A strategic interdisciplinary approach for non-lethal pigeon control on the University of South Africa's Muckleneuk campus

by

EMMA HARRIS

submitted in accordance with the requirements for
the degree of

MASTER OF SCIENCE

in the subject

ENVIRONMENTAL SCIENCE

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: MS A WILSON

JOINT SUPERVISOR: DR EP DE CROM

AUGUST 2016

DECLARATION

Name: Emma Harris

Student number: 51812363

Degree: Master of Science (Environmental Science)

I declare that **A strategic interdisciplinary approach for non-lethal pigeon control on the University of South Africa's Muckleneuk campus** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

01.08.2016

SIGNATURE DATE
(Ms E Harris)

ACKNOWLEDGEMENTS

This study would not have come to be without the perseverance and support of my primary supervisor, Ann Wilson. Thank you for your guidance, patience and attention to detail. Your support has extended beyond that of academics and for that I am immensely grateful. To Dr Nellie de Crom, my joint-supervisor, thank you for your qualitative guidance and consistent background support.

Thank you to the Applied Behavioural Ecological & Ecosystem Research Unit (ABEERU), in particular to Professor Leslie Brown at the University of South Africa, the National Research Foundation (NRF) and University Estates for the funding of this research.

To my family - Judy, Amy and Reilly who should have earned an honorary degree for the support, cheerleading and pigeon enthusiasm you never ceased to provide. I am truly grateful.

Santa Barbara, your love of birds has lived on in the pigeons.

ABSTRACT

Often perceived as pests, pigeon control is applied without investigating environmental, ecological and anthropogenic factors which affect their populations and response to controls. Estate Management of the University of South Africa's Muckleneuk campus identified a need to investigate and address a perceived pigeon problem.

Staff perceptions regarding the presence and attitude towards control of the pigeons was undertaken through an online Survey Monkey questionnaire and semi-structured interviews until saturation was achieved. It was determined that the assumed negative perception towards the pigeons was in fact incorrect. Participants would rather encourage the nesting and breeding activities of pigeons on campus, as they felt that the human–pigeon interactions and viewing of squabs in nests contributed positively to their work environment. Participants did not consider the pigeons or their related activities to pose a problem. It was felt that should control be imposed, the birds should rather be humanely managed through non-lethal measures rather than eradication.

Pigeon numbers on five buildings on the University's campus were counted at dawn and dusk, every week, for two years. The first year provided baseline data and the second year was when control measures were applied. The study determined that the pigeon population index fluctuated seasonally while breeding occurred throughout the year, with notable peaks and declines relating to physiological and population dynamics. The pigeons seemed to make opportunistic use of crop availability in surrounding farmlands during optimal production periods, while conserving energy when not favourable. Site selection in relation to building aspect indicated significant differences in all the seasons except for winter, while a positive significant relationship between level height and pigeon number was recorded.

Once the control measures were applied, the total pigeon index on the campus declined by 50%. Control structures differed significantly in efficacy. Bird spikes indicated the highest efficacy at reducing the pigeon population index and seasonality did influence this efficiency. Birds of prey and an audio bird scarer were used to compare actual versus implied predator presence, it was determined that there was an association between method of scaring and the number of pigeons observed on the different time periods. Pigeons were observed to continue the natural trend of dispersion and return at the dawn and dusk counts during the audio bird scarer trial without being actively discouraged or dislodged from the building. Pigeons reacted positively to the visual raptor presence, which caused them to take flight from the buildings. The visual effect was only temporary however as pigeons returned once the threat had been removed 10 minutes post scare.

The studies concluded in an interdisciplinary management plan presented to the University Estates.

KEYWORDS

Pigeon control; Non-lethal; Humane; Bird spikes; Eagle Eyes™; Fire Flags; Birds of prey; BirdXPeller PRO™; Public perceptions; Green university.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER ONE: INTRODUCTION

Urbanisation

Urbanisation is interconnected with sustainable environmental management. According to United Nations Department of Economic and Social Affairs (2014), more than half the world's total population has already been urbanised, with most of the planet's urban population to be concentrated in Asia and Africa by the year 2050. Over 60% of Africa's population will be living in urban areas by the year 2050 (Department of Cooperative Governance and Traditional Affairs, 2014). Even though urban development takes up a relatively small percentage of the world's surface area, its environmental impacts and effects are extensive and, more often than not, detrimental. According to Jokimaki, Kaisanlahti-Jokimaki, Sorace, Fernandez-Juricic, Rodriguez-Prieto & Jimenez (2005), urban environments have large scale consequences on the abundance and distribution of wildlife species and animal communities. Unmodified areas are diminishing and with them a reduction in species and ecological diversity resulting in a homogenisation of the biosphere (Lawton, 1998; Luniak, 2004).

The population division of the United Nations Department of Economic and Social Affairs (2014) has predicted that the world's urban population will reach 6.3 billion by 2050, an increase of more than two thirds. This will no doubt result in an increased pressure on species composition, abundance and diversity in urban environments. Environmental pressure is compounded by people's ability to influence wildlife through habitat loss, anthropogenic food provision, the protection of popular species and the eradication of species considered to be pests (Shochat, Lerman & Fernandez-Juricic, 2010; Krimowa, 2012).

Even though cities have played a significant role in the transformation of natural environments and the species that depend on their resources, Shochat *et al*. (2010) explains that urban settings should not be viewed as lost habitat but instead new habitat with free ecological niches. Built-up environments are considered to be unique ecosystems characterised by high food abundance (Hadidian, 2007), permanent water supply (Hadidian, 2007), protective shelter (Hadidian, 2007), low predator abundance (Hadidian, 2007; Tsurim, Abramsky & Kotler, 2008), and milder micro-climates (Jokimaki *et al*., 2005). As a result of the creation of new habitats, Haag-Wackernagel (2008) suggests that learning and genetic adaptability is required for species to not only survive, but thrive by exploiting the conditions of urbanised spaces. Commensal species, in particular Feral Pigeons (*Columba livia*) and Speckled Pigeons (*Columba guinea*) are favoured by urban ecosystems as they dominate and monopolise resources by their incredible ability to exploit and adapt to human lifestyles (Shochat *et al*., 2010).

Urban ecology

Krebs (2001) defines the study of ecology as the relationship between animals and their environments, a field of study primarily focussed on wildlife within their original habitats. However, Shochat *et al*. (2010) suggest that urban ecosystems should function as its natural counterparts, as certain species of wildlife have had to adapt and flourish within man-made borders as a result of diminishing original habitats.

Ryan (2011) considers the application of traditional ecology to commensal species in developed settings to be beneficial to understanding ecosystems in the world today.

Luniak (2004) states that wildlife can be enriched and managed in urban spaces, an idea confirmed by Sarvard, Clergeau and Mennechez (2000) who believes that natural biodiversity concepts can be applied to efficiently manage and maintain wildlife existing in urban environments. In order for this to be achieved one needs to realise that urbanisation has profoundly transformed landscapes significantly impacting on ecological systems and wildlife (Priego, Breuste& Rojas,2008). Wildlife which remains exists in harmony or discord with people. Management of wildlife populations and their relationships with people both play significant roles in the maintenance of urban bionetworks.

Urban ecology is an important concept because as Krimowa (2012) points out, urban populations are predictedto continue to increase along with their expanding modified habitats. Included in the study is the awareness of environmental issues, which are becoming more complex, multidimensional and interconnected (Alshuwaikhat & Abubakar, 2008). As most of the world's population live in cities, conservation initiatives and environmental understanding depend on these very people for their success and sustainability (Krimowa, 2012). Mooallem (2006) explains that besides from essential resources, wildlife live and die according to how willing people are consider and tolerate them. Krimowa (2012) expresses that interaction with limited wildlife within developed areas, and the general annoyance relating to commensal species can affect conservation projects and general environmental awareness. Nonetheless environmental experiences influence peoples' attitudes towards wildlife, and more importantly these attitudes influence peoples' behaviour and intentions towards the environment (Fransson & Garling, 1999). It is therefore essential that we try and understand what shapes peoples' attitudes towards urban wildlife. Seamans and Blackwell (2011) describes how interaction and exposure to urban wildlife can enhance or detract from peoples' quality of life. Clashes between man and beast most often occur when wildlife are in conflict with peoples' economic, aesthetic or vital interests (Wetherbee, Coppinger, Wenthworth & Walsh, 1964), or when they are considered to have transgressed the boundary and spaces defined for humans only (Jerolmack, 2008).

Human – wildlife conflict

With the continued rise in human populations and development, uneasy cohabitations between people and wildlife occur more and more frequently (Jerolmack, 2008). As urban species are the main source of human-wildlife interaction and subsequent conflict, people's attitudes are in turn influenced. This results in a polarised view of the urban bio community (Temby, 2004). Human–wildlife conflict occurs when 'the needs and behaviour of wildlife impact negatively on people's goals or when these goals negatively impact on the needs of wildlife' as defined by the World Parks Congress Recommendation (2003).

Jerolmack (2008) indicates that people are less tolerant of urban wildlife; an observation which may be linked to a general deep felted cultural anxiety about the disorder wildlife tends to bring to an ideally ordered and sanitised city. People have indicated standardised views about the placement and belonging of certain species (Michael, 2004). Distinct ontological zones for non-humans where their presence in urban environments is considered to be out of place unless compartmentalised, controlled, subdued or civilised (Philo 1995). Conflict with wildlife is considered to be culturally mediated as Jerolmack (2008) explains; the way we place animals reveals our idea of nature and society; something that we want to keep separate from the other (Latour, 1993). It may also be referred to as a social disorder which reveals itself when people and untamed wildlife collide in urban environments (Douglas, 1966).

Peoples' attitudes influence their behaviour and tolerance towards wildlife that they consider to have defied human and non-human boundaries. Conflict often arises when people have a lack of tolerance, low environmental awareness and negative attitudes towards wildlife (Krimowa, 2012). This is especially relevant as an animal's value is often based on its usefulness to the human race (Jerolmack, 2008). It may therefore be considered that an animal's worth may appreciate in rank simply from a change in human attitude.

Human–wildlife companionship

As humans and non-humans become increasingly part of each others' lives in urban environments (Michael, 2004), research is focusing more and more on the interactions between people and nature (Matusoka & Kaplan, 2008). Priego *et al.*(2008) describe the many ways in which frequent contact and exposure to nature can contribute to an improved quality of life, enhanced environmental awareness and perception of environmental problems in comparison to those who have limited contact with wildlife and nature. Sanders (2003) explains the positive impact that interacting with animals has on the physical and psychological states of people resulting in an improved state of well being. These interactions have also been recognised for their therapeutic ability and utility amongst people (Keniger, Gaston, Irvine & Fuller, 2013).

According to Matusoka and Kaplan (2008), people who live in cities express a desire to have contact with nature, even if the only wildlife accessible to them is commensal species. They consider it a need in order to fulfil personal development, pursue general well being and achieve an improved quality of life (Priego *et al*. 2008).

The relevance and contribution of human-wildlife interaction, whether as a source of conflict or companionship should not be overlooked or underestimated. This interaction may involve a recognised source of conflict (Ryan, 2011) such as pigeons, however its value surpasses controversy as it may be the only daily contact people have with a living creature (Lawton, 1998).

Pigeons

Speckled pigeon (*Columba guinea* Linnaeus, 1758) and Feral pigeon (*Columba livia* Gmelin, 1789) (hereafter referred to collectively as pigeons) were first described by Gmelin in 1789 (Geigenfeind, 2013). These species are in fact only separated by genetic variation. Darwin described that the breeds and variations of Feral Pigeon are variants and descendents of the Speckled Pigeon (previously known as the Rock Pigeon) (Stringham, Mulroy, Xing, Record, Guernsey, Aldenhoven, Osborne & Shapiro, 2012); which originally descended from the coastal and inland cliffs of the central and western Paleartic, northern Ethiopia and Indian subcontinent regions (Goodwin, 1983). Over the centuries pigeons have evolved to display a remarkable distinction in traits and characteristics representing a diverse gene pool (Stringham *et al.* 2012). Haag-Wackernagel (1995) explains that this variation has been predominantly achieved through the extensive genetic selection by man, as characteristics have been adapted and changed over time to meet the needs and desires for ornamental, racing and domesticated purposes (Hutton & Dobson, 2007).

According to Geigenfeind (2013), Mooallem (2006) and Sossinka (1982) pigeons were among the first species to be domesticated by man more than 5000 years ago as a source of food. Their high reproductive rate, ability to habituate to humans (Magnino, Haag-Wackernagel, Geigenfeind, Helmecke, Dovc, Prukner-Radovcic, Residbegovic, Ilieski, Laroucau, Donati, Martinov & Kaleta, 2009) and loss of male aggressiveness due to the selective reduction in their strong territorial character (Haag-Wackernagel, 1995; Magnino *et al.* 2009); has resulted in an apt evolved ability to establish populations in most urban centres worldwide.

Considered to be the most successful colonisers of urban environments (Haag-Wackernagel, Heeb & Leiss, 2006), pigeons are found on every continent except Antarctica (Reinke, 1959; Lawton, 1998). Johnston and Janiga (1995) stated that while the earliest observation of pigeons was documented in London in 1385, they only started causing problems to humans in the 1930s (Sacchi,, Gentilli, Razzetti & Barbieri, 2002). Pigeons were first brought to southern Africa by the early Europeans in the seventeenth century (Brooke, 1981). Since then pigeons are found extensively throughout South Africa, with concentrated populations in urban settlements and across agricultural landscapes, with preference for sorghum, maize and sunflower fields (van Niekerk, 2003; van Niekerk & van Ginkel, 2004). Elsewhere in the world they were introduced and utilised for agricultural purposes, considered to be eaten like poultry (Fitzwater, 1988; Pimentel, Lach, Zuniga & Morrison, 1999).

Historically pigeons have been recorded to conjure up positive, heavenly images (Crossland, 2007), represent fertility (Flannery, 2009), peace (Flannery, 2009), be a food source (Driscoll, Macdonald & O'Brien, 2009), and were scarified as a sacred gift to the Egyptian god Amon (Flannery, 2009). More recently humans consider pigeons to enrich urban environments (Magnino *et al*. 2009), allow a connection to nature (Flannery, 2009), be a tourist attraction (Magnino *et al*. 2009) and provide a cleaning up function in city landscapes (Magnino *et al*. 2009). Similarly people also consider them to be pests and a source of nuisance (Keenan, 2000), presenting a health hazard (Hutton & Rostron, 2005), physically deteriorating infrastructure with their flocking, droppings and nesting material (Giunchi, Albores-Barajas, Baldaccini, Vanni & Soldatini, 2012) as well as psychologically and intrinsically degrading urban spaces with the perceived sense of social disarray (Jerolmack, 2008).

Food availability and buildings for roosting and nesting are the key ecological factors attracting pigeons to urban environments (Haag-Wackernagel, 1995). Haag-Wackernagel and Bircher (2010) has estimated that there are between 170 and 340 million pigeons worldwide, an average of one pigeon for every 10–20 people living in cities (Johnston & Janiga, 1995). Guinchi *et al.* (2012) suggests that pigeons are linked to people, an important factor in their survival (Hutton & Rostron, 2005). This relationship is supported by Haag-Wackernagel (1987, 1995) who found that the number of pigeons in an urban setting is directly and indirectly related to the number of people inhabiting the same space.

Pigeons obtain their adult plumage at six months of age around the same time as their ability to breed commences (Murton, Thearle & Thompson, 1972), potentially producing up to 10 or 12 broods per annum (Murton, Thearle & Thompson, 1972; Haag-Wackernagel, 1984). Male and female pigeons pair for life (Levi, 1957; Ryan, 2011). A long breeding season, with a peak between spring and summer, is typical of pigeons in urban environments (Johnston & Janiga, 1995; Hetmanski, 2004); however they can breed consistently year round when permanent resources are available. Nests are simple (Ryan, 2011), built in safe and sheltered openings in buildings (Krimowa, 2012) which resemble a cave or crevice that their ancestors would have used in rock cliffs (Haag-Wackernagel, 1998). One to two eggs are laid per breeding cycle (Krebs, 1974; Hutton & Rostron, 2005; Ryan, 2011), incubation is shared (Hetmanski & Wolk, 2005; Rose, Nagel & Haag-Wackernagel, 2006) and the squabs which hatch 18 days after laying are tended to by both parents (Krebs, 1974). Juveniles fledge 28–32 days after hatching, whereby they may disperse to other low density breeding flocks (Giunchi *et al.* 2012), but as Murton, Thearle and Coombs (1972) explains the site where they were born often offers the best breeding prospects resulting in juveniles remaining in their parent flocks.

Pigeon flocking enhances foraging efficiency and contributes to predator avoidance (Krebs & Davies, 1993). Ryan (2011) indicates that flocks are either stable, unstable or both, as pigeons may feed with one flock but roost with another (Murton, Thearle & Coombs, 1972). However, most of the pigeons will remain in the same flock, participating in similar activities (Sol & Senar, 1995). Flock size will also vary as not all individuals in the flock feed at the same time (Murton, Thearle & Coombs,1972; Buijs & van Wijnen, 2001). Soldatini, Mainardi, Baldaccini and Giunchi (2006) reported that pigeons flew out of cities in pairs or small groups, presumably to feed in neighbouring agricultural areas. The returning flock was often greater than the departing flock indicating that the benefits of flocking with regards to reducing predation risk when flying home to roost outweighed the costs involved.

Pigeons have retained the foraging habits of their ancestors who utilised agricultural fields as their primary source of food (Hewson, 1967), often flying 15–20 km daily (Earle & Little, 1993; Little, 1994) to feed on cereals. Pigeons in South Africa feed extensively on sunflower seeds, maize and sorghum (van Niekerk, 2003; van Niekerk & Van Ginkel, 2009; Collett, 2015). However in an effort to adapt to urban environments they have developed new foraging strategies and patterns, in addition to agricultural feeding, to exploit alternative potential food resources (Rose *et al.* 2006). They have become one of the most efficient urban foragers due to their dominance and ability to hamper the foraging of subordinate avian species (Shochat *et al*., 2010). Anthropogenic refuse, exotic vegetation, bird feeders (Shochat *et al*., 2010) and direct human feeding (Haag-Wackernagel, 1995; Mooallem, 2006; Haag-Wackernagel, 2008; Jerolmack, 2008) all contribute to urban pigeons' subsistence. Pigeons are granivores by nature, but have evolved to being omnivorous in order to utilise a wider food supply (Ryan, 2011). Research has shown that they display bimodal feeding activity (Johnston & Janiga, 1995; Baldaccini, Giunchi, Mongini, Ragionieri, 2000; Soldatini *et al*. 2006), the result of alternating sexes on the nest as described by Soldatini *et al*. (2006).

Smythe (1975) explains that their monocular and colour vision allows for food and sex recognition as well as improved orientation in flocks, while their ability to perceive ultra violet rays facilitates signalling, foraging and species recognition (Bennett & Cuthill, 1994). They have a superior hearing ability for communication and navigation (Hamershock, 1992) enabled by their ability to regenerate hair cells (Langemann, Hamann & Frieb, 1999) and react to infrasound (Hamershock, 1992; Dobeic, Pintaric, Vlahovic & Dovc, 2011).

The average lifespan of pigeons is a mere three years (Johnston & Janiga, 1995), short relative to its size; nevertheless their high reproductive rate and low adult mortality compensates for this discretion (Haag-Wackernagel, 1984). Their ability to adjust to urban environmental conditions also contributes to maximising the productivity of a short lifetime.

Synurbanisation

Synurbanisation is the ability to ecologically, demographically and behaviourally change in response to urban environments (Luniak, 2004). Pigeons have successfully adapted to co-exist with humans and exploit new ecological niches by increasing their range of habitat and dietary requirements; primarily in response to the global expansion of urbanisation (Luniak, 2004). They display the typical features of synurbic populations as described by Luniak (2004) namely, high population density, reduced migratory behaviour, changes to dietary and foraging habits, increased longevity, lowered immunity and health parameters, prolonged breeding seasons, changes in breeding ecology, prolonged and changed circadian activity, as well as their ability to co-exist with humans demonstrating tameness and adaptations to human behaviour and activities.

Adaptations

Considered to be the most adaptive wildlife species in urban settings (Jerolmack, 2008), pigeons have adjusted physiologically as well as behaviourally (Shochat *et al.,* 2010) in response to the urban sprawl taking over their original habitats (Fitzwater, 1988). Krimowa (2012) explains that they display different resource preferences compared to their rural counterparts; such as the inclusion of anthropogenic food into their original diet, changes in feeding behaviour to orientate around human activity and the use of tall buildings instead of cliff faces for nesting and roosting. Greater genetic variability and the ability to fly faster in urban individuals (Adams, Lindsey & Ash, 2006) contribute to increasing the chances of survival in pigeons that exist in man-made environments.

Biological changes manifest over generations, however pigeons also display the remarkable ability to adapt within short isolated periods of time. This is evident in their capacity to adapt to control structures and strategies imposed on them by people, a component which is often not taken into account when developing control programmes (Hutton & Dobson, 2007).

Pigeons as pests

Many of their adaptations to urbanisation are the reason humans consider pigeons to be pests. Defined as “any animal or plant which has a harmful effect on humans, their food or their living conditions” (Department of Health, 2010), pigeons are considered to have a negative impact on peoples’ social, economic and cultural lifestyles. As Jerolmack (2008) illustrates, their pest-like attributes are fundamentally grounded in their ‘natural’ characteristics. Group foraging, association and habituation towards people, high reproductive rate, diet variation and alimentary storage canal are factors which contribute towards displaying pest-like behaviour (Johnston & Janiga, 1995). Fitzwater (1988) stated that pigeons are often regarded as a widespread aerial nuisance. They can represent a problem in high densities where there is ample food, spatial resources and a lack or absence of natural selection factors (Dobeic *et al.,* 2011). Jerolmack (2008) has suggested that pigeons are one of the most despised of urban wildlife due to their lifestyles being so public. Their visible diurnal habits (Jerolmack, 2008), public droppings, tendency to associate with people, beggging for food (Hutton & Rostron, 2005) and flocking in large numbers (Krimowa, 2012) creates a sense of anxiety amongst people suggesting a lack of population control(Jerolmack, 2008).

Bacterial, fungal and ectoparasitic health hazards relating directly to the pigeons and indirectly to their droppings (Giunchi *et al.* 2012) have been known to cause alarm (Hutton & Rostron, 2005) even though the risk of infection is relatively low (Phillips, Snell & Vargas, 2003; Haag-Wackernagel & Moch, 2004; Hutton & Rostron, 2005; Hadidian, 2007). Nesting material and droppings which accumulate in and below nesting or roosting sites are considered to be unhygienic (Giunchi *et al.* 2012), cause structural and aesthetic degradation (Belant, Woronecki, Dolbeer & Seamans, 1998; Hutton & Rostron, 2005; Giunchi *et al.* 2012) and result in ongoing maintenance costs (Murton, Thearle & Thompson, 1972; Pimental *et al*., 1999). Disturbances from nesting activities and squabs (Hutton & Rostron, 2005), and the vocalisations from large populations have been known to cause hysteria and insomnia in humans (Carle, 1959).

On a broader scale pigeons have been known to be the cause of bird strikes (Harris & Davies, 1998, Giunchi *et al.* 2012) and extensive crop depredation (Krebs, 1974; Linz & Homan, S.a.; van Niekerk & van Ginkel, 2004; Giunchi *et al.* 2012), particularly in South Africa where agricultural staples such as maize, sorghum and sunflowers are the preferred crop of pigeons (van Niekerk, 2003; van Niekerk & van Ginkel, 2004,van Niekerk, 2009, Collett, 2015).

Jerolmack (2008) explains that since the 1970s pigeons have been considered to be "rats with wings", convicting them of being dirty birds which pollute urban environments. This metaphor expresses how pigeons are evaluated by society (Jerolmack, 2008). However, with such a label the sense of entitlement towards dismissing, detesting or killing pigeons considered to be a pest becomes an accepted distancing mechanism amongst the general public (Jerolmack, 2008). The feeling of disorder and the need to 'clean up cities' by removing species regarded as pests, illustrates how humans aim to achieve hygienic standards and to restore order (Jerolmack, 2008).

Nevertheless, as Angier (1991) explains, the interaction between humans and pigeons is a love-hate relationship. Literature indicates that people living in urban areas will retain positive attitudes towards pest species (Krimowa, 2012; Naylor, 2015). Jerolmack (2008) states that pigeons have many friends among the public, people who believe that pigeons provide a natural balance to the man-made development of cities (Krimowa, 2012). People who are 'pro-pigeons' associate some of birds' characteristics to that which society holds in high regard namely; being monogamous, mating for life, and the shared responsibility of both parents raising the young (Jerolmack, 2008). This in essence attempts to minimise the imaginary, psychological geographical gap between their placement in urban environments and ours. Pigeons often attract dedicated human feeders, many of which feel responsible for the ongoing well being of the birds or simply as a means for social interaction (Weber, Haag-Wackernagel & Durrer, 1994). This direct and seemingly life-saving activity allows people to empathise with wildlife, and creates a sense of interest and appreciation in species other than our own. Ryan (2011) concludes that where there is positive interaction with wildlife, the potential for considerate and conservation orientated actions in public increases.

Nonetheless due to pigeon biology and behaviour, they often come in conflict with peoples' interests; consequently sparking a demand for population control and spatial placement in human environments. Actions that are often opposed by people who are pro-pigeons (Krimowa, 2012).

Pigeon control

Management of pigeons which are regarded as a perceived problem or pest is not achieved by an immediate, short-term solution. Pigeon control requires a continuous integrative strategy with a combination of variants to ensure long term sustainability and prevent habituation (Hutton & Rostron, 2005; Hutton & Dobson, 2007; Haag-Wackernagel & Bircher, 2010). As there is not a 'one-size fits all solution' to managing pigeons in urban environments, various factors namely; the extent and nature of the problem (Hutton & Rostron, 2005), knowledge of the species (Fitzwater, 1970), and the behavioural and ecological characteristics of the pigeons specific to the site of problem (Boudreau, 1968a; Giunchi, Baldaccini, Sbragia &

Soldatini, 2007; Giunchi *et al.* 2012) need to be considered for the programme to be successful. These are often overlooked or not taken into account when pigeon control is deemed a necessity to a perceived problem, thus resulting in failed attempts and temporary solutions (Hutton & Rostron, 2005; Alshuwaikhat & Abubakar, 2008). Jerolmack (2008) explains that the process of problematising species and the consequences which affect their lives and shape the way society perceives them are also often ignored when control measures are implemented.

Control methodologies can be placed into various categories depending on the desired outcome. Lethal measures which increase mortality have become increasingly controversial and have declined in public support as welfare and ethical concerns of wildlife management are considered (Treves & Noughton-Treves, 2005). Non-lethal methods which decrease natality, manage resources and modify behaviour are considered to be the most sustainably effective and acceptable by the greater public (Environmental Health Directorate, 2006; Health Protection Programs, 2011; Ryan, 2011). Still every structure and strategy has its advantages and disadvantages as expressed by Hutton and Dobson (2007). However the effect of pigeon control techniques on populations has not been adequately evaluated and reported upon in literature (Buijs & van Wijnen, 2003; Oxley, 2013; Fukuda, Frampton & Hickling, 2008) resulting in the effectiveness of individual techniques being under or over estimated. Oxley (2013) explains that there is also a limited amount of information on the animals' welfare relating to the applied techniques and peoples' perceptions thereof. This is an important component as recognised and humane control plays a significant role in the protection of pigeons against members of the public taking measures into their own hands (Ryan, 2011), measures which are often inhumane and unethical.

Cities need to be recognised as ecosystems with their own set of resources, unique niches and enabling factors which contribute to the successful colonisation of pigeons. According to Belant (1997) preventative strategies and landscape level management plans contribute to managing urban wildlife conflicts Pigeon control should therefore be holistic (Hutton & Rostron, 2005) and integrated in its approach. Murton, Thearle and Thompson (1972) claim that a number of smaller control actions are more effective than one large operation. Pigeon managementl cannot simply be biologically orientated, as social acceptability and support are crucial to its success. Public inclusion, education and behavioural change should be complementary to any envisioned management plan (Dobeic *et al.* 2011).

Public participation

Pigeon control is not an isolated discipline; people who are affected both negatively and positively by the birds play a significant role in the success of proposed management projects. These people can be considered to be stakeholders who have a say in the decisions to control the urban wildlife which impact their lives. Brunet and Houbaert (2007) define stakeholders in terms of “their responsibility towards avoiding or controlling a perceived problem, or as their roles in dealing with the consequences”. Alshuwaikhat and Abubakar (2008) insist that all affected and interested stakeholders need to be recognised to ensure co-operation and participation that is required to successfully manage urban wildlife. If public is excluded from the identification of the problem, control programme development and implementation of acceptable strategies; they may feel neglected or poorly served resulting in an ineffectual management project (Brunet & Houbaert, 2007).

Brunet and Houbaert (2007) explain that stakeholders may be official, visible and known; or non-official. People who are pro-pigeons are non-official, as they tend to be less evident during periods of non-control and only become known to authorities in their protest once management measures are implemented. Recognising both these stakeholders will provide the opportunity to change their behaviour in order to be conducive with the project's sustainability goals. It will also build people's confidence in public and private authorities (Brunet & Houbaert, 2007) allowing them to feel acknowledged and be provided with a forum to voice their opinions.

Public participation provides insight into understanding peoples' attitudes and perceptions of urban wildlife as well as the control imposed on managing these populations (Fraser, 2001; 2006). By understanding peoples' attitudes towards pigeons, one can effectively inform educational campaigns and information provision. This has significant value as stated by Bremner and Park (2007) who believe that awareness and education can considerably increase public support with regards to wildlife management.

Studies addressing public participation with regards to pigeon control have mostly been focused in Europe, Australia and New Zealand (Bremner & Park, 2007) with limited research in South Africa. There needs to be a transition towards interdisciplinary urban wildlife management and participatory decision making if sustainable humane solutions are to be found. Peoples' involvement in environmental challenges will provide them with the opportunity to improve self awareness, understand the impact humans have on the planet, and how their attitudes affect their perceptions and behaviour towards urban wildlife.

Rollinson, O'Leary and Jones (2003) explain that human-wildlife interactions have important consequences on peoples' willingness to become involved in environmental awareness and conservation initiatives. Management should therefore mitigate peoples' negative experience of the species (Reiter, Brunson & Schmidt, 1999) by considering stakeholders' opinions and animal welfare.

Humans play a significant role in the way in which pigeons impact people and infrastructure, having the ability to limit human-wildlife conflict. The existence between pigeons and people is interconnected, whether it is formally recognised or not, each plays a role in the others' lives. The role of people on managing pigeon populations can be subtle and informal or direct and official depending on the awareness of the pigeons and their associated impacts on people and infrastructure at an identified site. Direct and formal pigeon control is often the preferred option, this once a pigeon population has been deemed to be a pest in an urban environment.

Pigeons on the University of South Africa's Muckleneuk campus

The University of South Africa's (UNISA) Muckleneuk campus in Pretoria is host to a large number of Speckled and Feral Pigeons inhabiting the academic and administrative buildings. Over the years structural integrity and social acceptability have been compromised due to faecal and nesting material accumulation and noise disturbance experienced by staff in a working environment (Westington, pers. comm. 2013). Thus far management of the pigeons and their associated impacts through nest removal, office fumigation and balcony cleaning have been ad hoc and reactive with high finiancial implications (eg. balcony cleaning of R 167 721.15 over a five month period) (Ntshoe, pers. comm. 2013).

University Estates Management, who is responsible for the upkeep of the campus, has since expressed health concerns relating to the build-up of their faeces and associated fungi, nest mites and bird lice which have been reported to infest the offices and inhabitants of certain buildings on campus. Furthermore management has received justification for a formal proposed pigeon control programme through the complaints and requests for pigeon management from staff members who hold negative views of the pigeons and their related activities.

However pigeon control is not an isolated discipline as social, environmental and ecological factors affect the success and sustainability of a proposed programme. Equally the people who are affected by the birds play significant roles in the successful management of the birds. Literature referring to pigeons as pests in urban areas is deficient in South Africa as well as the lack of public participation reglating to pigeon control (Bremner & Park, 2007) thereby resulting in pigeon control programmes being directed by the suggestions and solutions of the pest industry and not by those affected by the pigeons.

University Estates Management has identified the need for a long term and sustainable pigeon control strategy. Literature (Murton, Thearle & Coombs, 1972;

Haag, 1984; Kautz 1985; Sol & Senar, 1995) has established that humane non-lethal control measures are effective and sustainable at controlling pigeon populations in urban environments. However science seems to be lacking in quantitative reviews of these control methods and their effectiveness at managing pigeon populations (Buijs & van Wijnen, 2003; Oxley, 2013; Fukuda, Frampton & Hickling, 2008).

Research is therefore required to determine the extent of the perceived pigeon problem on the Muckleneuk campus, staff members' views and opinions of the birds and the quantified efficacy and cost effectiveness of various non-lethal humane pigeon control methods conducive to the campus environment. The use of the term control will hence forth be used as a term to limit pigeon population numbers, and should not be confused with statistical control which is instead referred to as a baseline for this study.The results of the study will inform an interdisciplinary and integrative management plan for future pigeon management on the University of South Africa's Muckleneuk campus.

CHAPTER TWO: STUDY AREA

The University of South Africa is situated on top of a hill near the central business district of Pretoria (-25.76776, 28.199158) in the Gauteng province of South Africa (Figure 1).

Pretoria, the administrative capital of South Africa, is positioned 50 km north of Johannesburg in the north-east of the country. Located 1411 m above sea level, the city is surrounded by the Magaliesburg mountain range in the transitional zone between Central Bushveld and Moist Highveld Grassland (Kruger, 2004). The city has a moderate warm temperature climate with average annual temperatures ranging from 11.3^{o}C in winter (July–August) to 24.4^{o}C in summer (October–March) (South African Weather Service, 2010). Precipitation averages 677 mm, while relative humidity ranges between 44% and 75% annually. Pretoria experiences a 3 254 hours of sunshine a year with 2.4–2.7 okta cloud cover on average recorded annually (South African Weather Service, 2010). The city includes commercial, industrial, suburban and rural areas, with farming and crop (maize, soya, sorghum and sunflowers) production in the surrounding districts (distances 1.59–317.04 km from Pretoria) (Collett, 2015).

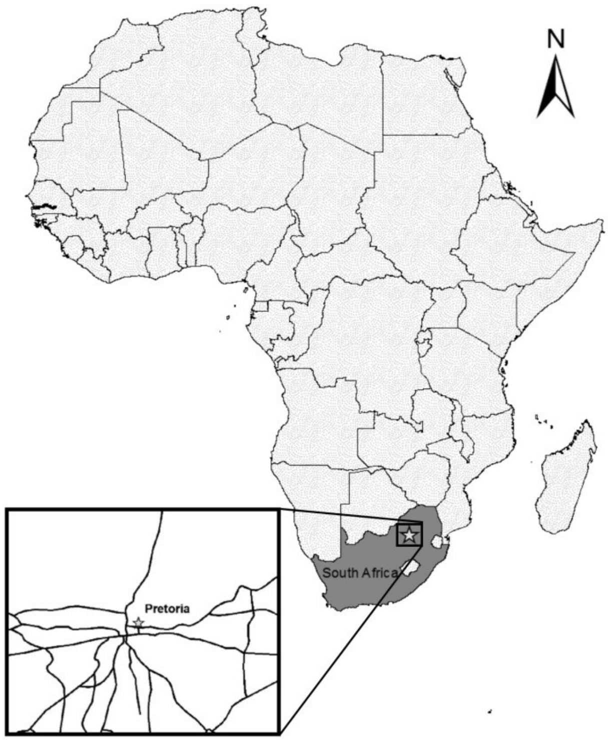


Figure 1: Indicates the location of the study site, the University of South Africa's Muckleneuk campus, which is located in Pretoria, South Africa

The University of South Africa, founded in 1873, is the largest university in Africa. It provides open distance education to South African as well as international students. Seven regional centres serve students across South Africa, the main campus being located in Muckleneuk, Pretoria.

Established in 1972, the Muckleneuk campus consists of seven administrative and academic buildings positioned parallel to each other with prominent north and south facing aspects.

Muckleneuk campus buildings

The Muckleneuk campus consists of seven academic and administrative buildings. For the purpose of this study five buildings were investigated, due to their size and staff capacity. They were as follows; Theo van Wijk, OR Tambo, AJH van der Walt, Cas van Vuuren and Samuel Pauw (Figure 2).

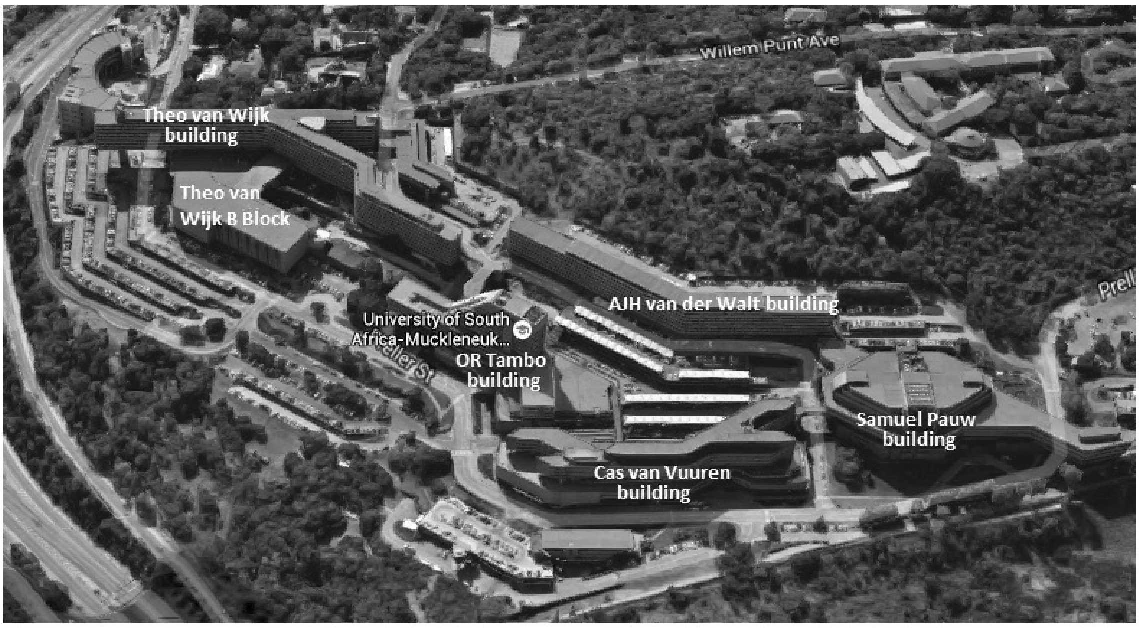


Figure 2: Aerial view of the University of South Africa's Muckleneuk ampus indicating the building layout where the research took place during year one and year two of the research. The buildings indicated were censused to determine pigeon indices (Google maps, 2015).

Each campus building is unique in its design and dimensions with multiple levels and structural components. Academic and administrative offices positioned lengthwise along the buildings face out onto the balconies. Beige square tiles and natural concrete are the building material of choice.

Theo van Wijk, the largest building positioned on the far western side of the campus, has 11 levels uniform in design with balconies and exterior cabling ducts (trunking) running the length of the building. Due to its y-shape, the building offers two north facing and two south facing aspects. The Philadelphia cafeteria is positioned on the third floor, which includes an extensive catering balcony. AJH van der Walt building is positioned on the northern side of the campus facing an undeveloped kopje which meets the campus' northern boundary. All seven levels are continuous in balcony and trunking design.

To the east of the campus is the library, the Samuel Pauw building, roughly hexagonal in shape with eight levels; it has continual balconies and no trunking. Beyond this building towards the campus boundary in the east is parking space and natural vegetation. OR Tambo, the administrative building is positioned to the south. Due to its 14 levels, it is the tallest building on campus. Balconies and trunking provide uniform exterior structural design; with the exception of the Good Hope cafeteria and balcony on below level four. Adjacent to this building is Cas van Vuuren with seven levels, continual balconies and no trunking.. Natural areas extend to the southern and south western boundaries.

Stacked parking spaces are positioned below Theo van Wijk and in the centre between OR Tambo, AJH van der Walt, Samuel Pauw and Cas van Vuuren buildings.

Due to the nature of open-distance learning offered by the university, the Muckleneuk campus primarily functions academically and administratively, with minimal student presence. According to Kruger (2015), 5 614 academic and administrative staff members are employed at this campus, a number which fluctuates monthly. However the number of humans on the campus at any given time during the week is presumably considerably higher as permanent and ad hoc labourers, independent contractors, temporary staff, visitors and students frequent the campus.

The campus is located within a green belt which includes the surrounding Groenkloof Nature Reserve, Fountains Valley, Apies River, Voortrekker Monument and Freedom Park. Manicured gardens and the abundance of natural vegetation support various small mammals and bird species within the University's grounds. These include small raptors, avian migrants, rock hyrax (*Procavia capensis*) and a feral cat population which is partially supported by staff on campus (pers. obs. 2014).

CHAPTER THREE: RESEARCH OBJECTIVES

The primary objective of the research was to develop a holistic interdisciplinary non-lethal pigeon management plan for the University Estates department on the University of South Africa's Muckleneuk campus to reduce pigeon occurrence in a sustainable and ethical manner. The opinions and perceptions of staff members were taken into account as well as the environmental and ecological factors specific to the area which influences the fluctuations within the pigeon population.

In order to achieve this, the following research objectives needed to be answered:

- **Investigate and determine the perceptions and views on pigeons by UNISA staff members.**

  Research question: How are the pigeons and the associated problems perceived by the UNISA staff members on the Muckleneuk campus?

- **Determine as a control, the annual pigeon population fluctuation index and the use of the urban environment by the pigeon population on the Muckleneuk campus.**

  Research question: How does the pigeon population make use of the University of South Africa's Muckleneuk campus' urban environment?

- **Investigate and compare the efficacy of various non-lethal humane pigeon control techniques for the Muckleneuk campus.**

Research question: Are non-lethal and humane pigeon control techniques efficient at managing pigeon populations on the Muckleneuk campus?

.

CHAPTER FOUR: RESEARCH METHODOLOGY

A three year research study was initiated to investigate the relevant factors in order to provide management with an interdisciplinary holistic non-lethal management plan for pigeon control specific to the Muckleneuk campus. Permission from University Estates and ethical clearance for pigeons and staff was obtained (2013/CAES/017).

The study was divided into qualitative and quantitative methodologies to investigate the social, ecological and environmental factors affecting the research.

Qualitative methodology

Qualitative research focussed on the social aspect of the research through questionnaires and interviews relating to pigeons, their activities and potential control options as perceived by staff members based on the Muckleneuk campus. The cross-sectional mixed methodology study comprised of two parts, namely an online questionnaire and interviews.

A quantitative design (Jennings, 2001) was adopted for the online questionnaire, which was electronically accessible to all staff members between September 2013 and September 2014 on SurveyMonkey, an online survey development cloud based company (SurveyMonkey, 2015) (Appendix A). Information about the online survey was communicated to staff members throughout the year in the form of e-notices (Appendix B)

Data was gathered from consented staff members in both administrative and academic positions on the UNISA Muckleneuk campus. Primary data was collected from the direct input of participants into the online survey. Participants provided their personal opinions and perceptions relating to pigeons and their activities, potential impact the pigeons have on the staff members, various pigeon control options and the perceived problem on the UNISA Muckleneuk campus. Content analysis (Braun & Clarke, 2006) was used to analyse the data.

In addition to the online survey, semi-structured qualitative interviews were conducted with consented participants to corroborate, clarify and qualitatively supplement the questionnaire data (Appendix C). Saturation was determined by participants' responses. Data was recorded and transcribed and thematic content analysis (Braun & Clarke, 2006) was used to analyse the data.

Ethical issues were considered in order to ensure that the rights of participants were observed, namely: anonymity, respect for the dignity of persons, nonmaleficence and confidentiality (Terre Blanche, Durrheim & Painter, 2006). Participation was voluntary and participants required informed, voluntary consent to participate in the research (Appendix D).

Quantitative methodology

Quantitative research was divided over two years. A control of the annual pigeon population fluctuation index and the use of the urban environment by the pigeon population on the Muckleneuk campus was investigated during the first year. During the second year various non-lethal humane control measures to reduce the pigeon population index on the Muckleneuk campus were implemented and investigated.

As the pigeons were free roaming and not fenced in, the exact number of pigeons on the Muckleneuk campus could not be established. An index of the population was therefore determined, and the population fluctuation was in relation to this index.

Year one investigated the environmental use of the campus by the pigeon population with regards to population index fluctuation, breeding seasonality, agricultural crop availability and site selection relating to aspect and height. A baseline index of pigeon numbers inhabiting the buildings comprising the Muckleneuk campus, over the course of a year was determined.

For the purpose of year one, five of the seven buildings on the Muckleneuk campus were investigated. These were as follows; Theo van Wijk building, OR Tambo building, AJH van der Walt building, Cas van Vuuren building and Samuel Pauw building. Each building is unique in its design providing various roosting and nesting site possibilities to the pigeon population on campus. Data on pigeon distribution, density and breeding activity presence was estimated and described along a 1.9 km line transect (Figure 3).

