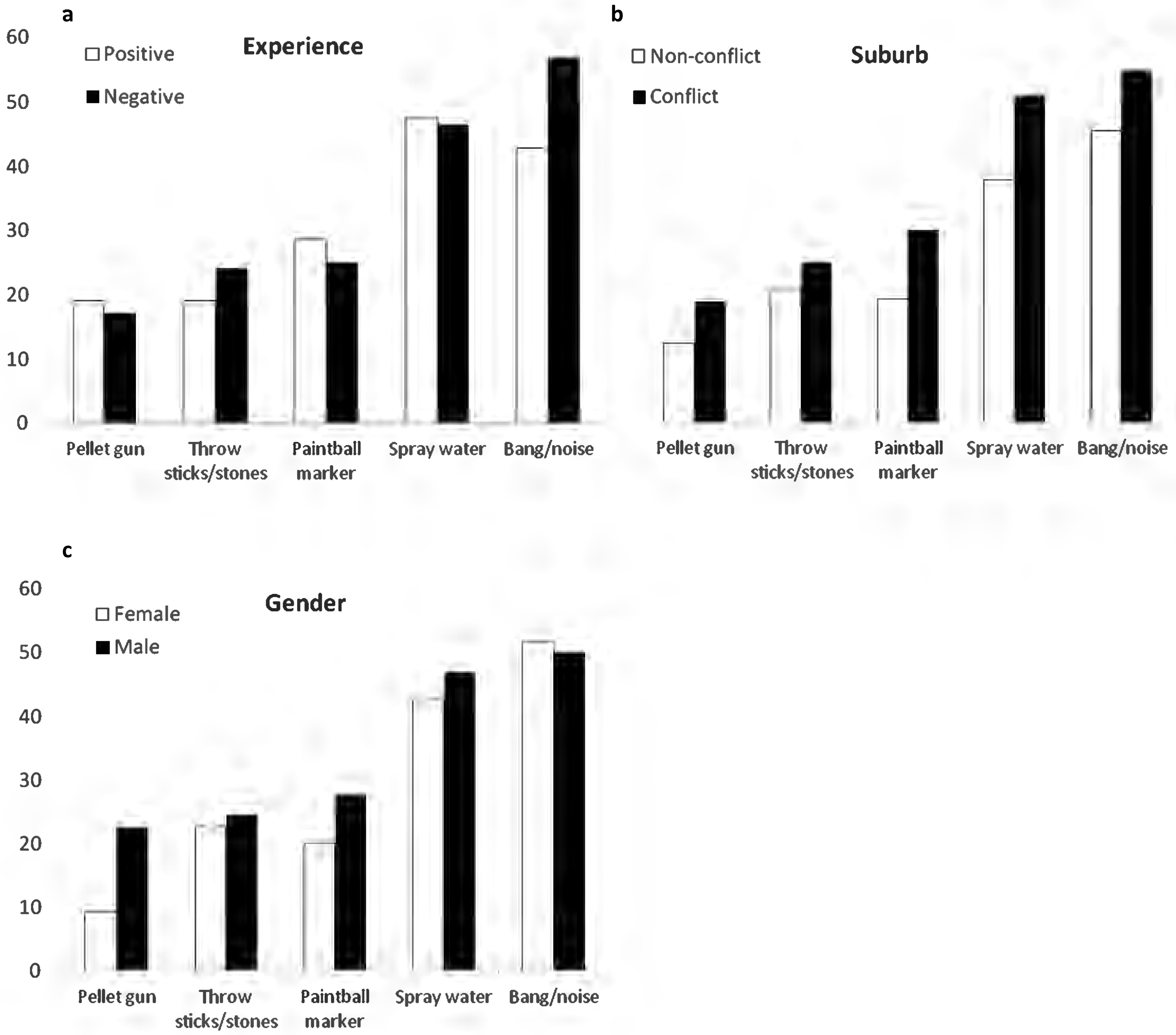


Figure 5.11. Percentage of respondents that approved of baboon authorities using various sub-lethal management techniques (pellet gun; throwing sticks/stones; paintball markers; spraying water; loud bang/noise) according to a) respondent experience (positive: white; negative: black), b) suburb (out-conflict: white; in-conflict: black) and c) gender (female: white; male: black).

Knowledge of baboons, management responsibility and the media

Of respondents living outside conflict areas, 48.98% believed the chacma baboon to be endangered while 45.95% did not. Respondents living inside conflict areas had marginally but not significantly (X^2=1.174, df=1, p=0.278) better knowledge with 41.73% believing the chacma baboon to be endangered and 55.12% believing that it wasn't (Fig. 5.12). Education level could not account for knowledge of baboon conservation status, with the 60% of the least educated respondents (junior school) answering correctly, followed by tertiary educated respondents (53.57%) and lastly, respondents that had passed high school (50.56%), although these groups were not significantly different (X^2=0.902, df=2, p=0.637). All surveyors reported that respondents were most unsure about the question concerning the organisations responsible for baboon management in the Cape Peninsula and required more urging to answer this particular question (Figure 5.13). Four organisations are mandated to manage the Cape Peninsula population. Three of these are local, provincial or national authorities (City of Cape Town Municipality, Cape Nature, South African National Parks, respectively) and one is the service provider contracted to run the monitor/field ranger programme (NCC: July 2010 - July 2012; Human Wildlife Solutions: September 2012 - present). Respondents identified SANParks (45.58%) and Cape Nature (39.82%) more frequently than the City of Cape Town (26.1%) or the baboon management service provider (24.33%). While researchers were rarely seen as responsible for baboon management (11.06%), Baboon Matters, the non-profit organisation that previously (up until 2009) functioned as service providers for baboon management was most frequently deemed to be responsible for baboon management (55.75%).

Finally, the greatest number of respondents (142) listed newspapers as one of their sources of baboon information, followed by signs (92), pamphlets (56), television (41), internet (41), public talks (36) and schools (6) (Fig. 5.14). In terms of general media use, television was listed as being used most frequently (101 respondents), internet (79), newspaper (38), radio (37) and magazines by 16 respondents (Fig. 5.15).

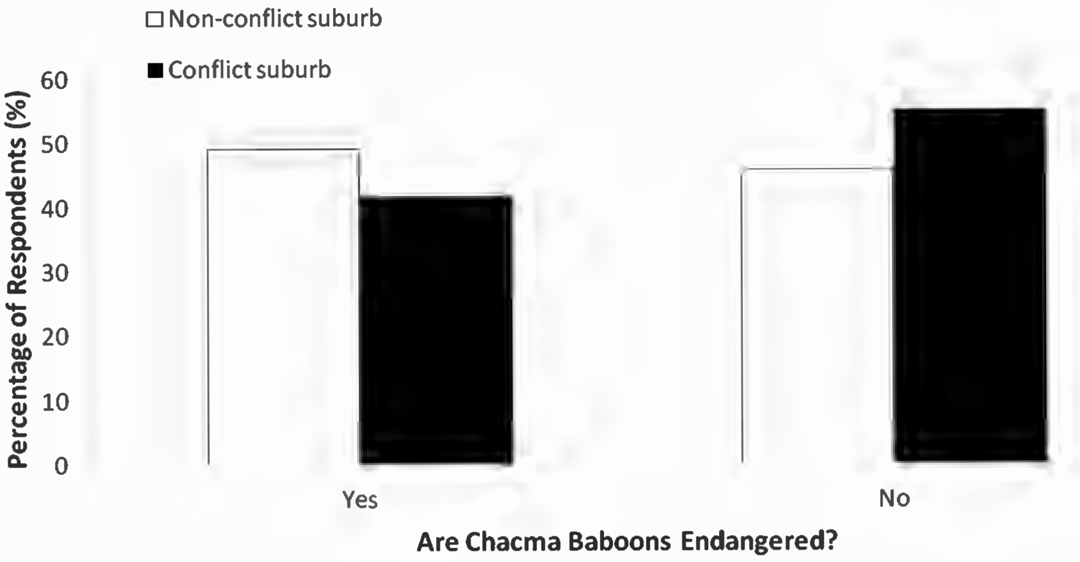


Figure 5.12. Percentage of respondents from non-conflict suburbs (white) and conflict suburbs (black) that answered either "yes" or "no" when questioned whether the chacma baboon (the species occurring in the Cape Peninsula) was endangered.

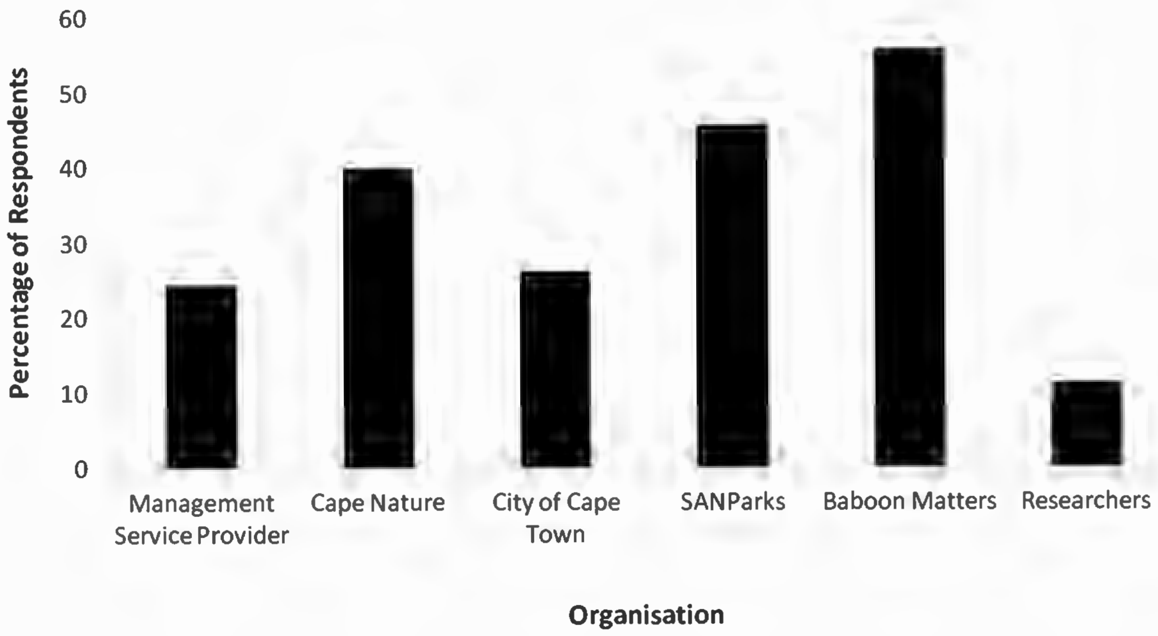


Figure 5.13. Percentage of respondents that, in a question allowing multiple answers, identified groups or organisations (Management Service Provider: NCC or Human-Wildlife Solutions [service contract was transferred from NCC to Human-Solutions during the survey]; Cape Nature; City of Cape Town; South African National Parks; Baboon Matters; Researchers) as being responsible for baboon management.