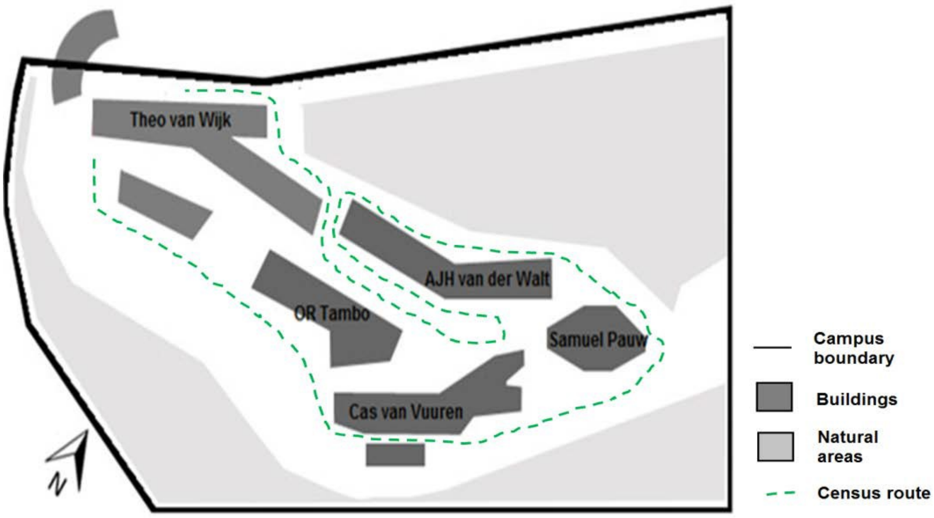


Figure 3: Map of the University of South Africa's Muckleneuk campus indicating the route walked during the year one and two of the pigeon census

Counting of adult and juvenile pigeons perched on the buildings took place in relation to the pigeons' bimodal foraging activities which have been recorded to peak in the morning and afternoon (Rose, Nagel & Haag-Wackernagel, 2006; Soldatini, Mainardi, Baldaccini & Giunchi, 2006; Krimowa, 2012). These counts took place early morning during the first two hours after sunrise and again in the evening during the last two hours before sunset, once a week for 52 weeks (March 2013–February 2014). If the particular chosen day for counting experienced extreme weather conditions, then the next consecutive day with fine weather was chosen and documented. Double counts of individuals taking off and perching on the same building was taken into consideration and avoided. The same observer maintained a standard designated route in clockwise west–east direction counting each building (OR Tambo, Theo van Wijk, AJH van der Walt, Samuel Pauw and Cas van Vuuren) during the course of the study period. Observations were aided by 9 X 30 binoculars and a digital camera, and were recorded on a data sheet. The results have been interpreted as an index of pigeon population size.

The objective to determine whether pigeon populations fluctuate seasonally on the UNISA Muckleneuk campus required the arithmetic mean and standard errors of the monthly pigeon population indices to be depicted graphically for both the Speckled and Feral Pigeon populations over the course of a full year. The graphical representation of the data were described and inferences were supported by literature reviews on pigeon ecology and the seasonal parameters of the study area.

The presence of breeding activity was observed through reproductive behaviour, nesting behaviour and/or the presence of young. These were recorded in the following categories: courting, mating, nesting, squabs and juveniles. Courting referred to vocalisations and head bobbing of a male pigeon directed at a female pigeon; mating referred to copulation of a male pigeon mounted onto the back of a female pigeon; nesting referred to activities associated with nest building or physically sitting on nests; squabs referred to very young pigeons in nests from the date of hatching to one month old when they are due to fledge from the nest (Krebs, 1974; Hetmański & Wołk, 2005); and juveniles referred to young pigeons (1-6 months of age) which have fledged the nest but have not yet obtained adult plumage (Murton, Thearle & Coombs, 1972; Murton, Thearle & Thompson, 1972).Data was converted from 52 (week) counts to 12 (month) counts. The presence or absence was ranked, where 0 referred to no presence of a breeding activity and or reproductive behaviour within a particular month, to 4 referring to a particular activity or behaviour as having been present in each of the 4 weeks of that particular month.

Seasonal agricultural crop availability was linked to pigeon population fluctuation through the a list of agricultural crops ecologically important to pigeons (maize, sorghum and sunflowers) in a 20 kmkm radius (Little, 1994; van Niekerk, 2009) from the Muckleneuk campus obtained from the Department of Agriculture, Forestry and Fisheries (Collett, 2015). Their respective planting and harvesting times were linked to the pigeon population index on campus. While no statistical methodologies were applied to this data, inferences were made with regards agricultural crop use by the pigeons and associated with their presence on the campus during these times. These inferences were supported by literature reviews on pigeon foraging behaviours through a process of deductive reasoning.

The highest building on campus (OR Tambo–14 levels) was used to conduct site selection studies in relation to aspect and level height choice of pigeons perching on balcony ledges and cabling ducts.. Counts were conducted on the north and south side between levels 4–14, as these were identical in structural design. Pigeon activity on the roof was also counted but for the purpose of data analysis, was not included as it was not identical in structure to the other levels.

To investigate site selection in terms of aspect choice by pigeons on building ledges and cabling ducts, a chi-square test, typically used to compare observed data with expected data was used to determine if there was in fact a significant association between the north and south sides of the OR Tambo building, for each of the four seasons.

To investigate site selection in terms of building level height by pigeons on building ledges and cabling ducts, a Spearman's rho correlation was used. This correlation does not assume any assumptions about the distribution of data and is considered an appropriate correlation analysis for variables in an ordinal scale. The building levels were therefore ranked to levels according to height and the Spearman's rho correlation determined whether or not an association between the height of the building and pigeon use/presence exists. This was also done for each season respectively.

On completion of the baseline year (year one), various control measures were implemented on the buildings for the management year (August 2014–August 2015, 52 weeks, year two). Control measures were sub-divided into three groups to determine their efficiency to each other and to the reduction of the pigeon population index. The first group consisted of optical deterrents (Eagle Eyes™ and Fire Flags), bird spikes and a combination recommended by the pest control industry; secondly predator presence in the form of an audio bird scarer and birds of prey; and finally the application of nest boxes for egg replacement and an educational poster campaign as supplementary control strategies. All three groups were applied concurrently to provide integrated pigeon control on campus.

The features and position of each building on campus directed the type of control structure chosen. The quantities and placement of structures on the respective buildings were directed by the pest control company.

Optical deterrent: Eagle Eyes™

Theo van Wijk, the largest building on campus was chosen to implement Eagle Eyes™ units. Eagle Eyes™ are rotating prisms that reflect light within the ultra violet spectrum that are designed to interfere with pigeons' line of flight as the light causes a distraction (Eagle Eye, 2015). Due to the building's size the light reflected by the units was able to cover a greater surface area relative to the other control structures. Its proximity to other buildings also played a role as light from the units would affect surrounding buildings thus influencing their respective control strategies. Eagle Eyes™ units were placed along the 11 stories and roof (north and south facing).

Optical deterrent: Fire Flags

OR Tambo, the tallest building with 14 levels, was selected to test the Fire Flags which are made from reflective gold and silver plastic and designed to move with the wind to give the impression of fire and danger (Eagle Eye, 2015). The building's height and wind updrafts experienced at high altitudes (Kochert, 1972) presented the most ideal site for fire flag application. The units were placed along each of the levels (north and south facing).

Physical barriers: bird spikes

Cas van Vuuren, is a building without exterior electrical and air conditioning ducts (trunking) which are positioned just below the balcony ceilings above the office windows. These ducts provide ideal sites for pigeons to roost and nest on campus. A single continuous strand of dual pronged stainless steel bird spikes was placed along the length of the balcony ledge on all seven levels (north and south facing) to prevent and deter pigeons from perching on the building.

Pest control industry combination recommendation

The University's library, Samuel Pauw, hexagonal in shape was chosen for the implementation of the control structure combination recommended by the pest control company. These included Eagle eyes™, Fire Flags and bird spikes on the building's eight levels (north and south facing).

The effect of the optical deterrents, bird spikes and pest control combination recommendation on the pigeon population was ascertained by repeating the methodology applied in year one. The results were interpreted as an index of pigeon population size and a percentage decrease.

The pigeon index and efficacy rate was determined by calculating the percentage change in the number of counts of pigeons between year one and year two in which the control structures were implemented. This indicated the reduction in percentage each of the control structures had on the pigeon population index.

To test whether or not there was a difference in the mean efficacy percentages between the different control structures, a one-way ANOVA was used. Where significant differences between the control structures were observed, Bonferroni post-hoc tests were employed to determine which of the control structures differed significantly from each other in one to one comparisons.

Predator presence

AJH van der Walt building with seven north and south facing levels, was used to establish the efficiency of predator presence (implied versus actual) in the form of an audio bird scarer and birds of prey. The two trials (audio bird scarer and falconry) took place over two months (September 2014 and April/May 2015). Each pigeon control method was tested for a total of four weeks, the suggested amount of time for each of methods to take effect (Ryzhov & Mursejev, 2010; Bird stop, 2015).

Testing the methods and the subsequent counting of adult and juvenile pigeons took place in relation to the pigeons' bimodal foraging activities which have been recorded to peak in the morning and afternoon (Rose, Nagel & Haag-Wackernagel, 2006; Soldatini, Mainardi, Baldaccini & Giunchi, 2006; Krimowa, 2012). The trials took place early morning during the first two hours after sunrise and again in the evening during the last two hours before sunset, once a week for eight weeks. If the particular chosen day for testing the methods experienced extreme weather conditions, then the next consecutive day with fine weather was chosen and documented.

The observer maintained a standard designated route in east-west direction while testing the methods. Double counts of individuals taking off and perching on the same building was taken into consideration and avoided. Observations were aided by 9 X 30 binoculars and a digital camera, and were recorded on a data sheet. The results have been interpreted as an index of pigeon population size.

The first trial, which tested the effect of the BirdXPeller PRO™ on the pigeon population, took place at dawn and dusk, once a week during September 2014. Prior to playing the BirdXPeller PRO™, the observer counted the pigeons on each level of the south facing side of AJH van der Walt. The observer, wearing a security bib similar to that of the security guards on campus as to minimise recognition, then walked parallel to the building in a westerly direction holding up the active BirdXPeller PRO™ unit. A 12V battery, which the observer carried in a backpack, powered the unit. The BirdXPeller PRO™ unit was programmed to use one bird of prey recording (peregrine falcon) and two alarm/distress recordings of pigeons in sequence as suggested by the BirdXPeller PRO™ manual. The calls were played at random to prevent the pigeons from adapting to the predetermined pattern of sounds. A time interval of 1–4 minutes was observed between each set of recordings. A recount of the building after the audio scare was conducted to determine if the recordings had an effect on the pigeon numbers. Recounts were conducted every 10 minutes after the post-scare count for a total of 30 minutes to determine if or what the lasting effect of the audio scare was. This methodology was then repeated on the northern side of the building.

The second trial, which tested the effect of the raptors on the pigeon population, took place at dawn and dusk, once a week during the last two weeks in April and the first two weeks in May 2015.

A falconer handled the birds of prey required for this study. The raptors were flown from the roof of AJH van der Walt to mimic, as close as possible, the natural behaviour of predators on pigeons. Harris and Davies (1998) suggest that several raptors be used to ensure the success of pigeon control programmes. Thus three different birds of prey which naturally hunt pigeons were used for this trial; a Rock Kestrel (*Falco rupicolus*) which is ideal for high altitude flying; an African Goshawk (*Accipiter tachiro)* which displays agility in being able to fly through narrow spaces and a Jackal Buzzard (*Buteo rufofuscus*) for its intimidating size and success in static situations (Freeman, 2015).

During the trial the observer remained at ground level. Prior to flying the raptors, the observer counted the pigeons on each level of the south facing side of AJH van der Walt. The choice of raptor varied over the trial period, depending on the falconer's discretion. The falconer slowly moved in a westerly direction along the roof's length flying or walking the bird of prey along the overhanging balcony ledge. On completion, the observer conducted a recount of the building to determine if the presence of the bird of prey had an effect on the pigeon numbers. Recounts were conducted every 10 minutes after the post-fly count for a total of 30 minutes to determine if or what was the last effect of the raptor presence was. This methodology was then repeated on the northern side of the building.

As the predator presence trials were only conducted for eight weeks of the management year, AJH van der Walt was without control structures for the remainder of the study. Computer generated data replaced the 16 index counts conducted during the trials so as to use the building as a control to determine if pigeons deterred from surrounding buildings simply moved to an untreated building (Mooallem, 2006).

For data analysis the sum of the data collected was determined. Pearson's chi-squared test was used to determine if there was an association between the method of scaring (audio or falcon) and the number of pigeons observed on the different time periods.

Nest boxes

As pigeon control does not remove or displace all the pigeons in a population, individuals with established territories will remain on the buildings and continue to breed. However their reproductive turnover can be controlled by providing them with designated breeding sites which are monitored and maintained. Artificial nest boxes were placed on two of the buildings on campus, Theo van Wijk and OR Tambo. Seventy one nest boxes were placed on four levels (level 7 and 9 north facing, and level 5 and 6 south facing) of Theo van Wijk, while 59 were placed on two levels (level 12 north and south facing, and level 13 north and south facing) of OR Tambo based on the highest density index of pigeons determined during the baseline year (March 2013–February 2014). Pigeons prefer dark, secluded nesting sites (Hurst, 2006; Haag-Wackernagel, 2008) thus dark blue plastic and wooden boxes were used, each with the dimensions of 30 cm x 30 cm x 25 cm as suggested by Malan pers. comm. (2014). These were mounted on steel brackets which slotted over the cabling ductswhich runs the length of the two buildings. A 15 cm x 15 cm carpet square was placed in each nest box which was treated with Dovastof (pigeon mite, tick, flea and fly) insecticide. Plastic white pigeon dummy eggs were used to replace removed eggs. Nest boxes were checked once a week for nesting activity and eggs to prevent hatching. On finding an egg(s), it was removed and replaced with a dummy egg. The removed egg was subsequently taken to a local nature reserve as a food source for egg-eating mammals. Dovastof was sprinkled onto the nest to manage ectoparasites on egg removal. As eggs are incubated for approximately 18 days before hatching (Krebs, 1974; Hetmański & Wołk, 2005; Jacquin, Cazelles, Prèvot-Julliard, Leboucher & Gasparini, 2010), dummy eggs were removed from the nests after 14 days, to allow for the initiation of another laying cycle.

<u>Educational campaign</u>

Various colourful A3 posters designed to make staff aware of the pigeon population on campus and control thereof, as well as discouraging deliberate pigeon feeding on and around campus buildings in an effort to manage the pigeons were placed on the interior and exterior of all the buildings on campus. Posters requesting staff not to feed the pigeons were also strategically placed at the cafeterias and sites of social gathering.

<u>Management precautionary measures</u>

Reactive measures directed at managing the pigeon population, such as balcony cleaning and nest clearing, which took place year round by University Estates continued as usual throughout the study.

The results from the qualitative and quantitative research culminated in the form of an integrated pigeon management plan presented to University Estates management on the Muckleneuk campus of the University of South Africa. The integrated pigeon management plan serves to guide the use of humane interdisciplinary pigeon management strategies to enable positive human-pigeon interaction, ensure health and safety of staff and maintain the structural and aesthetic integrity of infrastructure in relation to the pigeon population and associated activities on the University of South Africa's Muckleneuk campus. The plan aims to empower and inform management's decision making with regards to the efficiency and cost-effectiveness of humane, non-lethal pigeon control whilst upholding the University of South Africa's commitment to environmental stewardship.

CHAPTER FIVE: RESULTS AND DISCUSSIONS

Chapter 5.1

Harris, E., de Crom, E.P. & Wilson, A. 2016. Pigeons and people: mortal enemies or lifelong companions? A case study on staff perceptions of the pigeons on the University of South Africa, Muckleneuk campus. *Journal of Public Affairs,* doi: 10.1002/pa.1593.

Chapter 5.2

Harris, E., de Crom, E.P. & Wilson, A. Pigeon control and people: A case study on staff perceptions of the pigeon problem and control measures on the University of South Africa, Muckleneuk campus. *under review*

Chapter 5.3

Harris, E., de Crom, E.P., Labuschagne, J. & Wilson, A. (in press) Urban environment use by Speckled (C*olumba guinea)* and Feral (C*olumba livia)* Pigeons on the University of South Africa's Muckleneuk campus. *Applied Ecology and Environmental Research*

Chapter 5.4

Harris, E., de Crom, E.P., Labuschagne, J. & Wilson, A. Visual deterrents and physical barriers as non-lethal pigeon control on the University of South Africa's Muckleneuk campus. *SpringerPlus (preliminary acceptance)*

Chapter 5.5

Harris, E., de Crom, E.P., Labuschagne, J. & Wilson, A. Evaluation of audible and visible predator presence, for pigeon control purposes on the University of South Africa's Muckleneuk campus. *under review*

Chapter 5.6

Supplementary control strategies: nest boxes and educational campaign

Chapter 5.7

Harris, E., de Crom, E.P. & Wilson, A (in press) An interdisciplinary approach for non-lethal pigeon control. *International Pest Control*

CHAPTER 5.1

Pigeons and people: mortal enemies or lifelong companions?

A case study on staff perceptions of the pigeons on the University of South Africa, Muckleneuk campus

E Harris, EP de Crom, A Wilson

Submitted: 21 July 2015 ; Accepted: 7 December 2015

ABSTRACT

Pigeons have been a part of our lives for as long as we can remember. Some people view them with joy, others disdain. Regardless of the perception, control measures are often implemented against the birds in a bid to reduce their presence in urban environments without considering members of the public in the process. Complaints associated with pigeon activity are, by human nature, heard earlier than praise for these birds. However, people who are pro-pigeons are often not provided with the forum to express their views of the birds. This study explored the perceptions of staff concerning the pigeons inhabiting the University of South Africa's Muckleneuk campus. Two hundred and forty six participants provided their opinions on the pigeons, their related activities and the perceived impact on staff on campus. Recognising that both people and urban wildlife play a role of cause-and-effect in human-wildlife conflicts, this can contribute to understanding peoples' relationships and perceptions of animals which transgress the boundaries between urbanisation and nature. By considering peoples' perceptions, attitudes and behaviours towards urban wildlife, management strategies can be significantly informed in the process of

mitigating conflict. The study has shown that the negative perception of pigeons which was assumed to be a blanket response of all the people affected by the pigeons at the University of South Africa's Muckleneuk campus is in fact incorrect. Participants would rather encourage the nesting and breeding activities of the pigeons on campus, as they felt that the human-pigeon interactions and the viewing of squabs in nests contributed positively to their work environment. Pigeon control strategies should therefore not solely be on the biological aspect of a perceived pigeon problem, but should also include the human association.

KEYWORDS: *pigeons, urban environments, public perceptions, green universities, urbanisation*

INTRODUCTION

Urban environments house more than half of the world's population (United Nations, Department of Economic and Social Affairs, Population Division, 2014). While only constituting a relatively small percentage of the world's surface, its effects are far reaching and disproportionate to its size. Despite the negative and often detrimental impacts on the natural environment, urban environments have the potential to contribute to biodiversity (Pickett, Cadenasso, Grove, Boone, Irwin, Groffman, Kaushal, Marshall, Mcgrath, Nilon, Pouyat, Szlavecz, Troy & Warren, 2011). Modified habitats, shelter, abundant food resources, permanent water availability and reduced predator presence, are synonymous with city environments. These factors enable certain species to undergo *synurbanisation*, whereby animal populations adapt successfully to urban environments by overcoming certain ecological barriers (Luniak, 2004). Theriologists-ecologists have defined synurbanisation as the ability of animal populations to adjust to specific conditions of urban environments, thereby enabling permanent existence (Andrzejewski, Babiñska-Werka, Gliwicz &Goszczyñski, 1978; Babiñska-Werka, Gliwicz & Goszczyñski, 1979). Synurbanisation enables species to adapt and transgress the societal boundaries of human habitation, to live successfully, side by side with people. The Feral Pigeon (*Columba livia*) and Speckled Pigeon (*Columba guinea)* (hereafter referred to collectively as pigeons) have adapted well, globally, to the urban environment (Haag-Wackernagel, Heeb & Leiss, 2006).

These birds have for centuries been amongst the most abundant bird species in built up environments, having adapted their housing requirements and foraging habits to be conducive with urban lifestyles. According to Luniak (2004), species such as the pigeon, tend to be ecological generalists, with high reproductive capacities and prolonged breeding seasons. Abundant resources, shortened breeding cycles and the scarcity of predators contribute to urban pigeon populations' ability to increase within short time periods. These pigeon populations are thought of with mixed emotions by society. Negative perceptions of pigeons result in them being viewed as pests and termed as ‘flying rats’ (Jerolmack, 2008), while their droppings, nesting material, mites and their perceived potentially transmissible diseases, are noted with fear and disdain, to which the pest-control industry offers solutions. To others however, the presence of pigeons is considered complementary to city life and beneficial in providing a connection to nature through their daily interaction.

The University of South Africa's (UNISA) Muckleneuk campus in Pretoria is host to a large number of pigeons. The birds have access into the ceilings of the buildings through open access points and loose exterior ceiling boards, as well as into open electrical and air conditioning ducts which are positioned on the exterior of the buildings. This easy access for the pigeons has created an increase in the number of protected and sheltered breeding and roosting sites, as well as health concerns relating to the build-up of their faeces and associated fungi, nest mites and bird lice which have been reported to infest the offices and inhabitants of certain buildings on campus (Westington, pers. comm. 2013). Faeces build up on the various balconies on the campus buildings and accumulating nesting material is also a concern which requires attention. According to Ntshoe (pers. comm. 2013), large financial inputs have been put towards trying to manage the birds and their associated problems on an ad hoc and reactive basis.

University Estates Management, responsible for the upkeep of the campus, identified the need for a long term, successful and sustainable pigeon control strategy. The campus' pigeon problem is interdisciplinary in nature, as both the people affected by the birds, as well as various environmental factors, will all play significant roles in the successful management of the problem. This paper will explore the human and social disciplines of the study by reflecting on staff perceptions and views of the pigeons, and the pigeon associated perceived impacts on the people and the campus.

METHODS

This cross-sectional mixed methodology study comprised of two parts, namely an online questionnaire and interviews.

A quantitative design (Jennings, 2001) was adopted for the online questionnaire, which was electronically accessible to all staff members between September 2013 and September 2014 on SurveyMonkey, an online survey development cloud based company (SurveyMonkey, 2015). Data was gathered from consenting staff members in both administrative and academic positions on the UNISA Muckleneuk campus. Primary data was collected from the direct input of participants into the online survey. Participants provided their personal opinions and perceptions relating to pigeons and their activities as well as the potential impact the pigeons have on the staff on the UNISA Muckleneuk campus. Content analysis (Braun & Clarke, 2006) was used to analyse the data.

In addition to the online survey, semi-structured qualitative interviews were conducted with consenting participants to corroborate, clarify and qualitatively supplement the questionnaire data. Participants provided their personal opinions and perceptions relating to pigeons, their related activities and the impact thereof on the UNISA Muckleneuk campus. Saturation was determined by participants' responses. Data was recorded and transcribed and thematic content analysis (Braun & Clarke, 2006) was used to analyse the data.

Institutional ethical permission was received for the research. Ethical issues were considered in order to ensure that the rights of participants were observed, namely:

anonymity, respect for the dignity of persons, nonmaleficence and confidentiality (Terre Blanche, Durrheim & Painter, 2006). Participation was voluntary and participants required informed, voluntary consent to participate in the research.

RESULTS AND DISCUSSION

A total of 246 participants contributed to this study, of which 226 (92%) were online surveys and 20 (8%) face to face interviews, after which saturation was obtained. Figure 1 depicts the summary of these findings.

The results are discussed as per the following main themes obtained from the questionnaires and interviews:

- Pigeons as flying rats or a connection to nature
- People's perceptions of pigeons
- Pigeon activities

- Feeding
- Roosting
- Nesting and breeding

- Pigeon activities that impact people

- Nesting material
- Ectoparasites
- Viewing of squabs in nests
- Interacting with pigeons
- Direct feeding of pigeons

- Humans and their responsibility towards the environment

ARE PIGEONS FLYING RATS OR A CONNECTION TO NATURE?

An age old societal perception of pigeons in urban environments is that of them being 'flying rats'. "Rats with wings" is a metaphor which captures the felt potential of this bird to wreak havoc on civilization, and not only by unleashing disease (Jerolmack, 2008). However according to staff who participated in the study, 77% of them disagreed with this statement as the pigeons are not seen as vermin and their behaviour towards people is not considered to be as destructive as that of rats. Such labels attempt to reinforce that the appearance of pigeons in human space should be experienced with disgust or anxiety (Jerolmack, 2008). Only 12% of the participants agreed with the statement as they believed that pigeons host fleas and lice, and as one participant stated: *"They fly from different locations to come and bring disease".* Eleven percent of the participants were undecided as to their opinion regarding pigeons being considered to be flying rats.

The majority of the participants (77%) felt that pigeons were a part of nature; they indicated affection towards the birds and considered them to be "*God's creatures*". The pigeons are considered to provide an opportunity to get closer to wildlife while in a working environment and provide a living connection to nature in a usually 'dead' urban environment. This relates to the insistent desire that modern humans have to reconnect with that which is natural despite the continued domination and suppression of nature that goes hand in hand with development (Player, 2007). While 13% of the participants were undecided in their opinion, 11% of the participants disagreed with the concept of pigeons allowing a connection to nature. This they based on the perceived irrelevance of the pigeons' contribution to the ecosystem and the view that pigeons which have habituated to thrive in urban environments are domesticated and do not fit the description of 'wildlife'. Wolch and Emel (1998) describe the moral panic that accompanies the idea of 'wild' animals defying the boundary between 'proper' spaces for humans and animals. The way in which people view nature, impacts the way in which wildlife is controlled or managed in urban environments. Thus, how people construct animals reflects our conception not only of nature but also of society (Sabloff, 2001). Botkin (2012) explains that environmental issues can only be effectively confronted once people change their perception of nature.

PEOPLE'S PERCEPTIONS OF PIGEONS

Peoples' perceptions of pigeons strongly influence their reaction towards the birds, as well as their behaviour, opinions and interpretation of how pigeon related activities affect them. Stern, Kalof, Dietz and Guagnano (1995) describe how individual's attitudes about an issue influence their behavioural intentions towards that issue. When participants were requested to state what their perceptions or views of pigeons were, just over half (53%) indicated that they positively perceived pigeons and encouraged their presence on campus. The following is an example of a participant's response: *"They are part of nature. They are calming to look at and hear, especially in a stressful working place. It is nice to have nature close by".* As the participants were positive towards the birds sharing their work environment, they demonstrated higher levels of tolerance towards the noise associated with the pigeons and potential health risks associated with their breeding activities and were therefore less likely to formally complain. The following quotes are examples of what they stated: *"(I) encourage the pigeons, very positive perception"* and *"I think they are great creatures, they are beautiful*". Only 26% percent of the participants indicated negative perceptions towards the birds based on the pigeons and their activities having a direct impact on them. These participants were sensitive towards pigeon-related health risks and found the birds to be *"irritating, especially in the work context..."*. Priego, Breuste and Rojas (2008) suggest that there is a wide range of ways in which contact with nature, in this case pigeons, contributes to generalised improved quality of life. Twenty one percent of the participants were neutral as to their perceptions of the pigeons on campus.

Participants indicated that their perceptions of the pigeons originated from friends (20%), the media (14%), other (personal opinions, observations, experience and religion) (10%), health authorities (8%) and the pest control industry (5%). However the majority (44%) of opinions of participants originated from those of the family in which they grew up. Participants between the ages of 51-60 years and 61-70 years were strongly influenced by family perceptions relating to the birds. This may be contributed to the pigeons having been a part of city life for many years (Levi, 1963) where their presence has been encouraged in public spaces and urban landscapes. People actively fed and interacted with them as part of an enjoyable past time for old and young alike. While the problematic framing of the pigeons is a recent phenomenon (Jerolmack, 2008), the control of the pigeons is likewise a relatively new concept. Older generations therefore, based their opinions and perceptions of the pigeons on how they were raised and the way society, at the time, positively viewed and encouraged the presence of pigeons. Personal opinions, observations and experiences of the pigeons and related activities, also shaped the participants' perceptions. The following are representative quotes from participants: *"I am nature lover, I didn't come from a home that loves nature, but I am one".*

Perceptions and attitudes may or may not change over time depending on a variety of factors. Cordano, Frieze and Ellis (2004) explain how attitudes and perceptions are influenced by socio-demographics, knowledge, experience, values, beliefs and affiliations of an individual. Eighty two percent of the participants' perceptions of the pigeons had not changed over time. Of these participants, the majority were not willing to change their perception of the birds. Participants continued to hold pigeons in a positive light, due to their affection towards the birds and desire to encourage their activities on campus. Pigeons are described to be an urban dweller's constant companion (Reynolds, 2013), filling city environments with life and character. Participants' willingness to change from a neutral perception of the birds to one that is positive could be achieved through the exposure to and acknowledgement of how people interact with the pigeons and view them as companions. The following quote is an example of this: *"Growing up I didn't realise they can be friends, but when I was at Church Square I saw a white man who had befriended the pigeons. I realised that they are friends instead of just birds who will fly away when you come near".*

Eighteen percent of the participants stated that their perceptions had changed over time. Participants who felt that their perceptions of the pigeons had changed from positive to negative based it on noise disturbance and health risks associated with pigeons. The following is a quote from a participant: *"Before I became asthmatic 4* *years ago, I loved them but becoming aware of the health risks and their impact on me…it has changed my view of them to negative"*. However, participants' also felt that their perceptions changed over time depending on the context in which they experience the pigeons and related activities. An example of this was stated by a participant *"It depends on the context, (I am) more negative (towards them) if they mess on my car, but they are also part of nature, so I just live with them*". These findings are consistent with the findings of Krimowa (2012), which suggests that peoples' perceptions may vary regularly depending on the context or situation in which they experience the birds.

PIGEON ACTIVITIES

Food resources and human buildings are the key ecological factors that bring pigeons into most urban environments (Haag-Wackernagel, 1995). Pigeon feeding is a worldwide phenomenon as reported by 20% of United States of America's households (Deis, 1986) and 36-48% of Australian households (Rollinson, O'Leary & Jones, 2003; Ishigame & Baxter, 2007). It is a past time that individuals participate in for a number of reasons; for enjoyment, having an interest in wildlife, to compensate for loneliness, or simply to reconnect with nature. At the Muckleneuk campus, pigeons make use of various buildings as a source of shelter to roost, obtain protection from the elements and safety for rearing of young. Food is provided from direct feeding by staff members and left over food outside the cafeterias on campus. Participants were asked to respond to the various pigeon activities on campus, namely feeding artificially by people, roosting, nesting and breeding. The findings are as follows:

Pigeon feeding

More than half (60%) of the participants indicated that they disapproved of people feeding the pigeons, especially in a work environment. The following quote from a participant represents the feelings expressed: *"Not on campus...it can result in health risks. Working environment is not your exclusive social environment so you must have respect for other people. You might not even be aware of asthma etc because it doesn't impact on you".* These findings were consistent with the research of Rollinson *et al*. (2003) who found that human-wildlife conflicts were intensified when bird feeding occurred due to the increased animal population densities and the wildlife's habituation to people, with the concomitant adverse effects of overpopulation. Twenty four percent of the participants encouraged feeding of the pigeons, they believed that it is *"…positive as it makes them (pigeons) feel welcome".* Even though feeding the pigeons is considered to lead to a greater appreciation of wildlife (Ryan, 2011), there are negative implications on the birds themselves and the urban environment. Sixteen percent of the participants were undecided whether pigeon feeding should be encouraged or discouraged on campus.

Roosting

Jerolmack (2008) describes how pigeons are now a 'homeless' species. The past century has redefined an ever-increasing number of spaces as off-limits to pigeons (and other animals), until there seems that nowhere humans live to be accepting of pigeons. On the Muckleneuk campus, 35% percent of the participants agreed that the roosting activities of pigeons should not be encouraged due to health concerns relating to potential lice and mite transmission from pigeons roosting on and in the cabling ducts on campus. On the contrary 32% of the participants feel a sense of responsibility towards the displaced birds, as suggested by Weber, Haag and Durrer (1994) who stated that some individuals consider it their duty to be responsible for the pigeons. These participants welcome pigeons roosting on campus because they consider the birds to provide a pleasant distraction from the daily mundane work-related tasks. Thirty three percent of the participants were undecided as to whether roosting should be encouraged or discouraged on campus.

Nesting and breeding

The breeding season for pigeons peaks between March and July (Murton, Thearle & Coombs*,* 1972), however due to the minor fluctuations in resources on campus compared to that of natural areas they are able to breed throughout the year (Shochat, Lerman, Katti & Lewis, 2004). Nearly 40% of the participants felt that the birds' nesting and breeding activities on the buildings (in or on the cabling ducts and balcony floors) were positively perceived and should be encouraged, as one participant stated: *"They need a safe place to breed..."*. It was suggested that there was no reason to restrict their reproductive behaviour, as the pigeon population was perceived to pose no problem on campus. However not all participants were activists with regards to the pigeons' nesting and breeding activities. Due to health-related concerns, 37% perceived this to be negative in a working environment, causing the buildings to go into disrepair from the faecal buildup and messy nesting material, and the pigeons being a distraction from work-related tasks. The following is an example of a participant's response: "*It should be discouraged. I had a nest below my window but had to wait for the chicks to fly away before the nest could be destroyed…it is noisy and irritating"*. On the other hand the participants who negatively perceived the nesting and breeding activities of the pigeons had nothing against the birds situating their nests and participating in breeding activities in the trees which populate the campus, as long as this behavior did not take place on the buildings. This suggests that the participants did not negatively perceive the pigeons *per se*, only their reproductive behaviour associated with the buildings in close proximity to their work space. Twenty five percent of the participants were undecided regarding the breeding and nesting activities of the pigeons on campus.

PIGEON RELATED ACTIVITIES IMPACTING STAFF ON CAMPUS

The abovementioned pigeon related activities may directly or indirectly affect people on campus in a positive or negative light, if at all. Participants responded to these impacts as follows:

<u>Nesting material</u>

Litter, in particular nesting material, accumulates under breeding sites or in the cabling ducts. This can be problematic for hygiene as well as creating an untidy image of the buildings (Giunchi, Albores-Barajas, Baldaccini, Vanni & Soldatini, 2012). Nevertheless 43% of the participants stated that they were either undecided (39%) or that nesting material had no impact (4%) on the people working on campus; they believed that the cleaning thereof would however provide an opportunity for job creation. Forty one percent of the participants supported the unhygienic claims as they felt that nesting material negatively impacts staff on campus due to the harboured ecotoparasites and feathers which could affect allergic and asthmatic sufferers. Sixteen participants considered the nesting material to positively impact staff on campus.

Ectoparasites

Pigeons are of considerable epidemiological importance, being potential vectors for a host of ectoparasites such as fleas, mites and ticks (Giunchi *et al*., 2012). Infestation of these parasites does not depend on direct contact with the birds, as exposure can occur with the pigeons and their nesting or roosting sites being in close proximity to human habitation, or working environments. Sixty five percent of the participants consider these ectoparasites to pose a threat to staff on campus, as stated by one participant: *"It is a big problem; we have to evacuate the offices for fumigation. The fumigation also has health impacts".* This finding validates the complaints received by University Estates from staff that referred to lice infestations in offices adjacent to pigeon nesting sites which were positioned in the cabling ducts. However, it does not appear that pigeons are the exclusive hosts or carriers of disease in comparison to that of other urban birds (Angier, 1991; Helen, 2001). According to Jerolmack (2008), their ability to transfer diseases to humans is seldom demonstrated. Magnino, Haag-Wackernagel, Geigenfeind, Helmecke, Dovc, Prukner-Radovcic, Residbegovic, Ilieski, Laroucau, Donati, Martinov & Kaleta (2009) state that pigeons harbour at least 110 human pathogenic organisms, but only seven of these have caused 230 reported infection cases in humans worldwide, 13 of which were fatal (Haag-Wackernagel, 2006). Over 30% of the participants stated that the ectoparasites or the potential threat thereof had an undecided or no impact on staff. These participants felt that they had not been made aware of any documented cases relating to colleagues' offices or experienced infestations on a personal level. The following quote is an example of a participant's response: *"It doesn't impact people, never heard of anyone being affected".* These findings suggest that the perceived lice and mite infestations associated with the pigeons on campus occur sporadically and are not the norm. Two percent of the participants indicated that potential ectoparasites associated with pigeons positively impact staff.

Viewing of squabs in nests

Nesting sites are identified and selected based on suitability relating to the protection from the elements and safety from potential predators such as rats, crows and birds of prey, which could raid the nests of eggs and chicks. Pigeons on campus construct their nests on the floor of the highest balconies as well as in or on top of the exterior cabling and air conditioning ducts. Nests positioned within view of offices provide staff the opportunity to observe eggs and squabs in the nest, which result in a potentially positive experience as agreed upon by just more than half (52%) of the participants. It allows staff to observe pigeon behaviour and the growth progression of the squabs without intruding or influencing the activities relating to the raising of young. Participants felt that it allowed a connection to nature and the Christian faith. Pluta (2012) explains that spirituality is often spoken in terms of a connection to something higher than ourselves, which for many consists of the faith community, connection to God, or connection to nature. This finding therefore suggests that observing squabs in nests could be a spiritual experience as stated by a participant *"It is a pretty sight, it's a beautiful moment, I realise God is there"*. Thirty three percent of the participants stated that this activity had an undecided or no impact on staff suggesting that even though this activity was not actively encouraged, it was also not negatively perceived. The following quote is an example of this: *"It will have* *no impact, only if you want to know more and are interested then it will be a positive impact".* Fifteen percent of the participants felt that the presence and viewing of squabs in their nests had a negative impact on staff and the working environment. The reason for the negative impacts was however not given.

Interacting with pigeons

Botkin (2012) explains that we interact with nature in two ways: rationally and through an inner, personal, non-intellectual response. The latter includes feelings of spirituality, intrinsic value and religious sensitivities. Both ways of interacting with nature are important and perceived in various degrees, as with pigeons, whereby perceptions range from harmless domesticated birds to harmful pests, depending on the participants' personal cultural background (Johnston & Janiga, 1995; Jerolmack, 2008). The impact that the pigeon-human interactions have on staff is considered to positive. Half of the participants indicated that the interaction with the birds is a calming and peaceful experience. This interaction also provides the opportunity for staff to observe pigeon behaviour and allow a sense of connectedness to nature in the sterile work place which is usually void of natural life. One participant stated: *"It is peaceful and calming. I would rather have pigeons on windowsill than car noises. Having them brings nature closer".* This sense of connectedness and viewing pigeons as a means to bring nature closer to the office reiterates how people living in cities subconsciously seek to reconnect as suggested by Player (2007). Twenty three percent of the participants stated that interaction with the pigeons should not take place in a working environment as it reinforces their presence on campus and dependency on human-related resources. Twenty seven percent of the participants were either undecided and or considered pigeon-human interaction to have no impact on staff.

Direct feeding of pigeons

Certain staff members have taken it on themselves to actively provide sustenance in the form of seed on a regular basis to the pigeons on campus. This deliberate and direct feeding was considered to have a negative impact on other staff members by 46% of the participants. These participants regard the university as a working environment which should be considered as a public space. Individuals' decisions to feed the birds on campus can affect others who may consider them to be pests or have health sensitivities. Artificial feeding encourages pigeons' dependency on people which would have negative repercussions on their wellbeing when the individuals feeding the birds take a leave of absence. This is especially true for the pigeons on campus that breed throughout the year and would therefore have reliant young to feed. The following quote is an example of a participant's response: *"It must not happen, as the pigeons must not be encouraged to be dependent on people for their food".* Interestingly, staff who discouraged feeding were more concerned about the food type and quality that was being fed to the pigeons than the actual act of feeding. This finding is similar to the Rollinson *et al*. (2003) study where direct feeding was found to create inappropriate diets in birds. Participants suggested that as the pigeons become reliant on the food provision, they become increasingly vulnerable to being poisoned or captured by people.

Thirty two percent of the participants felt that direct feeding of the pigeons had a positive impact on the staff of the campus. It was considered to promote a sense of selflessness through the act of sharing with others, creating empathy for wildlife (Rollinson *et al*., 2003), appreciation for nature and enjoyment in the activity. The following quote is an example of a participant's response: *"People do it because they enjoy it".* Twenty two percent of the participants were undecided or considered the direct feeding of pigeons to have no impact on staff. The study also found that the majority of the participants, who felt that feeding had positive impacts on staff, were female. A finding supported by Weber *et al.* (1994) who suggested that pigeon feeders tend to be female.

HUMANS AND THEIR RESPONSIBILITY TOWARDS THE NATURAL ENVIRONMENT

Shochat, Lerman and Fernández-Juricic (2010) describe how most of the world's land is managed and dominated by humans, resulting in a globally high rate of urbanisation and rapid loss of wild habitat land. Humans are often blamed for the encouragement and growth of 'pests' in urban environments based on the provision of shelter and food. Sixty four of the participants agreed with this statement as they believed that humans are the cause of pigeon population problems. Of these participants, 60% stated that the reason was the abundant food resources due to an increase in exotic vegetation, refuse, the use of feeders (Schotat *et al*. 2010) and direct feeding. Twenty five percent of these participants indicated that the encroachment of natural habitat is a reason for problem pigeon populations. However, Schotat *et al*. (2010) explain that urban environments can no longer be viewed as lost habitat for wildlife, but rather as new habitat that, with proper management, has the potential to support diverse bird communities. This is supported by Hutton and Rostron (2005) who say that provision of shelter to roost and breed on the infrastructure provided in built-up landscapes, especially that of cities with tall buildings, provide habitats very similar to the cliff homes of the pigeons' ancestors. The ample provision of shelter (5%), humans affecting the predator-prey balance (5%), encouragement of the pigeons into urban spaces (3%) and being unsure (2%) were also provided as reasons for problematic pigeon populations in urban environments.

Thirty six percent of the participants opposed the statement depicting humans to be the cause of problematic pigeon populations in urban environments. They indicated that it is rather due to the lack of natural predators resulting in lower predation pressure in urban environments which enable pigeons to live in higher densities in cities (Sorace, 2002) and that pigeons display a remarkable ability to exploit resources and adapt over time and space.

Cities are now viewed as challenging ecosystems for sustaining biotic communities and rich diversity for which humans are responsible for managing. The vast majority of the participants (96%) deem it the responsibility of public and private authorities, namely municipalities, local councils, conservation organisations, Department of Water and Environmental Affairs and independent building owners, to control or manage pigeons in urban environments. It was also stated that responsibility was multi-tiered, suggesting that every person has to be accountable for their actions and realise that interfering with nature has knock-on effects, even if they are not immediately visible. As evidence suggests, people exposed to nature in their daily lives heighten their perception of environmental problems (Priego *et al*., 2008). An individual's behaviour and behavioural intentions towards the natural environment are influenced by their environmental attitudes (Frasson & Gärling, 1999). More than half (51%) of the participants indicated that they were interested in or participated in conservation related activities therefore suggesting that they had an awareness of environmental issues, such a problem pigeons, as well as an identity of their roles as humans in the natural world. The majority of the remaining participants who stated that they weren't actively interested or involved in conservation related topics; were however aware of the pigeons and their related activities on campus. Suggesting that through their regular exposure to the birds on campus, they became aware of the natural world without participating in formal conservation related activities outside of their working environment. This is in line with a study that has concluded that interactions between humans and urban wildlife influence individuals' attitudes and willingness to contribute to conservation (Krimowa, 2012).

As most of the world's population lives in urban environments, the success of conservation projects and human-wildlife conflict resolution depends on the attitudes and perceptions of people in cities relating to urban wildlife as well as their interest and involvement in conservation initiatives.

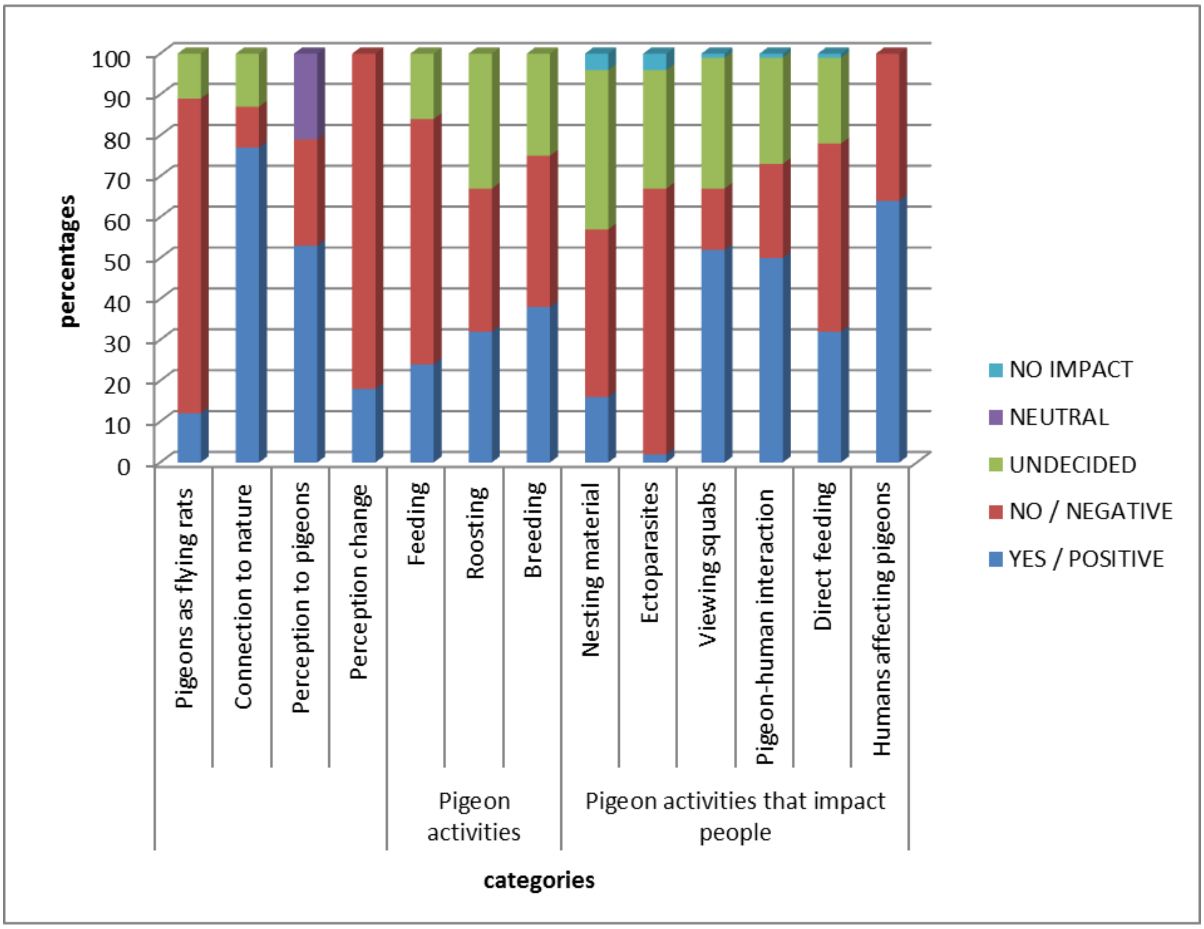


Figure 4: Summary of categories and results of staff perceptions of the pigeons on the University of South Africa's Muckleneuk campus

CONCLUSION

The generalised negative perception of the pigeons on the Muckleneuk campus is inaccurate.

The vast majority of participants indicated to be 'pro-pigeon'. They did not perceive, nor experience the pigeons to be a problem on campus but instead welcomed and encouraged their presence and activities in their work environment. They felt that pigeons allow a connection to nature, improve staffs' quality of life by creating a sense of peace and calm in stressful working conditions and are a pleasant distraction from routine work related tasks. Their positive perceptions largely originated from their family background and opinion of the birds.

Nesting and breeding were positively perceived and encouraged by most on campus as they enabled a connection to nature in a usually sterile man-made environment. However, participants were concerned about the pigeons' wellbeing relating to food dependency and the quality that was provided by some staff members on a regular basis. Regardless of the potential negative implications of having pigeon populations in close proximity to the work space, participants mostly continued to perceive the presence of the birds as positive.

Humans play a significant role in the way in which pigeons impact people and infrastructure. There needs to be a paradigm shift in the way people think and act towards the environment. Jerolmack (2008) pertinently explains that with the loss of everyday animal encounters, there has come a loss of tolerance for them, in essence causing isolation from the natural world. The existence between pigeons and people is interconnected, whether it is formally recognised or not, each plays a role in the others' lives. It is therefore imperative that scientific understanding and peoples' perceptions relating to human-pigeon interactions are thoroughly investigated in order to successfully manage conflicts in urban spaces.

IMPLICATIONS OF THE STUDY

There is an assumption that pigeons in urban environments are generally viewed in a negative light. However, this study has shown that most staff welcome and encourage the presence of the pigeons in their working environment. Problems and potential irritation associated with the birds are assumed to be a blanket response of all the people affected by pigeons in urban spaces, in particular in the work place. This proposes that a small vocal minority can give the impression that the problem is greater than the actual reality (Ryan, 2011). The concept of pigeon control is often based on the complaints of a perceived problem and public nuisance that these birds could potentially pose. However people who are 'pro-pigeon' are equally significant in the success of managing human-wildlife conflicts. The consideration of opinions and perceptions of all people affected, both negatively and positively, by the pigeons should be investigated prior to the removal or reduction of the species from urban spaces. This study has shown that pigeons play a significant role in society, and the rash elimination or control thereof could potentially not only result in an environmental void but also a societal psychosomatic loss in people positively affected by the birds.

ACKNOWLEDGEMENTS

Acknowledgement and thanks to the Applied Behavioural Ecological and Ecosystem Research Unit (ABEERU), at the University of South Africa, and the National Research Foundation NRF) for funding this research.

BIOGRAPHICAL NOTE

Emma Harris is currently a final MSc student at the University of South Africa. Her research explores human-wildlife conflict and animal welfare concerns. She has been academically recognised for outstanding academic achievement at undergraduate and post-graduate levels and will pursue a PhD in the future.

REFERENCES

ANGIER, N. 1991. New York's Tough Pigeons Fight Predators for Survival. *New York Times,* July 8:A1.

ANDRZEJEWSKI, R., BABINSKA-WERKA, J., GLIWICZ, J. & GOSZCZYNSKI, J. 1978. Synurbanisation processes in an urban population of *Apodemus agrarius*. I. Characteristics of population in urbanization gradient. *Acta Theriologica,* 23:341–358.

BABINSKA-WERKA, J., GLIWICZ, J. & GOSZCZYNSKI, J. 1979. Synurbanisation processes in an urban population of *Apodemus agrarius*. II. Habitats of the Striped Field Mouse in town. *Acta theriol.* 26:405-415.

BOTKIN, D. 2012. The Moon in the Nautilus Shell. New York: Oxford University Press.

BRAUN, V. & CLARKE, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2):77-101.

CORDANO, M., FRIEZE, I. & ELLIS, K. 2004. Entangled affiliations and attitudes:an analysis of the influences on environmental policy stakeholders' behavioralintentions. *Journal of Business Ethics,* 49(1):27–40.

DEIS, R. 1986. Is bird feeding a no-no? *Defenders,* 54:17-18.

FRANSSON, N. & GÄRLING, T. 1999. Environmental concern: Conceptual definitions, measurement methods, and research findings. *Journal of environmental psychology*, 19(4):369–382.

GIUNCHI, D., ALBORES-BARAJAS, Y.V., BALDACCINI, N.E., VANNI, L. & SOLDATINI, C. 2012. Feral Pigeons: Problems, Dynamics and Control Methods. In: Soloneski, S. (ed.). Integrated Pest Management and Pest Control - Current and Future Tactics. Intech.

HAAG-WACKERNAGEL, D. 1995. Regulation of the street pigeon in Basel. *Wildlife Society Bulletin,* 23(2):256-260.

HAAG-WACKERNAGEL, D. 2006. Human diseases caused by feral pigeons. In: FEARE, C.J. & COWAN, D.P. (eds.). Advances in Vertebrate Pest Management, Filander Verlag, Fűrth 4:31-58.

HAAG-WACKERNAGEL, D., HEEDB, P. & LEISS, A. 2006. Phenotype-dependent selection of juvenile urban feral pigeons Columba livia: Capsule we suggest the existence of colour-based selection processes on juvenile feral pigeons in an urban environment. *Bird Study*, 53(2):163-170.

HELEN, B. 2001. "City Pigeons: Coo or Shoo?" *The Dominion (Wellington)* Feb. 6:9.

HUTTON & ROSTRON, 2005. *Method statement for the control of feral pigeons* [Online]. Available from: http://www.handr.co.uk/literature/feral_pigeons.htm. [Accessed: 05/08/2014].

ISHIGAME, G. & BAXTER, G.S. 2007. Practice and attitudes of suburban and rural dwellers to feeding wild birds in Southeast Queensland, Australia. *Ornithological Science,* 6:11–19.

JENNINGS, G. 2001. *Tourism Research*. John Wiley and Sons: Queensland.

JEROLMACK, C. 2008. How pigeons became rats: The cultural-spatial logic of problem animals. *Social problems,* 55(2):77-94.

JOHNSTON, R.F. and JANIGA, M. 1995. *Feral pigeons.* New York: Oxford University Press.

KRIMOWA, S. 2012. Pigeons and people: resource ecology and human dimensions of urban wildlife. M.Sc. Victoria University of Wellington.

LEVI, W.M. 1963 [1941]. *The Pigeon*. Sumter: Levi Publishing Co.

LUNIAK, M. 2004. Synurbanization – adaptation of animal wildlife to urban development. In: SHAW, W.W., HARRIS, L.K. & VANDRUFF, L. (eds.). *Proceedings of the 4th International Symposium on Urban Wildlife Conservation*. Arizona: Tucson:50–55.

MAGNINO, S., HAAG-WACKERNAGEL, D., GEIGENFEIND, I., HELMECKE, S., DOVC, A., PRUKNER-RADOVCIC, E., RESIDBEGOVIC, E., ILIESKI, V., LAROUCAU, K., DONATI, M., MARTINOV, S. & KALETA, E.F. 2009. Chlamydial infections in feral pigeons in Europe: Review of data and focus on public health implications. *Veterinary Microbiology,* 135:54-67.

MURTON, R.K., THEARLE, R.J.P. & COOMBS, C.F.B. 1972. Ecological studies of the feral pigeon Columba livia var. lll. Reproduction and plumage polymorphism. *Journal of .Applied. Ecology,* 9:841-853.

NTSHOE, L. 2013. Catering and Cleaning manager, University Estates, UNISA. Personal communication.

PICKETT, S.T.A, CADENASSO, M.L., GROVE, J.M., BOONE, C.G., IRWIN, E., GROFFMAN, P.M., KAUSHAL, S.S., MARSHALL, V., MCGRATH, B.P., NILON,

C.H., POUYAT, R.V., SZLAVECZ, K., TROY, A. & WARREN, P. 2011. Urban ecological systems: A decade of progress. *Journal of Environmental Management* 92:331–362.

PLAYER, I. 2007. *Zululand Wilderness Shadow and Soul*. Cape Town: David Philip Publishers.

PLUTA, A. 2012. Integrated Well-being: Positive Psychology and the Natural World. MAPP. dissertation, Pennsylvania: University of Pennsylvania.

PRIEGO, BREUSTE & ROJAS. 2008. Perception and Value of Nature in Urban Landscapes: a Comparative Analysis of Cities in Germany, Chile and Spain. *Landscape Online,* 7:1-22.

REYNOLDS, E. 2013. Fowl friends. Socialist explores the love-hate relationship between people and pigeons. *NYU Alumuni Magazine* [Online] 20:Spring. Available from: https://www.nyu.edu/alumni.magazine/issue20/nyc_1.html [Accessed: 04/09/2014].

ROLLINSON, D., O'LEARY, R. & JONES, D.N. 2003. The practice of wildlife feeding in suburban Brisbane. *Corella*, 27:52–58.

RYAN, A.C. 2011. The distribution, density, and movements of feral pigeons *Columba livia* and their relationship with people. M.Sc. Victoria University of Wellington.

SABLOFF, A. 2001. *Reordering the Natural World*. Toronto: University of Toronto Press.

SHOCHAT, E., LERMAN, S.B., KATTI, M. & LEWIS, D.B. 2004. Linking optimal foraging behavior to bird community structure in an urban-desert landscape: Field experiments with artificial feeding patches. *American Naturalist,* 164:232-243.

SHOCHAT, E., LERMAN, S. & FERNáNDEZ-JURICIC. 2010. Birds in Urban Environments: Population Dynamics, Community Structure, Biodiversity, and Conservation. *Urban Ecosystem Ecology.*

SORACE, A. 2002. High density of bird and pest species in urban habitats and the role of predator abundance. *Ornis Fennica,* 79:60-71.

STERN, P., KALOF, L., DIETZ, T. & GUAGNANO, G. 1995. Values, beliefs, andproenvironmental action: Attitude formation toward emergent attitudeobjects. *Journal of Applied Social Psychology,* 25(18):1611–1636.

SURVEY MONKEY. 2015. *Survey Monkey* [Online]. Available from: https://www.surveymonkey.com/ *[Accessed: 28/01/2015].*

TERRE BLANCHE, M., DURRHEIM, K. & PAINTER, D. 2006*. Research in practice: Applied methods for the social sciences* (2nd ed.). Cape Town, SA: University of Cape Town Press.

UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION 2014. *World Urbanization Prospects: The 2014 Revision, Highlights.*

WEBER, J., HAAG, D. & DURRER, H. 1994. Interaction between humans and pigeons. *Anthrozoos*, 7:55–59.

WESTINGTON, J. 2013. Pest control manager, UNISA. Personal communication.

WOLCH, J. & EMEL, J. **(eds.).** 1998. *Animal Geographies*. New York: Verso.

CHAPTER 5.2

Pigeon control and people:

A case study on staff perceptions of the pigeon problem and control measures on the University of South Africa, Muckleneuk campus

E Harris, EP de Crom, A Wilson

ABSTRACT

Pigeons are often considered a nuisance in urban environments, leading to the attempted control or eradication of their populations. Pigeon control is however not an isolated discipline. People affected, either positively or negatively by the birds, are often not provided the opportunity to voice their opinions about the birds, in particular, the control of methodologies employed. A study was initiated as a result of a perceived pigeon problem, needing urgent attention on the University of South Africa's Muckleneuk Campus. This aspect of the study explored the perceptions of the staff employed on the campus. Two hundred and forty six participants (n=246) provided their opinions on the perceived pigeon problem, the control methodologies and management, as well as the effectiveness and sustainability thereof. The study found that staff did not consider the pigeons or their related activities to pose a problem on campus. This combined with the isolated pigeon related complaints received by University Estates, showed that the negative perception of the pigeons was not representative of reality. Staff felt that should control be imposed, the birds should rather be humanely managed through non-lethal measures rather than eradication. The study supported the idea that public participation in the

development and implementation of pigeon control plans is an integral part of the process and will provide the opportunity to learn from others, build peoples' confidence in management, as well as ensure sustainability and effectiveness of proposed pigeon control programmes. Focus should therefore not be exclusive to the ecological aspects of controlling pigeons, but should also include the human association because unless all stakeholders are recognised and heard it is unlikely that actions to reduce or eradicate pigeons from a particular area will be successful and sustainable.

KEYWORDS: *pigeons, pest management, control measures, perceptions*

INTRODUCTION

University campuses can be regarded as 'small cities' due to their large human population and the various complex activities taking place on them, which have both direct and indirect impacts on the environment (Alshuwaikhat & Abubakar, 2008). Universities worldwide are responding to the call for 'greener' campuses and practices, the need to sustainably develop and consider the environment in which they function. The University of South Africa (UNISA) has responded to the need for environmental awareness by recognising and promoting sustainable practices through the implementation of several institutional measures. As a member of the United Nations Global Compact (UNGC) which contributes to and abides by practices that support sustainability and social transformation, the institution has taken a voluntary stand to promote environmental responsibility, undertake a precautionary approach towards environmental hurdles and to encourage the development and use of environmentally friendly tools (UNISA, 2015).

With urban development comes the environmental displacement of certain species. Species are forced to perish, flee or adapt to their new living environments in order to survive. Particular animals are apt at adjusting, such as the Feral Pigeon (*Columba livia*) and Speckled pigeon (*Columba guinea)* (hereafter referred to collectively as pigeons). Pigeons are known to be one of the most successful colonisers of urban environments (Haag-Wackernagel, Heeb & Leiss, 2006). Separated only by genetic variation, Feral Pigeon are descendents of domesticated breeds of wild Speckled Pigeon (previously known as the Rock Pigeon) (Jonston & Janiga, 1995; Stringham, Mulroy, Xing, Record, Guernsey, Aldenhoven, Osborne & Shapiro, 2012) which have adapted their original diets of grain to include anthropogenic sources of food. They also have managed to successfully exploit urban infrastructure for breeding and roosting purposes. Low levels of predation (Sorace, 2002) and abundant resources (Sol, Santos, Garcia & Cuadrado, 1998) contribute to the demographic success of pigeons in cities.

Pigeon populations live close to human activities. Their behaviour, foraging abilities and bi-products are cause for their acceptance or dismissal by people. Belguermi, Bovet, Pascal, Prévot-Julliard, Jalme, Rat-Fischer and Leboucher (2011) describe how the majority of city dwellers are hostile to pigeons, often chasing them away. However, others who are 'pro-pigeon', encourage these birds as a means to connect to nature, to fill a void of loneliness, or to simply enjoy their presence (Weber, Haag-Wackernagel & Durrer, 1994).

Negative views and perceptions of these birds and their associated impacts are often heard first, resulting in the pigeons being considered as an environmental issue or pest to which action should be taken. However, traditional practices and regulations to address environmental issues, such as pigeon control within urban environments, are reactive and ad hoc and have become highly inefficient without guaranteed sustainability (Alshuwaikhat & Abubakar, 2008). Dealing with environmental issues is complex and multidimensional and pigeon control cannot be seen as a 'one-size-fits-all' solution. Interconnectedness between people and the environment needs to be considered as there appears to be a general lack of a holistic understanding of pigeon problems amongst management, which results in individual inappropriate and misapplied control techniques (Hutton & Rostron, 2005).

The need for public participation

A pigeon population which has been identified as problematic within an urban setting and the control thereof, is not an isolated discipline. Those who are affected by the birds, as well as environmental factors, play significant roles in the successful management of the birds. The social aspect however, appears to be lacking when dealing with environmental issues, particularly with perceived pests. People affected both positively and negatively by the pigeons, are not consulted during the design or implementation of the control and management plans. Pest management or control is often initiated by peoples' initial complaints requesting a need for action, but no formal platform is created for those who are pro-pigeons to express their opinions. According to Alshuwaikhat and Abubakar (2008), the integration of public participation and social responsibility strategies will remedy the limitations of current environmental management practices. Through the recognition and participation of stakeholders in the control process, management plans can be interdisciplinary and sustainable in the way in which they provide remedial and long term action towards reducing and managing pigeon populations in urban environments. Shea, Thrall and Burdon (2000) confirm this as integration across disciplines is an important source of ideas, leading to new avenues for theoretical and empirical investigations.

Stakeholders are usually defined in terms of their responsibility for avoiding or controlling an environmental issue, or by their roles in dealing with the consequences (Brunet & Houbaert, 2007). However, these groups are loosely constructed by the society in which they operate and are dependent on the issue at hand. Involving all stakeholders in a public participation process contributes to the planning and implementation of pest control strategies such as with pigeons. It also allows management to consider all stakeholders' views, opinions and perceptions of the perceived problem and ascertain the validity of the complainants.

Alshuwaikhat and Abubakar (2008) pointed out that public participation communicates the interests, and meets the process needs of all participants and provides them with the information they need to participate in a meaningful way. It also indicates how their input affects the decision. This is a vital component of a sustainable plan as decisions which affect people and the environments in which they work or live, are often taken without their consideration or input. Exclusion from the process in which decisions are made can cause people to harbour resentment towards authorities and can result in the rebellion against such decisions.

This article proposes a need for public participation and social responsibility in an integrated approach to achieving sustainable pigeon management which is both holistic and interdisciplinary. In the light of the above, the main aim of this study was to explore the views of people on the perceived pigeon problem, complaints relating to the pigeons, pigeon management and the pest industry's control measures.

METHODS

This cross-sectional mixed methodology study comprised of two parts; namely an online questionnaire and interviews.

A quantitative design (Jennings, 2001) was adopted for the online questionnaire, which was electronically accessible to all staff members between September 2013 and September 2014 on SurveyMonkey, an online survey development cloud based company (SurveyMonkey, 2015). Data was gathered from consenting staff members in both administrative and academic positions of the UNISA Muckleneuk campus. Primary data was collected from the direct input of participants into the online survey. Participants provided their personal opinions and perceptions relating to pigeons, population control and the perceived problem on the UNISA Muckleneuk campus. Content analysis (Braun & Clarke, 2006) was used to analyse the data.

In addition to the online survey, semi-structured qualitative interviews were conducted with consenting participants to corroborate, clarify and qualitatively supplement the questionnaire data. Participants provided their personal opinions and perceptions relating to pigeons, industry population control options and the perceived problem on the UNISA Muckleneuk campus. Saturation was determined by participants’ responses. Data was recorded and transcribed and thematic content analysis (Braun & Clarke, 2006) was used to analyse the data.

Institutional ethical permission was received for the research. Ethical issues were considered in order to ensure that the rights of participants were observed, namely: anonymity, respect for the dignity of persons, nonmaleficence and confidentiality (Terre Blanche, Durrheim, & Painter, 2006). Participation was voluntary and participants had to give informed, voluntary consent to participate in the research.

RESULTS AND DISCUSSION

A total of 246 participants contributed to this study, of which 226 were online surveys (n1 = 226; 92%) and 20 were interviews (n2 = 20; 8%), after which saturation was obtained. Figure 5 depicts the summary of these findings.

The results are discussed as per the following main themes obtained from the questionnaires and interviews:

- Pigeons posing a problem
- Pigeon related complaints
- Pigeon population control
- Pigeon control measures

PIGEONS POSING A PROBLEM

Abundant food availability, prime nesting sites and the absence of natural selection factors in urban environments encourage pigeons to display pest-like qualities (Dobeic, Pintaric, Vlahovic & Dovc, 2011). Pigeons have been known to be a nuisance to people (Keenan, 2000), deface structures with their droppings and nesting material (Giunchi, Albores-Barajas, Baldaccini, Vanni & Soldatini, 2012) and present a health hazard to people in close proximity to their roosting and nesting sites (Hutton & Rostron, 2005) all of which represents a problem in an urban setting.

Urban environments are conducive to pigeon populations. The University of South Africa (UNISA) Muckleneuk campus, in Pretoria, is host to a number of pigeons. They are reported to be a source of public nuisance as a result of damage to buildings (due to their faeces) and also their perceived health risk to the staff who are employed on the campus (Ntshoe, 2013, pers. comm.). Reactive ad hoc cleaning and nest removal has had limited impact on reducing the resident pigeon population inhabiting the buildings on campus. University Estates, the Department responsible for the upkeep of the campus, would like to limit the number of pigeon-related complaints through a long term, cost efficient and sustainable pigeon control programme specific to the Muckleneuk campus (Ntshoe, 2013, pers. comm.).

Pigeon control is usually done without consulting the people affected, whether they are affected positively or negatively. Complaints of pigeon related concerns are often the catalyst for the action taken against the birds. There is however, a group of people who are pro-pigeons, and who may present greater concerns once action has been taken to control or remove the pigeons. Brunet and Houbaert (2007) explain that these stakeholders are far less evident during periods of normality (i.e. non-control), but instead emerge mainly during or after the pigeon control or removal. This study found this to be true as the majority of participants (68%) did not consider the pigeons to be a problem on campus.

These participants indicated that the pigeons did not display pest-like qualities and were a part of nature and the working environment. The following are quotes from the participants: *"They are not bothering me"* and *"They are a part of nature; they improve peoples' understanding of animals. It (forms) a part of learning about animals"*.

Only 32% of the participants considered the pigeons and their related activities to pose a problem on campus. This, they felt, was due to the birds being a nuisance, a source of lice infestations in the offices and posed heath-risks to staff. Humane discouragement of pigeons from buildings (13%), non-lethal control (12%), removal of pigeons and nests without squabs from buildings (7%), leave the pigeons alone (4%) and lethal methods of control (4%) were suggested by these participants as the preferred solutions to the perceived problem. Sixty percent of the participants did not comment on preferred solutions.

PIGEON RELATED COMPLAINTS

Awareness and concern regarding the presence of pigeons in an urban environment are often brought about by people who complain about the birds and their related activities to various authorities. These complaints often initiate the desire to control pigeon populations.

A mere 12% of the participants complained about the pigeons and their related activities on campus. These were reported to the University Estates and mostly referred to the request for the removal of droppings and the fumigation of offices due to lice infestations assumed to arise from nearby pigeons, as stated by a participant: *"I reported about lice, Buildhelp came and fumigated (my office)".* Complaints indicated by the participants were received over a six year period, from 2009 to 2014. Therefore, it can be said that the pigeon population on campus does not directly impact many staff members negatively and that the perceived pigeon problem is caused by isolated incidents. The request for action to be taken against the birds from the staff on campus may be related to who complains rather than being based on the actual number of complaints received. This was validated as many participants' complaints were directed through a chief of department who requested that the pigeons be removed. Participants who negatively perceived the pigeons, and complained about their presence and activities on campus, were in positions of authority with the influence to make decisions against the birds.

Regardless of the potential negative impacts associated with pigeons and related activities, the majority of participants indicated that the birds did not pose a problem on campus. However, few studies have been done to evaluate the direct costs and economic losses related to pigeons in urban environments (Bevan, 1990; Haag-Wackernagel, 1995; Pimentel, Lach, Zuniga & Morrison, 2000; Phillips, Snell & Vargas, 2003; Zucconi, Galavotti & Deserti, 2003). The alleged harm and damage caused by the pigeon population on campus has yet to be quantified. Suggesting that until an analysis of the pigeon-related damage is conducted on campus, the perceived problem of the pigeons for which control measures are planned, could simply be an unsupported view by management.

PIGEON POPULATION CONTROL

Pigeon population management, eradication or reduction can be used to achieve control. Dobeic *et al*. (2011) explain that the general intent of any population control is to achieve and maintain a manageable and suitable population size through various structures and strategies.

University management should ease potential conflict between people and pigeons (Krimowa, 2012). Therefore, management responsible for pest control and hygiene in the University Estates department has proposed that control measures should be taken against the pigeons. In this regard, 76% of the participants stated that the birds should in fact be managed. All these participants, however, agreed that this should be done not due to the pigeons posing a problem, but instead, as an alternative to eradication and as a means to learn from and monitor the current population on campus.

An alternative solution was suggested by 28% of the participants, namely, the provision of a designated area for the pigeons. This would allow the birds to continue their activities as 'normally' as possible without the concern of it impacting staff or buildings. This finding suggests that the participants are aware that the pigeons will ultimately be controlled or at the very least managed. This realization resulted in the suggestion of an alternative which is considered to not be as drastic as removal. A designated area would allow the birds to continue living on campus which would benefit both the animals and the people who positively observe them. The following quotes are examples of what participants had to say: *“We should make their own area that I can go and see them. If people have a problem with the pigeons they won’t be around them”* and *“There should be a place or a (piece of) land where all the pigeons can gather so we can learn about what they desire and to learn about them”.*

Another alternative described by participants would be the discouragement of the pigeons from utilizing the buildings for roosting and breeding activities and thereby forcing them to make use of the natural habitat on campus. This too would favour both the birds and the people. If control of the pigeons has been proposed by participants, they suggested that the measures and strategies should be non-lethal and humane.

Participants who held a generally negative perception of pigeons (26%), had their views confirmed by the negative experiences they encountered with the birds in their working environment. The following quote is an example of a participant’s response: *“(The pigeons are) irritating, distracting, noisy, mess and dirty*”. These participants believed that there should be zero tolerance towards pigeons and their activities on campus. This suggests that people who already hold a negative view the birds will by default be negatively inclined in their perception of the presence and activities of the pigeons in their personal space.

Pigeon control ranges from non-existent to aggressive. Public and private authorities choose the course of action, if any, against the birds in an effort to remedy the perceived problem. Non-lethal management, lethal eradication or simply leaving the birds alone are broad control options, each achieving a different outcome. Participants view pigeon population control on the Muckleneuk campus as follows:

Broad pigeon population control

When staff members were posed with the broader concept of pigeon control on campus, 76% of the participants stated that the birds should be managed. This would provide an opportunity to monitor the pigeon population and to be informed about their behaviour which could potentially affect humans. The following was stated by a participant: *"It will be easy for us to learn about them and to monitor them".* Pigeon control and monitoring are intimately related, as estimates of pigeon abundance are not only essential for the assessment of population size in order to justify control, but also for the choice of appropriate control methods, with a plausible estimate of their costs and effectiveness (Giunchi *et al*., 2012). Participants believed that management would favour both the birds, who would continue to live on campus, and the people, who enjoy their presence. The following quotes are examples of participants' responses: *"…I think people should be managed more than the pigeons"* and *"It would be in favour of pigeons and people*". It was also stated that management of the birds would be suitable if the pigeons currently posed a problem on campus, however if the contrary were to be proved true, the pigeons should rather be left alone.

The statement that the pigeons should rather be left alone is the opinion of 15% of the participants. These participants felt that the pigeons did not need to be managed or controlled as they did not pose a problem to staff members, nor affect the structural elements of the university. The following quotes are examples of participants' responses: *"They are not a problem, wondered why people would want to keep the pigeons away"* and *"They are not doing anything wrong".* According to Lever (1987) pigeons have formed naturalized populations all around the world, particularly in urban environments. This statement is supported by participants who believed the birds should be left alone, as they consider them to be a part of the environment in which they work and an integral part of nature.

Interestingly the majority of the interviewed participants, who stated that the pigeon population should be managed, was male, while those who believed the birds should be left alone were female. This finding is supported by Bremner and Park (2007) who found that men were more supportive of wildlife control and eradication as opposed to women.

Less than 10% of all participants stated that the pigeon population on campus should be eradicated for health related concerns and the nuisance they pose in the workplace. During interviews it became clear that this view was shared by participants who had negatively experienced the birds' activities on campus, resulting in a negative impression and desire for eradication.

Pigeon management

Pigeon management should be a specific control programme which meets the identified requirements of the particular management unit, whilst taking into account pigeon biological behaviour, abundance and presence, environmental factors, financial constraints and the human association. It will ultimately provide a more integrated pigeon control strategy which may be positively received by interested and affected parties if peoples' opinions and the consideration of animal welfare are taken into account (Krimowa, 2012).

Management of the pigeons on campus was considered to be a *necessity* by 35% of the participants. It was proposed that management would prevent the current pigeon population from becoming a problem in the future. The following quote is an example of a participant's response: *"(Management is a necessity because) otherwise if they become a problem in the future, they will get rid of them and then something of nature will go missing".* This finding suggests that active management of the birds is not presently required on campus as the pigeons do not currently pose a problem. Participants felt that if University Estates intend on implementing pigeon control, managing the birds should rather be the preferred alternative. The only direct reference linking management as a necessity to the perceived pigeon problem was indicated by one interviewed participant who stated that management would resolve and prevent further health risks to staff relating to the pigeons and their activities. The remaining participants who considered pigeon management as a necessity justified their views in favour of the birds, as management would be the most favourable option as opposed to lethal measures. It would also provide an opportunity to learn about the pigeons as stated by a participant: *"...to learn more about pigeons - what they do, how they think".*

Furthermore pigeon management was considered to be a *solution* by 35% of the participants. It was regarded as a precautionary measure to prevent the population from potentially becoming a pest and as an alternative to eradication which was not deemed a viable option. Reference to the perceived problem on campus was indicated by one of the interviewed participants who stated that the *"mite problem affects people",* therefore deeming management to be a solution to address ectoparasite infestations in offices presumably related to pigeon roosting and nesting activities.

A relatively low number of 13% of all participants considered management of the pigeon population to be a waste of time. They either do not consider the birds to be a problem on campus and therefore do not require control or management; or they believe that pigeon management would be a waste of finances and university resources, suggesting that the birds were not presently a problem. The following quote is an example of a participant's response: *"They are part of nature, so spending the money (on controlling the pigeons) is a waste when it could be used for better purposes".*

Less than 10% of all participants indicated that they were not interested in the prospective pigeon management programme as they were of the opinion that the birds were not a pest on campus, as stated by a participant: *"...they are not bothering me"*. These participants were more concerned about the costs involved in a control programme than the management actions pertaining to the pigeons. Gilsdorf (2003) claims that public are more likely to support control measures when the pigeons pose a health hazard or there is economic loss experienced associated with the birds' presence and related activities.

PIGEON CONTROL MEASURES

Pigeon control systems are aimed at increasing mortality, decreasing natality, resource management, or a combination thereof (Haag-Wackernagel, 2008). Even though a wide range of control options exist (Haag-Wackernagel & Geigenfeind, 2008), integrative measures are more likely to ensure a sustainable solution specific to the pigeon problem (Haag-Wackernagel & Bircher, 2010).

The pest management industry has a variety of lethal and non-lethal control options available to the public to control pigeon populations in urban environments. Haag-Wackernagel (2008) summarizes a number of techniques that have been applied to urban environments to try and achieve control and or eradication of problem pigeon populations. Generally the techniques are classified under certain management strategies which include increasing mortality, reducing natality and resource management.

Pigeon control methods commonly increase population mortality through killing by shooting, poisoning and trapping. In this regard 16% of participants indicated that trapping and removal of pigeons would have a sustainable impact on the pigeon population on campus. Killing by poisoned baits and shooting was considered to be sustainably effective by only seven percent of the participants. Killing was considered to be unsustainable, as well as unacceptable, by all 93% of the remaining participants.

Pigeon populations can also be controlled by decreasing natality through hormones and sterilants. The birth rate is limited through the application of chemosterilants to baited food (Dobeic *et al*., 2011). Contraception was suggested as a sustainable solution to the pigeon population on campus by 15% of the participants as they considered it to be a humane and non-lethal option which did not adversely affect adults' physical conditions.

Physical structures, such as bird spikes and netting, which hinder or minimise the prevalence of pigeons on buildings may be implemented with varying degrees of success (Magnino, Haag-Wackernagel, Geigenfeind, Helmecke, Dovc, Prukner-Radovcic, Residbegovic, Ilieski, Laroucau, Donati, Martinov & Kaleta, 2009). Bird spikes prevent pigeons from perching or roosting on the structure on which they are installed. Thirty percent of participants considered spikes to have the most impact on controlling the pigeon population for a sustainable period of time. However those who disagreed believed that *"They won't help, the bird will always find a way around them; it just prevents them from sitting at that exact spot*". Netting which completely excludes pigeons from entire buildings, or parts of buildings is an effective and economical way of preventing pigeon damage to buildings (Huston & Rostron, 2005). In this regard, 19% of the participants agreed that it would have a sustainable impact on the pigeon population on campus.

Another form of physical structure which aids in the control of pigeons, are scare devices. Hutton and Rostron (2005) explain that they produce a stimulus that is perceived to be frightening to the birds. More than 30% of all participants considered scare devices to be effective and sustainable at controlling the pigeons on campus.

A humane and environmentally friendly option which reduces the prevalence of pigeons in urban environments is the presence of falcons. Trained falcons disperse pigeons and frequent flights ensure that pigeons associate the site with danger (Ryzhov & Mursejev, 2010). The use of falcons to sustainably impact the pigeon population on campus was considered by 27% of the participants. Participants who disagreed felt that there was no guarantee that the falcon would remain as a resident on campus and that it was unnatural to introduce an unfamiliar predator into the ecosystem. Rutz (2012) describes how falcons (Peregrine Falcon and Lanner Falcon) and hawks (Goshawks and Sparrowhawks) are in fact the main predators of pigeons. Both species have been identified on campus (Harris, 2014, pers. obs.).

Resource management which refers to the reduction or elimination of resources, such as space which is required by pigeons for roosting and breeding activities, is another strategy for control. Clearing away of nests, when squabs are not present (for ethical and humane reasons), can deter pigeons from making use of particular areas for breeding purposes as it conveys a sense of instability. This is regarded to be a viable and sustainable option by 21% of participants who indicated nominal support of control strategies such as the management of reproduction through nest removal as opposed to habitat modification through physical deterrents. Participants who disagreed with this method of control were *"...concerned about the eggs and chicks"*.

Alternative pigeon control methods and strategies were provided by 24% of all participants. These included strategies ranging from the use of elastic bands as a frightening device to be shot at perching pigeons from open office windows, to increasing the feral cat population on campus. The latter suggests potentially encouraging predation on the birds which could negatively impact dispersal and recruitment of pigeons (Shochat, Lerman & Fernández-Juricic, 2010). However previous research suggests that the behaviour and population size of urban birds does not appear to correspond with the proposed affect of frequent cat predation resulting in the selection of a small group of cat-resistant species such as the Feral Pigeon (Shochat, Warren, Faeth, Mcintyre & Hope, 2006; Shochat *et al*., 2010). The use of pigeon houses was also suggested by a number of participants during interviews. Pigeon houses would enable egg removal and the placing of dummy eggs in an effort to limit the hatching rate of the birds (Jacquin, Cazelles, Prévot-Julliard, Leboucher & Gasparini, 2010).

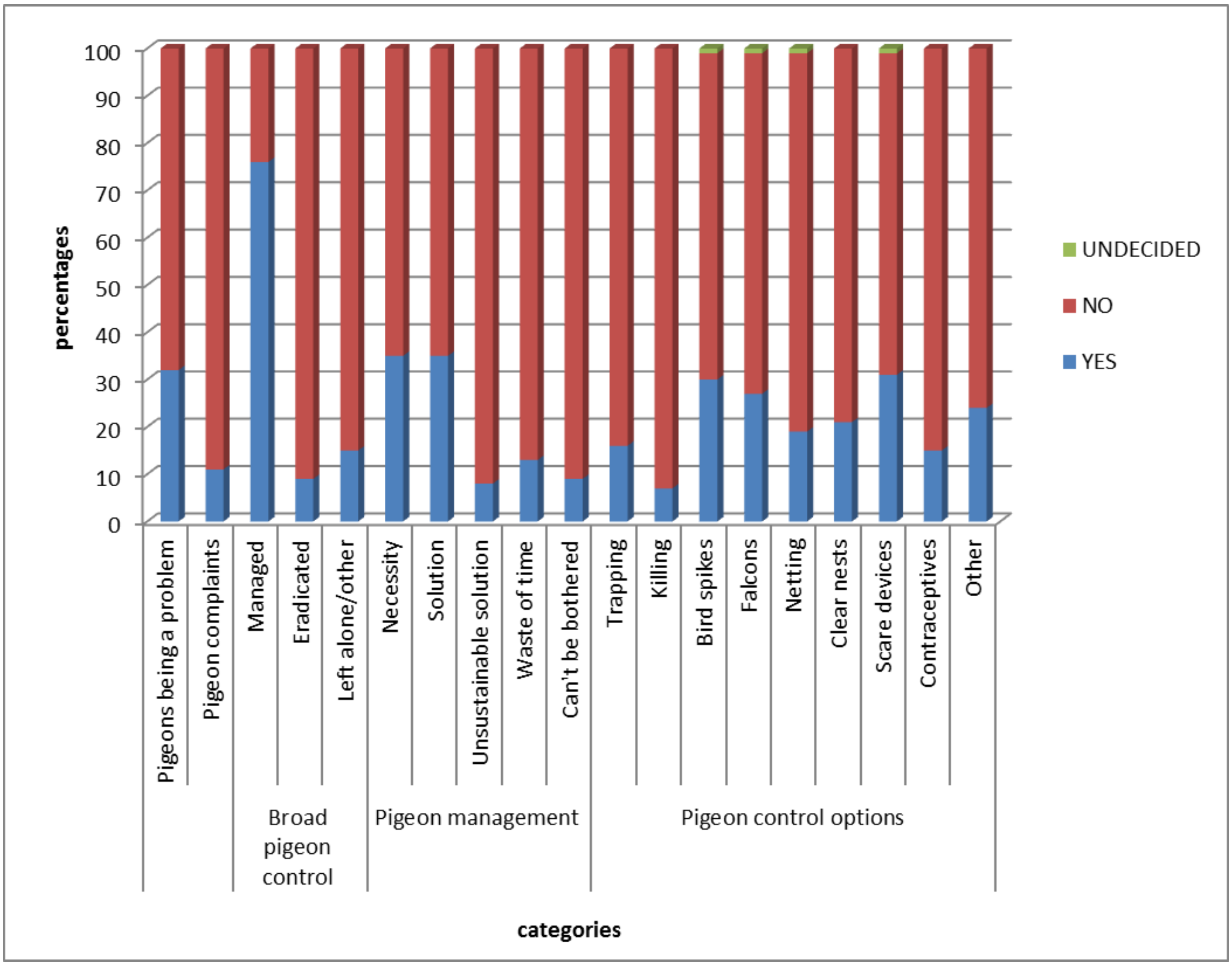


Figure 5: Summary of categories and results of staff perceptions of the pigeons and pigeon control on the University of South Africa's Muckleneuk campus

CONCLUSION

The perceived pigeon problem on the Muckleneuk campus is neither reality, nor based on staff opinions. Instead the idea of pigeons being pests and the subsequent request for pigeon control has originated from a vocal, influential minority which created an inaccurate impression of the current situation.

Regardless of the potential negative implications of having pigeon populations in close proximity to the work space, the majority of participants continued to perceive the presence of the birds as positive and did not consider the birds problematic in the work environment. This finding reiterates the hypothesis that the pigeons do not currently pose a large enough problem on campus to require control.

As with many proposed pest control programmes, action will eventually occur. Staff therefore felt that by contributing their opinion, they could try to influence the decision that would ultimately affect them. Thus, it was suggested that management of the pigeons, rather than eradication, would be a more acceptable and preferable choice.

Management would act as a precautionary measure, therefore implying that the pigeon population does not currently pose a problem to the university staff or infrastructure. In an effort to favour both the birds and the staff who enjoy their presence on campus, alternative holistic managerial measures were suggested to minimize the pigeons' potential to become a pest while simultaneously reducing the pigeon population to a healthy manageable size.

Literature and the pest control industry mention a variety of lethal and non-lethal pigeon control measures aimed at deterring and or removing the birds from identified areas. Participants in this study identified the use of scare devices and falcons as the preferred humane control strategies that would have a sustainable impact on the pigeon population on campus, relative to the other suggested control options. The erection of pigeon houses or dovecotes away from the buildings on campus was also suggested as a sustainable solution. They would serve a dual purpose by providing a welcoming environment for the pigeons to continue living on campus without negatively impacting staff or infrastructure, as well as the means to limit the hatching rate of eggs to create a small and healthy pigeon population.

Staff complaints about the presence and activities on UNISA's campus were minimal, implying that the pigeons were not presently negatively impacting on people or displaying pest-like qualities on a large scale. The results of this study also determined that stakeholders who were previously quiet prior to the proposed control of the pigeons, were now the complainants against the implementation of control and management measures. By providing all staff members with the opportunity to have a say in the proposed pigeon management on campus, the likelihood of the plan's effectiveness and sustainability will improve.

Staff perceptions will be incorporated into an interdisciplinary management plan for the future humane and non-lethal pigeon control of the Muckleneuk campus of the University of South Africa.

RECOMMENDATIONS FOR FUTURE RESEARCH

There is limited reference to the involvement of public opinions and attitudes in the development and implementation of proposed control programmes directed at wildlife in urban environments. Research has indicated that the publics' concerns over pigeons need to be addressed as peoples' associations with wildlife may have important consequences for their willingness to participate in wildlife management and conservation (Dunn, Gavin, Sanchez & Solomon, 2006; Krimowa, 2012). Ryan

(2011) explains that stakeholders may indicate contrasting views and attitudes which make it difficult to find management solutions which are acceptable to all. It is therefore imperative that the attitudes and opinions of the different stakeholders relating to the perceived problem and control options are identified and considered to ensure the sustainability and success of any control or management programme (Krimowa, 2012).

REFERENCES

ALSHUWAIKHAT, H. M. & ABUBAKAR, I. 2008. An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. *Journal of Cleaner production,* 16:1777-1785.

BELGUERMI, A., BOVET, D., PASCAL, A., PRÉVOT-JULLIARD, A., JALME, M.S., RAT-FISCHER. L. & LEBOUCHER, G. 2011. Pigeons discriminate between human feeders. *Animal Cognition,* 14:909-914.

BEVAN, R.D.R. 1990. The costs of feral pigeon. In: *British Ornithological Union: proceedings of a symposium in October 1990.* London: ADAS/British Ornithologists' Union: 10-11.

BRAUN, V. & CLARKE, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology, 3* (2):77-101.

BREMNER, A. & PARK, K. 2007. Public attitudes to the management of non-native species in Scotland. *Biological Conservation,* 139:306-314.

BRUNET, S. & HOUBERT, P. 2007. Involving stakeholders: The Belgian Fowl Pest Crisis. *Journal of Risk Research*, 10(5):643-660.

DOBEIC,M., PINTARIC,S., VLAHOVIC,K., & DOVC,A. 2011. Feral pigeon (*Columba livia*) population management in Ljubljana. *Veterinarski Arhiv*, 81:285-298.

DUNN, R.R., GAVIN, M.C., SANCHEZ, M. & SOLOMON, J.N. 2006. The pigeon paradox: dependence of global conservation on urban nature. *Conservation Biology*, 20(6):1814-1816.

GIUNCHI,D., ALBORES-BARAJAS, Y.V., BALDACCINI, N.E., VANNI, L. & SOLDATINI, C. 2012. *Feral Pigeons: Problems, Dynamics and Control Methods*. In: Larramendy, M.L. & Soloneski, S. (eds.). Integrated Pest Management and Pest Control - Current and Future Tactics. Intech Open Science: Rijeka, Croatia: 215-240.

GILSDORF, J.M. 2002. Use of frightening devices in wildlife damage management. *Integrated Pest Management Reviews,* 7:29-45.

HAAG-WACKERNAGEL, D. 1995. Regulation of the street pigeon in Basel. *Wildlife Society Bulletin,* 23(2):256-260.

HAAG-WACKERNAGEL, D., HEEDB, P. & LEISS, A. 2006. Phenotype-dependent selection of juvenile urban feral pigeons Columba livia: Capsule we suggest the existence of colour-based selection processes on juvenile feral pigeons in an urban environment. *Bird Study*, 53(2):163-170.

HAAG-WACKERNAGEL, D. 2008. *Feral Pigeon Management* [Online]. Available from: www.Anatomie.unibas.ch/integrativeBiology/hag/Feral-Pigeon Strassentauben/pigeon-management.html [Accessed: 12/02/2013].

HAAG-WACKERNAGEL, D. & BIRCHER, A.J. 2010. Ectoparasites from feral pigeons affecting humans. *Dermatology*, 220:82-92.