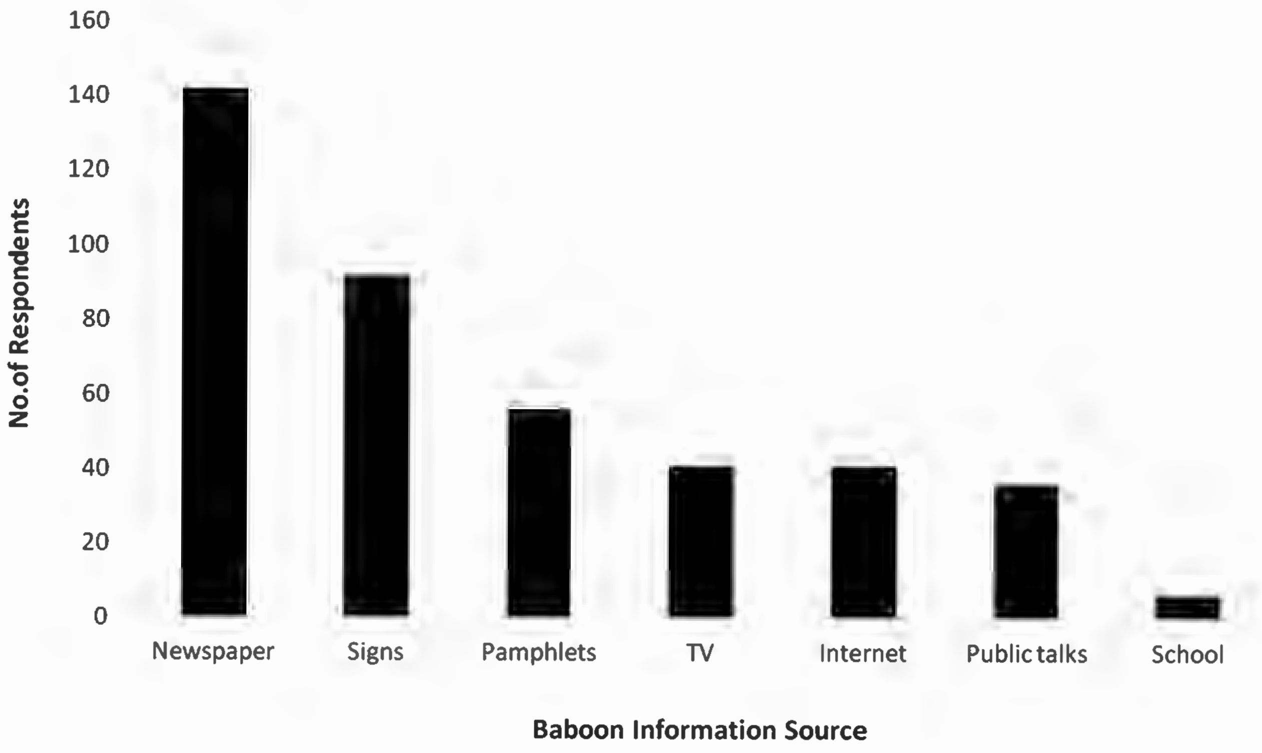


Figure 5.14. Number of respondents that listed, in a question allowing multiple answers (newspaper; signs; pamphlets; television; internet; public talks; school), their sources of information regarding baboons.

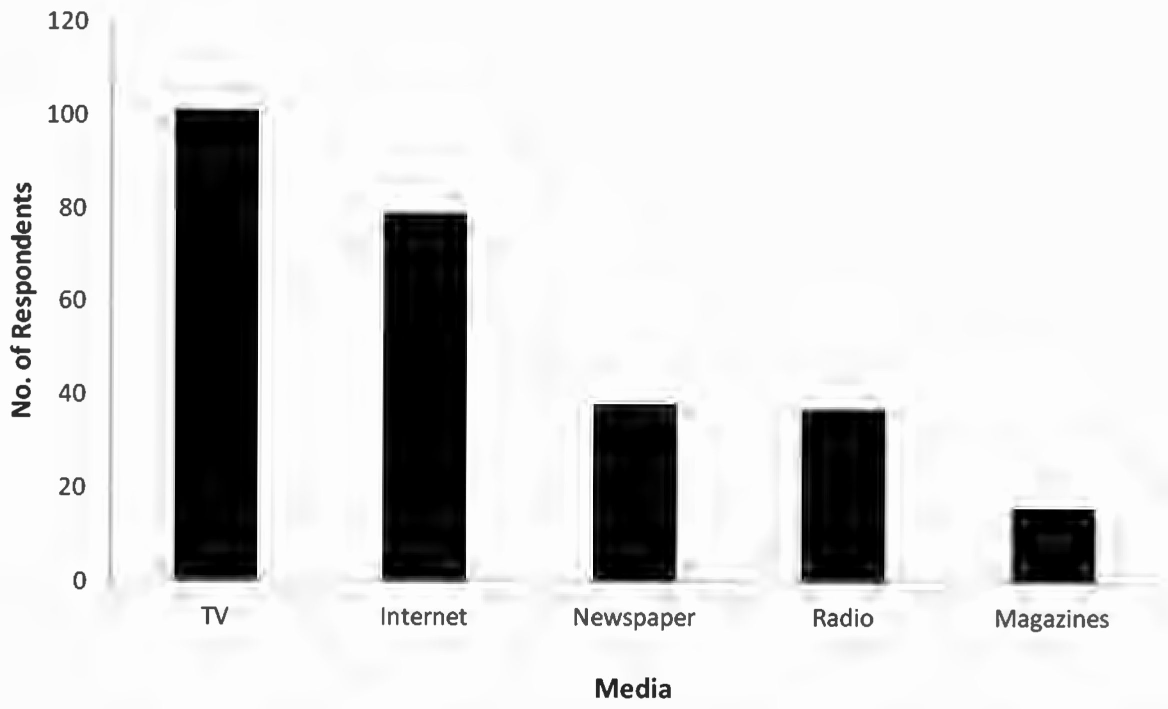


Figure 5.15. Number of respondents that listed one of five media sources (television; internet; newspaper; radio; magazines) as being the one that they used most frequently.

Discussion

In the realm of human-wildlife conflict, members of local communities, as directly-affected parties, can be faced with emotive and anecdotal information that can become the dominant narrative of a particular conflict in the absence of systematic accounts. In such scenarios, violent incidents (Packer et al. 2005; Luther 2013) or polarised viewpoints (Marshall, White & Fischer 2007) may not be representative but can nevertheless dominate perceptions. It is thus critical to gather conflict indices from a range of sources (Naughton-Treves & Treves 2005). In the Cape Peninsula, conflict between humans and baboons can be measured through a variety of proxies, including raiding success (RFI: Chapter 2) human-induced injuries and mortalities (Beamish 2009), injuries to pets (generally dogs, NCC/HWS reports) and the volume of complaint calls to the baboon management hotline.

It is equally important to understand the perceptions held by individuals within communities of a conflict species and that species' interface with the community. The proxies of human-baboon conflict mentioned above are sourced only through conflict incidents and preclude positive experiences with baboons that may occur. Therefore, I ensured that residents in my sample originated from both conflict and non-conflict suburbs. With this objectivity, my findings indicate that while positive experiences of baboons were recalled (and take place approximately as often as neutral experiences); over two-thirds of respondents had negative experience profiles. In addition, sightings of baboons in houses, gardens and picnic sites* (where conflict is particularly prevalent), together numbered more than the combined sightings of baboons in the 'natural' areas of Tokai plantation and the Cape of Good Hope Section of the Table Mountain National Park (Cape Point). Considering the types of baboon experiences and the location of these experiences translates into a predominantly negative human-baboon interface. One small positive note was that respondents more frequently approved of non-lethal deterrents (see below) than witnessed them being used, suggesting that (observed) human behaviour is within acceptable bounds.

* While picnic sites occur within both the Tokai plantation and Cape Point, I chose to make picnic sites distinct entities as they have the potential to be (and often are) sites of conflict between humans and baboons.

In any community, divided opinion over particular management actions can hamper the ability of wildlife authorities to implement conflict mitigation strategies. Therefore, understanding what factors might divide opinion is key to resolving some human-human conflicts (e.g. Redpath et al. 2012; Madden 2004). I predicted that three factors relevant to managers will lead to differences in opinions over the use of management techniques, namely respondent gender (Herzog, 2007), whether they live in a conflict area and the nature of their recent experiences with baboons (positive, neutral or negative). Where experiences are negative and a cost has been imposed by wildlife the prediction is for an increased willingness to behave retributively (see Liu et al. 2011). There was consensus in the ranking of non-lethal methods from least to most acceptable (pellet gun; throwing sticks/stones; paintball marker; spraying water; making bang/noise). There was also a tendency for respondents with negative experience profiles and those living in conflict suburbs to be more accepting of these methods than those with positive experience profiles and those living outside conflict suburbs, respectively but these differences were not significant. Further, when I used multiple regressions to test respondent agreement with two lethal management actions (euthanasia of single habitual raiding baboons and culling whole troops), none of these factors emerged as significant predictors. Of interest is that vegetarians/vegans differed in their acceptance of euthanasia of single baboons to other respondents, but not the culling of whole troops. This suggests that culling as a management technique is too ‘extreme’ to divide opinion, with 78% of all respondents disagreeing with it whereas only 47% of respondents disagreed with euthanizing individual habitual raiders. Complicating this assertion somewhat is that respondents that approved of euthanasia were significantly more likely to find culling acceptable. This suggests that there is a consistency in the approval of lethal techniques, even if their management goals are fundamentally different. In contrast to other studies (e.g. Bjerke et al. 1998), the support for lethal methods was higher among educated (tertiary education) respondents and this may be a factor of these respondents having a better knowledge of problem animal removal or culling as common management practice in wildlife management. Future studies should look to explore this relationship more thoroughly.

Community knowledge of the species in question can be useful in aiding mitigation efforts and in bringing about pro-environmental behaviour (Hines, Hungerford & Tomera 1987; Kollmuss & Agyeman 2002; Barney, Mintzes & Yen 2005). In the survey, I employed a single question to test respondent knowledge of the conservation status of the chacma baboon. While future studies may choose to focus on aspects of baboon behaviour and morphology, I chose to ask only if respondents believed the chacma baboon to be endangered as impressions of a species' vulnerability can be influential in the views of that species' management (Bjerke *et al.*, 1998). While the chacma baboon is widely distributed and listed as *Least Concern* by the IUCN (2008), efforts by NGOs to raise funds for the management of the Cape Peninsula baboons have focused on threats to the local population without making reference to the ubiquity of the species throughout southern Africa (Swedell 2011a) and also the increase in the Cape Peninsula population in recent years (Beamish 2009). Thus, although I posed a simple question, with a simple answer, the ambiguity of the information available to respondents makes it unsurprising that they only performed slightly better (53% of respondents correct) than if they had been guessing. Further, neither living inside a conflict area, nor having a higher level of education had any bearing on the likelihood of respondents to answer correctly.