HAAG-WACKERNAGEL, D. & GEIGENFEIND, I. 2008. Protecting buildings against feral pigeons. *European Journal of Wildlife Research*, 54:715-721.

HUTTON & ROSTRON, 2005. *Method statement for the control of feral pigeons* [Online]. Available from: http://www.handr.co.uk/literature/feral_pigeons.htm. [Accessed: 05/08/2014].

JACQUIN, L., CAZELLES, B., PRÉVOT-JULLIARD, A., LEBOUCHER, G. & GASPARINI, J. 2010. Reproduction management affects breeding ecology and reproduction costs in feral urban pigeons (*Columba livia*). *Canadian Journal of Zoology,* 88:781-787.

JENNINGS, G. 2001. *Tourism Research*. John Wiley and Sons: Queensland.

JOHNSTON, R.F. & JANIGA, M. 1995. *Feral pigeons.* New York: Oxford University Press.

KEENAN, K. 2000. Town to roust birds from roost. *Telegram and Gazette*, Jan. 17.

KRIMOWA, S. 2012. Pigeons and people: resource ecology and human dimensions of urban wildlife. M.Sc. Victoria University of Wellington, Wellington.

LEVER , C. 1987. *Naturalised Birds of the World*. New York: Wiley.

MAGNINO, S., HAAG-WACKERNAGEL, D., GEIGENFEIND, I., HELMECKE, S., DOVC, A., PRUKNER-RADOVCIC, E., RESIDBEGOVIC, E., ILIESKI, V., LAROUCAU, K., DONATI, M., MARTINOV, S. & KALETA, E.F. 2009. Chlamydial infections in feral pigeons in Europe: Review of data and focus on public health implications. *Veterinary Microbiology,* 135:54-67.

NTSHOE, L. 2013. Catering and cleaning manager, University Estates, UNISA. Personal communication.

PHILLIPS, R.B., SNELL, H.L. & VARGAS, H. 2003. Feral rock doves in the Galápagos Islands: Biological and economic threats. *Noticias de Galápagos*, 62:6-10.

PIMENTEL, D., LACH, L., ZUNIGA, R. & MORRISON, D. 1999. Environmental and economic costs associated with non-indigenous species in the United States. *Cornell Chronicle*, June 12.

RUTZ. C. 2012. Predator fitness increases with selectivity for odd prey. *Current Biology*, 22:820-824.

RYAN, A.C. 2011. The distribution, density, and movements of feral pigeons *Columba livia* and their relationship with people. M.Sc. Victoria University of Wellington, Wellington.

RYZHOV, S.K. & MURSEJEV, M.R. 2010. Trained Goshawks against pigeons. *Raptors Conservation*, 20:25-34.

SHEA, K., THRALL, P.H. & BURDON, J.J. 2000. An integrated approach to management in epidemiology and pest control. *Ecology letters*, 3:150-158.

SHOCHAT, E., WARREN, P.S., FAETH, S.H., MCINTYRE, N.E. & HOPE, D. 2006. From patterns to emerging processes in urban evolutionary ecology. *Trends in Ecology & Evolution,* 21:186-191.

SHOCHAT, E., LERMAN, S., & FERNáNDEZ-JURICIC. 2010. Birds in Urban Environments: Population Dynamics, Community Structure, Biodiversity, and Conservation. <u>In:</u> Aitkenhead-Peterson, J. & Volder, A. (eds.). *Urban Ecosystem Ecology, 55:75-86.*

SOL, D., SANTOS, D.M., GARCIA, J., CUADRADO, M. 1998. Competition for food in urban pigeons: the cost of being juvenile. *Cooper Ornithological Society,* 100:298-304.

SORACE, A. 2002. High density of bird and pest species in urban habitats and the role of predator abundance. *Ornis Fennica,* 79:60-71.

STRINGHAM, S.A, MULROY, E.E, XING,J., RECORD,D., GUERNSEY, M.W., ALDENHOVEN,J.T, OSBORNEE, J. & SHAPIRO, M.D. 2012. Divergence, convergence, and the ancestry of feral populations in the domestic rock pigeon. *Current Biology*, 22:1-7.

SURVEYMONKEY. 2015. *SurveyMonkey* [Online]. Available from: https://www.surveymonkey.com/ *[Accessed: 28/01/2015].*

TERRE BLANCHE, M., DURRHEIM, K., & PAINTER, D. 2006*. Research in practice: Applied methods for the social sciences* (2nd ed.). Cape Town: University of Cape Town Press.

UNISA. 2015. *UNCG* [Online]. Available from: http://unisa.ac.za/ungc/index.html [Accessed: 11/02/2015].

WEBER, J., HAAG – WACKERNAGEL, D., & DURRER, H. 1994. Interaction between humans and pigeons. *Anthrozoos*, 7:55-59.

ZUCCONI, S., GALAVOTTI, S. & DESERTI, R. 2003. I colombi in ambiente urbana

– Sintesi del progetto di ricera Nomisma. *Disinfestazione,* Nov/Dec:9-21.

CHAPTER 5.3

Urban environment use by Speckled (*columba guinea)* and Feral (*columba livia)* Pigeons on the University of South Africa's Muckleneuk campus

E Harris, EP de Crom, J Labuschagne, A Wilson

Submitted: 29 April 2016 ; Accepted: 21 July 2016

ABSTRACT

A study on a population of Speckled *Columba guinea* and Feral *Columba livia* Pigeons on the University of South Africa's (UNISA) Muckleneuk campus was conducted from March 2013 to February 2014. Morning and evening counts, once a week, were conducted by an observer who also noted the presence of breeding activity and the use of ledges in relation to aspect and levels of buildings. The pigeon population index fluctuated seasonally. Breeding occurred throughout the year, with notable peaks and declines relating to physiological and population dynamics. Opportunistic use of the crop availability was made during optimal production periods, while conserving energy when not favourable. Site selection in relation to building aspect indicated significant differences in all the seasons except for winter, while a positive significant relationship between level height and pigeon numbers was recorded. Knowledge of pigeon ecology and their use of urban landscapes contribute to further understanding wildlife management.

KEYWORDS

Pigeons; agricultural availability; ledge use; aspect choice; urban environments

INTRODUCTION

Separated by genetic variation, Speckled Pigeons (*Columba guinea* Linnaeus, 1758) and Feral Pigeons (*Columba livia* Gmelin, 1789) (hereafter referred to collectively as pigeons) (Stringham, Mulroy, Xing, Record, Guernsey, Aldenhoven, Osbornee & Shapiro, 2012) have for centuries populated urban environments worldwide (Robbins, 1995). The species has had to adapt to the expanding urban sprawl by learning to cohabit with human lifestyles to supplement and ensure their own survival (Fitzwater, 1988). Their ability to adjust through behavioural, physiological (Shochat, Lerman & Fernández-Juricic, 2010) and life-history strategy changes (Ditchkoff, Saalfeld & Gibson, 2006) has enabled the species to successfully colonise and adapt to abundant food and water resources, choose nesting and roosting sites (Bolger, 2001; Hadidian, 2007; Krimowa, 2012), select milder micro-climates (Jokimäki, Kaisanlahti-Jokimäki, Sorace, Fernández-Juricic, Rodriguez-Prieto & Jimenez, 2005) and fewer predators (Tigas, Van Vuren & Sauvajot, 2002; Hadidian, 2007; Tsurim, Abramsky & Kotler, 2008) in new and unfamiliar habitats (Luniak, 2004; Shochat *et al*., 2010). Changes in social and spatio-temporal strategies of the species have resulted in an estimated global occurrence of 165 to 330 million pigeons (Haag-Wackernagel and Bircher, 2009), with high densities being recorded in cities such as Milan (492/km^2) (Sacchi *et al*., 2002) and Basel (840/km^2) (Haag-Wackernagel, 1995).

Resource preferences have been recorded to differ between pigeons inhabiting urban, suburban and rural environments (Krimowa, 2012). While pigeon population densities decrease away from city centres (Sacchi, Gentilli, Razzetti & Barberi, 2002), their densities often exceed socially acceptable standards (Dobeic, Pintarič, Vlahović & Dovč, 2011). Numerous studies (Jones, 2001; Sacchi *et al*., 2002) suggest that structural design and environmental features of urban areas affect the species' movements, habitat selection and population densities as pigeons make use of infrastructure and anthropogenic resources for life-preserving activities.

Research has indicated a relationship between structural characteristics of buildings and pigeon abundance (Sacchi *et al*., 2002). Highest densities have been recorded on older buildings (Sacchi *et al*., 2002) at high altitudes (Shotter, 1978) which resemble the cliffs of their ancestors (Goodwin, 1983), while infrastructure made from glass and reinforced concrete were less favourable due to limited access points (Sacchi *et al.,* 2002). Other factors affecting site selection are the macro and microclimates (Kochert, 1972; Brambilla *et al*., 2006) thermoregulatory considerations (Bech and Reinertsen, 1989; Kőrtner and Geiser, 1999), risk of predation (Walsberg and King, 1980; Martin, 1993; Brambilla, Rubolini & Guidali, 2006) and proximity to available resources (Chandler, Ketterson & Val Nolan, 1995; McCollin, 1998).

By making use of building structures to roost and breed, pigeons select sites that are safe and sheltered (Haag-Wackernagel, 2008) resembling a cave or crevice that their ancestors would have used in rock cliffs (Haag-Wackernagel, 1998). According to Walsberg (1986), energetic costs involved with choosing a site crucially impact the remaining energy available for other life-preserving activities – an idea supported by Haag-Wackernagel and Geigenfeind (2008) who found that pigeons who had identified an ideal site would display special behavioural strategies such as sitting on steeply inclined and narrow ledges or even pass through the smallest of openings (6 cm x 6 cm) to ensure protection from predation and the elements.

Another such activity affecting site selection of buildings is communal roosting. Feral and Speckled Pigeons have been observed to roost and forage together (Johnston, 1992a; Earle and Little, 1993; Little, 1994; Lofts, Murton & Westwood, 1966). Horn (1967) suggests that this behaviour allows pigeons to be more vigilant of predators and improves learnt behaviours relating to foraging success, as individuals are able to follow experienced flock members to abundant and or guaranteed resources. Krimowa (2012) and Johnston and Janiga (1995) found that pigeons roost and or breed in cities but fly to surrounding agricultural areas to feed; while (Earle &Little, 1993) suggest that the opposite is also true whereby pigeons roost in rural areas but fly into the cities to forage. Regardless of seasonal fluctuations in communal roosting (Eiserer, 1984), large pigeon populations making use of urban environments have been considered to reduce the structural integrity of buildings (Krebs, 1974; Hutton and Rostron, 2005; Seamans and Blackwell, 2011) and are cause for ongoing maintenance and financial outlay (Giunchi, Albores-Barajas, Baldaccini, Vanni & Soldatini, 2012).

The University of South Africa's (UNISA) Muckleneuk campus in Pretoria is host to a large number of pigeons. The birds gain access into the buildings through open access points such as loose exterior ceiling boards and open electrical and air conditioning cabling ducts positioned on the exterior of the buildings. This easy access increases the number of protected and sheltered breeding and roosting sites available. It has also increased health concerns relating to the build-up of their faeces and associated fungi, nest mites and bird lice which have been reported to infest the offices and inhabitants of certain buildings on campus (Westington, pers. comm. 2013). Faeces and accumulated nesting material build-up on the various external structures of the campus buildings was also a concern raised. According to Ntshoe (2013) large financial inputs have been put towards trying to manage the birds and their associated problems on an ad hoc and reactive basis. University Estates Management, who is responsible for the upkeep of the campus, has identified the need for a long-term and sustainable pigeon control strategy.

The spatial and temporal use of the campus environment by pigeons will therefore be incorporated into an interdisciplinary management plan for a future humane and non-lethal pigeon control strategy for the Muckleneuk campus of the University of South Africa.

This paper explores the overall use of the UNISA Muckleneuk campus by pigeons, by addressing the following objectives and null hypotheses.

Objectives

- To determine whether pigeon populations fluctuate seasonally on the UNISA Muckleneuk campus
- To confirm the all year round breeding of pigeons on the UNISA Muckleneuk campus
- To determine whether the presence of regional agriculture crop production can be linked with a pigeon population change on the UNISA Muckleneuk campus

Null hypotheses

- Aspect choice by pigeons on building ledges will not be affected by seasons on the UNISA Muckleneuk campus
- Heights of building levels will not influence ledge use on the UNISA Muckleneuk campus

STUDY AREA

UNISA (-25.76776, 28.199158) is situated on top of a hill (1411.19 m above sea level) near the central business district of Pretoria in the Gauteng Province of South Africa. The city is surrounded by the Magaliesburg mountain range in the transitional zone between the Central Bushveld and Moist Highveld Grassland vegetation types (Kruger, 2004). The city has a moderate warm temperate climate with an annual minimum and maximum temperature average of 13°C (June) and 24°C (January) during the course of the study. According to the South African Weather Service (2010) precipitation averages 677 mm, while relative humidity ranges between 44% and 75% annually. Pretoria experiences 3 254 hours of sunshine a year with 2.4 to 2.7 okta cloud cover on average, recorded annually (South African Weather Service, 2010). The Pretoria region within a 20 km radius of UNISA includes commercial, industrial, suburban and rural areas, with farming and crop (maize, soya, sorghum and sunflowers) production in the surrounding districts (Collett, 2015).

The campus is located within a green belt which includes the surrounding Groenkloof Nature Reserve, Fountains Valley, Apies River, Voortrekker Monument and Freedom Park. Various small mammals and bird species inhabit the University's grounds. These include avian migrants and small raptors (Harris, 2014, pers. obs) (Figure 6).

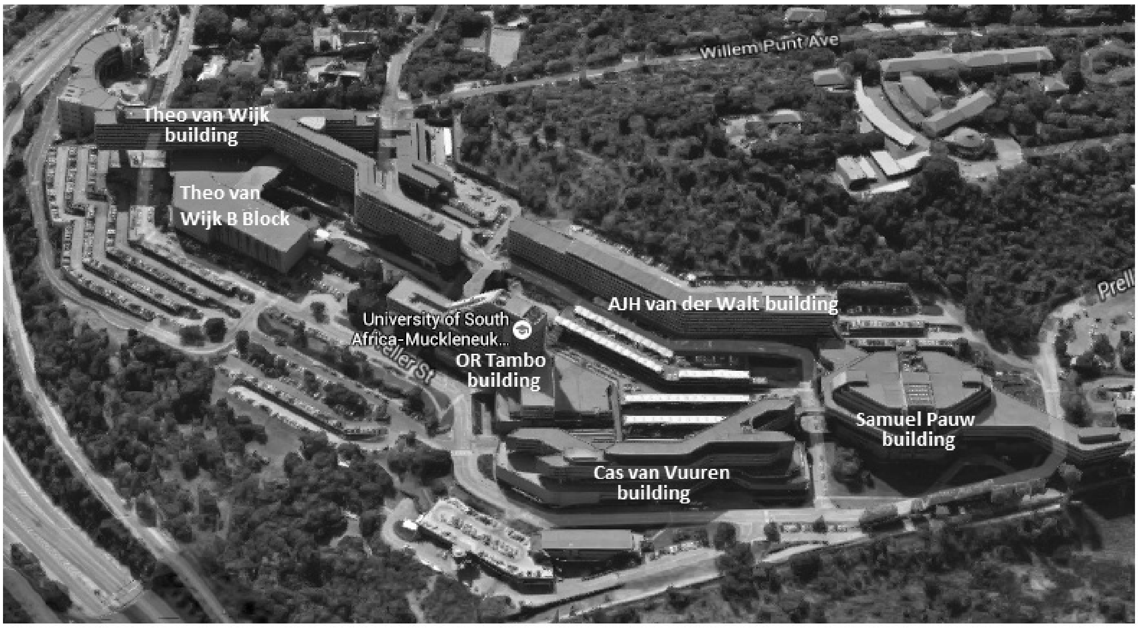


Figure 6: Aerial view of the University of South Africa's Muckleneuk campus indicating the building layout and surrounding habitat where the research took place. The buildings indicated were censused to determine pigeon indices (Google Maps, 2015).

Established in 1972, the Muckleneuk campus consists of seven administrative and academic buildings; however for the purpose of this study five of the seven buildings were investigated as part of the pigeon research. These are as follows: the Theo van Wijk building, OR Tambo building, AJH van der Walt building, Cas van Vuuren building and Samuel Pauw building (Figure 7). Each building is unique in its design, providing various roosting and nesting site possibilities for the pigeon population on the campus. Academic and administrative offices positioned lengthwise along the buildings face out onto balconies.

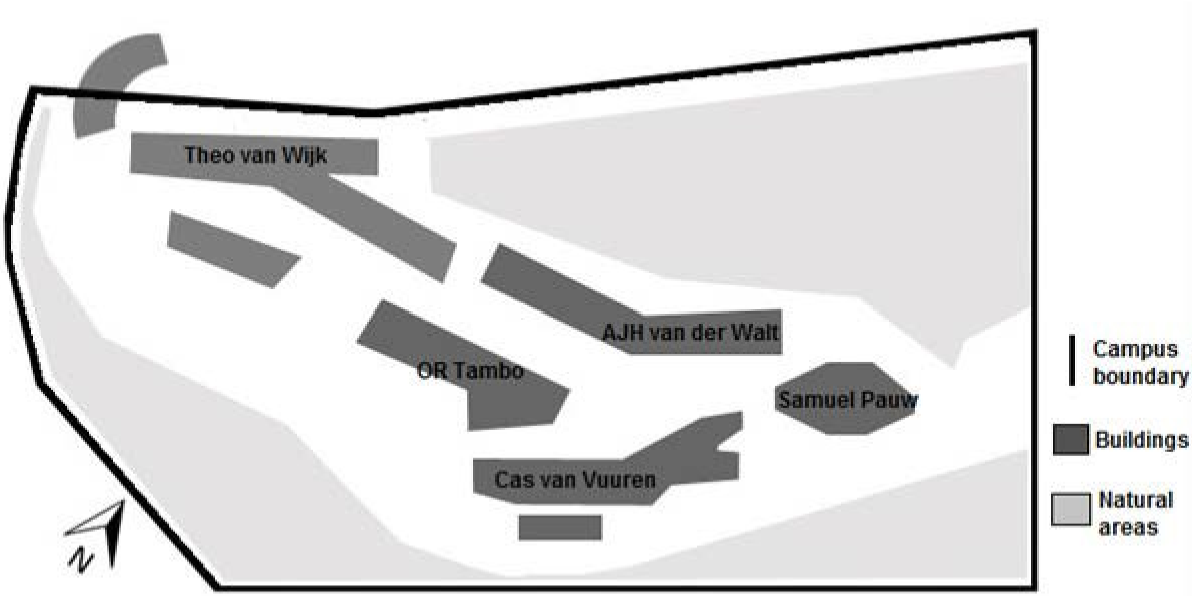


Figure 7: The University of South Africa's Muckleneuk campus in Pretoria, indicating the five buildings used in the pigeon count, showing their proximity to each other and indicating north

Theo van Wijk, the largest building positioned on the far western side of the campus, has 11 levels uniform in design with balconies and exterior cabling ducts running the length of the building. Due to its y-shape, the building offers two north facing and two south facing aspects. The Philadelphia cafeteria is positioned on the third floor, which includes an extensive catering balcony.

The AJH van der Walt building is positioned on the northern side of the campus facing an undeveloped vegetated mound which meets the campus' northern boundary. All seven levels are continuous in balcony and cabling ducts design.

To the east of the campus is the library, the Samuel Pauw building, roughly hexagonal in shape with eight levels; it has continual balconies and no cabling ducts.

Beyond this building towards the campus boundary in the east is parking space and natural vegetation.

OR Tambo, the administrative building, is positioned to the south. Due to its 14 levels, it is the tallest building on campus. Balconies and cabling ducts provide uniform exterior structural design, with the exception of the Good Hope cafeteria and balcony positioned on level four.

Adjacent to the OR Tambo building is Cas van Vuuren with seven levels, it has no exterior cabling ducts positioned above its balconies. Natural areas extend to the southern and south western boundaries.

A characteristic of all the buildings are the loose, broken or open exterior ceiling boards and or cabling ducts which provide additional roosting and breeding space for the pigeon population on campus.

MATERIALS AND METHODS

Objective 1

Data was collected for a full year from the beginning of March 2013 to the end of February 2014. The counting of adult and juvenile pigeons took place during the pigeons' bimodal foraging activity periods, which have been recorded to peak in the morning and afternoon (Krebs, 1974; Rose, Nagel & Haag-Wackernagel, 2006; Soldatini, Mainardi, Baldaccini & Giunchi, 2006). These counts took place early morning during the first two hours after sunrise and again in the evening during the last two hours before sunset, once a week for 52 weeks. If the particular chosen day for counting experienced extreme weather conditions, then the next consecutive day with fine weather was chosen and documented.

The observer maintained a standard designated route in a west to east direction, counting each of the campus' five buildings during the course of the research period. Observations were aided by binoculars, a digital camera and a dictaphone, later transcribed onto data sheets. Double counts of individuals taking off and perching on the same building was taken into consideration and avoided. As the pigeons were wild and free roaming, the exact number of pigeons on campus could not be determined. An increase or decrease in the number of pigeons counted was in essence a reflection of an increase or decrease in pigeon presence. Presence was represented as an index to monitor the extent of the increases or decreases as actual numbers could not be attained through the methodology implemented. The paper will therefore refer to indices to convey the extent of the pigeon presence, and it changes over time.

The objective to determine whether pigeon populations fluctuate seasonally on the UNISA Muckleneuk campus required the arithmetic mean and standard errors of the monthly pigeon population indices to be depicted graphically for both the Speckled and Feral Pigeons over the course of a full year. The graphical representation of the data will be described and inferences will be supported by literature reviews on pigeon ecology and the seasonal parameters of the study area.

Objective 2

Breeding season fluctuations have been debated extensively over the years (Lofts *et al*., 1966; Shotter, 1978; Shetty, 1992; Hetmański, 2004; Rose *et al*., 2006). The objective was to determine whether breeding on the campus' buildings took place all year round or indeed fluctuated seasonally. This was determined by observing breeding activity through reproductive behaviour, nesting behaviour (Shotter, 1978) and or the presence of young pigeons. The following reproductive associated behaviours were recorded: courting, mating, nesting, squab presence and juvenile presence. Courting referred to vocalisations and head bobbing of a male pigeon directed at a female pigeon. Mating referred to copulation of a male pigeon mounted onto the back of a female pigeon. Nesting referred to activities associated with active nest building or physically sitting on nests. Squabs describes very young pigeons in nests from the date of hatching to one month old when they are due to fledge from the nest (Krebs, 1974; Hetmański & Wołk, 2005). Juveniles describe young pigeons (one to six months of age) which have fledged the nest but have not yet obtained adult plumage (Murton,Thearle & Coombs, 1972; Murton, Thearle & Thompson, 1972).

If breeding were to be taking place all year round, the assumption would be that all breeding activity and reproductive behaviours would in fact be present all year round with no significant peaks being associated with seasonality. The presence or absence of a breeding activity or a reproductive behaviour was recorded during each count. Data was converted from 52 (week) counts to 12 (month) counts. The presence or absence could now be ranked, where 0 referred to no presence of a breeding activity and or reproductive behaviour within a particular month, to 4 referring to a particular activity or behaviour as having been present in each of the 4 weeks of that particular month.

Objective 3

In order to identify a relationship between surrounding agricultural crop production and the pigeon population index fluctuation on campus, a list of agricultural crops ecologically important to pigeons (maize, sorghum and sunflowers) within a 20 km radius of the Muckleneuk campus, was obtained from the Department of Agriculture, Forestry and Fisheries. Twenty kilometres is the distance from an urban centre that is considered to experience the highest agricultural damage by pigeons (Earle & Little, 1993; Little, 1994; van Niekerk, 2009). Their respective planting and harvesting times were linked to the pigeon population index on campus. While no statistical methodologies were applied to this data, inferences were made with regards agricultural crop use by the pigeons and associated with their presence on the campus during these times. These inferences were supported by literature reviews on pigeon foraging behaviours through a process of deductive reasoning.

Hypothesis 1

To determine whether building aspect and or height influenced the use of buildings by pigeons, OR Tambo (14 levels, 46.2 m) the campus' tallest building on campus was used. Data on the number of pigeons perched out in the open on balcony ledges and or cabling ducts was recorded in relation to height and aspect. Counts were conducted on the north and south side between levels 4-14, as these were identical in structural design. The roof was also counted, but for the purpose of data analysis, was not included, as it was not identical in structure to the other levels.

The first null hypothesis stated that aspect choice by pigeons on building ledges will not be affected by seasonality. As such, a chi-square test, typically used to compare observed data with expected data was used to determine if there was in fact a significant association between the north and south sides of the OR Tambo building, for each of the four seasons.

Hypothesis 2

The second null hypothesis states that the heights of the building levels will not influence ledge use by the pigeons. A Spearman's rho correlation does not assume any assumptions about the distribution of data and is considered an appropriate correlation analysis for variables in an ordinal scale. The building levels were therefore ranked to levels according to height and the Spearman's rho correlation determined whether or not an association between the height of the building and pigeon use/presence exists. This was also done for each season respectively.

Institutional ethical clearance and permission (2013/CAES/017) was received for the research.

RESULTS

Objective 1

The pigeon population index on the Muckleneuk campus had an arithmetic mean value of 344 individuals/month over the course of the year (SE = 10). Speckled Pigeon constituted the majority of the pigeons on campus at 84% ($\bar{x}$ = 290 individuals/month; SE = 8) and Feral pigeon considerably less at 16% ($\bar{x}$ = 55 individuals/month; SE = 4) of the total pigeon population (Figure 8).

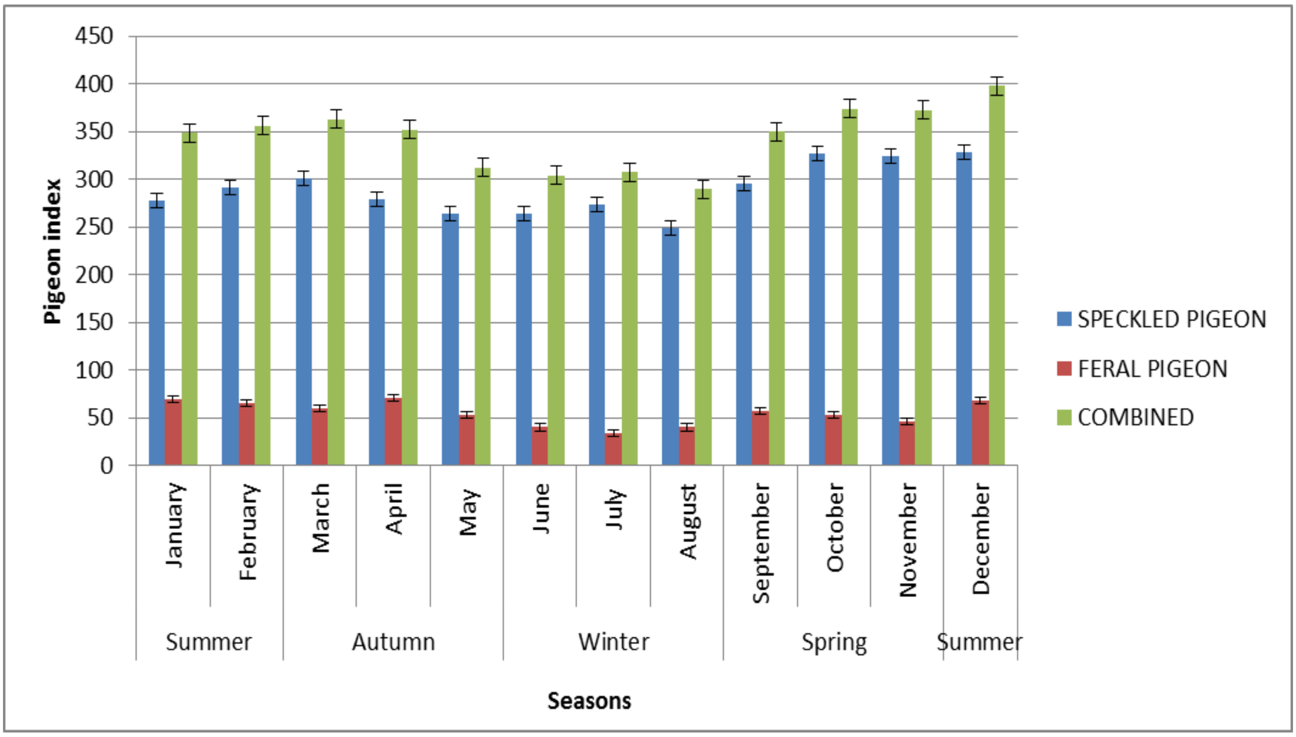


Figure 8: Indicating the pigeon population indices for both Speckled and Feral Pigeon populations on the UNISA Muckleneuk campus from March 2013 to February 2014

It was found that the pigeon populations on the UNISA Muckleneuk campus does fluctuate seasonally as population indices for both Speckled and Feral Pigeons peaked during the spring (x = 365; SE = 4) and summer (x = 367; SE = 8) seasons and similarly declined during autumn ($\bar{x}$= 342; SE = 8) and winter (x = 300; SE = 3) seasons.

Objective 2

The presence of breeding activity on campus was evident throughout the year (Table 1). However, a marked decrease in activity presence relating to reproductive and nesting behaviour was documented in autumn. There was an increase in squab presence during the winter and spring months coinciding with the annual peak breeding season (July to October). Low juvenile presence was noted during the year.

Table 1: Presence of breeding activity and reproductive behaviour of the Muckleneuk campus pigeon population in ascending order of rank

PRESENCE OF NESTING BEHAVIOUR						
SEASONS	**MONTHS**	**COURTING**	**MATING**	**NEST**	**SQUAB**	**JUVENILE**
Summer	January	0	1	2	2	2
	February	2	2	1	3	0
Autumn	March	0	0	0	2	0
	April	0	0	0	1	1
	May	0	1	1	2	0
Winter	June	0	1	1	3	0
	July	0	2	2	3	0
	August	0	1	2	4	0
Spring	September	0	0	1	1	0
	October	1	1	0	2	3
	November	0	0	0	0	2
Summer	December	1	1	0	2	0

Objective 3

The Speckled Pigeon population index showed an increase between January to April ($\bar{x}$ = 287; SE = 3) and again in September to December ($\bar{x}$ = 319; SE = 4). The objective that agricultural crop production will correlate with pigeon population change was therefore found to be true. Feral Pigeons supplement their diet with dry maize and sunflower seeds during harvesting in the autumn/winter months (May to August) (van Niekerk, 2003). However, their population index declined (x = 42; SE = 2) in relation to the rest of the year (x = 61; SE = 2) when crop seed availability is instead exploited by Speckled Pigeons – this decrease coincides with the colder winter months (Figure 9).

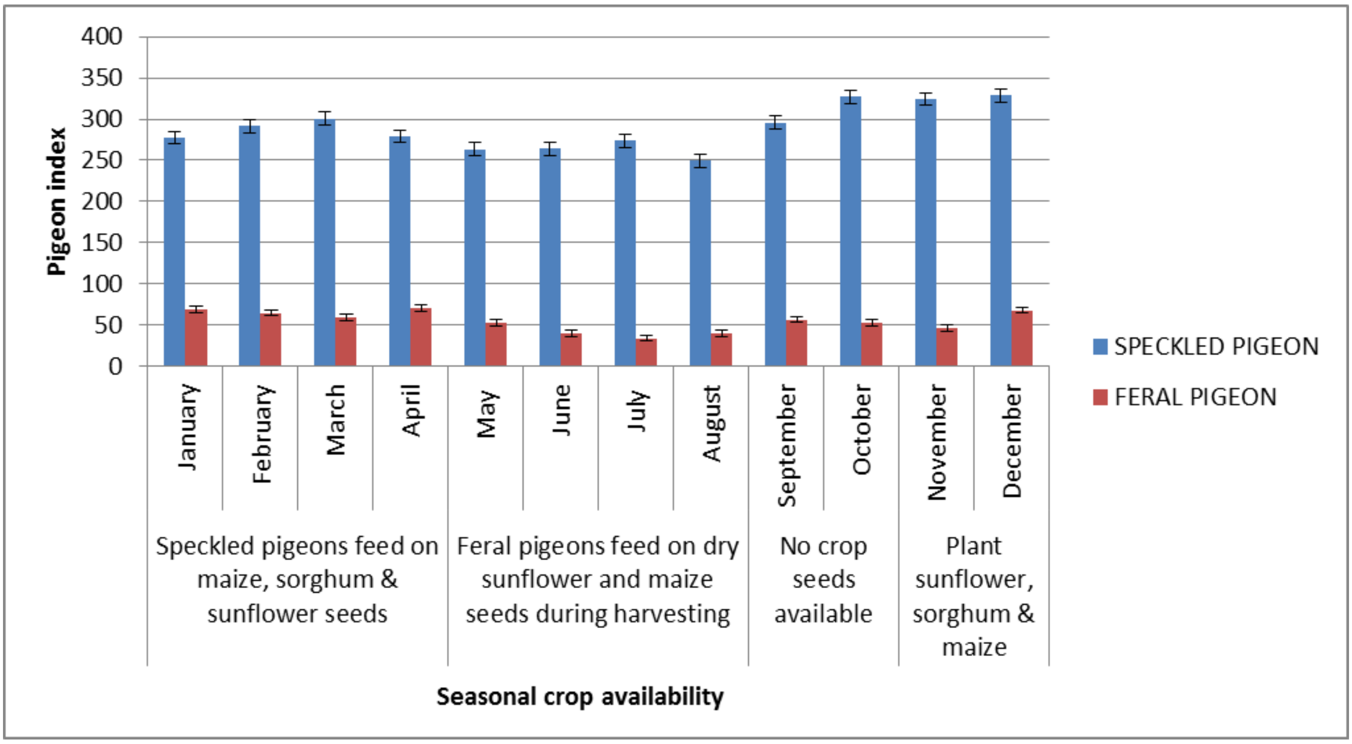


Figure 9: Pigeon population indices for both Speckled and Feral Pigeons on the UNISA Muckleneuk campus from March 2013 to February 2014, and indicating the seasonal availability of crops within a 20 km radius of the study site

Hypothesis 1

The selection and use of sites by pigeons aid survival and reproduction of the species. The null hypothesis stating that the choice of a building's aspect will not be affected by season was rejected, as significant differences were observed in all the seasons except winter (X^2 (df = 1, n = 52) = 0.26, p = 0.610) as indicated in Table 2. These results are graphically illustrated in Figure 10.

Table 2: Seasonal difference in balcony ledge use by pigeons on the north and south side of the OR Tambo building

	Summer	Autumn	Winter	Spring
*Chi Square statistic	6.02	16.95	0.26	4.14
Df	1	1	1	1
*P-value	0.014	<0.0001	0.6101	0.0419
*[Note that for df=1, the calculated value of chi-square is corrected for continuity.]				

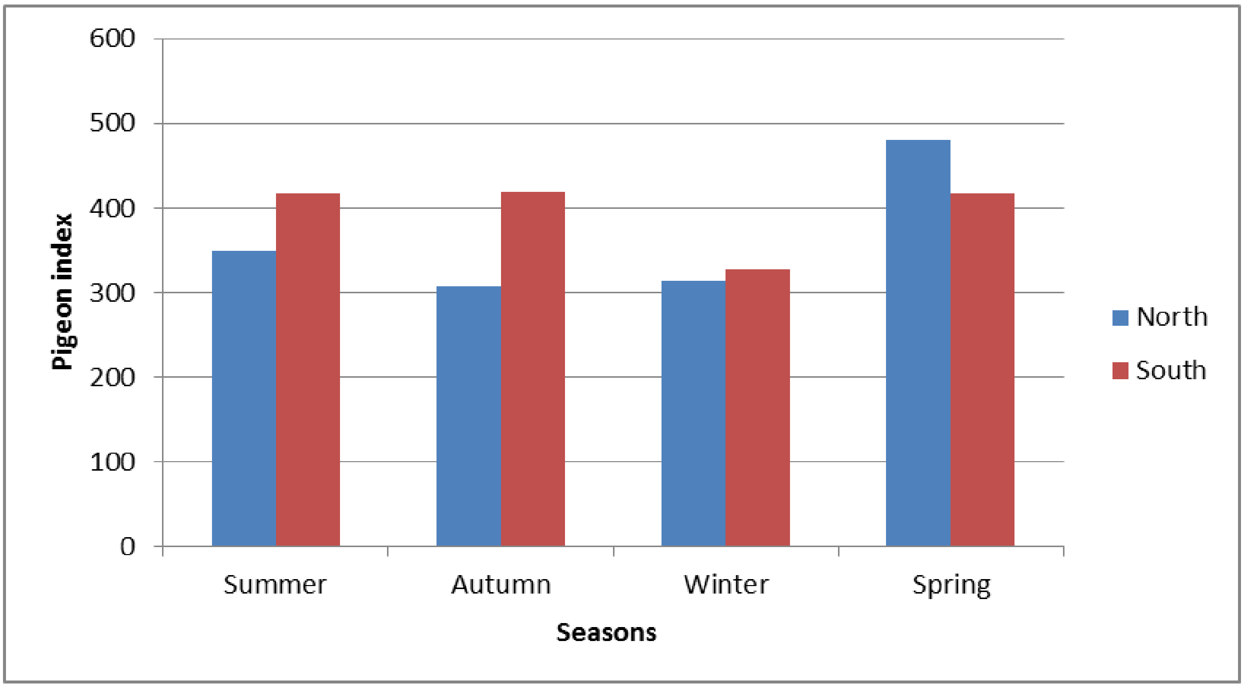


Figure 10: Indicating the seasonal aspect choice by both Feral and Speckled Pigeons collectively on the OR Tambo building of the UNISA Muckleneuk campus from March 2013 to February 2014.

Hypothesis 2

Pigeons perching on the cabling ducts and balcony ledges of the OR Tambo building, the tallest building with 14 levels (46.2 m), indicated a preference in the choice of level. The study rejected the null hypothesis of no association between the height of building levels and ledge use, as Spearman coefficients indicated a positive significant relationship, and a moderately strong association between the number of pigeons on the building ledges and the building level (r_S = 0.64, p = 0.035) (Table 3). For the purpose of analysis the number of pigeons making use of the roof (level 15) was not included as the structure is not identical to the other ledges – as indicated in Figure 11.

Table 3: Correlation between number of perched pigeons and level height on OR Tambo building

Spearman's rho	Level	Correlation Coefficient	1.000	.636*
		Sig. (2-tailed)		.035
		N	11	11
	Count	Correlation Coefficient	.636*	1.000
		Sig. (2-tailed)	.035	
		N	11	11

*. Correlation is significant at the 0.05 level (2-tailed).

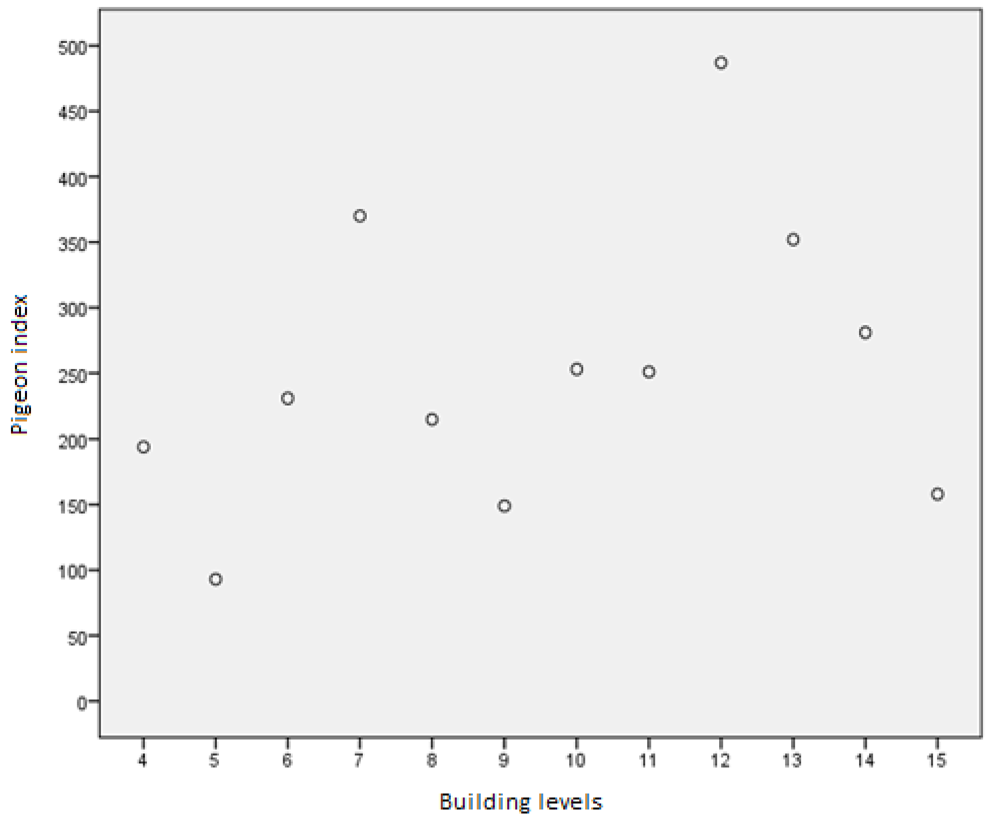


Figure 11: A scatter plot indicating the correlation between pigeon indices and ledge height selection, on the OR Tambo building on the UNISA Muckleneuk campus from March 2013 to February 2014

DISCUSSION

Pigeon ecology

Speckled and Feral Pigeon population indices on the University's Muckleneuk campus indicated a small yet distinct seasonal fluctuation. The study found that the pigeon population index peaked in spring (x = 365) and summer (x = 367) and declined during autumn (x = 342) and winter (x = 300) similar to the outcome of numerous studies (Hetmański & Wołk, 2005; Giunchi *et al.,* 2012; Murton *et al*., 1972). Ecological factors (Ali, Rakha, Hussain, Nadeem & Rafique, 2013) such as breeding activity, seasonal variations, resource distribution and availability (Soldatini *et al.,* 2006), regulates the seasonal patterns of pigeons in urban environments. Increased visibility of pigeons perched on building ledges during the warmer months contributed to the population index peaks noted during spring and summer with minimum and maximum temperature averages ranging between 15◦C-28◦C (ICAE, 2013). Whilst in winter, when the average minimum and maximum temperatures in Pretoria range between 6◦C-23◦C (ICAE, 2013), the pigeons were most likely hidden from the cooler elements and consequentially also from the observer.

This finding is similar to findings of European studies which describe pigeon population increases during breeding season and declines in winter (Johnston & Janiga, 1995; O'Regan, Flynn, Kelly, O'callaghan, Pokrovskii & Rachinskii, 2012). However, this finding is in contrast to a study conducted in the coastal city of Wellington, New Zealand, which found that pigeon population densities were higher in winter (6.8/ha) as individuals were more visible during courting or in search of mates, in comparison to the summer months (4.5/ha) when they were less detectable because of nest incubation (Ryan, 2011).

That said the population structure on the Muckleneuk campus remains stable and relatively constant regardless of the rise and fall between the warmer and cooler months leading to the deduction that it is in fact a resident population utilising the permanent resources available. This was corroborated by Ali *et al*. (2013), who found that the pigeon population density in Pakistan remained relatively similar over the seasons due to constant roosting and nesting sites and food and water availability, all of which can be found on the Muckleneuk campus.

Resource abundance results in the extension of the breeding seasons (*Shochat et al*., 2010) and improved reproductive capacities (Ryan, 2011). Pigeons are physiologically ready to start breeding between six to seven months of age (Murton *et al.,* 1972; Murton *et al*., 1972). Once a mate is found, they pair for life (Johnston, 1992b) producing up to 12 squabs a year (Mooallem, 2006; Haag-Wackernagel, 2008), if the pair is experienced in overlapping clutches, to shorten clutch intervals (Krebs, 1974; Hetmański & Wołk, 2005). The research found that breeding seasons did not affect the pigeon population's use of the Muckleneuk campus, as the presence of breeding activity was recorded all year without seasonality. This finding is supported by numerous studies which found that pigeons breed throughout year, the extent of which depends on food availability and climate (Lofts *et al*., 1966; Hetmański & Wołk, 2005; Hutton & Rostron, 2005; Ryan, 2011; Murton *et al.,* 1972). Shotter (1978) and Mooallem (1969) also found this to be true for studies of pigeons in Africa where breeding activity occurred year-round with a peak between July to October. Shetty (1992) explains how pigeons are non-seasonal breeders. However, just because pigeons are physiologically capable of prolonged breeding, it does not necessarily mean that they do (Lofts *et al*., 1966). Murton *et al*. (1972) explain that not all pigeons in a population breed simultaneously, or even throughout the year – meaning that some pigeons breed erratically or not at all. This could be the reason for the low presence of reproductive and nesting behaviour noted in November, or a direct response to the regular weekly sightings of Pied Crow (*Corvus albus*), a known predator of pigeons (Gregory & Marchant, 1995; Gŏrski, 1997; Wanless & Jupiter, 2002), over the buildings throughout the month (Harris, 2014, pers. obs.), resulting in pigeons being less detectable as they cower in roosts or on nests (Hutton & Rostron, 2005; Hutton & Dobson, 1993).

Numerous factors affect the breeding of pigeons. Hetmański (2004) suggests these factors to be historical as ancestral breeding seasons were prolonged, intra-populational as some individuals are more experienced in breeding and therefore able to frequently overlap clutches for maximum reproductive output, and extrinsic in terms of food availability and seasonal day length. The latter affects physiological functions as photoperiods act as a timing device for gonadal regression in anticipation of moulting during autumn. This was evident on the Muckleneuk campus, where the presence of courting, mating and nesting activities were not recorded between March to April. This drop in breeding activity allows costly energy to be diverted for feather regrowth and plumage change (Murton, 1966; Johnston & Janiga, 1995). Lofts *et al*. (1966) did however find that not all pigeons in a population go through this regression and do not therefore remain in a reproductive condition for continual breeding.

The rearing process of squabs from hatchling to fledgling takes between four to six weeks (Krebs, 1974; Jacquin, Cazelles, Prévot-Julliard, Leboucher & Gasparini, 2010). On fledging the nest, juveniles undergo natural dispersion towards lower density populations, thereby allowing the parent population to remain stable (Hetmański, 2007). The low presence of juveniles on the University's campus may be indicative of the 30% of fledglings that disperse yearly (Hetmański, 2007). These results paralleled Skead's (1969) observations who noted the relative absence of juveniles in Speckled Pigeon flocks even though breeding occurred throughout the year.

Food availability and distribution is another extrinsic factor which affects breeding and therefore population density and structure. Flocks living within urban environments have adopted flexi foraging strategies to maximise on food consumption (Rose *et al.,* 2006), in addition to retaining the foraging habits of their ancestors who utilised agricultural fields as their primary source of food [Goodwin, 1983; Little, 1994; Ryan, 2011).

Pigeon populations worldwide have been recorded to commute from urban roosts to farmlands and agricultural feeding grounds, often in very high numbers (over 6 500 pigeons in Pisa (Giunchi *et al.,* 2012), and in doing so create very large temporary congregations – over 5 000 pigeons in Gauteng (van Niekerk, 2003).

Pigeons in South Africa feed extensively on sunflower seeds, maize and sorghum (van Niekerk, 2003; van Niekerk & van Ginkel, 2004), often travelling 3 to 50 km daily to feed on these crops (van Niekerk, 2009). Studies have shown that the highest degree of damage to crops by pigeons is within 20 km of a city (Earle & Little, 1993; Little, 1994; van Niekerk, 2009). Within a 20 km radius of the campus nearly a total of 130 maize, sunflower and sorghum fields were available to pigeons for consumption before and during the harvesting season when Speckled and Feral Pigeons show preference for moist and dry seeds (van Niekerk & van Ginkel, 2004; Collett, 2015).

Pigeons display bimodal feeding because of the alternation of sexes on the nest (Johnston & Janiga, 1995; Krimowa, 2012). Rose *et al.* (2006) found that the females incubate through the night and early morning and are only relieved once the males return from their morning foraging; thereafter the females leave to forage until the afternoon, thus resulting in at least one individual of a pigeon pair remaining on campus at any given time. Crop availability for Speckled Pigeon falls in the months just prior to ripening of maize, sorghum and sunflower seeds in January to April, with limited crop seeds being available for consumption between September and December when planting recommences (van Niekerk, 2003; van Niekerk & van Ginkel, 2004). During the pre-harvest months (January to April) Speckled Pigeons have been recorded to feed on the moist crop seeds, thought to sustain energy and endurance for long distance flights (van Niekerk, 2003). The slight percentage difference between the two spring/summer peaks in the Muckleneuk campus population index may be inversely related to crop availability, thus supporting the objective that agriculture crop production will correspond with pigeon population change. During the available crop seed months individuals may have departed at first light to maximise on food availability in farmlands as suggested by Counsilman (1974), leaving their partners to incubate on nests. In doing so fewer pigeons were visible on the buildings. The higher Speckled Pigeon population density index during the months when crops were less likely to provide guaranteed sustenance (September to December) may be related to energy expenditure (Bryant, 1997). Pigeons may be aware of the lower agricultural availability, and therefore do not waste costly energy undertaking long distance flights towards the farmlands when they are required to forage locally, thus remaining on buildings for longer periods.

Feral Pigeons rely heavily on deliberate feeding and scraps (Brown, 1969; Little, 1994), with dry maize kernels available during harvesting (May to August) to a lesser extent (Soldatini *et al*., 2006). Of the resident pigeon population on campus, Feral

Pigeons constitute 16%. These individuals may make use of the campus for roosting and breeding whilst exclusively travelling to surrounding maize fields. This is, however, unlikely considering the anthropogenic food availability on campus around which they congregate (Harris, 2014, pers. obs.).

Site selection ecology

Pigeons have been recorded to favour certain heights when making use of natural and man-made sites (Haag-Wackernagel & Geigenfeind, 2008). Pigeons making use of ledges on the north and south facing sides of the OR Tambo building indicated a preference for the southern aspect during autumn (X^2 (df = 1, n = 52) = 16.95, p < 0.0001) and summer (X^2 (df = 1, n = 52) = 6.02, p = 0.014), contrary to numerous avian studies which documented a northerly site selection (Leonard, 1998; Kőrtner & Geiser, 1999; Ontiveros, 1999; Fisher, Fletcher, Willis & Brigham, 2004). Studies demonstrate that the primary motivation for a northerly aspect preference is energetic considerations (Walsberg, 1986; Zwartjies & Nordell, 1998; Antczak, 2010). Yet during the coldest season, when the warmer northerly side would minimise heat loss and thermoregulation costs, pigeons did not indicate a significant preference X^2 (df = 1, n = 52) = 0.26, p = 0.610).

Winter climate in Pretoria is cool and dry with the annual rainfall of approximately 700 mm being experienced during the summer months (ICAE, 2013). Climatic temperatures in Pretoria rarely drop below zero as average temperatures range between 6◦C-23◦C, therefore the need to warm up quickly after a cold night is not as acute as in the Northern Hemisphere where a northerly site with higher temperatures would be beneficial to survival. Maximum sun exposure during winter, heat retention of building materials, insulated balconies and cabling ducts availability create warmer microclimates and minimise exposure to low temperatures. Thus the selection of sites is not influenced by cold climatic conditions.

Aspect choice may also be environmentally related, as sites are chosen in relation to the direction of preferred feeding sites (Chandler *et al.,* 1995; Sacchi *et al.,* 2002). Pigeons indicated a significant preference for the southern aspect when seasonal crop availability was at its highest. Maize, sorghum and sunflower seeds are planted and ripen during summer and autumn thus correlating with a peak in pigeon foraging. The nature reserves and protected areas located to the south of the campus also have natural grasses which flower and produce seed which are consumed by pigeons, within the overlapping summer and autumn months. Due to the campus positioning, flocks in excess of 40 Speckled Pigeons were recorded departing from the campus and flying in a south-easterly direction during the early mornings in summer to forage in surrounding agricultural lands. The converse applied in spring, when pigeons indicated a northerly site selection preference as preferred foraging sites had limited crop availability.

The height at which sites are selected also affects ecological parameters. Having originally descended from the coastal and inland cliffs (Goodwin, 1983), pigeons have easily adapted to prominent tall buildings in urban environments (Hutton & Rostron, 2005). The pigeon population on the ledges of OR Tambo building indicated a positive significant relationship with a moderately strong association between the number of pigeons using the ledges and the building level ($r_S = 0.64$, $p = 0.035$). Pigeons and level indicated an upward trend, with the pigeon index increasing in ledge use the higher the level. These results are supported by a nesting ecology study which found Band-tailed Pigeons (*Columba fasciata)* nesting at heights of 26.5 m and 36.3 m depending on the natural substrate (Leonard, 1998). Similarly, in human-modified habitats, Shotter (1978) found that pigeons on the Ahmadu Bello University campus in Nigeria preferred ledges at high altitudes while (Haag-Wackernagel, 2008) recorded pigeon sites to be positioned at elevated altitudes and on the upper sections of structures.

Preference for elevated heights is considered to contribute to the creation of microclimates, in particular thermoregulation, as high altitudes allow for individuals to control insulation by reducing the exposure to cold temperatures (Mosher & White, 1976). Site placement can also offer updrafts which aid in flight (Kochert, 1972). High positioning of sites essentially contribute to the evasion of predators as height, along with sheltered building features offer protection and camouflage (Kőrtner & Geiser, 1999). However, the opposite is true for pigeons that make use of the roof without the protective structural characteristics found on the other levels. Previously considered to be ‘safe-zones’ due to lower predator pressure (Jokimäki *et al.,* 2005) urban areas no longer hold this characteristic as several raptor species have adapted to the modified macro-climate of cities which provide suitable nesting sites and an abundance of prey species (Ratcliffe, 1993). The exposure of pigeons to the elements, but more importantly to predators, is the driving factor which limits the selection of sites on the roof of buildings. This is especially applicable as Pied Crows (*Corvus albus*), Peregrine Falcons (*Falco peregrinus*) and African Goshawks (*Accipter tachiro*), known predators of pigeons, have been identified on campus (Harris, 2014, pers. obs.).

CONCLUSION

Pigeons over the centuries have become one of the most successful colonisers of urban environments (Haag-Wackernagel, Heeb & Leiss, 2006). They developed the remarkable ability to utilise buildings to nest, breed and roost while simultaneously exploiting various forms of food supplied by urban lifestyles and surrounding farmlands. The pigeon population on UNISA's Muckleneuk campus is no different. The population index indicated peaks over the warmer months, and a decline during the cooler periods. The population has however been considered to be stable and constant, regardless of fluctuations as the difference between peaks and dips is nominal along with suggested juvenile dispersal.

Responses to environmental releasers (day length), proximity of available food and known predators were evident in the population. Pigeons considered energy drivers with regards to foraging, as the population index was higher on campus when crops were not at their optimum for consumption, and lower when crop seeds were available as they departed early to maximise on consumption on neighbouring agricultural fields.

Unlike most avian studies relating to spatial dynamics, the University's pigeon population on the OR Tambo building indicated significant differences between the north and south aspect in all the seasons except for winter. Temperate climate and feeding site direction during optimal agricultural availability contributed to the behavioural responses and energetic decisions of pigeons when choosing sites in relation to aspect. The investigation of pigeons making use of OR Tambo building in relation to aspect and height was limited to individuals on the balcony ledges and cabling ducts. However, this is not a true representation of the selection of roosting and nesting sites as those on the floor of the balcony, in cabling ducts or in open access points, were not visible and thus not recorded. A further study of actual nesting and roosting sites needs to establish preference for aspect and building height in relation to breeding and roosting sites.

Pigeons did however support other research study findings with regards to site selection and building height. Individuals chose the higher altitudes on which to select their sites, as the benefits of controlled microclimates and predator evasion contribute to their survival.

Pigeons are known to display nest and roosting site plasticity (Haag-Wackernagel & Geigenfeind, 2008) while architectural features, age and substrate colour of buildings have been recorded to affect site selection (Sacchi *et al.,* 2002; Ali *et al.,* 2013). The University's Muckleneuk campus' building design and structure dates back over 40 years reflecting prominent architectural overhangs, ledges and balconies which provide ideal environments for roosting and breeding pigeons. Human negligence is also a contributing factor as exterior ceiling boards and cabling ducts are left open providing safe and sheltered access to pigeons. Two of the buildings in the study did not have cabling ducts which in turn provides fewer sites for pigeons to breed and roost in comparison to the remaining four buildings. Due to the inconsistency in the design and size of each of the buildings, comparative data could not be collected and therefore the difference in pigeon preference could not be established. Nonetheless, it can be suggested that due to the favourable benefits obtained from roosting and breeding in abundant open cabling ducts, accessible balcony ceilings and structural overhangs, pigeons are able to breed without restricted safety and spatial limitations.

The use of urban environments within space and time by wildlife has been a topic of discussion by researchers for many years (Philo & Wilbert, 2000). There is a need to understand the implications of man-made developments, urban-related consequences and opportunities on urban wildlife inhabiting these spaces in order to understand how they use these fragmented environments. An idea seconded by Ditchkoff *et al.* (2006), considers science to be lacking in understanding wildlife management in urban spaces, thus resulting in continual challenges and difficulties in managing these wildlife populations. Hutton and Rostron (2005) also stated that inappropriate strategies to control populations often result from wildlife management programmes when management and building professionals have a lack of understanding the problem.

Knowledge of pigeon biology, ecology and behaviour relating to the use of urban environments are therefore important factors to consider when designing wildlife management plans (Giunchi *et al.,* 2007; Giunchi *et al.,* 2012). Cities need to be recognised as ecosystems, with new niche habitats that require specific attention and management, ultimately guided by wildlife's use of urban spaces.

Pigeon population fluctuation will be used as a control (baseline) to determine the efficiency of various humane and non-lethal control measures implemented on the campus. The combined results will inform an interdisciplinary management plan for pigeon control on the University of South Africa's Muckleneuk campus.

ACKNOWLEDGEMENTS

Acknowledgement and thanks to the University Estates Department, the Applied Behavioural Ecological and Ecosystem Research Unit (ABEERU) at the University of South Africa and the National Research Foundation (NRF) for funding. Climatic and agricultural data was provided by the South African Weather Service and the Department of Agriculture, Forestry and Fisheries.

REFERENCES

ALI, S., RAKHA, B.A., HUSSAIN, I., NADEEM, M.S. & RAFIQUE, M. 2013. Ecology of Feral Pigeon (*Columba livia*) in Urban Areas of Rawalpindi/Islamabad, Pakistan. *Pakistan Journal of Zoology*, 45(5): 1229 – 1234.

ANTCZAK, M. 2010. Winter Noctural Roost Selection by Solitary Passerine Bird, the Great Grey Shrike *Lanius excubitor*. *Ornis Fennica*, 87: 99 – 105.

BECH, C. & REINERTSEN, R.E. (eds.). 1989. *Physiology of Cold Adaptation in Birds*. Plenum Press: New York.

BOLGER, D.T. 2001. Urban Birds: Population, Community and Landscape Approaches. In: Marzluff, J.M. (ed.). Avian ecology and conservation in an urbanizing world. Kluwer Academic Publ., Boston: 155 – 177.

BRAMBILLA, M., RUBOLINI, D. & GUIDALI, F. 2006. Factors affecting Breeding Habitat Selection in a Cliff-Nesting Peregrine *Falco peregrinus* population. *Journal of Ornithology,* 147: 428 – 435.

BROWN, R.G.B. 1969. Seed Selection by Pigeons. *Behaviour*, 34(3): 115 – 131

BRYANT, D.M. 1997. Energy Expenditure in Wild Birds. *Proceedings of Nutrition Society,* 56: 1025 – 1039.

CHANDLER, C.R., KETTERSON, E.D. & VAL NOLAN, J.R. 1995. Spatial Aspects of Roost-Site Selection in Breeding Male Dark-Eyed Juncos. *The Condor*, 97: 279 – 282.

COLLETT, A. (AnnelizaC@daff.gov.za). 2015. Agricultural crop list. [E-mail to:] Harris, E. (emmaharris09@gmail.com) Oct. 21.

COUNSILMAN, J.J. 1974. Waking and Roosting Behaviour of the Indian Myna. *Emu*, 74: 135 – 148.

DITCHKOFF, S.S., SAALFELD, S.T. & GIBSON, C.J. 2006. Animal Behaviour in Urban Ecosystems: Modifications due to human-induced stress. *Urban Ecosystem,* 9: 5 – 12.

DOBEIC, M., PINTARIČ, S., VLAHOVIĆ, K. & DOVČ, A. 2011. Feral Pigeon (*Columba livia*) Population Management in Ljubljana. *Veteinarski Arhiv*, 81(2): 285 – 298.

EARLE, R.A. & LITTLE, R.M. 1993. Hematozoa of Feral Rock Doves and Rock Pigeons in Mixed Flocks. *South African Journal of Wildlife*, 23: 98 – 100.

EISERER, L.A. 1984. Communal Roosting in Birds. *Bird Behav*. 5: 61 – 80.

FISHER, R.J., FLETCHER, Q.F., WILLIS, C.K.R. & BRIGHAM, R.M. 2004. Roost Selection and Roosting Behaviour of Male Common Nighthawks. *American Midland Naturalist Journal,* 151: 79 – 87.

FITZWATER, W.D. 1988. Solutions to Urban Bird Problems. In: *Proceedings of the Thirteenth Vertebrate Pest Conference*: 254 – 259.

GIUNCHI, D, BALDACCINI, N.E., SBRAGIA, G. & SOLDATINI, C. 2007. On the Use of Pharmacological Sterilisation to Control Feral Pigeon Populations. *Wildlife Research*, 34: 306 – 318.

GIUNCHI, D., ALBORES-BARAJAS, Y.V., BALDACCINI, N.E., VANNI, L. & SOLDATINI, C. 2012. Feral Pigeons: Problems, Dynamics and Control Methods. In: Soloneski, S. (ed.). Integrated Pest Management and Pest Control – Current and Future Tactics. Intech.

GOODWIN, D. 1983. Behaviour. In: Wright, E.N. (ed.). *Physiology and Behaviour of the Pigeon*. Academic Press, London: 285 – 308.

GOOGLE MAPS, 2015. University of South Africa Muckleneuk campus [Online]. Available from:https://www.google.co.za/maps/dir//-25.756165,28.200316/@25.7681391,28.1981992,730m/data=!3m1!1e3?hl=en. [Accessed: 05/10/2015].

GŎRSKI, W. 1997. Urban and Rural Populations of the Magpie *Pica pica* in the Koszalin Region, NW Poland*. Acta Ornithologica*, 32: 51 – 59.

GREGORY, R.D. & MARCHANT, J.H. 1995. Population trends of Jays, Magpies, Jackdaws and Carrion Crows in the United Kingdom. *Bird Study*, 43: 28 – 37.

HAAG-WACKERNAGEL, D. 1995. Regulation of the Street Pigeon in Basel. *Wildlife Society Bulletin,* 23(2): 256 – 260.

HAAG-WACKERNAGEL, D. 1998. Ecology of Feral Pigeonsin Basel, Switzerland. In: Farina, A., Kennedy, J. & Bossu, V. (eds.). *INTECOL, VII International Congress of Ecology*, July 19-25, 1998, Florence.

HAAG-WACKERNAGEL, D. 2008. *Feral Pigeon Management* [Online]. Available from: www.Anatomie.unibas.ch/integrativeBiology/hag/Feral-Pigeon Strassentauben/pigeon-management.html [Accessed: 12/02/2013].

HAAG-WACKERNAGEL, D. & BIRCHER, A.J. 2009. Ectoparasites from Feral Pigeons affecting Humans. *Dermatology,* 220: 82 – 92.

HAAG-WACKERNAGEL, D. & GEIGENFEIND, I. 2008. Protecting Buildings against Feral Pigeons. *European Journal of Wildlife Research*, 54: 715 – 721.

HAAG-WACKERNAGEL, D., HEEB, P. & LEISS, A. 2006. Phenotype-dependent selection of juvenile urban feral pigeons *Columba livia*: Capsule we suggest the existence of colour-based selection processes on juvenile feral pigeons in an urban environment. *Bird Study*, 53(2):163 – 170.

HADIDIAN, J. 2007. *Wild Neighbours: The Humane Approach to Living with Wildlife.* 2nd ed. Humane Society Press, Washington DC.

HETMAŃSKI, T. 2004. Timing of Breeding in the Feral Pigeon *Columba livia f.* domestica in Słupsk (NW Poland). *Acta Ornithologica*, 39(2): 105 – 110.

HETMAŃSKI, T. 2007. Dispersion Asymmetry within a Feral Pigeon *Columba livia* population. *Acta Ornithologica*, 42(1): 23 – 31.

HETMAŃSKI, T. & WOŁK, E. 2005. The Effect of Environmental Factors and Nesting Conditions on Clutch Overlap in the Feral Pigeon *Columba livia f. urbana* (GM.). *Polish Journal of Ecology*, 53(4): 523 – 534.

HUTTON & ROSTRON, 2005. Method statement for the control of feral pigeons [Online]. Available from: http://www.handr.co.uk/literature/feral_pigeons.htm. [Accessed: 05/12/2012].

HUTTON, T.C., & DOBSON, J. 1993. The Control of Feral Pigeons: An Independent Approach. *Structural Survey*, 11(2): 159 – 167.

ICAE, 2013. About Pretoria. The 5th International Conference on Applied Energy July 1–4 2013 [Online]. Available from : http://applied-energy.org/2013/history/about%20pretoria [Accessed : 19.06.2016].

JACQUIN, L., CAZELLES, B., PREVOT-JULLIARD, A., LEBOUCHER, G. & GASPARINI, J. 2010. Reproduction management affects breeding ecology and reproduction costs in feral urban pigeons (*Columba livia*). *Canadian Journal of Zoology,* 88, Aug: 781 – 787.

JOKIMÄKI, J., KAISANLAHTI-JOKIMÄKI, M., SORACE, A., FERNÁNDEZ-JURICIC, E., RODRIGUEZ-PRIETO, I. & JIMENEZ, M.D. 2005. Evaluation of the “Safe Nesting Zone” Hypothesis across an Urban Gradient: a multi-scale study. *Ecography*, 28: 59 – 70.

JOHNSTON, R.F. 1992a. Evolution in the Rock Dove: Skeletal Morphology. *The Auk*, 109: 530 – 542.

JOHNSTON, R.F. 1992b. Rock Dove. In: Poole, A., Stettenheim, P. & Gill, F. (eds.). *The Birds of North America*. The American Ornithologists’ Union: Washington.

JOHNSTON, R.F. & JANIGA, M. 1995. Feral pigeons. Oxford University Press, New York.

JONES, J. 2001. Habitat Selection Studies in Avian Ecology: A Critical Review. *The Auk*, 118(2): 557 – 562.

KOCHERT, M.N. 1972. Population Status and Chemical Contamination in Golden Eagles in Southwestern Idaho. M.Sc. University of Idaho, Moscow, USA.

KŐRTNER, G. & GEISER, F. 1999. Roosting Behaviour of the Tawny Frogmouth (*Podargus strignides*). *Journal of Zoology,* 248: 501 – 507.

KREBS, L.B. 1974. Feral Pigeon Control. In: *Proceedings of the 6th Vertebrate Pest Conference*: 257 – 262.

KRIMOWA, S. 2012. Pigeons and People: Resource Ecology and Human Dimensions of Urban Wildlife. M.Sc. Victoria University of Wellington, Wellington.

KRUGER, A.C. 2004. *Climate of South Africa. Climate Regions. WS45*. South African Weather Service. Pretoria, South Africa.

LEONARD, J.P. 1998. Nesting and Foraging Ecology of Band-tailed Pigeons in Western Oregon. PhD Oregon State University, Oregon.

LITTLE, R.M. 1994. Marked Dietary Differences between Sympatric Feral Rock Dives and Rock Pigeons. *South African Journal of Zoology*, 29(1): 33 – 35.

LOFTS, B., MURTON, R.K. & WESTWOOD, N.J. 1966. Gonadal Cycles and the Evolution of Breeding Seasons in British Columbidae. *Journal of Zoology*, 150: 249 – 272.

LUNIAK, M. 2004. Synurbanization – adaptation of animal wildlife to urban development. In: Shaw, W.W., Harris, L.K., Vandruff, L. (eds.). *Proceedings of the 4th International Symposium on Urban Wildlife Conservation*. Arizona: Tucson: 50–55.

MARTIN, T.E. 1993. Nest Predation and Nest Sites: New Perspectives on Old Patterns. *BioScience*, 43: 523 – 532.

MCCOLLIN, D. 1998. Forest Edges and Habitat Selection in Birds: A Functional Approach. *Ecography*, 21: 247 – 260.

MOOALLEM, J. 2006. Pigeon Wars. *New York Times Magazine*, Oct. 15: 54.

MOSHER, J.A. & WHITE, C.M. 1976. Directional Exposure of Golden Eagle Nests. *Canadian Field Naturalist,* 90: 356 – 359.

MURTON, R.K. 1966. Natural Selection and the Breeding Seasons of the Stock Dove and Wood Pigeon. *Bird Study*, 13(4): 311 – 327.

MURTON, R.K., THEARLE, R.J.P. & COOMBS, C.F.B. 1972. Ecological studies of the feral pigeon *Columba livia* var. lll. Reproduction and plumage polymorphism. *Journal of Applied Ecology*, 9: 841 – 853.

MURTON, R.K., THEARLE, R.J.P. & THOMPSON, R.J.P. 1972. Ecological studies of the feral pigeon *Columba livia* var. l. Population, breeding biology and methods of control. *Journal of Applied Ecology*, 9: 835 – 874.

NTSHOE, L. 2013. Catering and Cleaning Manager, University Estates, UNISA. Personal communication.

O'REGAN, S.M., FLYNN, D., KELLY, T.C., O'CALLAGHAN, M.J.A., POKROVSKII, A.V. & RACHINSKII, D. 2012. *Ecological Modelling*, 224: 54 – 64.

ONTIVEROS, D. 1999. Selection of Nest Cliffs by Bonelli's Eagle (*Hieraaetus fasciatus*) in South-eastern Spain. *Journal of Raptor Research,* 33(2): 110 – 116.

PHILO, C. & WILBERT, C. (eds.). 2000. *Animal Spaces, Beastly Places: New Geographies of Human-Animal Relations*. Psychology Press, New York.

RATCLIFFE, D.A. 1993. *The Peregrine Falcon*, 2nd ed. Poyser, London.

ROBBINS, C.S. 1995. Non-Native birds. In: LaRoe, E.T., Farris, G.S., Puckett, C.E., Doran, P.D. & Mac, M.J. (eds.). Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals and ecosystems. Department of the Interior, National and Biological Service, Washington DC: 437 – 440.

ROSE, E., NAGEL, P. & HAAG-WACKERNAGEL, D. 2006. Spatio-temporal use of the urban habitat by feral pigeons (*Columba livia*). *Behavioral Ecology and Sociobiology*, 60: 241 – 254.

RYAN, A.C. 2011. The distribution, density, and movements of feral pigeons *Columba livia* and their relationship with people. M.Sc. Victoria University of Wellington.

SACCHI, R., GENTILLI, A., RAZZETTI, E. & BARBERI, F. 2002. Effects of Building Features on Density and Flock Distribution of Feral Pigeons *Columba livia var.domestica* in an Urban Environment. *Canadian Journal of Zoology*, 80: 48 – 54.

SEAMANS, T.W. & BLACKWELL, B.F. 2011. Electric Shock Strips as Bird Deterrents: Does Experience Count? *International Journal of Pest Management*, 57(4): 357 – 362.

SHETTY, S., BHARATHI, L., SHENOY, K.B & HEGDE, S.N. 1992. Biochemical properties of pigeon milk and its effect on growth. *Journal of Comparative Physiology*, 162: 632 – 636.

SHOCHAT, E., LERMAN, S. & FERNÁNDEZ-JURICIC, E. 2010. Birds in Urban Ecosystems: Population Dynamics, Community Structure, Biodiversity and Conservation. *Urban Ecosystem Ecology*, urbanecosysteme: 75 – 86.

SHOTTER, R.A. 1978. Aspects of the Biology and Paraistology of the Speckled Pigeon *Columba guinea* L. from Ahmadu Bello University Campus, Zaria, North Central State, Nigeria. *Zoological Journal of the Linnean Society*, 62: 193 – 203.

SKEAD, D.M. 1969. A Study of the Rock Pigeon *Columba guinea*. *Ostrich*, 42(1): 65 – 69.

SOLDATINI, C., MAINARDI, D., BALDACCINI, N.E. & GIUNCHI, D. 2006. A Temporal Analysis of the Foraging Flights of Feral Pigeons (*Columba livia f. Domestica*) from Three Italian Cities. *Italian Journal of Zoology*, 73(1): 83 – 92.

SOUTH AFRICAN WEATHER SERVICE, 2010. Climate of South Africa. WB42 Climate Statistics 0513465. University of Pretoria experimental farm, Pretoria.

STRINGHAM, S.A, MULROY, E.E, XING, J., RECORD, D., GUERNSEY, M.W., ALDENHOVEN, J.T., OSBORNEE, J. & SHAPIRO, M.D. 2012. Divergence, convergence, and the ancestry of feral populations in the domestic rock pigeon. *Current Biology*, 22: 1 – 7.

TIGAS, L.A., VAN VUREN, D.H. & SAUVAJOT, R.M. 2002. Behavioural responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. *Biological Conservation*, 108: 299 – 306.

TSURIM, I., ABRAMSKY, Z. & KOTLER, B.P. 2008. Foraging Behaviour of Urban Birds: Are human commensals less sensitive to predation risk that their nonurban counterparts? *The Condor*, 110(4): 772 – 776.

VAN NIEKERK, J.H. 2003. Grain Selection and Flocking of Rock Pigeons at a Cattle Feedlot in Gauteng Province, South Africa. *South African Journal of Wildlife*

Research, 33(2): 138 – 141.

VAN NIEKERK, J.H. 2009. Loss of Sunflower Seeds to Columbids in South Africa: Economic Implications and Control Measures. *Ostrich*, 80(1): 47 – 52.

VAN NIEKERK, J.H. & VAN GINKEL, C.M. 2004. The Feeding Behaviour of Pigeons and Doves on Sown Grain Crops on the South African Highveld. *Ostrich*, 75(1&2): 39 – 43.

WALSBERG, G.E. 1986. Thermal Consequences of Roost-Site Selection: The Relative Importance of Three Modes of Heat Conservation. *The Auk*, 103: 1 – 7.

WALSBERG, G.E. & KING, J.R. 1980. The Thermoregulatory Significance of the Winter Roost-sites selected by Robins in Eastern Washington. *Wilson Bulletin*, 92: 33 – 39.

WANLESS, R.M. & JUPITER, T.A. 2002. Predation on Doves by Pied Crows, *Corvus albus*, on Aldabra Atoll. Ostrich, 73(1&2): 59 – 78.

WESTINGTON, J. 2013. Pest control manager, UNISA. Personal communication.

ZWARTJIES, P.W. & NORDELL, S.E. 1998. Patterns of Cavity-Entrance Orientation by Glided Flickers (*Colaptes chrysoides*) in cardŏn cactus. *The Auk*, 115: 119 – 126.

CHAPTER 5.4

Visual deterrents and physical barriers as non-lethal pigeon control on University of South Africa's Muckleneuk campus

E Harris, EP de Crom, J Labuschagne, A Wilson

Submitted: 10 June 2016; accepted (subject to amendments): 27 September 2016

Abstract

A study on a population of pigeons on the University of South Africa's Muckleneuk campus was conducted over two years. Counts were conducted during a baseline year (March 2013 to February 2014) to establish the pigeon population index inhabiting the campus buildings, and again in the management year (August 2014 to August 2015) once Eagle Eyes™, Fire (Flash) Flags, bird spikes and a combination thereof were implemented on the buildings. An efficacy reduction percentage was determined for each of the control structures. The total pigeon index on the campus declined by 50% once the control structures were implemented. Control structures; however, differed markedly in efficacy from each other. Whilst bird spikes indicated the highest efficacy at reducing the pigeon population index, seasonality also influenced the efficacy of the control structure. Quantified understanding of the efficacy of pigeon control measures allows urban management to make informed decisions about reducing pigeon populations.

Keywords

Pigeons; Non-lethal control; Eagle Eyes™; Fire (Flash) Flags; bird spikes; seasonality

Introduction

Feral pigeons were first introduced by early Europeans to Southern Africa as a free-flying domesticated species in the seventeenth century (Brooke, 1981). However populations both feral (Columba livia Gmelin, 1789) and indigenous (speckled pigeon Columba guinea Linnaeus, 1758) have since populated urban regions throughout the subcontinent. Urban resources and lifestyles associated with human activity have enabled pigeons to establish populations as a result of the available supply and distribution of food and breeding space (Haag-Wackernagel, 1995) resulting in them being considered as the most successful avian coloniser of urban spaces.

Given their long history with humans (Sossinka, 1982), it is surprising that pigeons were only first considered to be problematic to the human environment in the 1930s (Sacchi, Gentilli, Razzetti & Barbieri, 2002). As pigeon populations increase people start experiencing aesthetic, vital and economic conflicts of interest (Wetherbee, Coppinger, Wentworth & Walsh, 1964) which include the exposure to droppings and debris accumulation (Murton, Thearle & Thompson, 1972; Fitzwater, 1988; Flannery, 2009), public health concerns (Hutton & Rostron, 2005; Haag-Wackernagel & Bircher, 2009), disturbance (Hutton & Rostron, 2005; Haag-Wackernagel & Geigenfeind, 2008), structural deterioration (Hutton & Rostron, 2005; Giunchi, Albores-Barajas, Baldaccini, Vanni & Soldatini, 2012) and to a lesser extent, bird strikes (Giunchi et al. 2012). Large flocks of pigeons have been considered to be a nuisance due to their vocalisations (Carle, 1959), disturbance from squabs and breeding activities (Hutton & Rostron, 2005), begging (Hutton & Rostron, 2005), potential transmission of pathogens and parasites (Haag-Wackernagel & Moch, 2004) and their sheer numbers resulting in an altered enjoyment of private and public spaces (McKeown, 2008).

Pigeon control has increased substantially over the decades (Giunchi, Baldaccini, Sbragia & Soldatini, 2007), with the pigeon control industry booming in the twenty-first century when public views of the birds became increasingly negative and there were calls for the systematic extermination of pigeons in urban environments (Jerolmack, 2008). Subsequently, with the increase in pigeon population densities, more pest control strategies have become readily available (Giunchi et al., 2012). These control strategies have been broadly directed at either reducing pigeon numbers through increasing mortality (Haag-Wackernagel, 2008; Giunchi et al., 2012), decreasing natality (Giunchi et al., 2007; Haag-Wackernagel, 2008; Dobeic, Pintarič, Vlahović & Dovč, 2011) or modifying behaviour through resource management (Haag-Wackernagel, 1995; Giunchi et al., 2007; Haag- Wackernagel, 2008). Pigeon control is often ad hoc, reactive and unsustainable (Brix, Brydon, Davidian, Dinse & Vidyarthi, 2006), aimed at short-term benefit to enable continued support for pest control businesses (Murton, Thearle & Thompson, 1972).

Lethal measures have become increasingly controversial and have lost public support (Treves & Noughton-Treves, 2005), while non-lethal forms of control are sustainably effective in the long term and are more acceptable to the greater public (Murton et al., 1972; Haag-Wackernagel, 1984). This is particularly applicable in light of the recent listing of the feral pigeon as a Category 3 invasive species in South Africa, in terms of the Alien and Invasive Species Regulations, 2014, in terms of the National Environmental Management: Biodiversity Act of 2004 (Act 10 of 2004) of South Africa which permits the legal control of feral pigeons in urban areas (Department of Environmental Affairs, 2015; SA, 2015:493).

Non-lethal pigeon control strategies are generally directed at the pigeons' visual, auditory and tactile senses; however, habitat modification and reduction can also be achieved by physical barriers. According to Jacobs (1992), pigeons are able to see in colour and ultra-violet spectrums to aid foraging, signalling and sex recognition, and thus visual control strategies aimed at irritating or impersonating danger have varying colour spectrums. These include decoys (Harris & Davis, 1998), moving lights and objects, lasers (Blackwell, Bernhardt & Dolbeer, 2002), threatening images and reflective items. Hutton and Dobson (1993) and Hutton and Rostron (2005) have both found that visual deterrents have their limitations and are generally ineffective due to habituation by the pigeons.

Habitat modification through the placement of physical barriers preventing pigeons from perching on buildings and other urban structures are used widely due to their durability and acceptance by the public (Giunchi et al., 2012). Haag-Wackernagel and Geigenfeind (2008) suggest that through the restriction of entrance dimensions and the exaggeration of sloping surfaces, access prevention to ideal roosting and nesting sites can be achieved. Anti-perching devices such as sprung wires (Hutton & Rostron, 2005) and bird spikes (Seamans, Barras & Bernhardt, 2007), or the total exclusion through netting (Hutton & Dobson, 1993) can be used to deter pigeons from making use of buildings in urban environments. Cost may be a limiting factor in their implementation, and the effectiveness of these barriers can depreciate over time if these devices are not maintained (Hutton & Rostron, 2005).

Nevertheless, every structure and strategy has its advantages and disadvantages (Hutton & Dobson, 1993). However, regardless of the control method used, if the benefits of the resources for the pigeons outweigh the costs of enduring device-related discomfort, pigeons will override any system (Haag-Wackernagel & Geigenfeind, 2008). Research suggests that science seems to be lacking in quantitative reviews of various control methods and their effectiveness at reducing pigeon populations (Buijs & van Wijnen, 2001; Fukuda, Frampton & Hickling, 2008). The level of pigeon reduction of such devices needs to be quantified so that urban management can make informed decisions about the cost effectiveness and efficacy at reducing pigeon populations with regard to non-lethal control methods.

The University of South Africa's (Unisa) Muckleneuk campus in Pretoria is host to a large number of pigeons. The birds gain access into the buildings through open access points such as loose exterior ceiling boards and open electrical and air conditioning ducts (cabling ducts) positioned on the exterior of the buildings. This easy access increases the number of protected and sheltered breeding and roosting sites available. It has also increased health concerns relating to the build-up of their faeces and associated fungi, nest mites and bird lice which have been reported to infest the offices and affect the staff working in certain buildings on campus. Faeces and accumulated nesting material build-up on the various external structures of the campus buildings have become an issue of concern. According to Ntshoe (pers. comm. 2013), large financial investments have been made in order to manage the birds and their associated problems on an ad hoc and reactive basis.

This paper evaluates non-lethal humane pigeon control strategies with particular focus on visual deterrents and physical barriers on the Unisa Muckleneuk campus and will examine the following objectives and null hypothesis.

Objectives

- To determine if the control structures have decreased the pigeon population index on campus.

- To determine if pigeons will move from a building with control structures to an untreated building.

- To establish if seasonality influences the efficacy of control structures.

- To validate the industry percentage reduction claims with regard to control structures.

- To evaluate the efficacy percentage reduction of Eagle Eyes™, Fire Flags, bird spikes and a combination thereof on the pigeon population index.

Null hypothesis

- Control structures, namely Eagle Eyes™ , Fire Flags, bird spikes and combinations of these, will not significantly differ from each other in efficacy at reducing the pigeon population index.

Study Area

Unisa (-25.76776, 28.199158) is situated on top of a hill (1411.19 m above sea level) near the central business district of Pretoria in Gauteng in South Africa. The city is surrounded by the Magaliesburg mountain range in the transitional zone between the Central Bushveld and Moist Highveld Grassland vegetation types (Kruger, 2004). The city has a moderate, warm temperate climate with an annual minimum and maximum temperature average of 13°C (June) and 24°C (January) respectively which was measured during the course of the study. According to the South African Weather Service (2010), precipitation averages 677 mm, while relative humidity ranges between 44% and 75% annually. Pretoria experiences 3 254 hours of sunshine a year with an average of 2.4–2.7 days of cloud cover recorded annually (South African Weather Service, 2010). The Pretoria region within a 20 km radius of Unisa includes commercial, industrial, suburban and rural areas, with farming and crop (maize, soya, sorghum and sunflowers) production in the surrounding districts (Collett, 2015).

The campus is located within a green belt which includes the surrounding Groenkloof Nature Reserve, Fountains Valley, Apies River, Voortrekker Monument and Freedom Park. Various small mammals and bird species inhabit the university's grounds. These include avian migrants and small raptors (Harris, 2014, pers. obs).

Established in 1972, the Muckleneuk campus consists of seven administrative and academic buildings; however, for the purpose of this study only the following five of the seven buildings were investigated as part of the pigeon research: Theo van Wijk building, OR Tambo building, AJH van der Walt building, Cas van Vuuren building and Samuel Pauw building (Figure 12). Each building is unique in its design, providing various roosting and nesting site possibilities for the pigeon population index on the campus. Academic and administrative offices are positioned lengthwise along the buildings and face out onto balconies.

Figure 12: The University of South Africa's Muckleneuk campus in Pretoria, indicating the five buildings and their respective pigeon control structures, in proximity to each other (GoogleMaps, 2016)

Theo van Wijk, the largest building positioned on the far western side of the campus, has 11 levels uniform in design with balconies and exterior cabling ducts running the length of the building. Due to its y-shape, the building offers two north facing and two south facing aspects. The Philadelphia cafeteria is positioned on the third floor, which includes an extensive catering balcony.

The AJH van der Walt building is positioned on the northern side of the campus facing an undeveloped vegetated mound which meets the campus' northern boundary. All seven levels are continuous in balcony and cabling ducts design.

To the east of the campus is the library, housed in the Samuel Pauw building, roughly hexagonal in shape with eight levels and continual balconies. Beyond this building towards the campus boundary in the east is parking space and natural vegetation.

OR Tambo, the administrative building, is positioned to the south. It is the tallest building on campus with 14 levels. Balconies and cabling ducts provide uniform exterior structural design, with the exception of the Good Hope cafeteria and balcony positioned on level four.

Adjacent to the OR Tambo building is the Cas van Vuuren building with seven levels and no exterior cabling ducts positioned above its balconies. Natural areas extend to the southern and south-western boundaries.

A characteristic of all the buildings are the loose, broken or open exterior ceiling boards and cabling ducts which provide additional roosting and breeding space for the pigeon population index on campus.

Materials and Methods

This study took place over two years. During the first year data was collected for a full year from the beginning of March 2013 to the end of February 2014 to provide a baseline year to determine the index of the pigeon population inhabiting the buildings on the Muckleneuk campus. This data was used to determine the efficacy of the control measures implemented on the campus buildings during the second year (August 2014 – August 2015).

For each year adult and juvenile pigeons were counted during the pigeons' bimodal foraging activity periods, which have been recorded to peak in the morning and afternoon (Rose, Nagel & Haag-Wackernagel, 2006; Soldatini, Mainardi, Baldaccini &

Giunchi, 2006). These counts took place early morning during the first two hours after sunrise and again in the evening during the last two hours before sunset, once a week for 52 weeks. If the particular chosen day for counting experienced extreme weather conditions, then the next consecutive day with fine weather was chosen and documented.

The observer maintained a standard designated route in a west to east direction, counting each of the campus' five buildings during the course of the research period. Observations were aided binoculars, digital camera and dictaphone, later transcribed onto data sheets. Double counts of individuals taking off and perching on the same building was taken into consideration and avoided. As the pigeons were wild and free roaming, the exact number of pigeons on campus could not be determined. An increase or decrease in the number of pigeons counted was in essence a reflection of an increase or decrease in pigeon presence. Presence was represented as an index to monitor the extent of the increases or decreases as actual numbers could not be attained through the methodology implemented. The paper will therefore refer to indices to convey the extent of the pigeon presence, and its changes over time. The results of the baseline year were therefore interpreted as an index of pigeon population size. The use of the term 'population' in this study does not refer to a biological population as a demographic unit but rather as a population index indicative of the census technique employed.

During the second year, once the baseline year was completed, various pigeon control structures were installed on four buildings (Theo van Wijk building, OR Tambo building, Cas van Vuuren building and Samuel Pauw building) for the management year (August 2014–August 2015, 52 weeks). One of the buildings, AJH van der

Walt building, was used as a control building without any pigeon control structures or strategies to determine whether pigeons deterred from surrounding buildings with control structures simply moved to an untreated building as suggested by Mooallem (2006).

Pigeon control structures chosen for this study included Eagle Eyes^{TM} (visual deterrent) which are rotating prisms that reflect light within the ultra violet spectrum designed to interfere with the pigeons' line of flight as the light causes a distraction (Eagle Eye, 2015) (Figure 13); Fire (Flash) Flags (visual deterrent), made from reflective gold and silver plastic, are designed to move with the wind to give the impression of fire and danger (Eagle Eye, 2015) (Figure 14); bird spikes (physical barrier), which are dual-pronged, stainless steel spikes continuously placed along the ledge of a building aimed at preventing pigeons from perching (Figure 15); and the combination of the above mentioned control structures (Eagle Eyes^{TM}, Fire Flags and bird spikes) recommended by a well-known pest control company in South Africa for optimal pigeon deterrence.

Figure 13: Eagle Eye™ unit evaluated as a pigeon deterrent on the University of South Africa's Muckleneuk campus

Figure 14: Flash Flag unit evaluated as a pigeon deterrent on the University of South Africa's Muckleneuk campus

Figure 15: Bird spikes evaluated as a pigeon deterrent on the University of South Africa's Muckleneuk campus

The pest control company marketing and selling the pigeon control structures identified the optimal placement of each control structure tested in this study per building on campus to ensure that each building was suitably covered by the chosen structure for pigeon control purposes.

The largest building, Theo van Wijk building, is positioned on the far western side of the campus. Due to its extensive size and y-shape creating two north and two south facing aspects, Eagle Eye™ units were chosen. Sunlight reflected by the 36 units was able to cover a greater surface area relative to the other control structures, and its proximity to other buildings contributed to the control structure choice as light from the units would affect surrounding buildings thus influencing their respective control strategies. Units were placed on each balcony of the 11 stories and at regular intervals along the roof (north and south facing).

OR Tambo, the tallest building with 14 levels, was selected to test the Fire Flags due to the updraft of wind that is experienced at such high altitudes. Eighty units were placed along the levels (north and south facing).

The Cas van Vuuren building was identified for use of bird spikes as the building does not have the exterior electrical and air conditioning ducts (cabling ducts) which are positioned just below the balcony ceilings above the office windows of other buildings on campus. These ducts provide ideal sites for pigeons to roost and nest on. A single continuous strand of bird spikes (1 720 m) was positioned along the length of the balcony ledge on all seven levels (north and south facing).

The university's library, Samuel Pauw, hexagonal in shape, was chosen for the implementation of the control structure combination recommended by the pest control company. This included six Eagle eye™ units, 12 Fire Flag units and 2 790 m of bird spikes applied to the eight levels of the building.