Respondents were also confused when selecting organisations that were responsible for baboon management. This confusion can likely be attributed to the complexity in official responsibility and the variability of this responsibility over the recent history of local baboon management (Hurn 2011). Respondents most frequently listed Baboon Matters as being responsible for baboon management. Arguably one reason for this is the presence of the word "baboon" which is absent from the title of the other organisations. Alternatively (or in addition), the historical profile of the organisation was sufficiently high for its perceived role to persist beyond its tenure in management. This misconception may be problematic as in reality this organisation has had no involvement with baboon management since 2009 and is currently listed as a charity that is focused on "raising awareness around the plight of baboons as well as education and training so that sustainable solutions can be found for areas of conflict between humans and baboons" (www.baboonmatters.org.za) and is frequently at odds with management authorities over both lethal and non-lethal management strategies.

Clearly, there is a need for the tri-partite management group (City of Cape Town Municipality, Cape Nature and SANParks) to establish a stronger public profile aligned with their responsibilities for baboon management. The uncertainty in the public arena concerning management responsibility is almost certainly a factor that has allowed for dissenting groups to attain a level of credibility on matters relevant to management. In light of this it is encouraging to learn that the BTT has, over the previous year, adopted a more pro-active media stance with a view to increased transparency and accountability for all management decisions.

Engaging with directly-affected parties and disseminating management messages would be greatly aided by an informed 'electorate'; aware of the basic facts of the baboon population and its management. In terms of their sources of knowledge on baboons, most respondents indicated newspapers. While this medium can be factually correct or give a positive impression of wildlife living along urban boundaries (Jacobson et al. 2012) and even de-escalate conflict (Bhatia et al. 2013), its role in resolving human-wildlife conflicts is not assured, sometimes becoming counterproductive by sensationalising events and actually increasing readers' risk-perception of a particular species (e.g. black bear: Gore & Knuth 2009). Muter et al. (2009) distil this point: "Many human-wildlife conflicts attract the attention of mass media (Corbett, 1995) because they feature recognisable personalities, polarized perspectives, and have local significance (Price & Tewksbury 1997)." Cape Peninsula respondents report signage and pamphlets as the next most frequent sources of their baboon information after newspapers. While this is encouraging for authorities that make use of signage and pamphlets, this avenue is open to various parties for the dissemination of misleading information on basic issues such as the conservation status of baboons.

Respondents in the survey reported using television as the primary medium of information with the internet second, followed by newspaper, radio and magazines. While managers might be tempted to focus on television, I propose that the advantages of internet-centric media (rapid updating; targeted audience [mailing list; social network groups]; relatively low cost; capacity for dialogue) over television are sufficient to motivate for its consideration as a platform for managers to disseminate information about baboons, their management and critically, ways in which residents can improve their own behaviour (e.g. properly using baboon-proof waste bins).

Conclusion

Despite the predominantly negative interface of humans with baboons in the Cape Peninsula, residents do not express particularly high support for lethal methods (40% of respondents agree with euthanasia of problem baboons and only 14% of respondents agree with culling whole troops as a means to control the population) and even the most acceptable deterrent technique I presented (loud bangs) enjoyed support from only about half (54%) of the respondents. This suggests a high level of tolerance of the baboon population, despite their 'transgressions'. The inability of respondent gender, baboon experience or whether respondents lived inside conflict suburbs to predict support of deterrent techniques presents a challenge to managers hoping to solicit support for these strategies. Respondents were also unsure of the conservation status of the chacma baboon and the organisations responsible for their management in the Cape Peninsula. Based on these findings, I propose that management authorities focus on clear, unambiguous campaigns to communicate to residents: which bodies are mandated for managing the population; the status of chacma baboons and the central challenges facing human-baboon coexistence. Reliance solely on newspapers/journalists to convey these management messages risks the misinterpretation of controversial and/or nuanced topics like euthanasia of problem baboons and will likely fail to communicate non-sensational, but vital information, e.g. proper bin-proofing measures. While the use of pamphlets and signage to this end has shown some success, the internet's facilitation of real-time, interactive dialogue via social network platforms makes it an appealing option for a manager looking to engage with residents. Ultimately, the myriad of social forces at play in human-wildlife conflicts results in considerably complex landscapes (see Neff 2012) and it would be naive of this researcher to oversimplify them. Instead, I advocate the consultation with research disciplines such as sociology, psychology, social anthropology, behavioural economics and policy. Arguably this kind of interdisciplinary approach will provide the best chance of resolving human-human conflict (and therefore human-wildlife conflict) in the Cape Peninsula and elsewhere.

Chapter 6

SYNTHESIS

Management strategies for the Cape Peninsula baboons

Prior to addressing human-wildlife conflict, three strategies should be considered by affected communities and management authorities. These are: doing nothing, removing either humans or wildlife from the conflict space or using interventions to reduce the scale of the conflict. The strategy that ultimately prevails should be the one that offers the best welfare and conservation prospect for wildlife; has the lowest monetary and environmental costs and the highest sociocultural acceptability (Treves et al. 2009; Redpath et al. 2012). Here I assess each of these strategies within the context of human-baboon conflict in the Cape Peninsula.

A strategy which entails taking no action would impose minimal monetary costs on the management authorities and carries negligible environmental costs. However, the attraction of baboons to lower altitudes for more desirable natural habitat as well as anthropogenic food sources (Hoffman 2011; Hoffman & O'Riain 2012a) will lead to persistent conflict. Together, access to nutrient-rich food sources, the absence of natural predators and improved management (see Musiani et al. 2003 [wolves]; O'Connell-Rodwell et al. 2000 [elephants] for examples of improved management exacerbating conflict) has led to sustained positive growth for the Cape Peninsula baboon population (Beamish 2012, Beamish unpubl. data). With increasing development of natural land to service a growing human population, the competition between humans and baboons for low-lying land is likely to escalate, setting the scene for increased conflict. This will increase the cost to residents, which is already high (e.g. damage to a single thatch roof = R135 000, gutter damage in a single house = R20 000, broken window frames in a single house = R22 500, van Zyl & Barbour in prep.), and unlimited access to urban areas would impinge negatively on baboon welfare (through poisoning, car collisions, electrocutions, pellet gun injuries). When combined with the low sociocultural acceptability of baboons being allowed to raid freely in dense residential areas and vineyards (NCC; HWS monthly reports) then this strategy is unlikely to receive much support from either communities or management authorities. As an additional point, while baboons have yet to inflict anything more than a minor injury (scratches) on humans in the Cape Peninsula, should something more serious occur adding an additional root of conflict (i.e. crop-raiding, human mortality: see Chapter 1), authorities will no doubt rue a failure to have addressed the conflict proactively.

The second strategy is to remove either baboons or people from the conflict space. While cases of human removal for the benefit of conservation areas have occurred, it is an approach that is now considered highly controversial and unlikely to be considered in the case of a wildlife species of low conservation concern (West, Igoe & Brockington, 2006; Mascia & Claus, 2009). Thus while it may be possible to limit further human incursion into extant baboon home ranges (Hoffman & O'Riain 2012b), the only likely removals to take place would affect baboons through either translocation or culling. Translocating genetically depauperate (Bishop et al. *in prep*), diseased (Drewe et al. 2011) and habitually raiding (van Doorn et al 2010, Kaplan et al 2011, Hoffman and O'Riain 2012) baboons carries few benefits to a potential receiving population of conspecifics or associated human communities. In addition, the ability of baboons to adapt to anthropogenic land transformation has resulted in their ubiquity throughout the Western Cape province, limiting the number of suitable (Strum 2010) release sites for translocated troops. In the face of these obstacles and the associated stress to baboons and financial costs of mass capture, transport and post-release monitoring, there is currently limited support for translocation as a viable solution to the removal of Peninsula from conflict areas.

Culling as a means to remove baboons from the conflict is an alternative to translocation and was last used as a management method prior to 1998 when at least three habitually raiding troops were removed. However this culling was met with strong public opposition and an immediate call for a moratorium and for both the sustainability and idiosyncrasies (genetic and behavioural) of the population to be investigated. While it is possible to argue that the welfare of a humanely euthanized baboon is higher than one that is in perpetual conflict with humans, the considerably low sociocultural acceptability (Chapter 5) and potential environmental cost (removing the last widely distributed and abundant medium sized mammal from Table Mountain Park) renders this strategy unrealistic.

The third strategy is to intervene and attempt to mitigate the conflict through the use of interventions that reduce the spatial overlap between baboons and human environments but allow for co-existence within the Cape Peninsula. This action may entail considerable monetary cost and moderate environmental cost (contingent on the specific methods used), but it does offer improved baboon welfare and conservation and has high sociocultural and hence, political, acceptability. Poignantly, during the Baboon Expert Workshop held in 2009 (a stakeholder meeting hosted by the City of Cape Town), Councillor Niewoudt (Mayoral

Executive Committee Member for Planning and Environment for the City of Cape Town), spoke to the importance of biodiversity in an international context and stressed that the chacma baboon is part of this 'bigger biodiversity picture' (Proc. Baboon Expert Workshop 2009). Thus, relative to doing nothing or removing baboons, a management plan that allows for a sustainable baboon population with reduced conflict should be favoured with baboons being viewed as an important part of the rich natural heritage of the Cape Peninsula that currently serves as a major attraction to local and international tourists; the monetary value of which can be considerable (see Kansky & Gaynor 2000). Indeed, properly understanding the range of values that baboons add to the Cape Peninsula (both ecologically and financially) is a critical area of future research, particularly for parties advocating the baboons' continued presence in this environment.

Towards a conflict mitigation toolbox

The baboons' ability to adapt to human environments and to source anthropogenic food makes it unlikely that conflict will cease as long as baboons are permitted to share space with humans. Therefore, the ultimate goal of management interventions is to reduce spatial overlap between humans and baboons by increasing the cost-to-benefit ratio for baboons entering urban areas. In Chapter 2 I tested the efficacy of three disruptive deterrent strategies with different stimuli (light, noise, pain) in achieving this goal. Light prisms are cheap and easy to install and have been used extensively in some urban areas to deter birds from rooftops (although I found no published data assessing their efficacy as a deterrent). In the case of deterring baboons, they proved completely unsuccessful, arguably due a combination of the 'empty' threat they pose and the prior habituation of the baboons to similar stimuli (mirrors, windows) that are abundant within the urban area. Noise aversion through the use of bear bangers however, showed considerably more success. While similar attempts to use loud bangs to deter wildlife species, such as coyotes and white-tailed deer (Pfeifer & Goos 1982; Koehler et al. 1990; Gilsdorf et al. 2002; Gilsdorf et al. 2004) may succeed for brief periods, they invariably succumb to habituation. In the SWB troop, the combination of human activators, a conditional basis for the stimulus and the baboons' previous association between similar loud bangs and bullets discharged from guns (x-rays on the alpha male from this troop revealed more than 70 foreign metal objects lodged subcutaneously including buckshot, birdshot and air rifle pellets) may have reduced the habituation susceptibility of bear bangers, allowing for their prolonged success as a deterrent. Finally, electric fencing proved 100% successful in excluding baboons from a suburban area that included both abundant high quality food and a suitable sleeping site. Thus, decision makers have at least two effective methods for achieving conflict mitigation through interventions. Although I only tested the efficacy of three deterrents in reducing spatial overlap between humans and baboons, other methods are currently in use (e.g. paintball markers which were introduced after my data collection period ended) and doubtless new ones will emerge in the future. It is imperative that in selecting conflict mitigation methods, management authorities have a template for their objective evaluation (see below).

In Chapter 3, I sought to provide a short-term solution to mitigate raiding during brief periods when monitors (the primary means for conflict mitigation) may not be available (e.g. on strike or between the appointment of new service providers) resulting in acute conflict with high levels of damage to property and injury/mortality to baboons. This was achieved by increasing the benefit to baboons of using natural areas through firstly provisioning food at a designated patch outside of the urban edge and subsequently, restricting access to high quality food sources within the human environment. The alpha male monopolised access to this finite resource and thus the troop spent more time in natural areas without impacting much on the resource intake of other troop members and hence the survival and reproductive potential of most troop members. This method was not considered to be a viable long-term method given the potential for a troop split (King et al. 2008) with lower ranking members reverting to urban raiding while the more dominant individuals monopolise the feeding patch. Indeed, in the absence of natural predators, the costs of forming a fission troop or even raiding alone are negligible and are more than offset by the foraging benefits.

Provisioning was only successful in reducing troop presence within human environments when large waste areas within the town were closed down. Thus reducing access to anthropogenic waste is clearly a key component of any strategy that seeks to reduce the benefits for baboons to enter urban areas. Consequently in Chapter 4, I assessed the feasibility of restricting baboon access to waste bins that are omnipresent in residential areas and provide baboons with a diverse array of high-quality food items. My results revealed that the City of Cape Town's baboon-proof waste bins, when used properly, were effective in excluding access to their contents. This chapter also revealed that similar to Chapter 3, male baboons dominated access to these food resources and that consequently, most behavioural interactions around waste bins are aggressive and hierarchical. This precludes the required social space for lower ranking individuals to learn how to open the latches that secure the bin lids and consequently bin-naive baboons appeared to learn exclusively by trial and error. If management authorities can reduce the total time that troop members interact with baboon-proof bins, it will reduce the probability that lower ranking troop members will acquire the skills to open the latches.

Together the results presented in Chapters 2, 3 and 4 suggest it is possible to increase the costs while simultaneously decreasing the relative benefits for baboons accessing human environments and in so doing to reduce spatial overlap between humans and baboons. Where managers have a range of options available to them, the comparison of the relative costs and benefits of each method (Treves et al. 2009; Hill & Wallace 2012) would prove useful and I have included such a comparison (Fig. 6.1) of the five conflict mitigation methods that I trialled. While a combination of methods (some still to be tested) will likely achieve the greatest long-term reduction in conflict levels, if Cape Peninsula managers were to favour a particular method to reduce human-baboon spatial overlap, my results suggest that electric fencing most successfully optimises monetary cost, welfare and conservation prospects for baboons as well as environmental costs and socio-political acceptability.

At a recent workshop on baboon management and related research held at the University of Cape Town (see Hurn 2010), international researchers and wildlife managers with relevant experience on baboons were asked to provide an objective assessment of the general behaviour and conservation status of the Cape Peninsula baboons. Citing an absence of natural predators, geographical isolation and high levels of habituation to people, chronic levels of raiding and current intensive management practices, the participants concluded that these troops were best classified as commensal and should thus either be culled or managed within a discretely fenced sanctuary. Three factors militating against this approach are 1) the general opposition to lethal control by the public (Chapter 5), 2) the opposition of both national and provincial conservation authorities to sanctuaries as conservation vehicles for non-threatened species and 3) the absence of private land or funding for achieving this goal (given this would no longer be a wildlife management issue). While all of these factors are theoretically surmountable, local scientists stressed that a more immediate alternative would be to use deterrents that had been shown to work on select troops more widely and to explore other as yet untested methods (e.g. electrified fencing) as possible longer term solutions. This was accepted as an outcome of the workshop with the acknowledged caveat that baboons would readily habituate to most deterrents and that the cost and efficacy of fencing remained unknown and possibly inappropriate as a long term solution.

Intriguingly the success of fencing (Chapter 2) would afford management authorities the opportunity to exclude human environments from most extant troops' home ranges for approximately R18 million (based on coarse extrapolations of the Zwaanswyk fence tested in Chapter 2). This fencing would largely 'fence in' the discrete residential areas that are particularly plagued by baboon raiding. The current annual budget for mitigating conflict using field rangers with noise and pain aversion is R10.5 million. Therefore, a fence with a lifespan of 10-15 years offers a significant reduction in the medium to long-term costs of baboon management with the added promise of greater success in preventing spatial overlap. Such an intervention will still afford sufficient space for baboons to complete their life history without further human intervention, effectively shifting the human-baboon interface from one of *kyosei* (harmonious and mutually beneficial coexistence) to *kyzon* (common presence in space and time; see Sprague & Iwasaki 2006; Chapter 1).

Table 6.1. Proposed evaluation categories for human-wildlife conflict mitigation methods, using the methods I tested in my thesis as an example. Deterrent characteristics (yellow), Cost and expertise (blue), efficacy (peach), sociopolitical acceptability (green) and unintented side-effects (purple) are included in this example.

	Prisms	**Bear Bangers**	**Elec Fencing**	**Provisioning**	**Waste Management**
Species	*Chacma baboon*	*Chacma baboon*	*Chacma baboon*	*Chacma baboon*	*Chacma baboon*
Location	Peri-urban	Peri-urban	Peri-urban	Peri-urbam	Urban/residential
Trial length	10 days	10 months	5 months	20 days	10 days
Spatial scale tested	800m per 4 prisms (manufacturer)	250x800m landscape bottle-neck	2.35km	10m x 10m	± 80m/4 bins (experimental area)
Buffer requirement	None	± 800m	None.	N/A	N/A
Monetary cost	5.8 ZAR/m (no maintenance)	50 ZAR/bear banger + 200 ZAR for launcher	400 ZAR/m (+maintenance)	1kg corn/day = 10ZAR	± 600ZAR/bin
Skills (installation and operation)	Basic. Works automatically	Basic/moderate; potential incendiary risk. Manual deployment, so needs to be	Advanced, experience required. Installation and periodic maintenance aside,	Basic	High for building, basic to use
Time needed (installation & maintenance)	1 day	1 day	Months to install (continual maintenace)	1 day	Once bins are modified, 1 day
Efficacy	Low. No change in ranging patterns	High. Complete exclusion from protected area	High. Complete exclusion from protected area	Moderate, improved by waste management	High; reliant on proper use
Habituation susceptibility	High	Low	Low	Short-term application only	N/A
Sociopolitical acceptability	High. Deterrent is economical and not harmful to baboons.	Variable. Loud noise disturbs some residents/stress baboons	Variable. Expensive and aesthetic objections	High (conceptually desirable)	High
Non-target species	Rreduced hyrax and starling numbers. Further study required	Unquantified. Noise-sensitive species (wild/domestic) may be affected.	Species accessing fenced have possibility of injury/mortality.	May feed local non-target fauna, increase populations	Positive - reduced waste access
Environment impact	None	Incendiary potential if not monitored	(see above)	Overuse of areaa & peripheral vegetation (and above)	None
Additional notes	Naive baboons may be susceptible but unlikely to work long-term.	Visible human presence and/or historical persecution with firearms may have	Reduces need for population management	Troop fission risk	Challenge of responsible use

Human behaviour, litigation and education

If local acceptance of baboon management methods is important, it is equally important to explore whether improving human behaviour can play a role in reducing a) existing conflict and b) the causes of conflict between humans and baboons. The behaviour of humans in respect of baboons within the Cape Peninsula is governed by law. Three laws in particular are of interest. The first is the S29 of the Nature and Environmental Conservation Ordinance 19 of 1974 which came into effect in the Cape Peninsula in 2000 and prohibits the killing, hunting, poisoning or wilful disturbance of baboons. The second law is the Animal Protection Act 71 of 1962, which has been invoked in past management debates but is generally applicable in captive or domestic contexts and prohibits the maltreatment of animals (e.g. goading, terrorising, and neglect). That human-induced baboon injury and death continues to occur within residential suburbs (Beamish 2009) suggests that while these laws are appropriate, both compliance and enforcement remains low. Similarly, despite the fact that feeding of baboons is illegal (offenders can be fined up to R1500 or be sentenced to six months in jail) and increases habituation to humans, anecdotal evidence suggests that feeding continues (HWS reports: http://www.hwsolutions.org/data-and-reports.php). Arguably compliance with these laws is contingent on the reasonable expectation that guilty individuals will be prosecuted. While some prosecutions have occurred (e.g. Yeld 2013), they are rare, largely due to the difficulty of obtaining prima facie evidence of the act and the lack of law enforcement capacity allocated to wildlife crimes. Improved enforcement of these laws will require increased funding for a greater number of officers and greater legal resources to prosecute offenders. While legitimate, these requests are competing for funding that might otherwise be allocated to more pressing environmental (e.g. the poaching of endangered flora and fauna) and animal welfare (e.g. organised dog-fights) concerns.

While few people actively encourage baboons to enter human environments, many residents perpetuate human-baboon conflict by unintentionally affording baboons access to human food in the form of exotic plants (e.g. guava trees and grapes) and residential waste. Reducing access to such food sources is essential to reducing raiding incentives within residential areas and hence pivotal to reducing conflict. In Chapter 4 I investigate whether the municipal “baboon proof” bin can successfully deprive baboons of access to residential waste and conclude that when used correctly the latch and lock mechanism is effective in excluding nearly all baboons (a single male forced one lock open after considerable effort). However, the mechanism's success was contingent on residents locking them properly - a requirement that was not fulfilled in 60% of bins assessed during an unannounced survey. Arguably educating residents about the importance of baboon-proofing waste bins will increase compliance, although Baruch-Mordo et al. (2009) demonstrate the need for specificity in these education campaigns and advocate that these campaigns be complemented by proactive enforcement, i.e. imposing costs for poorly managed waste. It is difficult to predict whether this combination of education and enforcement will result in a significant improvement in residents' waste management as instilling pro-environmental behaviour in people is a complex and nuanced process (de Groot & Steg 2009) and this challenge must therefore be included in the relative merits of this intervention (see Table 6.1).