The same methodology used in year one was applied in the second year to determine the efficacy of the control structures on the pigeon population index. Arithmetic means and standard errors of the monthly pigeon population indices are depicted graphically over the course of the two years. Pigeon population index and efficacy rate was determined by calculating the percentage change in the number of counts of pigeons between the baseline year and management year in which the control structures were implemented. This indicated the reduction in percentage of each control structure on the pigeon population index.

To test whether or not there was a difference in the mean efficacy percentages between the different control structures a one-way ANOVA was used. Where significant differences between the control structures were observed, Bonferroni post-hoc tests were employed to determine which of the control structures differed significantly from each other in one-to-one comparisons

Institutional ethical clearance and permission (2013/CAES/017) was received for the research.

Results

The mean pigeon population index declined by 50% between the baseline study year (March 2013–February 2014) ($\bar{x}$ = 344 individuals; SE = 10) and the management year (August 2014–August 2015) ($\bar{x}$ = 172 individuals; SE = 7) once the control structures were installed on the buildings (Figure 16).

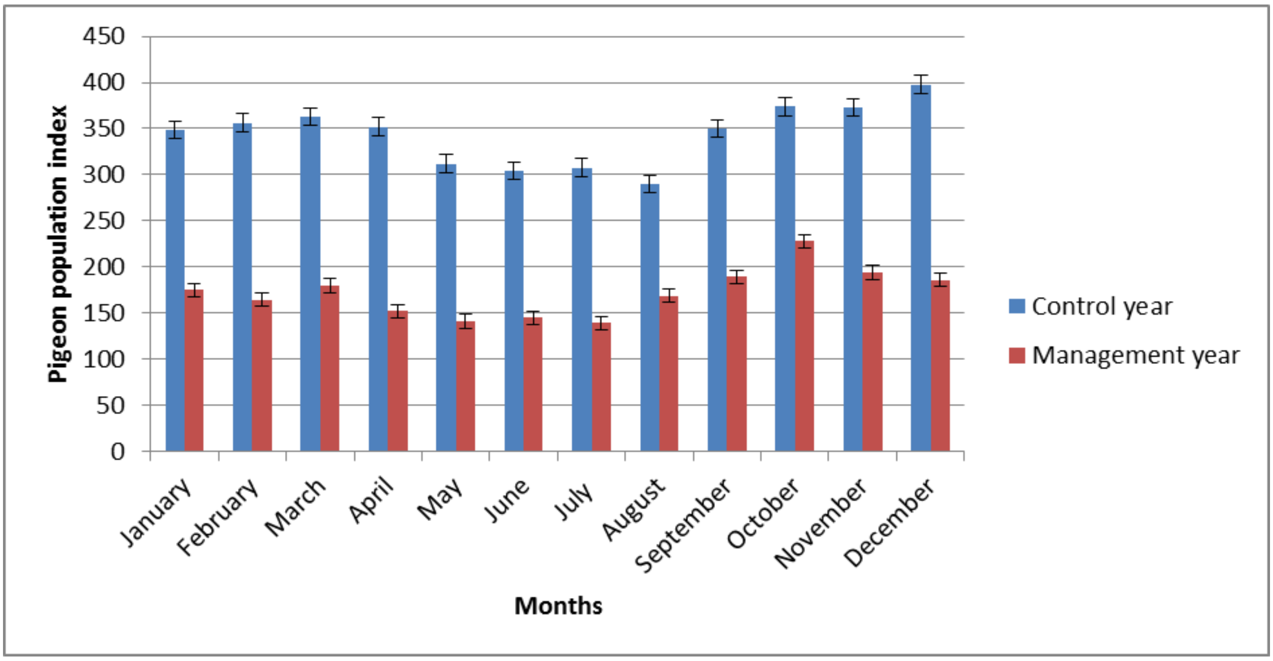


Figure 16: Pigeon population index between the baseline year (March 2013 – February 2014) and the management year (August 2014 – August 2015) indicating standard error.

As a natural decline in the campus' pigeon population on AJH van der Walt (untreated building) between the baseline (year 1) and management year (year 2) was observed. The control structure efficacies values were weighted proportionally to this decline in the population index.

Fire Flags reduced the pigeon population index by an average of 33%, while Eagle Eyes™ indicated a mean reduction in the pigeon population index by nearly 40%. The combination of control structures resulted in a mean reduction of 45%, while bird spikes reduced the pigeon population index the most by a mean of nearly 70%.

The efficacy of control structures on the pigeon population index increased in the warmer seasons, thus structures were more efficient at reducing the pigeon population index in spring than in autumn. While Fire Flags were the least efficient, bird spikes were the most effective at reducing the pigeon population index on the Muckleneuk campus across all seasons (Figure 17).

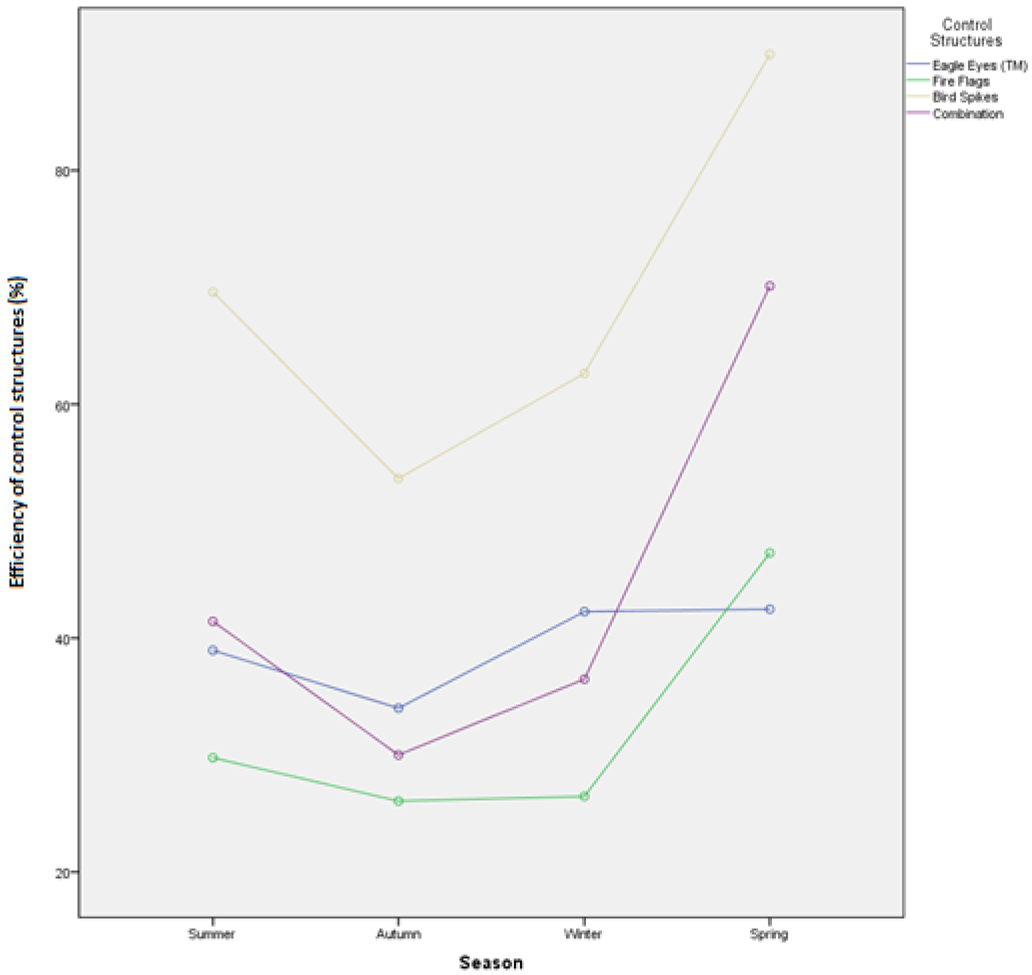


Figure 17: The efficacy of control structures over the seasons during the management year on the Muckleneuk campus (August 2014 – August 2015).

As the p-value was very small, there was a significant difference in mean efficacy value between the different control structures ($F = 5.666$, $p < .001$). Confidence intervals (95%) were included to incorporate the standard errors into the results.

The mean value of efficacy did not differ significantly between Eagle Eyes™, Fire Flags p = .144, 95% CI [-1.20, 15.28]; and the combination p = .646, 95% CI [-13.24, 3.24], but did significantly differ from bird spikes p= .000, 95% CI [-37.74, -21.26] (Table 4).

The mean value of efficacy did not differ significantly between Fire Flags and Eagle Eyes^{TM} p = .144, 95% CI [-15.28, 1.20]. However, the efficacy of Fire Flags did significantly differ between bird spikes p = .000, 95% CI [-44.78, -28.30] and the combination p = .001, 95% CI [-20.28, -3.80] (Table 4).

The mean value of efficacy did significantly differ between bird spikes and the other control structures, namely Eagle Eyes^{TM} p = .000, 95% CI [21.26, 37.74], Fire Flags p = .000, 95% CI [28.30, 44.78], and the combination p = .000, 95% CI [16.26, 32.74] (Table 4).

The mean value of efficacy did not differ significantly between the combination and Eagle Eyes^{TM} p = .646, 95% CI [-3.24, 13.24], but did significantly differ from Fire Flags p = .001, 95% CI [3.80, 20.28] and bird spikes p = .000, 95% CI [-32.74, -16.26] (Table 4).

Table 4: Bonferroni post-hoc test indicating one-to-one comparisons of the efficacy values of each control structure at reducing the pigeon population index during the management year on the Muckleneuk campus (August 2014 – August 2015).

Pigeon control strategy	Pigeon control strategy	Significance at 95% confidence
Eagle Eyes™	Fire Flags	.144
Eagle Eyes™	Bird Spikes	.000
Eagle Eyes™	Combination	.646
Fire Flags	Bird Spikes	.000
Fire Flags	Combination	.001
Bird Spikes	Combination	.000

Discussion

Knowledge of population processes and parameters, activity patterns, abundance, life requirements and resource use of pigeons (Fitzwater, 1970; Godin, 1994; Johnson, 2000) influences the choice and placement of control structures as well as their efficacy at reducing the population (Seamans, Martin & Belant, 2013). Furthermore, numerous studies (Seamans, Barras & Patton, 2003; Dinetti, 2006; Giunchi et al., 2012) have noted the positive benefits of integrated pest management, rather than a single method of control (Shea, Thrall, Burdon, 2000). Control methods focused on multiple scare devices such as Eagle Eyes™ and Fire Flags combined with habitat modification (Booth, 1994) and limiting ecological resources (Giunchi et al., 2012) appear to result in the successful reduction of pigeon populations (Seamans, Barras & Patton, 2003). This was found to be true on the Muckleneuk campus as the pigeon population index declined by 50% as a result of the various control structures placed on the campus buildings. However, few studies have quantified the efficacy that different control structures contribute to the overall decline in a pigeon population index. Instead control structures are recommended based upon informal reviews and incidental observations (Seamans, Barras & Bernhardt, 2007; Fukuda, Frampton & Hickling, 2008), whereas our study found the different control structures to be significantly different in efficacy.

The efficacy of bird spikes to reduce the pigeon population index on campus was significantly different from the other control methods, and thus the null hypothesis was rejected. Bird spikes were found to be the most successful in reducing the pigeon population (nearly 70%) as pigeons were physically hindered from perching on the treated building. Seamans, Barras and Bernhardt (2007) described similar findings at an airport; their research found the anti-perching spikes to be effective against preventing pigeons from perching on buildings. Based on biological principles, the spikes deny access to sites selected by pigeons (Harris & Davis, 1998). Nonetheless faeces and debris caught in the spikes can render them redundant and ineffective (Barnes, 1997) when pigeons build their nests on top of this accumulation. Ongoing maintenance and monitoring is therefore essential to retain efficacy.

Scare devices such as Fire Flags and Eagle Eyes™ are considered to have limited efficacy at reducing pigeon populations (Harris & Davis, 1998; Fukuda, Frampton & Hickling, 2008). This was found to be the case with the units placed on the Muckleneuk campus. There is much literature that describes habituation to the units as a limiting factor of visual deterrents (Godin, 1994; Harris & Davis, 1998). Due to the interdisciplinary nature of this study, the human component of staff on campus influenced the efficacy of the Eagle Eyes™ and Fire Flags as a number of units were removed and vandalised during the course of this study thus resulting in less than optimal unit placement and quantity.

Research conducted on structures with similar deterrent components to Fire Flags such as reflecting tape (Bruggers, Brooks, Dolbeer, Woronecki, Pandit, Tarimo & Hoque, 1986; Harris & Davis, 1998), mylar ribbon (Tobin, Woronecki, Dolbeer & Bruggers, 1988) and metallic streamers (Christensen, 1996) describes similar findings of their inefficiency at deterring bird species. Furthermore, Harris and Davis (1998) point out the lack of biological basis regarding the Fire Flags and the limited application in deterring birds from areas. In fact, Fire Flags were found to be the least efficient control structure (33%), and did significantly differ from bird spikes and the combination.

Eagle Eye™ units were also found to have limited efficacy at reducing the pigeon population index on campus, and differed significantly from the bird spikes. Research conducted on a similar European device, Peaceful Pyramid®, supported these findings as the reflecting mirrors were only marginally effective at altering pigeon behaviour (Seamans, Barras & Patton, 2003; Fukuda, Frampton & Hickling, 2008). According to the company's literature, the Eagle Eye™ unit has been successfully used to deter various avian species, including pigeons (Eagle Eye, 2015), but the efficacy of Eagle Eye™ units has thus far been based on subjective estimates and anecdotal reports. The limited efficacy can be attributed to habituation to the units (Fukuda, Frampton & Hickling, 2008; Giunchi et al., 2012). In other avian studies, flashing lights and mirrors, the fundamental control attributes of the Eagle Eye™ units, were also found to be ineffective (Seamans, Lovell, Dolbeer & Cepek, 2001) at deterring birds in urban environments.

The pest control industry recommends a combination of Eagle Eyes™, Fire Flags and bird spikes in order to achieve maximum efficacy at reducing pigeon populations. According to the literature supplied by Eagle Eye (2015), a reduction of up to 80% of pigeon populations can be expected. In spite of this, the combination applied to the Samuel Pauw building was less successful than the spikes-only application on another building, but significantly different from Eagle Eye™ and Fire Flag units. This is in contrast to the assumption that the combination would be more effective than its individual parts. However, it should be mentioned here that the building on which the combination was applied had numerous open exterior cabling ducts and open or loose exterior ceiling boards. These provided the pigeons with alternative sites to the spikes which reduced the perching surface area of the balcony ledges, consequently limiting the effect of the combination on the pigeon population index. According to Jerolmack (2008), the life-sustaining processes of pigeons are often ignored when control measures are implemented. The combination of methods used on the Samuel Pauw building supports this view, as the carrying capacity of the pigeon population index was not optimally reduced for this building due to the availability of alternative untreated space on the building. The combination did, however, differ significantly from the bird spikes and Fire Flags. Further replications of the pigeon control measures on numerous buildings would have improved the possibility of repeated results, however due to building access and financial implications; this study was limited to building availability.

On a larger scale, pigeon control does not influence the actual population size (Krimowa, 2012) but simply displaces individuals away from the deterring systems to untreated buildings or sites (Mooallem, 2006; Geigenfeind, 2013). Nevertheless, a decline in the pigeon population index on campus after the control structures were implemented was noted and a 23% reduction in the pigeon population index between the baseline year and the management year on the untreated building occurred. It can therefore be inferred that no pigeons which previously inhabited the treated buildings moved to the untreated control building.

Another contributing factor which affects the effectiveness of avian deterrents is seasonality (Seamans, Martin & Belant, 2013). Climatic conditions, environmental changes and food availability all have an influence on the behaviour of pigeons and their subsequent tolerance of control structures. The efficacy of structures was found to increase during the warmer months corresponding with the natural pigeon population index fluctuation on campus (spring ($\bar{x}$ = 365 pigeons; SE = 4) and summer ($\bar{x}$ = 367 pigeons; SE = 8) seasons in comparison to the autumn ($\bar{x}$ = 342 pigeons; SE = 8) and winter ($\bar{x}$ = 300 pigeons; SE = 3) seasons) (Harris, de Crom, Labuschagne & Wilson, in press). Pigeons on the Muckleneuk campus which breed year-round with a peak between July and October (Harris et al. in press), indicated a higher tenacity for tolerating the control structures in spring. According to Curio and Regelmann (1983), there is a trade-off between conflicting demands in great tits, and this study too found that pigeons on campus were willing to endure the discomfort of deterrents in order to rear their young. Wildlife regularly makes decisions that are crucial to their survival and fitness (Conradt & Roper, 2005). This was evident with the pigeons on the Muckleneuk campus as the population index on the campus buildings were found to be inversely related to the availability of their main food source, agricultural crops

(Harris et al., in press). Pigeons on campus rather directed their energy into foraging locally than travelling to surrounding agricultural areas in spring due to the limited crop availability (Harris et al. in press). As a result more pigeons were visible on the buildings. The higher spring population index in the visual deterrents may also imply that the structures installed may ultimately not impact on pigeons' behaviour in a significant way.

Even though Eagle Eyes™, Fire Flags and the combination of control structures presented an irritant to the pigeons inhabiting the buildings, pigeons were willing to tolerate the discomfort. As a result the seasonal efficacy of these measures was low. This is in contrast to the bird spikes installed on the Cas van Vuuren building which did not provide any additional perching space in the form of exterior cabling or open ceiling boards. Pigeons were physically unable to perch on the balcony ledge where bird spikes had been placed, which resulted in a high seasonal efficacy at reducing the pigeon population index.

All control structures on the campus buildings were found to be the least efficient during the autumn months. According to Pulliam (1976) and McCleery (1978), different behavioural options of wildlife result in a continual shift in relative costs and benefits. Due to the colder temperatures, pigeons were hidden as a result of thermal factors (Harris et al. in press) and consequentially also from the observer. Autumn also coincides with a biologically important season in the pigeon life cycle, namely moulting. As costly energy is diverted for feather regrowth and plumage change (Murton, 1966; Johnston & Janiga, 1995), pigeons are relatively inactive as opposed to the rest of the year in order to conserve energy.

Conclusion

The control of pigeons has become increasingly humane and non-lethal, with consideration for ecological processes and sustainability. Single methods of control are no longer viable nor sustainable, and successful management of pigeons can only be achieved with integrative measures as seen on the Muckleneuk campus.

This study found visual scare devices to be far less effective at reducing the pigeon population index on campus than the physical exclusion and habitat modification of the bird spikes. However, as site-specific environmental factors and ecological resource availability affect pigeon control, this is not to say that Fire Flags and Eagle Eyes™ will not be effective on a different site or building. They were simply ineffective on the Muckleneuk campus. A further comparative study evaluating the effect of control structures recommended by the pest control industry should be undertaken independently without the influence of people.

Similarly the combination of control structures targeted at maximising pigeon reduction would improve in efficacy if the open cabling ducts and ceiling boards that provide alternative perching sites are attended to. According to Ryzhov and Mursejev (2010), the success and efficacy of control structures to reduce pigeon populations depend on the conditions of usage. The success of control structures is therefore dependent on the context of application and factors influencing a site. Blanket statements on the expected percentage reduction of pigeon populations by control structures cannot be guaranteed as each site and pigeon population index interaction is unique as seen on the Muckleneuk campus. Similar studies at other sites considering building design and optimal pigeon control structure placement would need to be undertaken to confirm a range of efficacies for visual deterrents and physical barriers specific for managing pigeons.

Though seasonality affects the efficacy of control structures, with spring and autumn indicating respective peaks and dips, pigeons did not move from the treated to the untreated buildings as previously thought. This does not necessarily imply that pigeons did not move between treated buildings to limit their exposure to the deterrent, but merely that this study did not investigate this aspect.

As urbanisation continues to expand, human-wildlife conflicts involving pigeons are expected to increase, and subsequently an increase in the demand for control. The effect of control structures at reducing pigeon populations has not yet been extensively quantified (Seamans, Barras & Bernhardt, 2007; Fukuda, Frampton & Hickling, 2008). This is a vital component of urban management in order to be able to make informed decisions about the cost effectiveness and efficacy at reducing pigeon populations relating to non-lethal control methods. Integrative pest management, including a combination of measures based on sound biological principles (Davis, 1974), combined with time and use variation will result in more sustainable pigeon population reductions in urban environments.

There is a need for greater scientific understanding of the efficacy of non-lethal pigeon control measures in order to be able to manage pigeon populations to ensure healthy, socially acceptable standards (Dobeic, Pintarič, Vlahovič & Dovč, 2011).

Compliance with Ethical Standards

Institutional ethical clearance and permission (2013/CAES/017) was received for the research.

Consent to publish

As this manuscript does not contain any individual person's data, the consent to publish is not applicable.

Conflict of interest disclosure statement

The authors (Emma Harris, Engela P de Crom, Jean-Pierre Labuschagne and Ann Wilson) declare that they have no conflict of interest.

Acknowledgement of funding

This work was supported by the Applied Behavioural Ecological and Ecosystem Research Unit (ABEERU); University of South Africa's University Estates Department; and National Research Foundation (NRF) under Grant 90073.

Author contribution statement

- Ms E Harris is the primary researcher. She developed the project, collected and interpreted the data. She is responsible for drafting the article.
- Dr EP de Crom is the co-supervisor of the primary researcher. She reviewed the article and approved the finalised version.
- Mr J Labuschagne provided statistical support.
- Ms A Wilson is the supervisor of the primary researcher. She reviewed the article and approved the finalised version.

REFERENCES

BALDACCINI, N., GIUNCHI, D., MONGINI, E. & RAGIONIERI, L. 2000. Foraging flights of wild rock doves (Columba l. Livia): a spatio- temporal analysis. *Monitore Zoologico Italiano*, 67: 371 – 377.

BARBIERI, F. & DE ANDREIS, C. 1991. Indagine sulla presenza dei colombi (Columba livia forma domestica) nel centro storico di Pavia e nall'Oltrepó. *Suppl. Ric. Biol. Selvaggina*, 17: 195 – 198.

BARNES, T.G. 1997. *Managing urban pest bird problems in Kentucky*. University of Kentucky cooperative extension service.

BLACKWELL, B.F., BERNHARDT, G.E. & DOLBEER, R.A. 2002. Lasers as non lethal avian repellents. *Journal of Wildlife Management*, 66: 250 – 258.

BOOTH, T.W. 1994. *Bird dispersal techniques*. The handbook: prevention and control of wildlife damage: 58.

BRIX, A., BRYDON, T., DAVIDIAN,E., DINSE, K. & VIDYARTHI, S. 2006. Toward sustainable campus communities: evaluating alternative development scenarios. MSc University of Michigan: Michigan.

BRUGGERS, R.L., BROOKS, J.E., DOLBEER, R.A., WORONECKI, P.P., PANDIT, R.K., TARIMO, T. & HOQUE, M. 1986. Responses of pest birds to reflecting tape in agriculture. *Wildlife Society Bulletin*, 14: 161 – 170.

BUIJS, J.A. & VAN WIJNEN, J.H. 2001. Survey of feral rock doves (*Columba livia*) in Amsterdam, a bird-human association. *Urban Ecosystems*, 5: 235 – 241.

CARLE, R. 1959. Die Vorbereitung zur Bestandsregelung unter den verwilderten Haustauben in den Städten. Städtehygiene 8:164 –168. In: DEL MONTE, M. & SABBIONI, C. 1986. Chemical and biological weathering of an historical building: Reggio Emilia Cathedral. *Science of the Total Environment*, 50: 165 – 18.

CHRISTENSEN, W. 1996. Creative pigeon management. *New Hampshire Audubon*, 32(6): 11

COLLETT, A. (AnnelizaC@daff.gov.za). 2015. Agricultural crop list. [Email to:] Harris, E. (emmaharris09@gmail.com) Oct. 21.

CONRADT, L. & ROPER, T.J. 2005. Consensus decision making in animals. *Trends in Ecology and Evolution*, 20(8): 449 – 456.

CURIO, E.K. & REGELMANN, K. 1983. An anti-predator response in the great tit *(Parus major):* is it tuned to predator risk? *Oecologia* (Berlin) 60:83 – 88.

DAVIS, P.J. 1974. Fundamentals of bird scaring – a laboratory approach. *Annals of Applied Biology*, 76(3): 353 – 358.

DECHILLO, S. 1986. Owl decoys face off against pigeons. *New York Times*, Nov. 2.

DEPARTMENT of Environmental Affairs **see** SOUTH AFRICA. Department of Environmental Affairs.

DINETTI, M. 2006. Urban avifauna: is it possible to live together? *Veterinary Research Communications*, 30 (Supple. 1): 3 – 7.

DOBEIC, M., PINTARIČ, S., VLAHOVIĆ, K. & DOVČ, A. 2011. Feral Pigeon (*Columba livia*) Population Management in Ljubljana. *Veteinarski Arhiv*, 81(2): 285 – 298.

EAGLE EYE. 2015a. Eagle Eye bird control [Online]. Available from: http://www.eagleeye.co.za/popular-bird-control-products. [Accessed: 08/12/2015].

EAGLE EYE. 2015b. Eagle Eye placement guidelines [Online]. Available from: file:///C:/Users/Downloads/Eagle_Eye_placement_guidelines_metric_1.pdf. [Accessed: 08/12/2015].

FITZWATER, W.D. 1970. Sonic systems for controlling bird predations. In: *Proceedings of the Bird Control Seminars*: 203.

FITZWATER, W.D. 1988. Solutions to Urban Bird Problems. In: *Proceedings of the Thirteenth Vertebrate Pest Conference*: 254 – 259.

FLANNERY, M.C. 2009. The Value of Pigeons. *The American Biology Teacher 71(7): 430-431.*

FREEMAN, D. 2015b. Falconer, Top Turf, Bidvest Steiner. Personal communication.

FUKUDA, Y., FRAMPTON, C.M. & HICKLING, G.J. 2008. Evaluation of two visual birdscarers, the Peaceful Pyramid® and an eye-spot balloon, in two vineyards. *New Zealand Journal of Zoology*, 35(3): 217 – 224.

GEIGENFEIND, I. 2013. On the biology and epidemiology of the feral pigeon (*Columba livia*). PhD University of Basel: Basel.

GILSDORF, J.M., HYGNSTOM, S.E. & VERCAUTEREN, K.C. 2003. Use of frightening devices in wildlife damage management. *Integrated Pest Management Reviews*, 7: 29 – 45.

GIUNCHI, D. & GAGGINI, V. 2007. Distance sampling as an effective method for monitoring feral pigeon (*Columba livia* f. *domestica*) urban populations. *Urban Ecosystems*, 10: 397 – 412.

GIUNCHI,D., ALBORES-BARAJAS, Y.V., BALDACCINI, N.E., VANNI, L. & SOLDATINI, C. (2012). *Feral Pigeons: Problems, Dynamics and Control Methods*. In: Larramendy, M.L. & Soloneski, S. (eds.). Integrated Pest Management and Pest Control - Current and Future Tactics. Intech Open Science: Rijeka, Croatia: 215-240.

GIUNCHI, D, BALDACCINI, N.E., SBRAGIA, G. & SOLDATINI, C. 2007. On the Use of Pharmacological Sterilisation to Control Feral Pigeon Populations. *Wildlife Research*, 34: 306 – 318.

GODIN, A.J. 1994. *Birds at airports*. The handbook: prevention and control of wildlife damage: 56

GOODWIN, D. 1983. Behaviour. In: Wright, E.N. (ed.). *Physiology and Behaviour of the Pigeon*. Academic Press, London: 285 – 308.

HAAG-WACKERNAGEL, D. 1984. Ein Beitrag zur ökologie der Stadttaube. PhD Universität Basel: Basel.

HAAG-WACKERNAGEL, D. 1995. Regulation of the street pigeon in Basel. *Wildlife Society Bulletin*, 23(2): 256 – 260.

HAAG-WACKERNAGEL, D. 2008. *Feral Pigeon Management* [Online]. Available from: www.Anatomie.unibas.ch/integrativeBiology/hag/Feral-Pigeon Strassentauben/pigeon-management.html [Accessed: 12/02/2013].

HAAG-WACKERNAGEL, D. & BIRCHER, A.J. 2009. Ectoparasites from feral pigeons affecting humans. *Dermatology,* 220: 82 – 92.

HAAG-WACKERNAGEL, D. & GEIGENFEIND, I. 2008. Protecting Buildings against Feral Pigeons. *European Journal of Wildlife Research*, 54: 715 – 721.

HAAG-WACKERNAGEL, D. & MOCH, H. 2004. Health hazards posed by feral pigeons. *Journal of Infection*, 48: 307 – 313.

HARRIS, R.E. & DAVIES, R.A. 1998. *Evaluation of the efficacy of products and techniques for airport bird control*. Aerodrome Safety Branch Transport Canada: Ontario.

HURST, W. 2006. Watch the Birdie! [Online]. Available from: www.building.co.uk [Accessed: 06/05/2013].

HUTTON, T.C. & DOBSON, J. 1993. The control of feral pigeons: an independent approach. *Structural Survey*, 11(2): 159 – 167.

HUTTON & ROSTRON. 2005. Method statement for the control of feral pigeons [Online]. Available from: http://www.handr.co.uk/literature/feral_pigeons.htm. [Accessed: 05/12/2012].

JACOBS, G.H. 1992. Ultraviolet vision in vertebrates. *American Zoologist*, 32: 544 – 554.

JEROLMACK, C. 2008. How pigeons became rats: The cultural-spatial logic of problem animals. *Social problems,* 55(2):77-94.

JOHNSON, R.J., 2000. Management of pest birds in urban environments. *Other Publications in Wildlife Management*: 16.

JOHNSTON, R.F. & JANIGA, M. 1995. *Feral Pigeons*. Oxford University Press: New York.

KAUTZ, E.J. 1985. Effects of harvest on feral rock pigeon survival, nest success, and population size. PhD University of Cornell: Ithaca.

KAUTZ, E.J. 1990. Testing for compensatory responses to removals from wildlife populations. In: *Proceedings of the Trans 55th N.A. Wildl. & Nat. Res. Conf.*: 527 – 533.

KEENAN, K. 2000. Town to roust birds from roost. *Worcester Telegram & Gazette*, Jan. 17: B1.

KRIMOWA, S. 2012. Pigeons and people: resource ecology and human dimensions of urban wildlife. MSc Victoria University of Wellington: Wellington.

KRUGER, A. C. 2004. *Climate of South Africa. Climate Regions. WS45*. South African Weather Service. Pretoria. South Africa.

LIMA, S. L. 1985. Maximizing feeding efficiency and minimizing time exposed to predators: a trade-off in the black-capped chickadee. *Oecologia* (Berlin), 66: 60 – 67.

MATYJASIAK, P. 2008. Methods of bird control at airports. In: Uchmański, J. (ed.) *Theoretical and applied aspects of modern ecology*. Cardinal Stefan Wyszyński University Press: Warsaw: 171 – 203.

MCCLEERY, R.H. 1978. Optimal behaviour sequences and decision making. In: Krebs, J.R. & Davies, N.B. (eds.). *Behavioural ecology: an evolutionary approach*. Blackwell: Oxford: 377-410.

MCKEOWN, D. 2008. Toronto Pigeon feeding. Internal Document.

MOOALLEM, J. 2006. Pigeon Wars. *New York Times Magazine*, Oct. 15:54.

MURTON, R.K. 1966. Natural Selection and the Breeding Seasons of the Stock Dove and Wood Pigeon. *Bird Study*, 13(4): 311 – 327.

MURTON, R.K., THEARLE, R.J.P. & THOMPSON, R.J.P. 1972. Ecological studies of the feral pigeon Columba livia var. I. Population, breeding biology and methods of control. *Journal ofApploed Ecology,* 9: 835 - 874.

NTSHOE, L. 2013. Cleaning manager, University Estates, UNISA. Personal communication.

PHILLIPS, R.B., SNELL, H.L., & VARGAS, H. 2003. Feral doves in the Galápagos islands: biological and economic threats. *Noticasgalápagos*, 62: 6 – 10.

PULLIAM, H.R. 1976. The principle of optimal behaviour and the theory of communities. In: Bateson, P.P.G. & Klopfer, P.H. (eds.). *Perspectives in ethology, vol 2*. Plenum Press: New York: 311 – 332

ROSE, E., NAGEL, P. & HAAG-WACKERNAGEL, D. 2006. Spatio-temporal use of the urban habitat by feral pigeons (*Columba livia*). *Behavioral Ecology and Sociobiology*, 60: 242 – 254.

RYZHOV, S.K. & MURSEJEV, M.R. 2010. Trained goshawks against pigeons. *Raptor Conservation*, 20: 25 – 34.

SA **see** SOUTH AFRICA.

SACCHI, R., GENTILLI, A., RAZZETTI, E. & BARBERI, F. 2002. Effects of Building Features on Density and Flock Distribution of Feral Pigeons *Columba livia var.domestica* in an Urban Environment. *Canadian Journal of Zoology*. 80: 48 – 54.

SAVARD, J.L., CLERGEAU, P. & MENNECHEZ, G. 2000. Biodiversity concepts and urban ecosystems. *Landscape Urban Plan*, 48: 131 – 142.

SEAMANS, T.W., BARRAS, S.C. & BERNHARDT, G.E. 2007. Evaluation of two perch deterrents for starlings, blackbirds and pigeons. *International Journal of Pest Management,* 53: 45 – 51.

SEAMANS, T.W., BARRAS, S.C. & PATTON, Z.J. 2007. Are birds scared by rotating mirrors? In: *Proceedings of the Bird Strike Committee USA Canada 5th Annual Meetin, held in Toronto on 18 – 21 August, 2003*. Ontario: Toronto.

SEAMANS, T. W., LOVELL, C.D., DOLBEER, R.A., CEPEK, J.D. 2001. Evaluation of mirrors to deter nesting Starlings. *USDA National Wildlife Research Centre:* 613.

SEAMANS, T.W., MARTIN, J.A. & BELANT, J.L. 2013. Tactile and auditory repellents to reduce wildlife hazards to aircraft. *Wildlife Management Techniques*.

SHEA, K., THRALL, P.H. & BURDON, J.J. 2000. An integrated approach to management in epidemiology and pest control. *Ecology letters*, 3: 150 – 158.

SOL, D. & SENAR, J.C. 1995. Urban pigeon populations: stability, home range, and the effect of removing individuals. *Canadian Journal of Zoology*, 73: 1154 – 1160.

SOLDATINI, C., MAINARDI, D., BALDACCINI, N.E. & GIUNCHI, D. 2006. A temporal analysis of the foraging flights of feral pigeons (*Columba livia* f. *domestica*) from three Italian cities. *Italian Journal of Zoology*, 73(1): 83 – 92.

SOSSINKA, K. 1982. Domestication in birds. *Avian Biology*, 6: 373 – 403.

SOUTH AFRICA. Department of Environmental Affairs. 2015. Feral pigeon invasive species [Online]. Available from: https://www.environment.gov.za/mediarelease/feralpigeon_invasivespecies [Accessed: 10/12/2015].

SOUTH AFRICA. 2015. National Environmental Management: Biodiversity Act 2004 (Act No, 10 of 2004) Draft Amendments to the Alien and Invasive Species Lists, 2015. Government Gazette, 493, May 29. (Regulation Gazette No. 38833).

SOUTH AFRICAN WEATHER SERVICE, 2010. Climate of South Africa. WB42 Climate Statistics 0513465. *University of Pretoria Proefplaas*.

TOBIN, M.E., WORONECKI, P.P., DOLBEER, R.A. & BRUGGERS, R.L. 1988. Reflecting tape fails to protect ripening blueberries from bird damage. *Wildlife Society Bulletin*, 16: 300 – 303.

TREVES, A. & NOUGHTON-TREVES, L. 2005. Evaluating lethal control in the management of human-wildlife conflict. In: Woodroffe, R., THIEGOOD, S. & RABINOWITZ, A. *People and Wildlife, Conflict or Co-existence?* Cambridge University Press: New York.

WESTINGTON, J. 2013. Pest control manager, UNISA. Personal communication.

WETHERBEE, D.K., COPPINGER, R.P., WENTWORTH, B.C. & WALSH, R.E. 1964. Antifecundity effects of sudan black B and transovarian intravital staining in avian population control. *Experimental Station Bulletin* 543, College of Agriculture, University of Massachusettes Amherst, USA.

CHAPTER 5.5

Evaluation of audible and visible predator presence, for pigeon control purposes on the University of South Africa's Muckleneuk campus.

E Harris, EP de Crom, J Labuschagne, A Wilson

ABSTRACT

A study on the effect of audio and visual predator presence as a means of pigeon control on a building on the University of South Africa's Muckleneuk campus was conducted in April/May 2014 and September 2014. The audio trial (BirdXPeller PRO^{TM}) and falconry trial each took place over four week periods to determine the effect of implied versus actual predator presence on the pigeon population. Trials were conducted at dawn and dusk, once a week for a total of eight weeks. Pigeons were counted prior to the audio and falconry scare, after the scare and every 10 minutes for a period of 30 minutes post scare. The study determined that there was an association between method of scaring and the number of pigeons observed on the different time periods. Pigeons were observed to continue the natural trend of dispersion and return at the dawn and dusk counts during the audio bird scarer trial without being actively discouraged or dislodged from the building. Pigeons reacted positively to the visual raptor presence, which caused them to take flight from the buildings. The visual effect was temporary as pigeons returned once the threat had been removed. Knowledge of pigeons' response to audible and visible predator presence contributes to further understanding pigeon ecology and integrative pigeon control.

KEYWORDS

Pigeon control, predator presence, falconry, audio scare devices, Bird – X Peller Pro^{TM}.

INTRODUCTION

Pigeons are considered to be a source of human-wildlife conflict within urban environments. Named the most successful coloniser of urban environments (Ryan, 2011), pigeons have evolved the ability to exploit urban shelter and food resources (Giunchi, Albores-barajas, Baldaccini, Vanni & Soldatini, 2012.) resulting in population expansions consequently presenting a problem to people and infrastructure alike (Dobeic, Pintarič, Vlahović & Dovč, 2011). Flocks living within urban environments have adopted flexi foraging strategies to maximise on food consumption (Rose, Nagel, & Haag-Wackernagel, 2006). Pigeons display bimodal feeding (Johnston & Janiga, 1995; Krimowa, 2012) and have been recorded to travel up to 50 kmkm daily to forage in surrounding agricultural fields (van Niekerk, 2009), from urban roosts to farmlands and agricultural feeding grounds (van Niekerk, 2003; Giunchi, *et al.* 2012). In addition to the abundance of anthropogenic and natural food, sheltered roosting and breeding sites, as well as the absence of natural selection factors (Dobeic *et al.* 2011), such as low predator presence, contribute to pigeons being termed a wide spread aerial nuisance (Keenan, 2000). Fitzwater (1988) and Robbins (1995) noted that pigeons were the most reported pest in built-up environments, resulting in an evident social disorder (Jerolmack, 2008) due to the birds' pest-like qualities. To compensate for this the pest control industry has developed a wide range of lethal and non-lethal control strategies to reduce and or eradicate pigeon populations from urban environments (Boudreau, 1968b).

Amongst these methods is the implied or actual presence of predators through the use bioacoustics and falconry strategies to deter pigeons from making use of buildings and infrastructure. Bioacoustics or biosonics, as defined by Boudreau (1968b), is the "study of biologically significant sounds originated by animals, and the mechanisms which produce and receive these sounds". Natural distress and alarm sounds of specific species are recorded, amplified and projected over a designated area (Boudreau, 1968b), in an effort to warn others of potential danger resulting in the repulsion and discouragement of a targeted species (Gilsdorf, Hygnstrom & VerCauteren, 2002). Gilsdorf, Hygnstrom and VerCauteren (2002) explain that audio bird scarers are based on biological principles which relate to the strong intrinsic survival value held by individuals. Most studies conducted on testing the efficiency of commercial systems, have been directed at birds (Frings, 1964; Mott & Timbrook, 1988). In a report written by Harris and Davis (1998), bird scarers were used to deter gulls, starlings, skylarks, herons and geese with varying degrees of effectiveness. One such commercial system is the BirdXPeller PRO™ (Bird-X Inc, Chicago), a digital bird repeller designed to use a combination of species-specific distress calls and bird of prey calls to deter pigeons, gulls, starlings, sparrows, magpies, rooks and crows. According to the company's literature the unit is "highly effective when used alone" against modifying birds' behaviour and rids pest birds from outdoor areas up to one acre (4 047 m^2). The unit is not yet available in South Africa, however for the purpose of this study; it was imported from the United States of America. Informal reviews have been conducted by users on bio-sonic devices which recorded varying results from effectively deterring pigeons to being totally ineffective.

An exception to the negative implications of other killing methods is the promotion of natural enemies. Haag-Wackernagel (2008) classifies the introduction of natural enemies as a method to increase mortality, however it may be considered to be a method of behavioural modification instead. The introduction of birds of prey to an environment, allows for the gradual and long-term control of pigeon populations through being predated upon (which is minimal) as well as being a visual deterrent. Shochat, Lerman and Fernández-Juricic (2010) explain how the deliberate promotion of raptors affects pigeons on different scales; short-term which results in pigeon behavioural change through area avoidance; long term pigeon population reduction and evolutionary whereby pigeons are forced to adapt over time.

Birds of prey such as falcons (*Falco sp.*), goshawks and sparrowhawks (*Accipiter sp.*) are often active at dawn and dusk, to take advantage of pigeons moving to and from feeding areas (Koen & Jenkins, 2011; Rutz, 2012). Angier (1991) goes on to explain how much of their diet comprises of pigeons and doves; 75% of urban raptors' prey and more than half of Peregrine Falcon's (*Falco peregrinus*) prey items (López-López, Verdejo & Barba, 2009). However it has been recorded that only one kill may be necessary each day, leaving much time for resting. Haag-Wackernagel (2008) counter argues that falcons have very little effect on the reduction or control of pigeon population sizes. This can be increased however if falcon 'fliers' are introduced on an ad hoc basis, to give the impression that the birds of prey are active. Falconry has been used successfully in high density metropolis areas such as

New York City (Angier, 1991) and Trafalgar Square in London (McKeown, 2008) to reduce large congregations of pigeons. As a hands-on technique, this strategy can be used selectively resulting in a higher rate of efficiency than automatic methods (Harris & Davis, 1998), as it biologically based in the evolutionary response of birds to avoid and disperse away from predators (Ryzhov & Mursejev, 2010). Harris and Davis (1998) imply that frequent flights by the bird of prey over the designated area ensure that pigeons associate the site danger, thus preventing the pigeon population from habituating and becoming accustomed to behavioural patterns of a resident raptor pair. This method can be time consuming (Gilsdorf, Hygnstrom & VerCauteren, 2003), difficult (Haag-Wackernagel, 2008) and expensive (Matyjasiak, 2008) if not used to supplement other forms of pigeon control. Bioaccumulation of lead (Hutton & Goodman, 1980; De Ment & Chisolm, 1986; De Ment, 1987) and manganese (Loranger, Demers, Kennedy, Forget & Zayed, 1994) found in pigeons can also pose a risk to raptors resulting in adverse effects (Ditchkoff, Saalfeld & Gibson, 2006).

Research seems to be lacking in comparing the effectiveness of visually seeing a bird of prey as an immediate threat versus hearing one call in the vicinity coupled with alarm calls of the target species (Harris & Davies, 1998; Fukuda, Frampton & Hickling, 2008). The level of pigeon reduction of such control methods needs to be quantified so that urban management can make informed decisions about the cost effectiveness and efficiency relating to predator presence.

The evaluation of implied and actual predator presence as humane pigeon control will be incorporated into an interdisciplinary management plan for a future humane and non-lethal pigeon control strategy for the Muckleneuk campus of the University of South Africa.

This paper explores the predator's audio and visual presence as a humane pigeon control option, by addressing the following objectives and null hypothesis.

Objectives

- To determine if the effect of the audio scare will differ from the effect of the visual raptors on the pigeon population on AJH van der Walt building.
- To evaluate if the effect of the audio and visual raptor scare will diminish after 30 minutes post scare.
- To establish the influence of the audio scare on the natural trend of the pigeon population at dawn and dusk.
- To establish the influence of the visual raptor scare on the natural trend of the pigeon population at dawn and dusk.

Null hypothesis

- There is no association between the method of scaring (audio or visual) and the number of pigeons observed on the different time periods

STUDY AREA

UNISA (-25.76776, 28.199158) is situated on top of a hill (1411.19 m above sea level) near the central business district of Pretoria in the Gauteng province of South Africa. The city is surrounded by the Magaliesburg mountain range in the transitional zone between the Central Bushveld and Moist Highveld Grassland vegetation types (Kruger, 2004). The city has a moderate warm temperate climate with an annual minimum and maximum temperature average of 13^{o}C (June) and 24^{o}C (January) during the course of the study. According to the South African Weather Service (2010), precipitation averages 677 mm, while relative humidity ranges between 44% and 75% annually. Pretoria experiences a 3 254 hours of sunshine a year with 2.4–2.7 cloud cover on average recorded annually (South African Weather Service, 2010). The Pretoria region within a 20 km radius of UNISA, includes commercial, industrial, suburban and rural areas, with farming and crop (maize, soya, sorghum and sunflowers) production in the surrounding districts (Collett, 2015).

The campus is located within a green belt which includes the surrounding Groenkloof Nature Reserve, Fountains Valley, Apies River, Voortrekker Monument and Freedom Park. Various small mammals and bird species inhabit the University's grounds. These include avian migrants and small raptors (Harris, 2014, pers. obs).

Established in 1972, the Muckleneuk campus consists of seven administrative and academic buildings; however for the purpose of this study one of the seven buildings was investigated (Figure 18). AJH van der Walt building is positioned on the northern side of the campus facing an undeveloped vegetated mound which meets the campus' northern boundary. All seven levels face north and south respectively and are continuous in balcony and exterior cabling duct design. Academic and administrative offices positioned lengthwise along the buildings face out onto balconies.

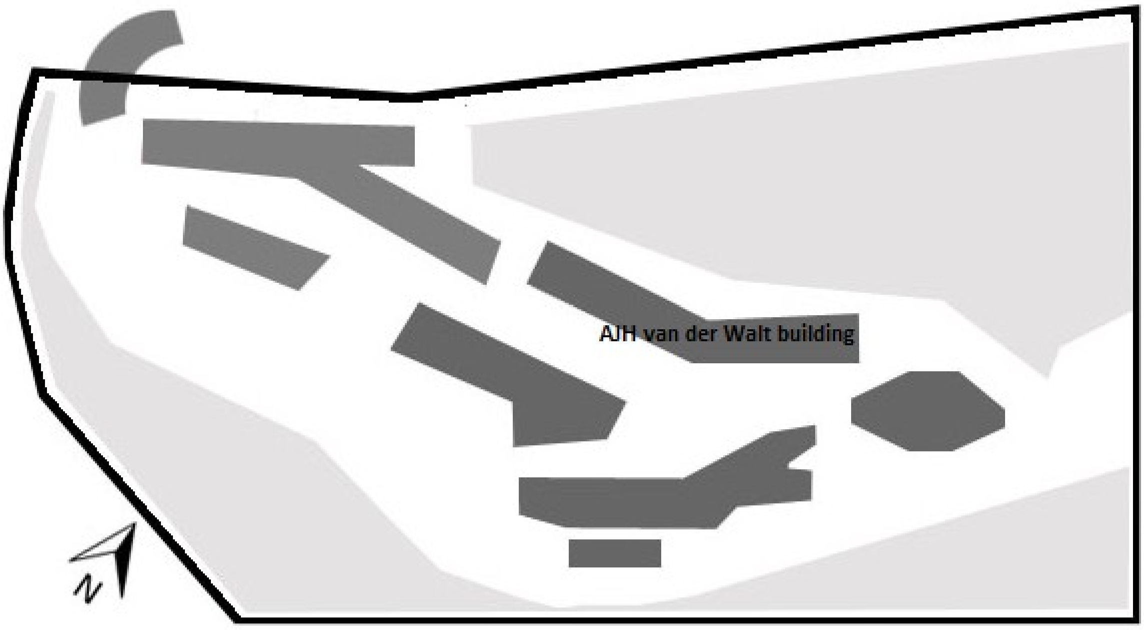


Figure 18: The University of South Africa's Muckleneuk campus in Pretoria, indicating AJH van der Walt building used in the audio and falconry trials, showing its proximity to the rest of the campus and indicating north

MATERIALS AND METHODS

The two trials (audio bird scarer and visual raptor) took place over two months (April/May 2014 and September 2014). Each pigeon control method was tested for a total of four weeks, the suggested amount of time for each of methods to take effect. Reactive measures directed at managing the pigeon population, such as balcony cleaning and nest clearing, which took place year round by University Estates continued as usual throughout the study.

Testing the methods and the subsequent counting of adult and juvenile pigeons took place to mimic the times of day when predators are most active and in relation to the pigeons' bimodal foraging activities which have been recorded to peak in the morning and afternoon (Baldaccini, Giunchi, Mongini & Ragionieri, 2000; Rose, Nagel, Haag-Wackernagel, 2006; Soldatini, Mainardi, Baldaccini & Giunchi, 2006). The trials took place early morning during the first two hours after sunrise and again in the evening during the last two hours before sunset, once a week for eight weeks. If the particular chosen day for testing the methods experienced extreme weather conditions, then the next consecutive day with fine weather was chosen and documented.

The observer maintained a standard designated route in east-west direction while testing the methods. Double counts of individuals taking off and perching on the same building was taken into consideration and avoided. Observations were aided by 9 X 30 binoculars and a digital camera, and were recorded on a data sheet. The results have been interpreted as an index of pigeon population size.

The first trial, which tested the effect of the BirdXPeller PRO™ on the pigeon population, took place at dawn and dusk, once a week during the last two weeks in April and the first two weeks in May 2015.

Prior to playing the BirdXPeller PRO™, the observer counted the pigeons on each level of the south facing side of AJH van der Walt. The observer, wearing a security bib similar to that of the security guards on campus as to minimise recognition, then walked parallel to the building in a westerly direction holding up the active BirdXPeller PRO™ unit. A 12V battery, which the observer carried in a backpack, powered the unit. The BirdXPeller PRO™ unit was programmed to use one bird of prey recording (Peregrine Falcon) and two alarm/distress recordings of pigeons in sequence as suggested by the BirdXPeller PRO^{TM} manual. The calls were played at random to prevent the pigeons from adapting to the predetermined pattern of sounds. A recount of the building after the audio scare was conducted to determine if the recordings had an effect on the pigeon numbers. Recounts were conducted every 10 minutes after the post-scare count for a total of 30 minutes to determine if or what the lasting effect of the audio scare was. This methodology was then repeated on the northern side of the building.

The second trial, which tested the effect of the visual raptors on the pigeon population, took place at dawn and dusk, once a week during September 2015.

A falconer handled the birds of prey required for this study. The raptors were flown from the roof of AJH van der Walt to mimic, as close as possible, the natural behaviour of predators on pigeons. Harris and Davis (1998) suggest that several raptors be used to ensure the success of pigeon control programmes. Thus three different birds of prey which naturally hunt pigeons were used for this trial; a Rock Kestrel (*Falco rupicolus*) which is ideal for high altitude flying; an African Goshawk (*Accipiter tachiro)* which displays agility in being able to fly through narrow spaces and a Jackal Buzzard (*Buteo rufofuscus*) for its intimidating size and success in static situations (Freeman, 2015a).

During the trial the observer remained at ground level. Prior to flying the raptors, the observer counted the pigeons on each level of the south facing side of AJH van der Walt. The choice of raptor varied over the trial period, depending on the falconer's discretion. The falconer slowly moved in a westerly direction along the roof's length flying or walking the bird of prey along the overhanging balcony ledge. On completion, the observer conducted a recount of the building to determine if the presence of the bird of prey had an effect on the pigeon numbers. Recounts were conducted every 10 minutes after the post-fly count for a total of 30 minutes to determine if or what was the last effect of the raptor presence was. This methodology was then repeated on the northern side of the building.

Counts were conducted and inputted as the following: pre-scare (0MIN), just after playing the audio bird scarer or flying the raptors (SCARE), at 10 minutes after the scare (10MIN), at 20 minutes after the scare (20MIN) and at 30 minutes after the scare (30MIN).

To determine a control for the study, pigeons were counted on AJH van der Walt over a four week period, without audio or visual raptor application.

For data analysis the sum of the data collected was determined. Pearson's chi-squared test was used to determine if there was an association between the method of scaring (audio or visual) and the number of pigeons observed on the different time periods.

Institutional ethical clearance and permission (2013/CAES/017) was received for the research.

RESULTS

Departing at first light to maximise on food availability (Counsilman, 1974), the pigeon population on AJH van der Walt building indicated an outgoing trend at dawn, resulting in fewer pigeons remaining on the building. Conversely at dusk, pigeons indicated an incoming trend as they returned to roost, thus increasing the pigeon population index on the buildings.

Pigeon populations on AJH van der Walt reacted differently to audio and visual scares and their dawn and dusk trends were influenced (Figure 19 & 20) (Appendix H). Pigeons on AJH van der Walt scared with the audio at dawn continued to depart at a similar rate to the control (control: 14 individuals per 10 minutes; audio: 19 individuals per 10 minutes), with a minor decline of 12 out of 165 individuals after scaring. In contrast pigeons scared visually with raptors at dawn indicated an initial substantial decline of 39 out of 72 individuals after scaring, but returned to the building once the threat had been removed 10 minutes post scare.

On the other hand, pigeons on AJH van der Walt scared with audio at dusk when individuals were returning to roost were not deterred from the building. This was evident as the population continued to increase after audio scaring (119 individuals pre-scare, 132 individuals post-scare). However the population reacted positively to the visual raptor scare at dusk as pigeons decreased by 36 out of 80 individuals post scare but after 10 minutes continued to return to roost.

The long term effect of audio and visual raptor scares after 30 minutes on the population index differed. During the dawn audio scare, the pigeon index indicated similar fluctuations to the natural behaviour observed in the control. Thus resulting in a continued decline in population index 30 minutes post scare at dawn (153 individuals post-scare, 90 individuals at 30 minutes). At dusk, the general upward trend of returning pigeons was evident; however the difference between the audio and control 30 minutes after the scare was one individual (control 30 minutes: 139 individuals; audio 30 minutes: 138 individuals).

Dissimilarly during the visual raptor scare at dawn, the pigeon population increased 30 minutes post scare (33 individuals post-scare, 74 individuals at 30 minutes), while at dusk the natural returning pattern was observed which resulted in an increase in pigeon population index on the building (56 individuals post-scare, 115 individuals at 30 minutes)

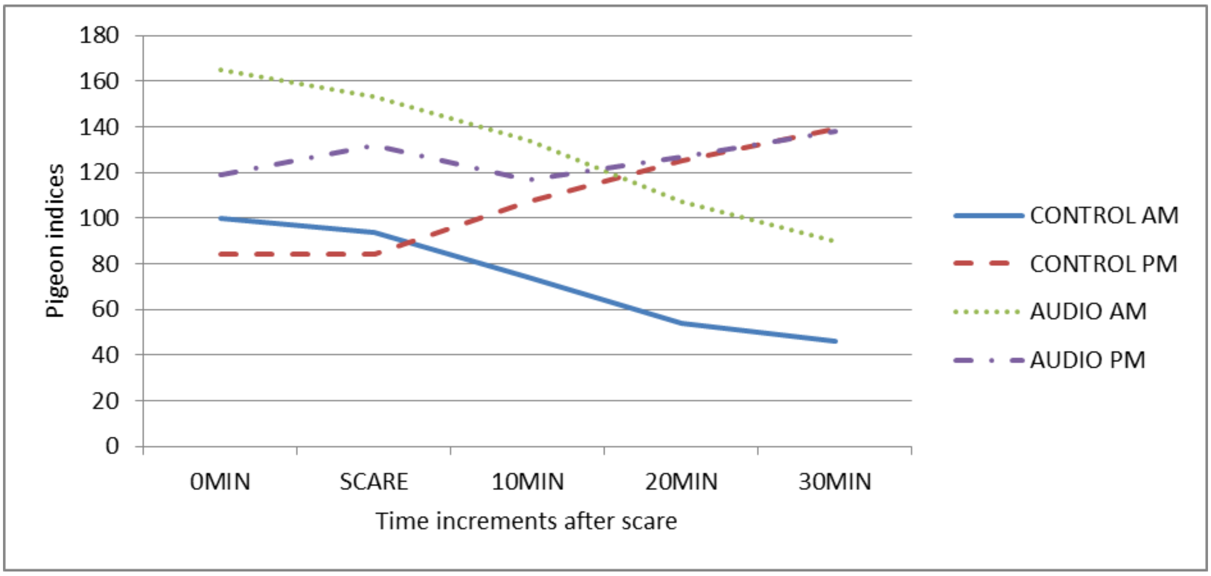


Figure 19: Pigeon population indices across time before and after audio scare between April and May 2015

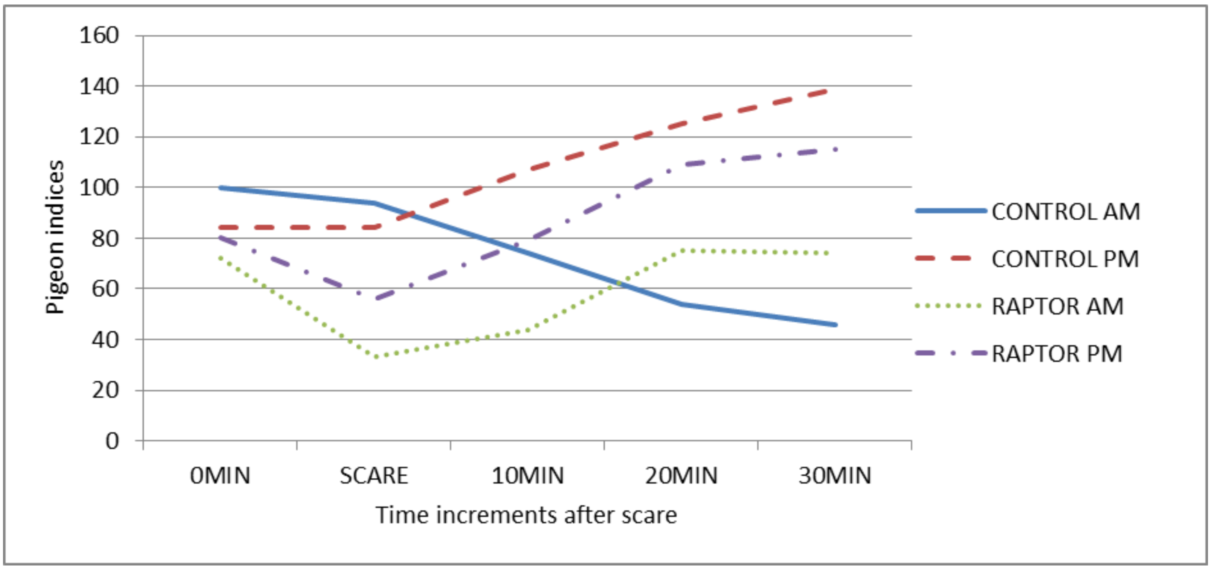


Figure 20: Pigeon population indices across time before and after the visual raptor scare in September 2015

The null hypothesis of independence between the method of scaring (audio or visual) and the number of pigeons observed on the different time periods was rejected ($p<0.001$). Results for dawn (AM) and dusk (PM) counts were as follows:

AM: X^2 (df = 2, n = 4) = 61.6572, $p<0.001$ (Table 5); PM: X^2 (df = 2, n = 4) = 27.4096, $p<0.001$ (Table 6).

Standardised residuals indicated that during the morning counts; the count before the scare (0 MIN) indicates no significant contributions towards the dependency. While counts immediately after visual raptor scaring and at 30 minutes after audio scaring indicate significant values. The discrepancy between the dawn and dusk audio and visual scares were larger at dawn, with a smaller effect at dusk.

Table 5: Standardised residual values for before the audio and visual scare, after the scares and 30 minutes after the scares in the morning

AM	0 MIN	SCARE	30 MIN
Audio	0.0699949	6.4637063	-6.7787510
Raptor	-0.699949	-6.4637063	6.7787510

Table 6: Standardised residual values for before the audio and visual scare, after the scares and 30 minutes after the scares in the evening

PM	0 MIN	SCARE	30 MIN
Audio	-2.350174	5.235351	-2.585575
Raptor	2.350174	-5.235351	2.585575

DISCUSSION

IMPLIED PREDATOR PRESENCE: Audio bird scarer (Birdxpeller Pro™)

Audio bird scarers have for decades been used as a means of avian control resulting in varying degrees of success (Harris & Davies, 1998; Baxter, 2000; Gilsdorf, Hygnstrom & VerCauteren, 2003). Lima and Dill (1990) explain that birds will perceive the recorded predator, alarm and distress calls as natural warnings. The pest control industry claims the audio units are designed to dislodge and relocate pigeons (Birdstop, 2016), however pigeons on the AJH van der Walt building were not significantly deterred directly after playing alarm, distress and raptor calls.

This finding was supported by numerous studies which found bioacoustics to be ineffective at controlling pigeon populations (Hutton & Dobson, 1993; Hutton & Rostron, 2005). Behavioural and biological factors can be recognised for the limited effect of audio on pigeons. This can be observed when pigeons are alarmed, their behavioural response is to remain stationary and instinctively cower down in roosts or nests (Hutton & Dobson, 1993; Hutton & Rostron, 2005). Furthermore pigeons lack of an alarm (Boudreau, 1968b; Inglis & Isaacson, 1984; Hutton & Dobson, 1993; Hutton & Rostron, 2005) and distress call (Bridgman, 1976). Fitzwater (1970) noted that not all birds have distinct distress or alarm calls, and in the case of pigeons visual cues in the form of open white wing bars are relied upon to provide warning (Inglis & Isaacson, 1984; Harris & Davis, 1998).

Recorded raptor calls, to signal a predator is in the vicinity, is not biologically sound and portrays an unnatural representation of reality as predators hunt silently (Harris & Davis, 1998). The lack of audio effect on pigeon populations may also be contributed to individual raptor voices influencing the response (Fitzwater, 1970) as the calls of raptor species from different countries may not produce the desired effect on a population that does not recognise the call (Matyjasiak, 2008).

Pigeons on AJH van der Walt continued to display a downward trend during the dawn audio scare which paralleled the natural trend of pigeons leaving to forage. At dusk, pigeons increased substantially after the scare as individuals already on the building came out to investigate the unfamiliar noise as suggested by Fitzwater (1970). Once 10 minutes post scare had lapsed the population index continued to increase on the building to roost similar to the control.

Without a negative reinforcement and biological basis (Seamans, Martin & Belant, 2013), pigeons habituate to recorded audio calls (Fitzwater, 1970; Dobeic *et al*, 2011). Similar avian findings have been documented in literature. Numerous studies noted that gulls habituated after four to six weeks and returned to pre-trial quantities after 10 weeks (Baxter, 2000; Cook, Rushton, Allan & Baxter, 2008). Summers (1985) found starlings habituated after seven days without lethal reinforcement, while oystercatchers without distress calls (Bridgman, 1976) and wild turkeys showed no response to audio trials (Harris & Davies, 1998). Informal reviews of the audio device describe the effect to range from exceptional to poor and short term. The latter stating the device's inefficiency to deter pigeons as habituation was rapid due to the lack of biological basis (Pigeon Control Resource Centre, 2016).

However other avian species have been successfully discouraged through the use of audio devices. Studies on bioacoustics describe the reduction of Canadian Geese (Mott & Timbrook, 1988) and crows (Gorenzel & Salmon, 1993) from an area, while Black-crowned Night Herons were deterred from aquaculture facilities (Spanier, 1980), larks from agricultural crops (Keidar, Moran & Wolf, 1975) and Cliff-swallows from nesting sites (Conklin, Delwiche, Gorenzel & Coates, 2009). These reports did however note that the effect of the audio was species specific and could not be a blanket response to numerous avian species, including pigeons.

Pigeons inhabiting urban environments encounter higher noise levels (Shochat, Lerman & Fernández-Juricic, 2010) and may be desensitised to alarm calls (Boudreau, 1968b). Resource abundance with regards to nesting and roosting sites as well as permanent food and water on the Muckleneuk campus, has resulted in high tolerance levels of the pigeon population. Pigeons will therefore endure discomfort if the benefits of the site outweigh the audio device. Boudreau (1968b) confirms this observation as certain species develop a strong association with a site or territory and will be difficult to deter from the area using audio.

ACTUAL PREDATOR PRESENCE: Raptors (visual)

Ryzhov and Mursejev (2010) consider raptors to be the most efficient means of scaring pigeon populations in an effort to disperse them from a site. This was found to be true on campus, as the pigeon population index on the AJH van der Walt building decreased directly after flying the birds of prey.

Based on biological and evolutionary principals (Harris & Davies, 1998; Ryzhov & Mursejev, 2010), raptors are flown to deter pigeons by their presence, pursuit and occasional hunt which strengthens the threat to prey survival (Harris & Davies, 1998). Due to the natural avoidance of predators, habituation is minimal (Harris & Davies, 1998), especially when negatively reinforced by the occasional hunt or kill. Pigeons on AJH van der Walt reacted as expected to avoid the presence of the raptors. In contrast to the natural decreasing trend at dawn, pigeon numbers on the building substantially declined directly after the raptor flight and then gradually increased over the 30 minute period post scare. Ryzhov and Mursejev (2010) found that pigeons changed their behaviour so as to avoid the discomfort of deliberate raptor presence; this was true of the study as pigeon flocks were observed perching on the buildings adjacent to AJH van der Walt during scare periods. However once the threat was removed, pigeons returned to AJH van der Walt. Kenward (1978) explains that the tendency to resettle after a raptor scare is determined by independent factors such as abundant roosting and nesting sites as found on the tested building. In his study it was found that Wood Pigeons behaved atypically to the presence of a bird of prey due to the abundant food resources available.

At dusk, the pigeon population index declined substantially again in response to the raptor presence. This decline was nonetheless short term as pigeons continued to follow the natural trend of returning to roost once the threat was removed. An finding supported by Matyjasiak (2008) who noted that even though raptors were highly effective at deterring pigeons, the effect was temporary unless used consistently over a long period of time. Likewise Warwick (2003) noted that even though the pigeon populations at Trafalgar Square indicated a successful short term decline, the resident population remained. Further studies have shown that pigeon populations in London roosted elsewhere after four to sixweeks of flying a bird of prey (Peter Cox, 2013), while in Moscow pigeon populations at a food factory declined by 91% over a four week period (Ryzhov & Mursejev, 2010).

In addition, the effect of raptor presence on the campus' pigeon population was multiplied as wild avian predators of pigeons such as sparrowhawks and goshawks (*Accipiter sp*.) and Pied Crows (*Corvus albus*) have been seen to frequent the campus (Harris, 2014, pers. obs). With the increased presence of unfamiliar trained raptors, resident birds of prey investigated to determine whether there is a threat to their established territories or not (Freeman, pers. comm. 2015b). Consequently increasing visible predator presence on campus.

CONCLUSION

Predation or the threat thereof is used to regulate prey populations in urban environments (Sorace, 2002). The presence of a bird of prey can be implied through the recorded calls of an audio device or a real threat of trained raptors. The choice of method depends on a variety of factors namely: pigeon population size, environmental conditions, cost and time implications, trained personnel, and pigeon resource availability. Each of the techniques are derived from the innate fear of pigeons and their need to avoid birds of prey presented in an audio or visual form, under the assumption that pigeons will respond accordingly. As pigeons do not have an alarm call, the recorded alarm calls assumed to warn pigeons did not contribute to the lack of response observed by the population on AJH van der Walt. Thus the factor with general biological basis but incorrect application, assumed to have an effect on pigeons is the recorded raptor call. However pigeons in this study were not deterred or discouraged by hearing the calls of raptors known to predate on populations in urban environments. As a result audio devices are not recommended as a method for pigeon control.

In comparison the visible presence of a bird of prey was found to be highly effective at frightening the pigeon population on AJH van der Walt, albeit temporarily. Due to the evolutionary and biological basis, trained raptors are able to bring about short term behavioural change in pigeon populations to avoid a treated area, or eventual reduction in population size as individuals move away to establish new territories due to the constant real threat of being predated upon (Shochat, Lerman & Fernández-Juricic, 2010). Considered to be a hands-on technique (Harris & Davies, 1998), the raptor and falconer are able to immediately adapt to environmental and populational fluctuations to maximise effect as opposed to automatic systems. To increase the temporal efficiency of the raptors on the pigeon population, wider application should be undertaken of the whole campus to minimise pigeon delaying behaviour (Ryzhov

& Mursejev, 2010). Essentially trained birds of prey should be flown frequently (Peter Cox, 2013) over a long period of time to associate the site with danger. Alternatively raptors can be flown selectively if an immediate reduction in pigeons at a site for a short period of time is required.

Use of predators as a form of biological control of pigeons in urban environments (Ryzhov & Mursejev, 2010), is considered to be humane and discrete (Peter Cox, 2013). Used as a supplementary technique with other pigeon control strategies, falconry is recommended to manage pigeon populations in urban environments in addition to its ecological and educational benefits (Dinetti, 2006).

Additional research should investigate which bird of prey species impacts the most on urban pigeon populations (Haskell, Knupp & Schneider, 2001; Sorace, 2002), and the role of top-down effects on urban pigeon populations should also be established (Shochat, Lerman & Fernández-Juricic, 2010) to contribute to further understanding the effect of raptors as a strategy for pigeon control.

The effect of pigeon populations hearing a predator versus seeing one has been investigated to inform an interdisciplinary management plan for pigeon control on the University of South Africa's Muckleneuk campus.

ACKNOWLEDGEMENTS

Acknowledgement and thanks to UNISA University Estates, the Applied Behavioural Ecological & Ecosystem Research Unit (ABEERU) at the University of South Africa, and National Research Foundation (NRF) for funding.

REFERENCES

ANGIER N. 1991. New York's tough pigeons fight predators for survival. New York Times July 8: A1.

BALDACCINI, N., GIUNCHI, D., MONGINI, E. & RAGIONIERI, L. 2000. Foraging flights of wild rock doves (Columba l. Livia): a spatio- temporal analysis. *Monitore zoologico Italiano*, 67: 371 – 377.

BAXTER, A. 2000. Use of distress calls to deter birds from landfill sites near airports. *International Strike Committee*, Amsterdam, 17 – 21 April.

BIRDSTOP. 2016. BirdXPeller Pro Digital 1 Channel Bird Scarer Version [Online]. Available from: http://www.birdstop.co.uk/birdxpeller_pro_digital_1_channel_bird_scarer_version_1.asp [Accessed: 16.03.2014].

BOUDREAU, G.W. 1968b. Status of bio-sonics in pest bird control. In: Bird Control Seminars Proceedings: 145: 38 – 43.

BRIDGMAN, C.J. 1976. Bio-acoustic bird scaring in Britain. In: *Proceedings Pan-Africa Ornithological Congress*, 4:383 – 387

COLLETT, A. (AnnelizaC@daff.gov.za). 2015. Agricultural crop list. [Email to:] Harris, E. (emmaharris09@gmail.com) Oct. 21.

COOK, A., RUSHTON, S., ALLAN, J. & BAXTER, A. 2008. An evaluation of techniques to control problem bird species on landfill sites. *Environmental Management*, 41: 834 – 843.

CONKLIN, J.S., DELWICHE, M.J., GORENZEL, W.P. & COATES, R.W. 2009. Deterring cliff swallow nesting on highway structures using bioacoustics and surface modifications. *Human-Wildlife Conflicts*, 3: 93 – 102.

COUNSILMAN, J.J. 1974. Waking and Roosting Behaviour of the Indian Myna. *Emu*, 74: 135 – 148.

DE MENT, S. 1987. Toxic lead exposure in the urban rock dove. *Journal ofWildlife Diseases*, 23(2): 273 – 278.

DE MENT, S. & CHISOLM, J. 1986. Lead exposure in an urban peregrine falcon and its avian prey. *Journal of Wildlife Diseases*, 22: 238 – 244.

DINETTI, M. 2006. Urban Avifauna: Is it possible to live together? *Veterinary Research Communications*, 30(Supp. 1): 3 – 7.

DITCHKOFF, S.S., SAALFELD, S.T. & GIBSON, C.J. 2006. Animal behaviour in urban ecosystems: Modifications due to human-induced stress. *Urban Ecosystems*, 9: 5 – 12.

DOBEIC, M., PINTARIČ, S., VLAHOVIĆ, K. & DOVČ, A. 2011. Feral Pigeon (*Columba livia*) Population Management in Ljubljana. *Veteinarski Arhiv*, 81(2): 285 – 298.

FITZWATER, W.D. 1970. Sonic systems for controlling bird predations. In: *Proceedings of the Bird Control Seminars*: 203.

FITZWATER, W.D. 1988. Solutions to Urban Bird Problems. In: *Proceedings of the Thirteenth Vertebrate Pest Conference*: 254 – 259.

FREEMAN, D. (dylfreeman1@yahoo.com). 2015a. Pest Control Write up. [Email to:] Harris, E. (emmaharris09@gmail.com) Jun. 8.

FREEMAN, D. 2015b. Falconer, Top Turf, Bidvest Steiner. Personal communication.

FRINGS, H. 1964. Sound in vertebrate pest control. *Vertebrate Pest Conference*, 2: 50 – 56.

FUKUDA, Y., FRAMPTON, C.M. & HICKLING, G.J. 2008. Evaluation of two visual birdscarers, the Peaceful Pyramid® and an eye-spot balloon, in two vineyards. *New Zealand Journal of Zoology*, 35(3): 217 – 224.

GILSDORF, J.M., HYGNSTROM, S.C. & VERCAUTEREN, K.C. 2003. Use of frightening devices in wildlife damage management. *Integrated Pest Management Reviews*, 7: 29 – 45.

GIUNCHI,D., ALBORES-BARAJAS, Y.V., BALDACCINI, N.E., VANNI, L. & SOLDATINI, C. (2012). *Feral Pigeons: Problems, Dynamics and Control Methods*. In: Larramendy, M.L. & Soloneski, S. (eds.). Integrated Pest Management and Pest Control - Current and Future Tactics. Intech Open Science: Rijeka, Croatia: 215-240.

GORENZEL, W.P. & SALMON, T.P. 1993. Tape-recorded calls disperse American crows from urban roosts. *Wildlife Society Bulletin*, 21: 334 – 338.

HAAG-WACKERNAGEL, D. 2008. *Feral Pigeon Management* [Online]. Available from: www.Anatomie.unibas.ch/integrativeBiology/hag/Feral-Pigeon Strassentauben/pigeon-management.html [Accessed: 12/02/2013].

HARRIS, R.E. & DAVIES, R.A. 1998. *Evaluation of the efficacy of products and techniques for airport bird control*. Aerodrome Safety Branch Transport Canada: Ontario.

HASKELL, D.G., KNUPP, A.M. & SCHNEIDER, M.C. 2001. Nest predator abundance and urbanisation. In: Marzluff, J.M., Bowman, R. & Donnelly, R. (eds.). *Avian ecology and conservation in an urbanising world*. Kluwer Academic: Norwell, 243 – 258.

HUTTON, M. & GOODMAN, G.T. 1980. Metal contamination of feral pigeons *Columba livia* from the London area. 1. Tissue accumulation of lead, cadmium, and zinc. *Environmental Pollution Series a-Ecological and Biological*, 22: 207 – 217.

HUTTON, T.C. & DOBSON, J. 1993. The control of feral pigeons: an independent approach. *Structural Survey*, 11(2): 159 – 167.

HUTTON & ROSTRON. 2005. Method statement for the control of feral pigeons [Online]. Available from: http://www.handr.co.uk/literature/feral_pigeons.htm. [Accessed: 05/12/2012].

INGLIS, I.R. & ISAACSON, A.J. 1984. The responses of Woodpigeons (*Columba palumbus*) to pigeon decoys in various postures: a quest for a super-normal alarm stimulus. *Behaviour*, 90(4): 224 – 240.

JEROLMACK, C. 2008. How pigeons became rats: The cultural-spatial logic of problem animals. *Social problems,* 55(2):77-94.

JOHNSTON, R.F. & JANIGA, M. 1995. *Feral Pigeons*. Oxford University Press: New York.

KEENAN, K. 2000. Town to roust birds from roost. *Worcester Telegram & Gazette*, Jan. 17: B1.

KEIDAR, H., MORAN, S. & WOLF, J. 1975. Playback of distress calls as a means of preventing losses to agriculture by birds. I. Playback experiment with larks (1970-

1974). Rep. for Israeli Ministry of Agriculture: 24.

KENWARD, R.E. 1978. The influence of human and Goshawk (*Accipiter gentilis*) activity on Wood Pigeons (*Columba palumbus*) at Brassica feeding sites. *Annals of Applied Biology*, 89: 277 - 286.

KOEN, J. & JENKINS, A. 2011. Raptors and racing pigeons [Online]. Available from: HAAG-WACKERNAGEL, D. 2008. *Feral Pigeon Management* [Online]. Available from: http://www.andersonafrica.co.za/pamphlets/Raptors_and_pigeons.pdf [Accessed: 01/05/2012].

KRIMOWA, S. 2012. Pigeons and people: resource ecology and human dimensions of urban wildlife. MSc Victoria University of Wellington: Wellington.

KRUGER, A. C. 2004. *Climate of South Africa. Climate Regions. WS45*. South African Weather Service. Pretoria. South Africa.

LIMA, S.L. & Dill, L.M. 1990. Behavioral decisions made under risk of predation: a review and prospectus. *Canadian Journal of Zoology*, 68: 619 – 640.

LÓPEZ-LÓPEZ, P., VERDEJO, J. & BARBA, E. 2009. The role of pigeon consumption in the population dynamics and breeding performance of a peregrine falcon (*Falco peregrinus*) population: conservation implications. *European Journal of Wildlife Research*, 55: 125 – 132.

LORANGER, S., DEMERS, G., KENNEDY, G., FORGET, E. & ZAYED, J. 1994. The pigeon (*Columba livia*) as a monitor for manganese contamination from motor vehicles. *Archives of Environmental Contamination and Toxicology*, 27: 311 – 317.

MATYJASIAK, P. 2008. Methods of bird control at airports. In: Uchmański, J. (ed.) *Theoretical and applied aspects of modern ecology*. Cardinal Stefan Wyszyński University Press: Warsaw: 171 – 203.

MCKEOWN, D. 2008. Toronto Pigeon feeding. Internal Document.

MOTT, D.F. & TIMBROOK, S.K. 1988. Alleviating nuisance Canada goose problems with acoustical stimuli. *Vertebrate Pest Conference*, 13: 301 – 304.

PETER COX. 2013. Commercial bird deterrence [Online]. Available from: https://www.petercox.com/commercial/bird-deterrence/ [Accessed: 05/11/2013].

PIGEON CONTROL RESOURCE CENTRE. 2016. Sonic and bio-acoustic pigeon and bird control [Online]. Available from: http://www.pigeoncontrolresourcecentre.org/html/reviews/sonic-pigeon-and-bird-control.html [Accessed: 05/08/2014].

ROBBINS, C.S. 1995. Non-native birds. In: LaRoe, E.T., Farris, G.S., Puckett, C.E., Doran, P.D. & Mac M.J. (eds.). *Our Living Resources: a Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals and Ecosystems.* U.S. Department of the Interior, National Biological Service: Washington, DC: 437 – 440.

ROSE, E., NAGEL, P. & HAAG-WACKERNAGEL, D. 2006. Spatio-temporal use of the urban habitat by feral pigeons (*Columba livia*). *Behavioral Ecological Sociobiology*, 60: 242 – 254.

RUTZ, C. 2012. Predator fitness increases with selectivity for odd prey. *Current Biology*, 22: 820 – 824.

RYAN, A.C. 2011. The distribution, density, and movements of Feral pigeons *Columba livia* and their relationship with people. M.Sc. Victoria University of Wellington.

RYZHOV, S.K. & MURSEJEV, M.R. 2010. Trained goshawks against pigeons. *Raptor Conservation*, 20: 25 – 34.

SEAMANS, T.W., MARTIN, J.A. & BELANT, J.L. 2013. Tactile and auditory repellents to reduce wildlife hazards to aircraft. *Wildlife Management Techniques*.

SHOCHAT, E., LERMAN, S. & FERNÁNDEZ-JURICIC, E. 2010. Birds in Urban Ecosystems: Population Dynamics, Community Structure, Biodiversity and Conservation. *Urban Ecosystem Ecology*,: 75 – 86.

SOLDATINI, C., MAINARDI, D., BALDACCINI, N.E. & GIUNCHI, D. 2006. A temporal analysis of the foraging flights of feral pigeons (*Columba livia* f. *domestica*) from three Italian cities. *Italian Journal of Zoology*, 73(1): 83 – 92.

SORACE, A. 2002. High density of bird and pest species in urban habitats and the role of predator abundance. *Ornis Fennica*, 79: 60 – 71.

SOUTH AFRICAN WEATHER SERVICE, 2010. Climate of South Africa. WB42 Climate Statistics 0513465. *University of Pretoria Proefplaas*.

SPANIER, E. 1980. The use of distress calls to repel night herons (Nycticorax nycticorax) from fish ponds. *Journal of Applied Ecology*, 17: 287 – 294.

SUMMERS, R.W. 1985. The effect of scarers on the presence of starlings (*Sturnus vulgaris*) in cherry orchards. *Crop Protection*, 4: 520 – 528.

VAN NIEKERK, J.H. 2003. Grain Selection and Flocking of Rock Pigeons at a Cattle Feedlot in Gauteng Province, South Africa. *South African Journal of Wildlife Research*, 33(2): 138 – 141.

VAN NIEKERK, J.H. 2009. Loss of Sunflower Seeds to Columbids in South Africa: Economic Implications and Control Measures. *Ostrich*, 80(1): 47 – 52.

WARWICK, C. 2003. Save The Trafalgar Square Pigeons [Online]. Available from: http://www.savethepigeons.org/HawkReportP1.pdf. [Accessed: 18/11 /2013].

CHAPTER 5.6

Supplementary Control Strategies

Breeding space and food resources are the ecological drivers in pigeon populations. Initiative aimed at reducing reproductive output combined with anti-feeding initiatives (Dobeic, Pintarič, Vlahović & Dovč, 2011) can result in successful and sustainable reduction of a population (Geigenfeind, 2013) to socially acceptable standards whilst meeting animal welfare concerns (Ryan, 2011).

Nest box initiative

As traditional non-lethal pigeon control methods do not remove nor displace all the pigeons in a population, individuals with established territories will remain on the buildings and overcome any control system if the resources outweigh the discomfort of management strategies. Those who remain will continue to breed, however their reproductive turnover can be mechanically (Mooallem, 2006) and ethically controlled by limiting hatching rate through egg removal (Jacquin *et al*., 2010). Fertile eggs are systematically replaced with plastic dummy eggs which are then incubated for the duration of the incubation period (Geigenfeind, 2013) until such a time as their viability is realised and the female lays again. This strategy not only decreases the birth rate but also maintains a small, healthy pigeon population (Haag-Wackernagel, 2008; Jacquin *et al.* 2010; Dobeic *et al.*, 2011) as breeding birds that have experienced multiple clutch failures will move to a better nesting sites (Hutton & Rostron, 2005).

Artificial nest boxes were placed on two of the buildings on campus; Theo van Wijk and OR Tambo. Seventy one nest boxes were placed on four levels (level 7 and 9 north facing, and level 5 and 6 south facing) of Theo van Wijk, while 59 were placed on two levels (level 12 north and south facing, and level 13 north and south facing) of OR Tambo based on the highest density of pigeons determined during the control year (March 2013–February 2014). Pigeons prefer dark, secluded nesting sites (Hurst, 2006; Haag-Wackernagel, 2008) thus dark blue plastic and wooden boxes were used, each with the dimensions of 30 cm x 30 cm x 25 cm as suggested by Malan pers. comm. (2014). These were mounted on steel brackets which slotted over the cabling ducts which run the length of the two buildings. A 15 cm x 15 cm carpet square was placed in each nest box which was treated with Dovastof (pigeon mite, tick, flea and fly) insecticide. Plastic white pigeon dummy eggs were used to replace removed eggs. Nest boxes were checked once a week for nesting activity and eggs to prevent hatching. On finding an egg(s), it was removed and replaced with a dummy egg. The removed egg was subsequently taken to a local nature reserve as a food source for egg-eating mammals. Dovastof was sprinkled onto the nest to manage ectoparasites on egg removal. As eggs are incubated for approximately 18 days before hatching (Krebs, 1974; Hetmański & Wołk, 2005; Jacquin *et al.* 2010), dummy eggs were removed from the nests after 14 days, to allow for the initiation of another laying cycle.

Of the one hundred and thirty nest boxes, 19 were actively used over the course of the management year. Pigeons indicated a preference towards the plastic nest boxes, with 181 incidents of nest activity recorded; this in comparison to the 37 incidents of nest activity recorded in the wooden boxes. This is however not an accurate representation of an ideal nest box application as the objective of controlling reproduction through egg removal can only be achieved if pigeons are excluded from alternative breeding sites thereby directing them to make use of the nest boxes. This could not achieved on the Muckleneuk campus, as open cabling ducts and exterior ceiling boards which provide safe and sheltered breeding space, were not closed as agreed upon at the commencement of the project.

Educational campaign

Similarly, breeding activity increases significantly when food resources are abundant and reliable. Geigenfeind (2013) considers people that feed pigeons to be responsible for the large pigeon populations in urban environments. As the birds spend less time actively foraging, the excess energy and time is directed towards reproduction (Mooallem, 2006; Krimowa, 2012; Geigenfeind, 2013). Mooallem (2006) and Ryan (2011) describe the different reasons why people feed but the sense of reliance and responsibility towards the birds is often the primary motivation. Contrary to this idea, deliberate feeding is not beneficial to the birds (Charles & Linklater, 2015) due to the inappropriate diet, change in population dynamics thereby facilitating the spread of disease (Ryan, 2011) and withdrawing from natural population regulatory mechanisms (Haag-Wackernagel, 2008) by depending on anthropogenic food. Human-wildlife conflict increases with the corresponding human-wildlife companionship encounters. Peoples' experience of the pigeons becomes negative due to their large congregational numbers and habituated behaviour where it is not publically welcomed (Charles & Linklater, 2015). The restriction of deliberate feeding and improved waste disposal does not result in starvation (Mooallem, 2006) but instead permanently reduces the pigeon population to a healthy, acceptable level as more energy is expended for foraging (Mooallem, 2006; Geigenfeind, 2013). Ryan (2011) suggests the use of educational campaigns to restrict indiscriminate feeding rather than banning the activity which can lead to public rebellion. As educational campaigns are considered to be one of the most successful long term control measures for problem pigeon populations (Hutton & Rsotron, 2005), this approach was initiated on campus.

Various colourful A3 posters designed to make staff aware of the pigeon population on campus and control thereof, as well as discouraging deliberate pigeon feeding on and around campus buildings were placed strategically on the interior and exterior of the buildings on campus (Appendix I). Posters requesting staff not to feed the pigeons were also placed at the cafeterias and sites of social gathering. Studies have shown that the creation of a responsible feeding zone offers an alternative to prohibiting pigeon feeding on or near buildings (Haag-Wackernagel, 1995; Krimowa, 2012; Geigenfeind, 2013). The idea promotes campus greening (Alshuwaikhat & Abubakar, 2008) as people will be encouraged to feed responsibly while still being provided the opportunity for human-pigeon interaction (Haag-Wackernagel, 1995), which is often the initial reason for feeding. This concept was attempted at a site of natural vegetation on the far eastern side of the campus, however due to the consistent removal of the posters indicating the feeding zone the initiative was not able to take hold.

Placement approval for the posters to be uploaded onto the campus' e-notice boards was obtained, however this had not yet occurred on the conclusion of the project.

The success of the educational campaign could not be measured as the posters were not placed in locked information cabinets as previously requested, and as a result many were removed by staff to be replaced with more pressing matters at the time. Those that remained did so for the duration of the project.

Staff members were provided with the opportunity to engage with the pigeon project during the management year through an active email address (unisapigeons@gmail.com) which was provided on the educational campaign posters. Staff directly reported open access points for pigeons, active nests, debris and faeces build up as well as staff feeding which allowed management the opportunity to efficiently attend to potential problems. Judging by the extensive use of the project's email address staff did read and take note of the information supplied on the posters.

Further research is required to obtain reliable data on the effect of the educational campaign on staff members, as well as alternative educational methods directed at managing the pigeon population on the Muckleneuk campus.

CHAPTER 5.7

An interdisciplinary approach for non-lethal pigeon control

E Harris, EP de Crom, A Wilson

Submitted: 29 June 2016; Accepted: 30 June 2016

Pigeons have been synonymous with urban environments for centuries. Often perceived as pests, pigeon control is applied without investigating environmental, ecological and anthropogenic factors which affect pigeon populations and their response to control treatments. As the management of wildlife in urban environments interdisciplinary, a two year study was conducted on the University of South Africa's Muckleneuk campus in Pretoria, South Africa (Figure 21).

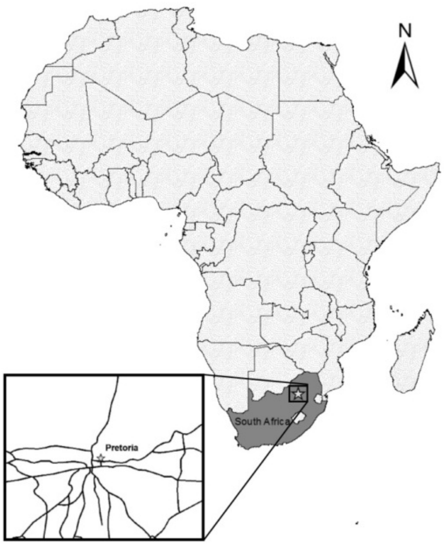


Figure 21: The University of South Africa's Muckleneuk campus is located in Pretoria, South Africa

Quantitative and qualitative research focussed on staff member's perceptions of the pigeons on campus and potential control thereof, the environmental use of the pigeon population and the evaluation of non-lethal control measures recommended by the pest control industry.

Pigeons on all levels of the north and south facing aspects of five of the seven buildings on campus were counted at dawn and dusk, once a week for two years (Figure 22).