Beyond residential waste, baboons are able to access human food through a wide range of avenues including houses, shops and outdoor eateries. Through their strength and agility, baboons are also able access closed houses, by physically de-railing sliding doors, breaking wood-framed windows, opening a range of door handles and entering eaves to gain entry through the ceiling (HWS reports). In most of these cases it is not possible, or would be considered excessive, to attempt to further baboon-proof against such behaviour. Further, no by-laws dictate house and garden designs and even if in place, enforcement of these laws would be unlikely (see above). Ultimately, the baboons' attraction into human environments to access both natural and exotic plant foods will bring them into proximity with humans that are unable to completely baboon-proof an urban lifestyle and categorically remove all attractants all the time.

Critically, this is not to say that no value exists in educating (see Sabbatini et al. 2006), or providing incentives for residents to behave more responsibly. Indeed, each incremental improvement in human behaviour will reduce the incentive for baboons to raid and when combined with increased costs (i.e. deterrents), the cost-to-benefit ratio for baboons to use urban areas becomes less favourable. In addition, people making use of natural areas in the Cape Peninsula (hikers, cyclists etc.), should understand that feeding or habituating baboons is prohibited. Thus, improving resident knowledge of baboons has (Kansky & Gaynor 2000; de Villiers Brownlie 2000; Proc. Baboon Expert Workshop 2009), and should continue to be a management priority. However, relying on improved human behaviour or baboon-proofing in human environments as the primary method to reduce human-baboon conflict may be naive.

Human-human conflict

Much of the challenge to successfully mitigating human-wildlife conflict is mitigating the conflict between humans and the various groups to which they are affiliated (see Norchi & Bolze 1995; Saberwal 1997); a challenge that can be expected when a variety of interest groups interact (Dickman 2010; Redpath et al. 2012). Human-baboon conflict in the Cape Peninsula is no exception (Hurn, 2011). For the sake of relevance, I will only consider the recent history (1998 and later) of the interface of various groups in Cape Peninsula baboon management. In 1998, the Baboon Management Team (BMT) was formed and consisted of representatives from national government (SANParks), local municipality (City of Cape Town), provincial conservation (Cape Nature Conservation) and the Western Cape Tourism Board, a local NGO (Kommetjie Environmental Awareness Group [KEAG]), Table Mountain Fund (a subsidiary of WWF), two local baboon researchers and select residents from baboon-affected areas. The BMT was "established to make recommendations to the relevant authorities in attendance regarding the holistic management of the chacma baboon populations on the Cape Peninsula to ensure their sustainability whilst minimising conflict between baboons and people" (de Villers Brownlie 2000). While the BMT is a model example of participatory planning for conflict mitigation (Treves et al. 2009) it was frequently hindered in making objective recommendations by a lack of relevant and recent data, including population dynamics, causes and consequences of conflict, baboon spatial ecology, genetics, disease, baboons' ecological role and independent evaluations on the effect of current and proposed management methods on baboon behavioural ecology. In the absence of such information, discussions were necessarily based on the subjective perspectives of participants and in combination with fundamental differences in philosophies pertaining to animal rights and conservation, resulted in a highly emotive and polemical discourse that seldom produced objectively defendable management decisions. This subjectivity coupled with media-based posturing by different parties led to systemic distrust in the BMT. In 2009 the Baboon Research Unit at UCT that had been formed specifically to address the paucity of relevant data, resigned from the BMT citing the ongoing infighting and dysfunctional discourse through the media as fatal barriers to the meaningful contribution of data to management decisions. Shortly thereafter Baboon Matters, the NGO which had previously managed the baboons and had up to that point led the media campaign against internally agreed management decisions, also resigned. Civic representatives called for the dissolution of the BMT demanding that the three conservation authorities assume complete responsibility for the management of the baboons.

In 2010 the BMT was disbanded and the three management authorities formed the Baboon Operations Authorities which later was renamed the Baboon Technical Team and was comprised of SANParks, Cape Nature and the City of Cape Town. Civic representatives formed the Baboon Liaison Group (BLG) and representatives from each new organisation pledged to maintain open channels of communication between residents in conflict areas and the management authorities. The Baboon Research Unit was then invited to both organisations to provide relevant data for management decisions (BTT) and general education (BLG). Within this new management and public participatory framework the City of Cape Town increased their annual budget for baboon management from <R1 million/annum to approximately R9 million and submitted the first tenders for a service provider to manage the baboons. NCC was the first organisation of this new era to win the tender followed by the current service provider HWS.

One aspect in particular that has plagued successful management of the population is finding the appropriate level of involvement for individuals and groups outside of authority structures. Central to resolving human-human conflict is an engagement between a variety of interest groups that is fair, transparent and collaborative (Halvorsen 2003; Raik et al. 2005; Treves et al. 2006; Thirgood & Redpath 2008). In these engagements, where emotive or complex issues are discussed, parties might fundamentally disagree with one another and these disagreements can delay the implementation of effective management measures. Options do exist for resolving these disputes, and include the use of third party mediators (Raik et al. 2005), alternative forms of engagement (Redpath et al. 2012) or increasing the capacity of parties by improving knowledge relevant to contentious issues (Raik et al. 2005). However, if one or more parties leave decision-making bodies and resort to other options, it can derail these negotiations. In the Cape Peninsula, for example, the media were used on a number of occasions as a platform to criticise research and management measures (e.g. Baboon Matters Trust 2008; Saayman 2008; Yeld 2008). This avenue is justified when drawing attention to legitimate management failures or unethical procedures. However, when this platform was used to generate sensationalist and misleading information about well-grounded, international-standard and ethically approved techniques (GPS tracking collars) it compromised effective management and, more importantly, made parties reticent to re-engage in debate. This particular example speaks broadly to the importance of stakeholders' ability to engage objectively. Indeed, Raik et al. (2005) suggest that in these engagements, technical learning ('efforts to find new policies and accomplish objectives') takes place relatively easily in comparison with conceptual learning ('defining problems and searching for objectives'). Therefore, in these engagements, all parties should be familiar with engagement procedures, agree to certain standards of engagement and if they fail to uphold this agreement, risk exclusion from these decision processes.

These human-human conflicts impacted directly on my own research objectives within this thesis. Having learnt of the BTT's willingness to explore deterrent (e.g. noise and pain aversion) that increase the costs to raiding baboons, I applied for ethical clearance to objectively quantify the efficacy and impacts of such methods on baboons and their raiding frequency. However the NSPCA that sits on the UCT Animal Ethics Committee opposed the testing of these methods, citing concerns that their use would violate the Animal protection Act, by "terrorising" baboons. In light of this conclusion, ethical clearance was withheld with the result that the deterrents were trialled in the absence of any rigorous data collection and the final decision to implement their use was based largely on subjective criteria.

At the international workshop (see above) both local and international researchers voiced concern over such censure of what they considered patently obvious methods to increase the costs of raiding and in so doing, mitigate the conflict. The Baboon Research Unit subsequently met with the NSPCA together with the BTT, and the service provider, NCC to evaluate whether noise (bear bangers) or pain (paintball markers) aversion could qualify as terrorising free-ranging baboons that could choose to move away from the deterrents' stimuli. Convincing data showing that the noise aversion strategy employed by residents in Simon's Town (Chapter 2) decreased the time baboons spent in human environments, as well human-induced injuries and deaths, were pivotal in these debates and ultimately resulted in unanimous agreement that these deterrents were not in violation of the Animal Protection Act and their use should be subject to rigorous assessment within a clearly defined research framework.

Unfortunately this agreement was reached too late for me to include an assessment of either method as originally proposed. Therefore, an opportunity to objectively evaluate a) the efficacy and b) the baboon welfare implications of paintball markers was lost. With hindsight, while I appreciate the conservative approach taken by the NSPCA representative on the UCT ethics committee, or similar agencies mandated to protect wild animals, I suggest that the nature of human-wildlife interactions are becoming increasingly complex and arguably more attention needs to be given to weighing the welfare costs of doing nothing (i.e. allowing conflict to continue) and intervening with a deterrent that imposes some cost to wildlife (see: McMahon et al. 2012; Draper & Bekoff 2013; McMahon et al. 2013) but ultimately offers improved conservation and welfare status.

Evaluation of current management structures for a conflict species

In the context of human-wildlife conflict, where the public can be emotive and decisions are scrutinised critically and extensively, it is crucial that the management structure in place is transparent, informed and collaborative. Based on the history of management in the Cape Peninsula and the literature, it is worth evaluating the current management structure for baboons in the Cape Peninsula. Arguably the greatest change in the previous decade was the separation of civic representatives (BLG) and management authorities (BTT) into two distinct groups. This was associated with a more pronounced division of labour with the latter focussing on short- and long-term management challenges of mitigating conflict and ensuring a sustainable baboon population within a framework of conservation. The civic body (BLG) ensures that the problems experienced within their communities are addressed and that current and pending management decisions are clearly communicated to residents. BLG members are further mandated to identify problems arising within their communities pertaining to increased raiding incentives for baboons (e.g., poor waste management and deliberate feeding) and consequently are aligned closer to the human-human conflict component of human-wildlife challenges. This civil responsibility (versus reliance on ‘governments, NGOs and researchers’) is a key component to successfully resolving human-wildlife conflict (Strum 2010). Representatives of both groups sit on the others’ monthly and quarterly (respectively) meetings to facilitate communication between the groups. Researchers are invited to attend and contribute their latest relevant research findings in addition to providing expert input on discussions pertaining to baboon behavioural ecology.

Currently the only group that previously participated in planning but is no longer involved is the NGO Baboon Matters. Having served as the first service provider to the BMT this NGO has a clear advocacy position that baboons should not be held responsible for poor human behaviours that incentivise raiding behaviour (Baboon Matters Trust 2008). Consequently they oppose the current use of lethal control for habitual raiders offering translocation and/or removal to sanctuaries as an alternative management option. The BLG voted against NGO participation on their civic forum citing potentially conflicting interests (e.g. fund-raising and advocacy positions) that might reduce the size of the management toolbox and hence impact adversely on conflict mitigation. The BLG accepts lethal control of habitual raiders within the current raiding baboon protocol (http://capenature.co.za/docs/1918/).

The tripartite, BTT, is an amalgam of SANParks ("broad conservation function within the borders of the Table Mountain National Park": Proceedings of Baboon Expert Workshop 2009), Cape Nature ("nature conservation and biodiversity management across the province [Western Cape]": Proceedings of Baboon Expert Workshop 2009) and the City of Cape Town (promotion of safe and healthy environment for its residents": Proceedings of Baboon Expert Workshop 2009) and presents an officially united front in managing baboons after signing the Intergovernmental Implementation Protocol in terms of the provisions of Section 35(1) of the Intergovernmental Relations Framework Act No. 13 of 2005. This united front was recently boosted following the inclusion of the Society for the Prevention of the Cruelty of Animals (SPCA) at BTT meetings. In a landmark public meeting the NSPCA and SPCA met with animal rights activists, the NGO Baboon Matters, the BTT, BLG representatives and researchers to discuss current management challenges. At this meeting both the NSPCA and SPCA stated their support for the current management approach (a combination of non-lethal and lethal management) which they consider to be in the best interests of improved welfare and conservation of the Cape Peninsula baboons.

Despite having a successful working relationship, the tripartite alliance members nevertheless face significant challenges pertaining to clear levels of responsibility for baboon management and resourcing the many conflict mitigation strategies involved. This is particularly pertinent given the annual cost of baboon management is high (R13.9 million/year: van Zyl & Barbour in prep.) and has to compete with other more pressing biodiversity challenges. Consequently the tripartite alliance members are involved in a legal dispute to clarify roles and responsibilities for baboon management but encouragingly these higher level deliberations have not impeded managers from the respective organisations addressing current challenges within monthly BTT meetings.

Uniting management groups does not necessarily result in a new and recognisable authority and residents do not yet relate to the BTT as strongly as they do to Baboon Matters – an organisation that identifies strongly with a particular cause and has a prominent spokesperson and whose legacy is reflected in the results of my survey (Chapter 5). The building of this type of profile is essential for authorities if they are to become trusted sources of information (Dunwoody 2007; Jacobson & McDuff 2009). Thus, whatever their differences out of the public eye, it is in the interests of the tripartite alliance within the BTT to invest in building a stronger and more visible identity.

To their credit, the authorities have already taken steps to establish this trust through the transparency of the raiding baboon protocol and through the publicising of each and every euthanasia event in the media. While the removal of 'problem' animals through euthanasia remains a contentious issue (see Treves & Naughton-Treves 2005) and not favoured by residents (Chapter 5), arguably the manner in which the decision to euthanize is taken is one of the more laborious (a case file for each raiding individual is compiled in which incidents of raiding are recorded with affidavits when necessary), objective (negative/dangerous behaviour is considered in the face of mitigating circumstances) and explicit (the protocol, as well information about each euthanasia, is available in the public domain) in wildlife management today. In addition, the final decision regarding the euthanasia is taken by Cape Nature's Wildlife Advisory Committee which is independent of the BTT and can only take decisions within the protocol's framework and based on the evidence presented. This transparency has brought its own challenges as interest groups and individuals fundamentally opposed to lethal control question the evidence presented and the honest implementation of the protocol (e.g. Yeld 2012). This is another example of the difficulty in striking the balance of "Encourag(ing) participation by non-government organisations, communities and other interested parties in baboon management" and ensuring that participation "is consistent with the accepted policy and management plan" (de Villiers Brownlie 2000).

In summary I consider the current baboon management structures to be an improvement for the effective management of the human-baboon conflict in the Cape Peninsula. The combination of multiple, united authorities, structured community representation that interfaces with these authorities and the routine contribution of peer reviewed research findings (Beamish 2009; van Doorn et al. 2010; Hoffman & O’Riain 2011; Kaplan et al. 2011; Drewe et al. 2012; Hoffman & O'Riain 2012; Hoffman & O’Riain 2012a; Hoffman & O’Riain 2012b; Ravasi et al. 2012; Ravasi et al. 2012) relevant to management, ensures broad representation and accountability for the management of a sensitive human-wildlife conflict scenario.

Predictions and final thoughts

What are the long-term implications of the current approach to managing Cape Peninsula baboons? More specifically, what are the implications to baboons and residents of a continued reliance on deterrence through field rangers/monitors armed with bear bangers and paintball guns. Firstly, baboon preference for both low-lying land and human environments makes it likely that baboons will continue to infringe on urban edges (Hoffman 2011). The current deterrent tools have been measurably effective, although they do not render human environments completely impermeable to baboon incursions. These incursions, although erratic in both space and time to residents, will perpetuate the appeal of human environments to raiders. As long as raiding persists, it is reasonable to assume that the occasional individual baboon (generally males) will grow increasingly brazen and ultimately become subject to lethal control using raiding baboon protocol. Critically, these raiding habits are not gained suddenly – they develop over time as a baboon becomes more proficient at raiding through trial and error (Chapter 4). Similarly, these habits are not removed quickly – arguably once preference for human food has been established, it endures through that animal’s lifetime (Strum 2010). So the current juvenile cohort, if not excluded from human environments, will produce at least some aggressive, raiding males in 5 to 8 years. Thus, at a bare minimum, lethal control of habitual raiders is likely to continue over this period. Should conflict-induced baboon mortality remain at current low levels, and the population continue to grow, the number of these aggressive raiding males is likely to increase as well, which, presumably, will increase the number of males that are euthanized. Further, as the cost of managing this population is directly related to baboon numbers, authorities can expect a steady increase in annual costs. This management will also require the continued input of skilled individuals and potentially further research as the population grows and new challenges arise.

This projection is problematic when considering the point made by Councillor Niewoudt (Mayoral Executive Committee Member for Planning and Environment for the City of Cape Town) at the Baboon Expert Workshop in 2009 that for the price of managing two baboons per year, one low-cost house could be built for a human family in need. The cost and management expertise devoted to this small population of non-endangered baboons will also frustrate any number of conservation professionals who have the challenge of stretching modest budgets and who lack sufficient manpower to conserve critically endangered species on the Cape Peninsula and indeed, elsewhere.

Electrified fencing – the Cape Peninsula panacea.

At this point that it is worth considering the possibility of electric fencing as a primary baboon deterrent (working on the assumption that its efficacy matches that achieved in Chapter 2) in the context of the Cape Peninsula. In this fencing scenario, field rangers will continue to be required (e.g. vehicle access points or areas not amenable to fencing) although in reduced numbers. If most urban edges in the Cape Peninsula relevant to human-baboon conflict were to be fenced (a prerequisite for ensured efficacy, see [Huygens & Hyashi 1999]), these costs would far exceed the cost of current methods, in the short-term. But over time, tentative projections indicate that if slowly introduced, electrified fencing can decrease the costs associated with baboon monitors/field rangers by 20% per year for three years until levelling at approximately half of their current levels (van Zyl & Barbour 2013 *in prep*). Those electric fencing costs are independent of baboon numbers and will allow the population to increase until it reaches a dynamic equilibrium which is determined by natural, density-dependent factors (i.e. food and space). In addition, fences are noiseless relative to bear bangers and paintball markers and hence do not disturb wildlife in natural land or humans and domestic animals in neighbouring residential areas. Fences also channel recreational users to specific entry points to the National Park and thus limit off-path walking which, together with monitors chasing baboons, tramples vegetation and exacerbates erosion. Future survey work may need to assess what the impacts of fencing will have on local residents' quality of life as compared with alternative baboon deterrent methods. Fencing also precludes the need for the intensive (dictating troop movement patterns and foraging areas, facilitating male dispersal, treating injured baboons) and sometimes controversial (lethal control) management techniques that are currently required. Lastly and perhaps most importantly in the context of the primary driver of conflict on the Cape Peninsula viz. loss of suitable space (Hoffman & O'Riain 2012c), fences do not require large buffer zones and thus baboons will gain access to existing natural land that is currently serving as a buffer zone between troops and residential areas (see Chapter 2). As a cautionary point, the impact of this fencing on non-target species will need to be explored in future research. It may well emerge that 'fencing in' human environments will be beneficial to local wildlife species (e.g. preventing domestic cats from preying on small mammals: [Woods, Mcdonald & Harris, 2003; Baker *et al.*, 2005a]) but this is only speculative in the absence of data.

The relative parsimony of electric fencing as a solution to human-baboon conflict in the Cape Peninsula is not typical of the majority of human-wildlife conflict mitigation efforts. Ultimately, the most critical aspect for any scientist or manager to understand is that human-wildlife conflict is the meeting point of a number of values and constraints, some of which are in direct opposition. The embodiment of these values by individuals or organisations leads to human-wildlife conflict's greatest contributor – the conflict between humans. These human interactions are complex and their outcomes will rarely bring complete satisfaction to any one party. The role of science in these interactions is to facilitate informed debate, to evaluate actual and potential management actions and perhaps most of all to encourage pragmatism in the face of emotive and divisive issues.

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Appendix 6.1. SWB ranging patterns recorded for a ten-month period, 7 months after the end of the experimental period used in Chapter 2. **235**

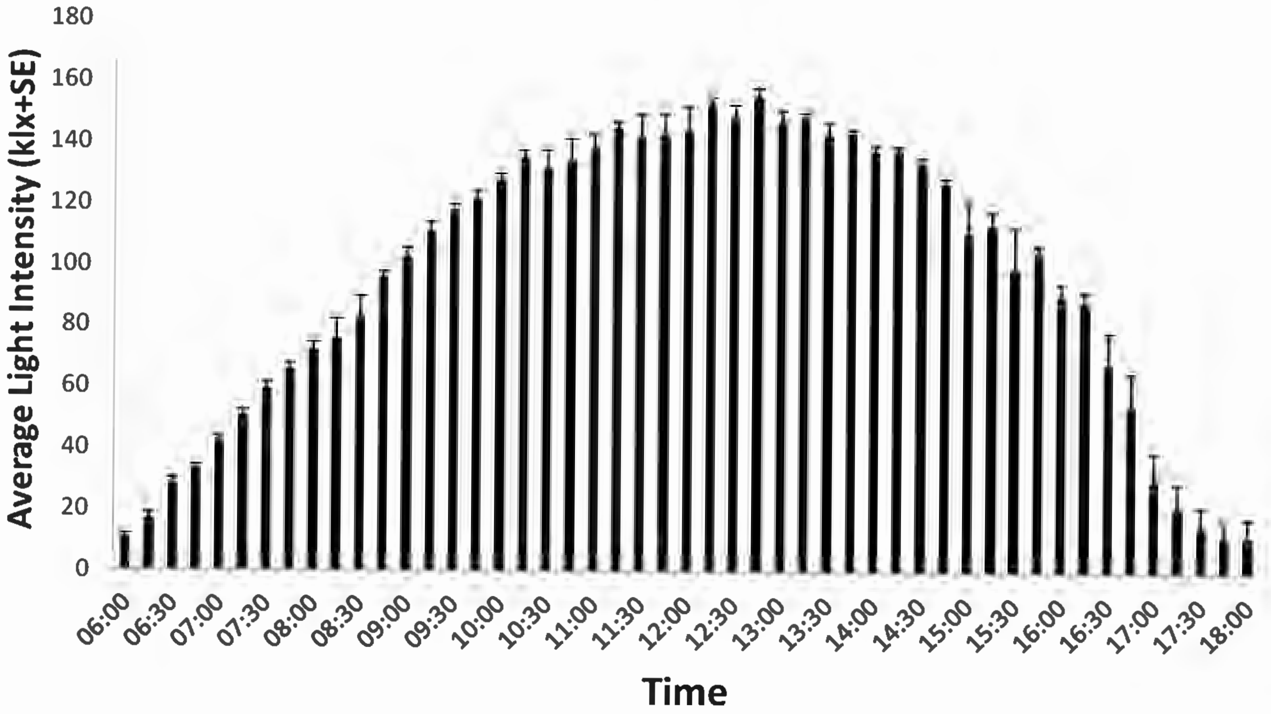
List of Acronyms

ANOVA	Analysis of Variance
CoCT	City of Cape Town
CoGH	Cape of Good Hope Section of the Table Mountain National Park
CTA	Conditioned taste aversion
GIS	Geographic Information System
GPS	Global Positioning System
HWS	Human-Wildlife Services
NCC	NCC Environmental Services
SANParks	South African National Park
TMNP	Table Mountain National Park
UCT	University of Cape Town

Baboon troops

DG	Da Gama
JT	John Travolta Troop
MT	Mountain Troop
SWB	Smitswinkel Bay
WT	Waterfall Troop

APPENDICES



Appendix 2.1. Light intensity recorded every 15 minutes during the experimental period with WT. Recordings were made in Watt/m^2 (converted to klux in the figure above) with a portable photometer. Cloud coverage during this period was minimal, reflected by the low variation in light intensity at each interval.

Appendix 2.2. Spatial overlap (km^2) between six kernel density estimates (50% contour/core use area; 95% contour/general use area) of SWB and three human environments, namely (a) Simon's Town, (b) Miller/Marlin and (c) Viewpoints before (Baseline) and after (Experiment) bear bangers were employed. For both the baseline and experiment, the kernels were developed for five, two-month periods (1, 2, 3, 4 & 5). Significant differences between mean values are indicated with '*' or '**'.

		Time Period	Area of General Use (km^2)	Area of Core Use (km^2)
a) SIMON'S TOWN	**Baseline**	1	2.53	0.22
		2	0.68	0.09
		3	0.66	0.05
		4	0.68	0.21
		5	1.81	0.25
		Mean	1.11*	0.17**
		Std. Err.	0.36	0.04
	Experiment	1	0	0
		2	0	0
		3	0	0
		4	0	0
		5	0	0
		Mean	0*	0**
		Std. Err.	0	0
b) MILLERS / MARLIN	**Baseline**	1	0.13	0.03
		2	0.13	0
		3	0.13	0
		4	0.13	0
		5	0.13	0.006
		Mean	0.13*	0.006
		Std. Err.	0.0003	0.005
	Experiment	1	0.12	0
		2	0.12	0
		3	0.13	0
		4	0.13	0
		5	0.07	0
		Mean	0.11*	0
		Std. Err.	0.01	0
c) VIEWPOINT	**Baseline**	1	0.13	0
		2	0.13	0
		3	0.13	0
		4	0.13	0
		5	0.13	0
		Mean	0.13	0*
		Std. Err.	0	0
	Experiment	1	0.13	0.03
		2	0.13	0.08
		3	0.13	0.08
		4	0.13	0.05
		5	0.13	0.05
		Mean	0.13	0.08*
		Std. Err.	0	0.01

Appendix 2.3. Percentage of GPS points recorded for SWB in three human environments (Simon's Town, Miller/Marlin & Viewpoints) before (Baseline) and after (Experiment) bear bangers were implemented. The baseline and experiment are represented by five, two-month periods (1, 2, 3 etc.). Significant differences between mean values are indicated with '*' or '**' or '***'

	Time Period	Simon's Town (%)	Miller/Marlin (%)	Viewpoints (%)
Baseline	1	22.51	5.24	1.05
	2	14.48	5.05	2.77
	3	16.67	3.66	2.03
	4	19.14	2.39	1.91
	5	23.73	2.54	1.27
	Mean	19.31*	4.09**	1.79***
	Std. Err.	1.73	0.49	0.29
Experiment	1	0	1.61	5.22
	2	0.21	1.29	12.23
	3	0	1.25	7.5
	4	0	0.93	9.35
	5	0	1.05	2
	Mean	0.04*	1.23**	7.26***
	Std. Err.	0.04	0.11	1.75

Appendix 2.4. Percentage of GPS points recorded for SWB in three human environments (Simon's Town, Miller/Marlin & Viewpoints) before (Baseline) and after (Experiment) bear bangers were implemented, corrected for the area of each zone. The baseline and experiment are represented by five, two-month periods (1, 2, 3 etc.). Significant differences between mean values are indicated with '*' or '**'.

	Time Period	Simon's Town (%/km^2)	Miller/Marlin (%/km^2)	Viewpoints (%/km^2)
Baseline	1	7.79	39.66	7.89
	2	5.01	38.26	20.29
	3	5.77	27.72	15.31
	4	6.62	18.12	14.42
	5	8.21	19.26	9.58
	Mean	6.68*	28.61**	13.5***
	Std. Err.	0.6	4.55	2.2
Experiment	1	0	12.17	39.34
	2	0.07	9.75	92.16
	3	0	9.47	56.51
	4	0	7.08	70.42
	5	0	7.97	15.31
	Mean	0.02*	9.29**	54.75***
	Std. Err.	0.02	0.87	13.12

Appendix 2.5. Spatial overlap (km^2) between six kernel density estimates (50% contour/core use area; 95% contour/general use area) of JT and three human environments, namely a) Zwaanswyk, b) Chrysalis and c) Picnic Site before (Baseline) and after (Experiment) electric fencing was erected around Zwaanswyk. For both the baseline and experiment, the kernels were developed for five, one-month periods (1, 2, 3, 4 & 5). Significant differences between mean values are indicated with '*'.

		Time Period	Area of General Use (km^2)	Are of Core Use (km^2)
a) ZWAANSWYK	Baseline	1	0.63	0.16
		2	0.86	0.19
		3	0.29	0
		4	0.16	0
		5	1.55	0.15
		Mean	0.70*	0.10
		Std. Err.	0.25	0.04
	Experiment	1	0.03	0
		2	0.02	0
		3	0	0
		4	0	0
		5	0	0
		Mean	0.01*	0
		Std. Err.	0.01	0
b) CHRYSALIS	Baseline	1	0.03	0
		2	0.21	0.01
		3	0.48	0.12
		4	0.37	0.02
		5	0.04	0
		Mean	0.23	0.03
		Std. Err.	0.09	0.02
	Experiment	1	0	0
		2	0.11	0
		3	0.21	0
		4	0.14	0
		5	0.13	0
		Mean	0.12	0
		Std. Err.	0.03	0
c) PICNIC SITE	Baseline	1	0	0
		2	0.06	0.06
		3	0.06	0.03
		4	0.06	0.02
		5	0.01	0
		Mean	0.04	0.02
		Std. Err.	0.01	0.01
	Experiment	1	0	0
		2	0.06	0
		3	0.05	0
		4	0	0
		5	0.02	0
		Mean	0.03	0
		Std. Err.	0.01	0

Appendix 2.6. Percentage of GPS points recorded for JT in three human environments (Zwaanswyk, Chrysalis & Picnic Site) before (Baseline) and after (Experiment) electric fencing was erected around Zwaanswyk. The baseline and experiment are represented by five, one-month periods (1, 2, 3 etc.) and the five-month combination of those periods (All). Significant differences between mean values are indicated with '*'.

	Time Period	**Zwaanswyk (%)**	**Chrysalis (%)**	**Picnic Site (%)**
Baseline	1	40.71	0	0
	2	24.17	5	5
	3	4.51	23.31	4.51
	4	7.58	23.48	3.79
	5	27.54	1.45	0
	Mean	20.9	10.65	2.66
	Std. Err.	6.68	5.27	1.1
Experiment	1	0	0.54	0
	2	0	1.55	1.55
	3	0	9.68	1.61
	4	0	16.19	0.58
	5	0	6.29	0
	Mean	0	6.85	0.75
	Std. Err.	0	2.85	0.36

Appendix 2.7. Percentage of GPS points recorded for JT in three human environments (Zwaanswyk, Chrysalis & Picnic Site) before (Baseline) and after (Experiment) electric fencing was erected around Zwaanswyk, corrected for the area of each zone. The baseline and experiment are represented by five, one-month periods (1, 2, 3 etc.) and the five-month combination of those periods (All).

	Time Period	**Zwaanswyk (%/km^2)**	**Chrysalis (%/km^2)**	**Picnic Site (%/km^2)**
Baseline	1	57.16	0	0
	2	33.93	8	84.35
	3	6.33	37.3	76.11
	4	10.64	37.58	63.9
	5	38.66	2.32	0
	Mean	29.34	17.04	44.87
	Std. Err.	9.38	8.43	18.61
Experiment	1	0	0.86	0
	2	0	2.47	26.09
	3	0	15.49	27.21
	4	0	25.9	9.75
	5	0	10.07	0
	Mean	0	10.96	12.61
	Std. Err.	0	4.57	6

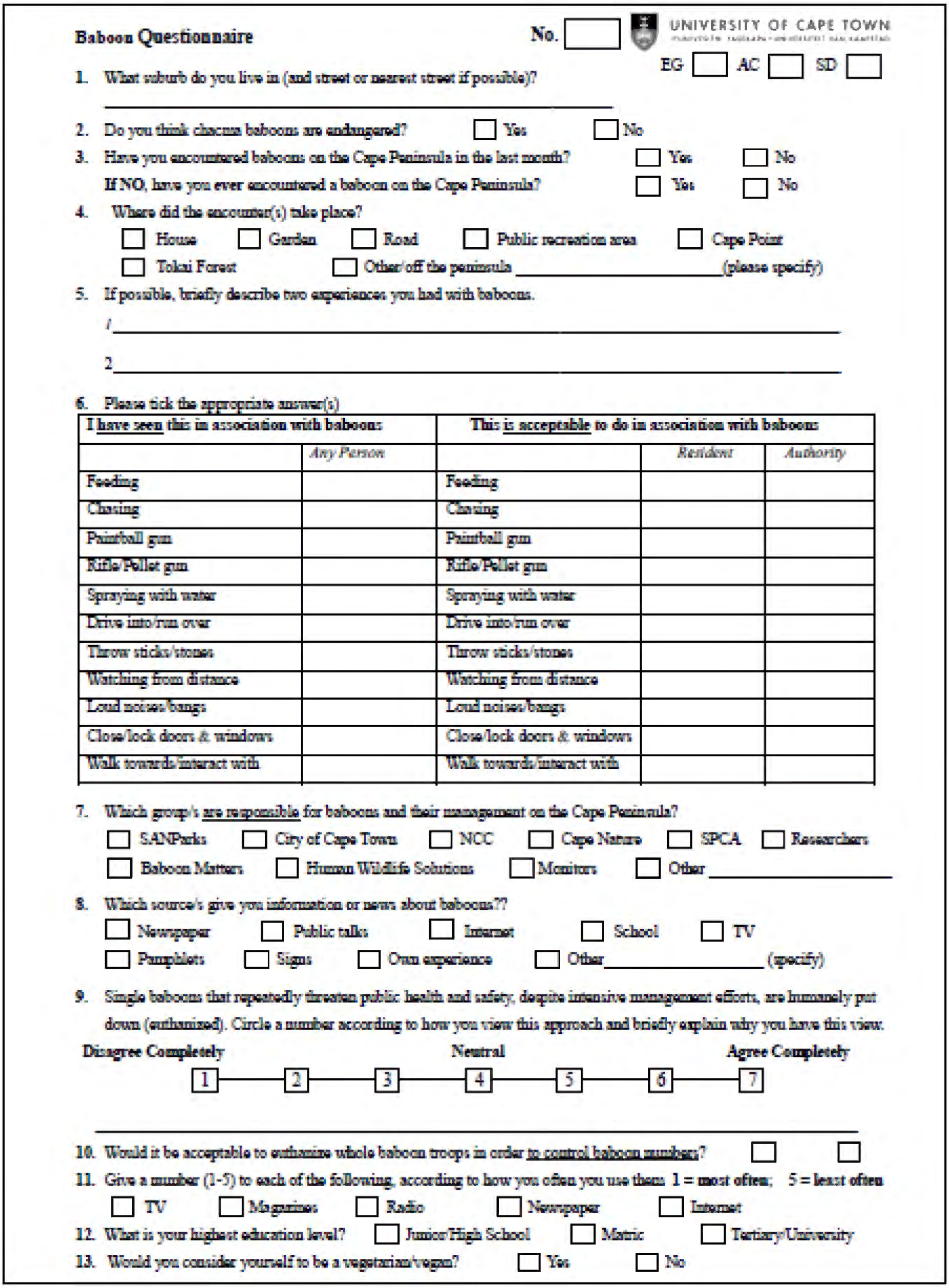
Appendix 4.1 Ranks of individuals within MT calculated using Normalised David's Scores (NDS) obtained from ad-libitum records of dyadic supplant/displace interactions.

Rank #	Sex	ID	Normalised David's Score
1	1	PP	15.43378
2	1	Cr	14.08106
3	2	WB	13.28923
4	1	En	13.20029
5	1	Pop	12.58574
6	1	DB	12.54264
7	1	Ja	12.31578
8	1	MB	12.25558
9	2	De	11.97979
10	1	Sa	11.95711
11	2	Ha	11.9391
12	2	BP	11.89478
13	2	Co	11.73221
14	2	Ni	11.70774
15	2	JS	11.68698
16	2	Sh	11.62415
17	2	Qu	11.60832
18	1	CG	11.57861
19	2	CE	11.54929
20	2	SL	11.41718
21	1	Gi	11.06804
22	2	Ma	11.0679
23	2	PJ	10.89006
24	2	Po	10.71282
25	2	Ho	9.88183
Modified Landau's h	0.2990437		
p	p<0.001		

Appendix 4.2. Ranks of individuals within DG calculated using normalised David's Scores (NDS) obtained from ad-libitum records of dyadic supplant/displace interactions.

Rank #	Sex	ID	Normalised David's Score
1	Male	Fo	12.26736
2	Male	JH	11.32414
3	Female	Sa	11.15421
4	Female	Po	10.9958
5	Male	Di	10.79263
6	Female	BA	10.34642
7	Male	Mo	10.28315
8	Female	Ne	10.17636
9	Male	El	10.04837
10	Male	JD	9.75608
11	Female	An	9.70425
12	Female	Pr	9.66101
13	Female	Tip	9.60689
14	Female	Ko	9.52393
15	Female	SS	9.4734
16	Female	Ma	9.4664
17	Female	Ti	9.34858
18	Male	Ho	9.25051
19	Female	Ra	9.01584
20	Male	Ca	8.91646
21	Female	At	8.88819

Modified Landau's h	1.233766
p	0.011



Baboon Questionnaire **No.** ☐

UNIVERSITY OF CAPE TOWN

EG ☐ AC ☐ SD ☐

1. What suburb do you live in (and street or nearest street if possible)?

____

2. Do you think chacma baboons are endangered? ☐ Yes ☐ No
3. Have you encountered baboons on the Cape Peninsula in the last month? ☐ Yes ☐ No

   If NO, have you ever encountered a baboon on the Cape Peninsula? ☐ Yes ☐ No
4. Where did the encounter(s) take place?

   ☐ House ☐ Garden ☐ Road ☐ Public recreation area ☐ Cape Point

   ☐ Tokai Forest ☐ Other/off the peninsula __________________(please specify)
5. If possible, briefly describe two experiences you had with baboons.

   1 ____

   2 ____
6. Please tick the appropriate answer(s)

I have seen this in association with baboons		This is acceptable to do in association with baboons		
	Any Person		*Resident*	*Authority*
Feeding		Feeding		
Chasing		Chasing		
Paintball gun		Paintball gun		
Rifle/Pellet gun		Rifle/Pellet gun		
Spraying with water		Spraying with water		
Drive into/run over		Drive into/run over		
Throw sticks/stones		Throw sticks/stones		
Watching from distance		Watching from distance		
Loud noises/bangs		Loud noises/bangs		
Close/lock doors & windows		Close/lock doors & windows		
Walk towards/interact with		Walk towards/interact with		

7. Which group/s are responsible for baboons and their management on the Cape Peninsula?

   ☐ SANParks ☐ City of Cape Town ☐ NCC ☐ Cape Nature ☐ SPCA ☐ Researchers

   ☐ Baboon Matters ☐ Human Wildlife Solutions ☐ Monitors ☐ Other ______________
8. Which source/s give you information or news about baboons??

   ☐ Newspaper ☐ Public talks ☐ Internet ☐ School ☐ TV

   ☐ Pamphlets ☐ Signs ☐ Own experience ☐ Other______________(specify)
9. Single baboons that repeatedly threaten public health and safety, despite intensive management efforts, are humanely put down (euthanized). Circle a number according to how you view this approach and briefly explain why you have this view.

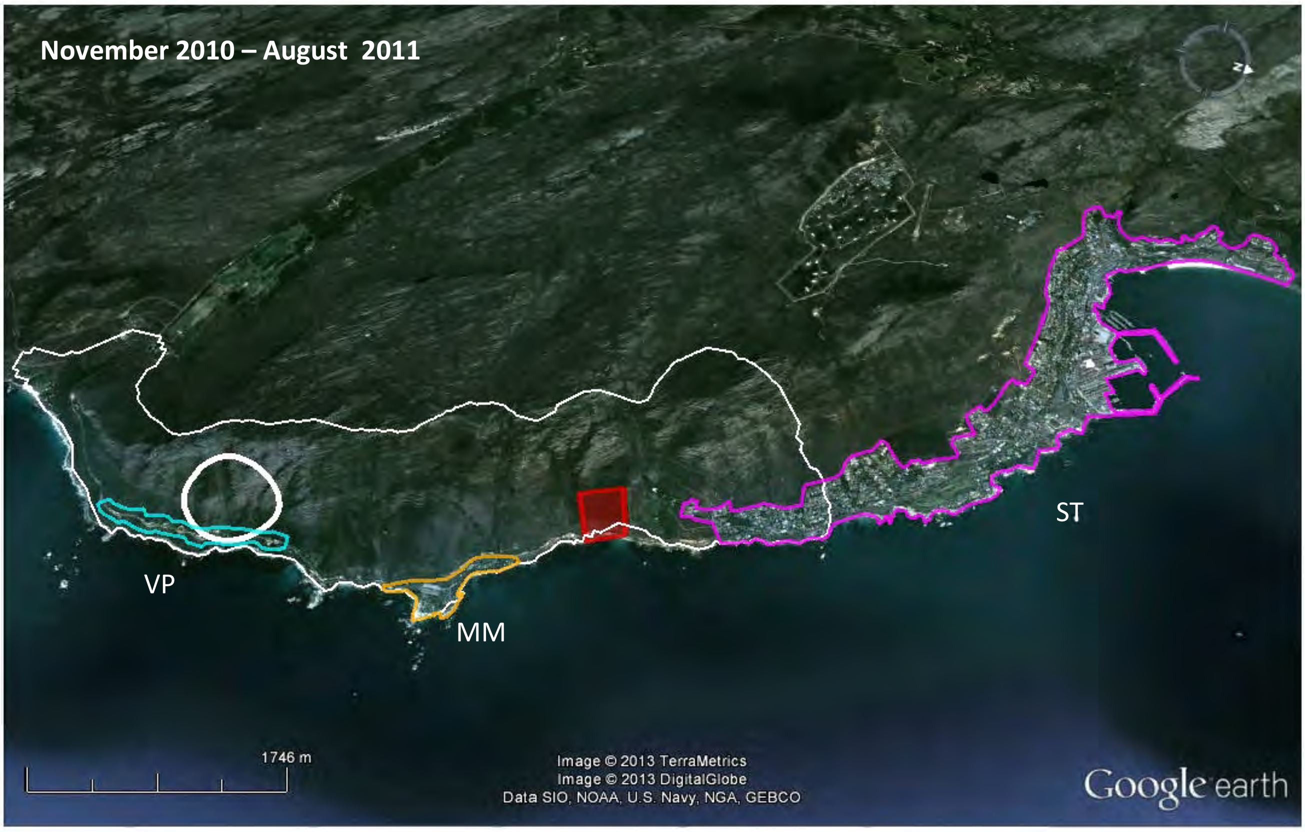
   Disagree Completely **Neutral** **Agree Completely**

   1 — 2 — 3 — 4 — 5 — 6 — 7

   ____
10. Would it be acceptable to euthanize whole baboon troops in order to control baboon numbers? ☐ ☐
11. Give a number (1-5) to each of the following, according to how you often you use them **1 = most often; 5 = least often**

    ☐ TV ☐ Magazines ☐ Radio ☐ Newspaper ☐ Internet
12. What is your highest education level? ☐ Junior/High School ☐ Matric ☐ Tertiary/University
13. Would you consider yourself to be a vegetarian/vegan? ☐ Yes ☐ No

Appendix 5.1. Survey conducted on Cape Peninsula residents



Appendix 6.1. Kernel density estimates of SWB (bold white: 50% contour/core use area: thin white: 95% contour/general use area) for a 10-month period (November 2010 – August 2011), seven months after the end of the bear banger experimental period. Coloured polygons indicate the three urban zones (pink: Simon's Town/ST; orange: Miller/Marlin/MM; blue: Viewpoints/VP) and the red band indicates the area in which bear bangers were deployed during the experiment.