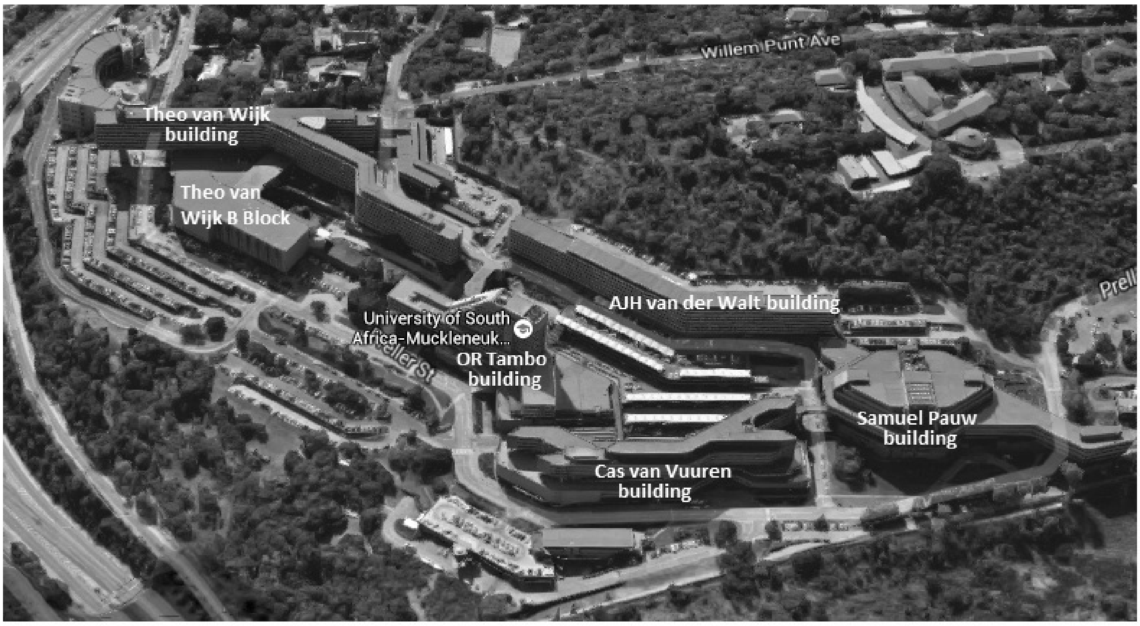


Figure 22: Detailed view of the University of South Africa's Muckleneuk campus indicating the buildings where the pigeon census took place during year one and year two of the research (Google Maps, 2015)

The first year provided the baseline study for the second year when various control measures were applied. Optical deterrents (Eagle Eyes^{TM} and Fire flags), physical exclusion (bird spikes), audible (BirdXPeller PRO^{TM}) and actual (birds of prey) predator presence were evaluated for pigeon control efficacy. Members of staff participated in an educational campaign, an online Survey Monkey questionnaire and semi-structured interviews to provide their personal opinions and perceptions relating to pigeons and their activities, the potential impact the pigeons have on the staff members, industry population control options and the perceived pigeon problem on the Muckleneuk campus.

People and pigeons

Pigeons are often considered a nuisance in urban environments, leading to the attempted control or eradication of their populations. Pigeon control and management is however not an isolated discipline. People affected, both positively or negatively by the birds, are often not provided the opportunity to voice their opinions about the birds and potential control methodologies.

The questionnaires and interviews (n = 246) determined that the negative perception of pigeons, which was assumed to be the opinion of staff affected by the pigeons on the Muckleneuk campus, was in fact incorrect. Seventy seven percent of the participants felt that the pigeons allowed a connection to nature in an otherwise sterile urban environment. Nesting and breeding activities of the pigeons on campus were therefore felt to be encouraged, as participants considered the human–pigeon interaction and viewing of squabs in nests to positively contribute to the work environment. Furthermore when queried as to if the pigeons on campus warranted control, 68% of the participants did not consider the pigeons or their related activities to pose a problem on campus. In addition seventy six percent of the participants felt that should control be imposed, the birds should rather be humanely managed through non-lethal measures such as scare devices and bird spikes rather than eradication to allow the current population to be monitored and to prevent future pigeon problems. The study found that management should not be solely focussed on the pigeon population when implementing control, but should also consider the human association. Unless all interested and affected parties are recognised and heard it is unlikely that actions aimed to reduce or eradicate pigeons from a particular area will be successful and sustainable.

Pigeons use of the urban environment

Similarly ecological and biological aspects influence and direct control strategies applied to pigeon populations. During the baseline year, it was found that the pigeon population on the Muckleneuk campus fluctuated seasonally with population index peaks during the spring ($\bar{x}$ = 365; SE = 4) and summer ($\bar{x}$ = 367; SE = 8) seasons and declines during autumn ($\bar{x}$ = 342; SE = 8) and winter ($\bar{x}$ = 300; SE = 3). While the presence of breeding activity (courting, mating, nesting, squab presence and juvenile presence) was evident throughout the year, the notable peaks and declines was related to physiological and population dynamics.

Pigeons in South Africa have been recorded to roost and or breed in cities but fly to surrounding agricultural areas to feed (van Niekerk, 2009). In order to identify a relationship between surrounding agricultural crop production to the pigeon population fluctuation on campus, a list of agricultural crops ecologically important to pigeons (maize, sorghum and sunflowers) within a 20 kilometre radius of the campus was obtained. The pigeon population index was found to be inversely related to crop availability, as pigeons seemed to make opportunistic use of the crop availability in surrounding farmlands during optimal production periods, while conserving energy when not favourable thus foraging locally.

Pigeons consider energetic implications when choosing sites to roost or nest. This was found to be true of the pigeon population on campus as site selection in relation to building aspect indicated significant differences in all the seasons except for winter. This may be environmentally related as sites were chosen in relation to the direction of preferred feeding sites (Sacchi et al., 2002). Pigeons indicated a significant preference for the southern aspect when seasonal agricultural crop and wild grass seed availability located to the south of the campus was at its highest. The converse applied in spring, when pigeons indicated a northerly site selection preference as preferred foraging sites had limited crop availability. Furthermore pigeons and choice of level indicated an upward trend, with the pigeon index increasing in ledge use the higher the level due to the availability of warmer microclimates, wind updrafts for flight and the essential evasion from predators. However, the opposite was found to be true for pigeons that make use of the roof without the protective structural characteristics found on the other levels. Without the knowledge and understanding of pigeon biology, ecology and behaviour relating to the use of urban environments, management plans directed at controlling their numbers have been found to be misguided and inappropriately designed (Giunchi et al., 2012).

Non-lethal pigeon control

During the second year of the study various control measures, directed by the ecological, biological and social results, were applied to the buildings on campus. A decline of 50% in the pigeon population index was observed. Control structures were found to differ significantly in efficacy from each other. Optical deterrents that were evaluated such as Eagle Eye™ units ,which are designed to interfere with birds' line of flight through sunlight reflection and reflective Fire Flags, which move in the wind thought to create a sense of danger were found to be the least efficient (33% and 39% respectively) at deterring pigeons from campus buildings (Figure 23).

Figure 23: Fire Flags on OR Tambo building of the University of South Africa's Muckleneuk campus

Physical barriers, in the form of bird spikes which prevent pigeons from perching on buildings ledges were found to have the highest efficacy (70%) at deterring pigeons. A combination of Eagle Eyes™, Fire Flags and bird spikes, the recommendation of the pest control industry for maximum efficiency at reducing pigeon populations, was found to be less efficient at 45% than the building with only bird spikes applied. This was as a result of alternative perching sites made available to the pigeons in the form of open ceiling boards on the tested building, thus limiting the combination's efficacy. Blanket reduction statements issued by pest control companies are therefore not guaranteed as each site and pigeon population interaction is unique.

Seasonality was also found to influence the efficiency of the control structures. Structure efficacy increased during the warmer months corresponding with the natural population index fluctuation. Furthermore pigeons displayed a higher tenacity to tolerate the structures during spring when they were rearing young and agricultural crop availability was limited causing them to forage locally. In doing so, pigeons were more visible on the buildings. On the other hand structures were least efficient in autumn when pigeons were relatively inactive during their moulting season and hidden away due to thermal factors, consequentially also from the observer.

Literature describes how control measures do not influence population size, but simply displaces pigeons away from deterrents to untreated sites (Mooallem, 2006). The study tested this hypothesis by monitoring a campus building without control structures and found that it did not in fact absorb the movement of pigeons moving away from treated buildings.

The use of birds of prey and an audio bird scarer (BirdXPeller PRO™) which compared actual versus implied predator presence was tested on the pigeon population. The study determined that there was an association between method of scaring and the number of pigeons observed on the different time periods. Pigeons were observed to continue the natural trend of dispersion and return at the dawn and dusk counts during the audio bird scarer trial without being actively discouraged or dislodged from the building. In contrast pigeons reacted positively to the visual raptor presence of trained birds of prey, which caused them to take flight from the buildings. However the visual effect was temporary as pigeons returned once the threat had been removed. (Figure 24 & 25).

Figure 24: BirdXPeller PRO™ unit used during the implied predator presence audio trial at University of South Africa's Muckleneuk campus

Figure 25: Rock kestrel (*Falco rupicolus*) flown presence visual trial at University of South Africa's Muckleneuk campus during the actual predator

Interdisciplinary approach to pigeon contro

Cities need to be recognised as ecosystems with their own set of resources, unique niches and enabling factors which contribute to the successful colonisation of pigeons. Pigeon control therefore needs to be holistic (Hutton & Rostron, 2005) and integrated in its approach with a number of smaller control actions being more effective than one large operation (Murton, Thearle & Thompson, 1972). Control cannot simply be biologically orientated, as social acceptability and support are crucial to its success as people and pigeons are interconnected whether it is formally recognised or not, each plays a role in the other's lives. Through the prioritisation of interdisciplinary non-lethal pigeon control living and working conditions can be ensured, structural integrity of the infrastructure can be upheld and pigeon populations in urban environments can be sustainably maintained at healthy acceptable levels.

References

GIUNCHI, D., ALBORES-BARAJAS, Y.V., BALDACCINI, N.E., VANNI, L. & SOLDATINI, C. (2012). *Feral Pigeons: Problems, Dynamics and Control Methods*. In: Larramendy, M.L. & Soloneski, S. (eds.). Integrated Pest Management and Pest Control - Current and Future Tactics. Intech Open Science: Rijeka, Croatia: 215-240.

HUTTON & ROSTRON. 2005. Method statement for the control of feral pigeons [Online]. Available from: http://www.handr.co.uk/literature/feral_pigeons.htm. [Accessed: 05/12/2012].

MOOALLEM, J. 2006. Pigeon Wars. *New York Times Magazine*, Oct. 15:54.

MURTON, R.K., THEARLE, R.J.P. & THOMPSON, R.J.P. 1972. Ecological studies of the feral pigeon Columba livia var. l. Population, breeding biology and methods of control. J. appl. Ecol. 9, 835 - 874.

SACCHI, R., GENTILLI, A., RAZZETTI, E. & BARBERI, F. 2002. Effects of Building Features on Density and Flock Distribution of Feral Pigeons *Columba livia var.domestica* in an Urban Environment. *Canadian Journal of Zoology*. 80: 48 – 54.

VAN NIEKERK, J.H. 2009. Loss of Sunflower Seeds to Columbids in South Africa: Economic Implications and Control Measures. *Ostrich*, 80(1): 47 – 52.

Further reading

This study has five research journal manuscripts available for further reading.

Harris, E., de Crom, E.P., & Wilson, A. (2016) Pigeons and people: mortal enemies or lifelong companions? A case study on staff perceptions of the pigeons on the University of South Africa, Muckleneuk campus. *Journal of Public Affairs*, doi: 10.1002/pa.1593.

Harris, E., de Crom, E.P., & Wilson, A. (*under review*) Pigeon control and people:

staff perceptions on University of South Africa's Muckleneuk campus.

Harris, E., de Crom, E.P., Labuschagne, J. & Wilson, A. (*in press)* The use of an urban environment by speckled pigeons (*Columba guinea*) and feral pigeons (*Columba livia*) with special reference to the University of South Africa's Muckleneuk campus. Applied Ecology & Environmental Research

Harris, E., de Crom, E.P., Labuschagne, J. & Wilson, A. (*under review*) Humane non-lethal pigeon control, with particular focus on visual deterrents and physical barriers on the University of South Africa's Muckleneuk campus.

Harris, E., de Crom, E.P., Labuschagne, J. & Wilson, A. (*under review*) Evaluation of audible and visible predator presence, for pigeon control purposes on the University of South Africa's Muckleneuk campus.

CHAPTER SIX: CONCLUSION

INTERDISCIPLINARY PIGEON MANAGEMENT PLAN FOR THE UNIVERSITY OF SOUTH AFRICA'S MUCKLENEUK CAMPUS 2016

PIGEONS, CONTROL AND PEOPLE

Pigeons are one of the most reported pests within urban environments (Fitzwater, 1988; Pimentel, Lach, Zuniga & Morrison, 1999). Known to be a frequent source of human-wildlife conflict in built-up environments; large congregations of pigeons are considered to adversely interfere with aesthetic, economic, health, or environmental interests of humans. Pigeons are viewed as pests and a source of nuisance (Keenan, 2000), a hazard to public health (Hutton & Rostron, 2005), corrode and deface infrastructure with their flocking, droppings and nesting material (Krebs, 1974), as well as psychologically and intrinsically degrade urban spaces with the perceived sense of social disarray (Jerolmack, 2008). In response to public outcry, the pest control industry supplies a wide range of lethal, non-lethal and alternative forms of pigeon control and management solutions. However many of structures and strategies marketed, lack quantitative backing outlining their effectiveness or lack thereof at reducing pigeon populations. An important component that contributes to making informed decisions about cost effectiveness and efficiency of control methods.

As a result of negative views and perceptions of these birds and their associated impacts, control and management is frequently the chosen response. Yet people who consider pigeons to enrich urban environments (Magnino, Haag-Wackernagel, Geigenfeind, Helmecke, Dovc, Prukner-Radovcic, Residbegovic, Ilieski, Laroucau, Donati, Martinov & Kaleta, 2009), allow a connection to nature (Flannery, 2009), as a tourist attraction (Magnino *et al*. 2009) and provide a cleaning up function in city landscapes (Magnino *et al*. 2009) are not provided with a formal platform to convey their views in support of the birds. Positive human-pigeon interaction, as with other forms of wildlife contact, contributes to an improved quality of life, enhanced environmental awareness and perception of environmental problems in comparison to those who have limited contact with wildlife and nature. Physical and psychological states of people have also been recorded to improve due to wildlife interaction (Sanders, 2003). Pigeons, a commensal species, may be the only contact people have with a living creature on a daily basis.

Whether considered to result in human-wildlife conflict or companionship, pigeon populations and the control thereof, is not an isolated discipline. Traditionally directed at addressing ecological aspects, social integration and consideration is often neglected in pigeon management plans. Yet environmental issues affecting people are multidimensional and complex requiring a holistic stance to ensure the support, success and sustainability of proposed solutions.

In light of the recent governmental draft outlining the norms and standards for the management of damage causing animals, such as pigeons (National Environmental Management: Biodiveristy Act, 10/2004) non-lethal repellents and scare tactics are permitted to be used as a component of remedial action to manage pigeon populations. Pigeon management plans should therefore provide non-lethal sustainable solutions towards reducing and managing pigeon populations in urban environments whilst considering and involving relevant affected stakeholders. Not only will this ensure that interested and affected parties contribute in a meaningful and proactive way, thus creating a supportive environment for proposed pigeon control measures but it will also represent an important source of innovative ideas, leading to new academic and experimental research.

PIGEON POPULATIONS ON THE MUCKLENEUK CAMPUS, UNIVERSITY OF SOUTH AFRICA

Universities worldwide are responding to the call for 'greener' campuses and practices, the need to sustainably develop and consider the environment in which they function (see Santa Barbara City College, 2012). The University of South Africa (UNISA) has responded to the need for environmental awareness by recognising and promoting sustainable practices through the implementation of several institutional measures. As a member of the United Nations Global Compact (UNGC) which contributes to and abides by practices that support sustainability and social transformation, the institution has taken a voluntary stand to promote environmental responsibility, undertake a precautionary approach towards environmental hurdles and to encourage the development and use of environmentally friendly tools (UNISA, 2015). This has extended to recognising the need for a holistic interdisciplinary pigeon management plan specific for the Muckleneuk campus to ensure a suitable working environment for staff, uphold infrastructure integrity and maintain the pigeon population at a healthy acceptable level.

The University of South Africa's Muckleneuk campus in Pretoria forms part of a green belt sustaining natural vegetation and indigenous wildlife. The campus is also host to a large number of pigeons (Speckled *Columba guinea* and Feral *Columba livia* Pigeons). The birds make use of the campus buildings' varying designs and heights to roost and breed, whilst making use of architectural overhangs, sheltered balconies and exposed ledges to engage in survival and supplementary activities. Access into the ceilings of the buildings through open access points and loose exterior ceiling boards and open electrical and cabling ducts (trunking) which are positioned on the exterior of the buildings also provide an increase in the number of protected and sheltered roosting and breeding sites. The campus environment provides year round food availability due to its abundance in natural vegetation, food spillage and anthropogenic waste near the cafeterias as well as direct supplementary feeding by some staff members. The campus' proximity to the city centre, surrounding green spaces and agricultural lands also contributes to sustained food accessibility. An extensive water feature provides a permanent water supply to pigeons on campus.

Management have expressed concerns of the pigeon population being a public nuisance due to noise disturbance, health concerns relating to the build-up of their faeces and associated fungi, nest mites and bird lice which have been reported to infest the offices and staff members of certain buildings on campus as well as the accumulation of faecal matter and nesting material on balconies (Westington, pers comm. 2013).

Thus far large financial inputs have been put towards trying to manage the birds and their associated problems through balcony cleaning, nest removal and office fumigation on an ad hoc and reactive basis (Ntshoe, pers. comm. 2013).

NEED FOR INTEGRATED PIGEON MANAGEMENT PLAN

University Estates, who is responsible for the upkeep of the campus, has over the years received complaints from staff members on campus relating directly and indirectly to pigeons which make use of the campus to feed, breed and roost. These complaints however were attended to in an *ad hoc*, reactive manner which overlooked the source of the grievance; and only complaints brought to management's attention were addressed.

Thus far no formal pigeon control strategy exists, nevertheless precautionary measures have been undertaken to reduce the accumulation of faeces and debris by regular cleaning of office windows, cabling ducts and balconies. Regular fumigation of the interior of offices has also been ongoing to eliminate potential ectoparasite transmission from pigeons to staff.

Staff members affected, both positively and negatively, by the pigeons have thus far played a passive or vacant role in the management of these birds with the pigeon control responsibility lying exclusively with University Estates.

As the pigeon problem is multidimensional and interdisciplinary in nature, University Estates has recognised the need for a formal pigeon management plan and appropriate procedures to include the various ecological, social and environmental factors which affect the pigeon population on campus and the control thereof. To address all relevant factors, social and ecological research was conducted over a three year period to investigate staff perceptions relating to pigeons, their associated impacts and available control measures; the use of the campus by the pigeon population and the evaluation of optical devices, physical barriers and predator presence as humane control measures on the pigeon population. The study culminated in the production of an integrated pigeon management plan guided by the results of the research. It will be presented to the University Estates to manage the pigeon populations on the Muckleneuk campus of the University of South Africa.

INTEGRATED PIGEON MANAGEMENT (IPM) PLAN

Purpose

The integrated pigeon management plan serves to guide the use of humane interdisciplinary pigeon management strategies to enable positive human-pigeon interaction, ensure health and safety of staff and maintain the structural and aesthetic integrity of infrastructure in relation to the pigeon population and associated activities on the University of South Africa’s Muckleneuk campus.

The plan aims to empower and inform management’s decision making with regards to the efficiency and cost-effectiveness of humane, non-lethal pigeon control whilst upholding the University of South Africa’s commitment to environmental stewardship.

Principles

- Apply integrative preventative measures and holistic pigeon control management
- Utilise efficient humane, non-lethal pigeon control strategies
- Minimise health risk to staff and damage to infrastructure
- Consider cost-effectiveness and operational feasibility
- Involve staff and consider their perceptions in pigeon management
- Educate staff and promote holistic interdisciplinary approach to pigeon management
- Apply IPM plan principles when planning, designing, constructing and renovating future projects on campus
- Ensure the accountability of relevant building managers relating to pigeons inhabiting their sites of responsibility.

Research outcomes

Research was conducted to understand the ecological, environmental and social dimensions affecting the pigeon population on campus as well as the efficiency of various control strategies in order to manage the birds holistically and sustainably. Each of the studies has been concluded upon and can be referred to in chapters 5.1 – 5.6 of the A strategic interdisciplinary approach for the non-lethal pigeon control on the University of South Africa's Muckleneuk campus (2016) dissertation for further information.

SOCIAL DISCIPLINE: involving staff

Staff can be directly affected by pigeons perching, roosting or breeding outside of their offices along the balconies; and or indirectly affected due to the associate impacts relating to pigeon activities.

Perceptions of staff on the pigeons, their perceived impacts, and control measures were reflected upon in a qualitative online questionnaire and semi-structured interviews. Participation was voluntary and anonymous. A total of 246 participants contributed to this study, of which 226 (92%) were online surveys and 20 (8%) face to face interviews, after which information saturation was obtained. Four e-notices were distributed to staff members throughout the year prompting their participation in the study. The relative low response rate may be due to bias as staff members who were interested in pigeons and control were more likely to participate.

The results were placed into two broad categories: ‘pigeons and people’ which included staff perceptions and their views of the pigeons, as well as the pigeon associated perceived impacts on the people and the campus; and ‘pigeon control and people’ which explored the views of staff on the perceived pigeon problem on campus, complaints relating to the pigeons, pigeon management and the pest industry’s control measures.

People's perceptions of pigeons

The results are discussed as per the following main themes obtained from the questionnaires and interviews namely: pigeons as flying rats or a connection to nature; people's perceptions of pigeons; pigeon feeding, roosting and breeding activities; pigeon activities that impact people with focus on nesting material, ectoparasites, viewing of squabs in nests, interacting with pigeons and the direct feeding of pigeons; as well as humans and their responsibility towards the environment. Figure 26 depicts the summary of these findings.

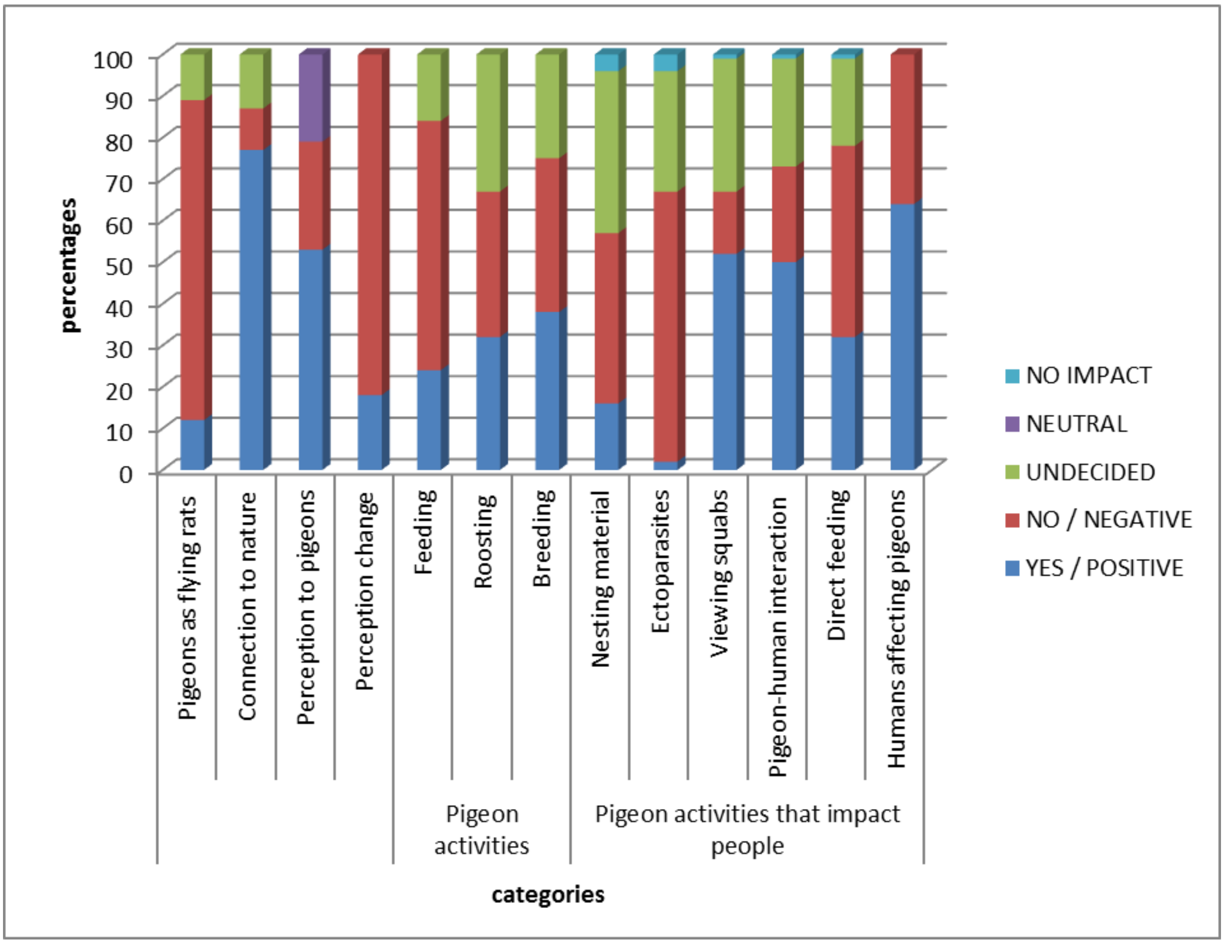


Figure 26: Summary of categories and results of staff perceptions of the pigeons on the University of South Africa's Muckleneuk campus

The study determined that the generalised negative perception of the pigeons by staff members on the Muckleneuk campus is inaccurate.

The vast majority of participants indicated to be ‘pro-pigeon’. They did not perceive, nor experience the pigeons to be a problem on campus but instead welcomed and encouraged their presence and activities in their work environment. They felt that pigeons allow a connection to nature, improve staffs’ quality of life by creating a sense of peace and calm in stressful working conditions and are a pleasant distraction from routine work related tasks. Their positive perceptions largely originated from their family background and opinion of the birds.

Nesting and breeding were positively perceived and encouraged by most participating staff members on campus as they enabled a connection to nature in a usually sterile man-made environment. However, participants were concerned about the pigeons’ wellbeing relating to food dependency and the quality that was provided by some staff members on a regular basis. Certain staff members actively provide food and water from their office balconies, in particular on the buildings of Cas van Vuuren, AJH van der Walt and Theo van Wijk (Figure 27).

Figure 27: Juvenile Speckled Pigeon being cared for by a staff member on an office balcony of Theo van Wijk at the University of South Africa's Muckleneuk campus

Anthropogenic food is also deliberately provided to pigeons congregating outside the cafeterias (Figure 28), as well as indirectly due to poor kitchen waste disposal.

Figure 28: Pigeons feeding on scraps outside the cafeteria at Theo van Wijk at the University of South Africa's Muckleneuk campus

Regardless of the potential negative implications of having pigeon populations in close proximity to the work space, participants mostly continued to perceive the presence of the birds as positive.

Cities are now viewed as challenging ecosystems for sustaining biotic communities and rich diversity for which humans are responsible for managing. The vast majority of the participants deem it the responsibility of public and private authorities, namely municipalities, local councils, conservation organisations, Department of Water and Environmental Affairs and independent building owners such as University Estates, to control or manage pigeons in urban environments. It was also stated that responsibility was multi-tiered, suggesting that every person has to be accountable for their actions and realise that interfering with nature has knock-on effects, even if they are not immediately visible. Please refer to Chapter 5.1 for further information.

People's perceptions of pigeon control

The results are discussed as per the following main themes obtained from the questionnaires and interviews namely; pigeons posing a problem on campus, pigeon related complaints, pigeon population control and pigeon control measures. Figure 29 depicts the summary of these findings.

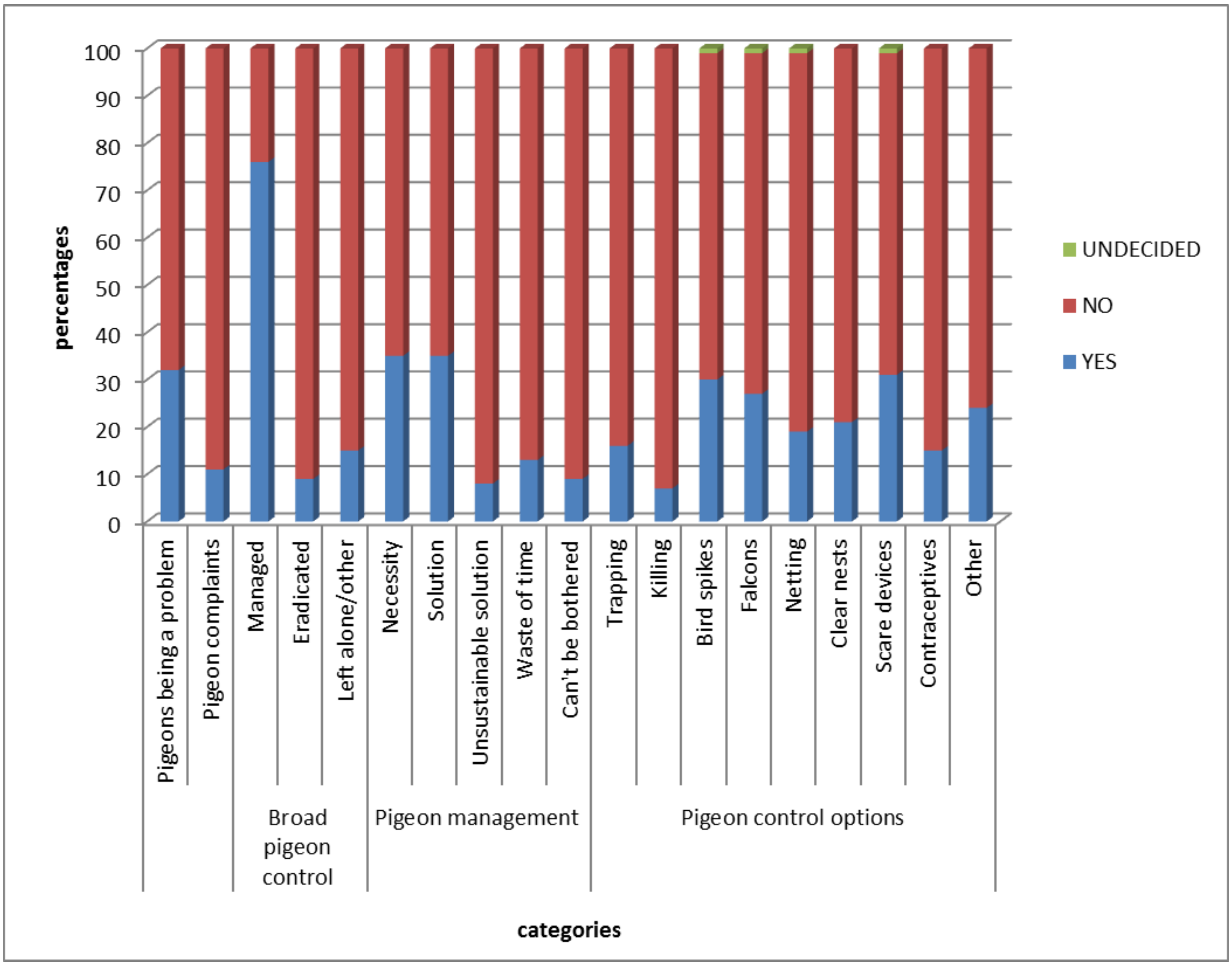


Figure 29: Summary of categories and results of staff perceptions of the pigeons and pigeon control on the University of South Africa's Muckleneuk campus

The study found that the perceived pigeon problem on the Muckleneuk campus is neither reality, nor based on staff opinions. Instead the idea of pigeons being pests and the subsequent request for pigeon control has originated from a vocal, influential minority which created an inaccurate impression of the current situation. Regardless of the potential negative implications of having pigeon populations in close proximity to the work space, the majority of participants continued to perceive the presence of the birds as positive and did not consider the birds problematic in the work environment.

As with many proposed pest control programs, action will eventually occur. Staff therefore felt that by contributing their opinion, they could try to influence the decision that would ultimately affect them. Thus, it was suggested that management of the pigeons, rather than eradication, would be a more acceptable and preferable choice.

Management would act as a precautionary measure, therefore implying that the pigeon population does not currently pose a problem to the university staff or infrastructure. In an effort to favour both the birds and the staff who enjoy their presence on campus, alternative holistic managerial measures were suggested to minimize the pigeons' potential to become a pest while simultaneously reducing the pigeon population to a healthy manageable size.

Literature and the pest control industry present a variety of lethal and non-lethal pigeon control measures aimed at deterring and or removing pigeons from identified areas. Participants in this study identified the use of scare devices and falcons as the preferred humane control strategies that would have a sustainable impact on the pigeon population on campus, relative to the other suggested control options. The erection of pigeon houses or dovecotes away from the buildings on campus was also suggested as a sustainable solution. They would serve a dual purpose by providing a welcoming environment for the pigeons to continue living on campus without negatively impacting staff or infrastructure, as well as the means to limit the hatching rate of eggs to create a small and healthy pigeon population.

Staff complaints about the presence of pigeons and their associated activities on campus, in the survey, were found to be minimal implying that the pigeons were not presently negatively impacting on people or displaying pest-like qualities on a large scale. Simultaneously University Estates received a total of 28 pigeon related complaints from staff on the entire campus over a one year period (January 2013–February 2014). The occasional staff member who attempted to deter pigeons from perching on balconies adjacent to their offices used a water pistol and elastic bands as a means of pigeon control (Figure 30).

Figure 30: Water pistol used by a staff member to deter pigeons from perching on the balcony adjacent to an office window

Once research related control methods were implemented on campus, pigeon related complaints reduced significantly to a mere six over the same amount of time (July 2014–August 2015). Conversely complaints relating to control structures, which were previously silent, increased (29 complaints). The main source of controversy being the flashing experienced from the Eagle Eye™ units installed on Theo van Wijk and Samuel Pauw. Participants, who were previously quiet prior to the proposed control of the pigeons, were now the complainants against the implementation of control and management measures.

The surveys found that the existence between pigeons and people is interconnected, whether it is formally recognised or not, each plays a role in the others' lives. Along with the surveys, staff members were provided with the opportunity to engage with the pigeon project during the control year through an active email address (unisapigeons@gmail.com). Staff directly reported open access points for pigeons, active nests, debris and faeces build up as well as staff feeding which allowed management the opportunity to efficiently attend to potential problems. Other staff engagement during the pigeon project included the regular distribution of informative e-notices, an article on the project in the University's Focus magazine (August 2014), an article published on the online e-connect forum about the birds of prey used in the pigeon project (May 2015), an interview on UNISA Radioand an information and interaction session with the birds of prey, which were tested as one of the pigeon control methods on campus (Figure 31). Due to this involvement and exposure an environment of support and public responsibility was fostered in the staff on campus, thus contributing to limiting the pigeon populations' potential to become pests.

Figure 31: Bird of prey interaction session at OR Tambo building prior to flying the birds of prey as a means of pigeon control on the University of South Africa's Muckleneuk campus

By providing all staff members with the opportunity to have a say in pigeon management on campus, the likelihood of the plan's effectiveness and sustainability will improve. It is therefore imperative that scientific understanding and people's perceptions relating to human-pigeon interactions are thoroughly investigated in order to successfully manage conflicts in urban spaces. Please refer to Chapter 5.2 for further information.

ECOLOGICAL AND ENVIRONMENTAL DIMENSION: use of the campus by pigeons

Pigeons over the centuries have become one of the most successful colonisers of urban environments (Haag-Wackernagel, Heeb & Leiss, 2006). The species has a remarkable ability to inhabit buildings to nest, breed and roost while simultaneously utilising various forms of food supplied by urban lifestyles and surrounding farmlands. The study found that the pigeon population on UNISA's Muckleneuk campus is no different. Adult and juvenile pigeons were counted on five of the seven buildings (Theo van Wijk building, OR Tambo building, AJH van der Walt building, Cas van Vuuren building and Samuel Pauw building) at dawn and dusk once a week for a period of one year. The results were interpreted as an index of pigeon population size. Seasonal fluctuation, breeding presence, seasonal agricultural crop correlation, and site selection were investigated to determine the use of campus environment by pigeons.

The research article concluded that the pigeon population density index on the Muckleneuk campus had an average value of 344 individuals/month over the course of the year. Speckled Pigeon constituted the majority (84%) of the pigeons on campus and Feral Pigeon considerably less at 16% of the total pigeon population.

Breeding took place all year, with the population index peaking over the warmer months, and declining during the cooler periods. The population has however been considered to be stable and constant, regardless of fluctuations as the difference between peaks and dips is nominal in relation to the population, with suggested juvenile dispersal.

Responses to environmental releasers (day length), proximity of available food, and known predators were evident in the population. Pigeons considered energy drivers with regards to foraging, as the population index was higher on campus when crops were not at their optimum for consumption, and lower when crop seeds were available as they departed early to maximise on consumption on neighbouring agricultural fields.

Unlike most avian studies relating to spatial dynamics, the University's pigeon population on the OR Tambo building indicated significant differences between the north and south aspect in all the seasons except for winter. Pigeons indicated a preference for the southern aspect during autumn and summer, contrary to numerous avian studies which documented a northerly site selection. Whilst in spring the opposite was found to be true as pigeons preferred a northerly aspect. The temperate climate and feeding site direction during optimal agricultural availability contributed to the behavioural responses and energetic decisions of pigeons when choosing sites in relation to the aspect. Pigeons did however support other research study findings with regards to site selection and altitude. Individuals chose the higher altitudes on which to select their sites, as the benefits of controlled microclimates and predator evasion contribute to their survival.

There is a need to understand the implications of man-made developments, urban-related consequences and opportunities on urban wildlife inhabiting these spaces in order to understand how they use these fragmented environments. Knowledge of pigeon biology, ecology and behaviour relating to the use of urban environments are important factors to consider when designing wildlife management plans (Giunchi, Baldaccini, Sbragia & Soldatini, 2007; Giunchi, Albores-Barajas, Baldaccini, Vanni & Soldatini, 2012).

Inappropriate strategies to control populations often result from wildlife management programmes when management and building professionals have a lack of understanding the problem (Hutton & Rostron, 2005). The pigeon population fluctuation will therefore be used as a control to determine the efficiency of various humane and non-lethal control measures implemented on the campus. Please refer to Chapter 5.3 in the dissertation for further information.

GENERAL PREVENTATIVE MEASURES

The first line of defence in any integrated pest management programme is hygiene and elimination of resources which enable the proliferation of pest populations. The availability of roosting and breeding space is the main controllable resource supporting the pigeon population, with anthropogenic food to a lesser extent. Exterior cabling ducts (trunking) which run the length of most of the buildings on campus provide an ideal environment for pigeons when left open due to human negligence and wind. The open access points in the cabling ducts and ceiling boards provide a safe and sheltered environment to breed and roost resulting in the accumulation of debris and droppings as they are out of reach from general cleaning activities. Open and loose ducts and exterior ceiling boards need to be regularly monitored and attended to prevent the pigeons from gaining access into the interior of the buildings.

The discouragement of deliberate feeding has been addressed in the educational campaign, and should continue to be reinforced. Indirect provision of food due to improper food disposal especially outside of cafeterias and kitchen dumpsters should be addressed. As the campus already has an extensive recycling initiative, food should be rinsed off containers before disposing of in the correct recycling depot thus minimising the amount of available scraps.

University Estates also regularly undertakes the cleaning of exterior windows and ledges in an effort to limit the amount of debris and dropping accumulation on balconies (Figure 32). University Estates has experienced fewer cleaning requests relating to pigeons since control strategies were implemented (Ntshoe pers. comm. 2014).

Figure 32: Pigeon dropping and debris accumulation on balconies of OR Tambo building on the University of South Africa's Muckleneuk campus

Staff engagement and involvement through the use of the email address, education campaign and e-notices have far reaching preventative impacts in minimising the pigeons from becoming a pest. It is also cost-effective and reduces the impact of the pigeon population on staff and infrastructure by taking important steps to prevent a potential or perceived problem. Alshuwaikhat and Abubakar (2008) suggest that staff participation will have future conservation repercussions, as alumni exposed to holistic pigeon management will be more likely to implement the initiative elsewhere and continue to hold social responsibility towards environmental issues. Involvement should be mandatory at all hierarchical levels as the knock-on effect of staffs' attitudes towards environmental issues influences management's attitudes which in turn influence the success of sustainable environmental practices implemented on campus (Krimowa, 2012).

HEALTH CONCERNS

The driving force behind the need to manage the pigeon population on campus was the concern for public health and safety relating to ectoparasites and pigeon diseases. Pigeons are of epidemiological importance as they are vectors to mites, lice, fleas and ticks; and a source of pathogens (Giunchi *et al*. 2012). Dense nesting and roosting activities create ideal environments for airborne allergens and diseases which originate from their droppings, secretions and feather dust. The most common pathogens transmitted to humans are histoplasmosis, a fungal disease found in droppings which affect peoples' lungs; psittacosis, a fungal disease found in droppings which affect peoples' lungs and cryptococcis which originate from a bacteria found in droppings and the eye or nasal secretions of the pigeons. However many studies (Phillips, Snell & Vargas, 2003; Haag-Wackernagel & Moch, 2004; Jerolmack, 2008; McKeown, 2008; Geigenfeind, 2013) indicate the possibility and rate of transmission risk is low, and that it is rather as a result of the immune status of people than just being exposed to pigeons and their activities (Haag-Wackernagel & Moch, 2004). Phillips, Snell and Vargas (2003) explain that due to their gregarious nature, there is high inter-specific disease transmission between pigeons and other birds including poultry and pet birds. An idea supported by Jerolmack (2008) who stated that diseases carried by pigeons are also carried by other birds synonymous with urban environments such as starlings and sparrows.

The transmission of airborne diseases and ectoparasite occurrence in staff offices claimed to originate from pigeons roosting and nesting in cabling ducts and open balcony ceilings have not been positively confirmed. A microbiological report conducted in 2009 in the Samuel Pauw building verified that airborne microorganisms were within health and safety guideline limits and there was no trace of histoplasmosis, psittacosis or cryptococcis (Buys, 2013). After numerous fumigation requests and a failed attempt of staff members taking fumigating into their own hands, an investigation was conducted in the building of AJH van der Walt in 2012 (Grobler, 2012). Pigeons were suggested to be the source of mites found in the offices however there was no mention of lice actually being found on pigeons or in the nests within the immediate vicinity of the office reported upon. Pigeons are not the only vector of bird mites; sparrows which frequent the campus buildings are also known carriers (Clayton & Tompkins, 1995). A bird lice report which had been seemingly conducted in 2013 could not be accounted for, yet when a control test for bird lice was undertaken in AJH van der Walt, Theo van Wijk and Cas van Vuuren in 2015, no bird lice were found. This is not to suggest that the pigeons inhabiting the Muckleneuk campus are free of ectoparasites; the researcher did identify the parasitic fly which allows for inter-species transmission of wing lice, in the nests of some pigeons on balcony ledges. It does however suggest that the prevalence and risk of ectoparasite and airborne disease transmission directly related to pigeons and their activities to staff members on campus seems to be nominal and insignificant. As a precautionary measure and to maintain health and safety University Estates regularly fumigates all the offices on campus. Additional fumigation takes place on request by staff members. Nonetheless further investigation to obtain reliable data pertaining to the actual zoonotic risk of pigeons to staff is required to properly direct concerns relating to ectoparasites and pigeon diseases.

PIGEON CONTROL

The abundance in the availability of food and shelter resources in urban environments has resulted in an increase in pigeon population densities, in turn creating a growing market for pest control strategies (Giunchi, Gaggini & Baldaccini, 2007). Broadly directed at either reducing pigeon numbers through increasing mortality (Haag-Wackernagel, 2008; Health Protection Programs, 2011; Giunchi et al. 2012), decreasing natality (Giunchi, Baldaccini, Sbragia & Soldatini, 2007; Haag-Wackernagel, 2008; Dobeic, Pintarič, Vlahović & Dovč, 2011), and or modifying behaviour through resource management (Giunchi, Baldaccini, Sbragia & Soldatini, 2007; Haag-Wackernagel, 2008; Giunchi *et al.* 2012); pigeon control is often *ad hoc*, reactive and unsustainable (Alshuwaikhat & Abubakar, 2008) aimed at short term benefit to enable continued support for pest control businesses (Murton, Thearle & Thompson, 1972).

Lethal measures have become increasingly controversial and have declined in public support (Treves & Noughton-Treves, 2005), while non-lethal forms of control are most sustainably effective long term and acceptable by the greater public (Environmental Health Directorate, 2006; Health Protection Programs, 2011; Ryan, 2011). These strategies are generally directed at the pigeons' visual, auditory and tactile senses; however habitat or resource modification and reduction can also be achieved by physical barriers and prohibiting the deliberate feeding of pigeons by people.

Research suggests that science seems to be lacking in quantitative reviews of various control methods and their effectiveness at reducing pigeon populations (Buijs & van Wijnen, 2001; Fukuda, Frampton & Hickling, 2008). The level of pigeon reduction of such devices and or strategies was quantified so that University Estates can make informed decisions about the cost effectiveness and efficiency relating to control methods specific to the Muckleneuk campus.

Optical Deterrents, Physical Barriers and Pest Industry Recommended Combination

For the purpose of this study optical deterrents and physical barriers were implemented on four buildings (Theo van Wijk building, OR Tambo building, Cas van Vuuren building and Samuel Pauw building). The structural features and position of each building on campus directed the type of control structure chosen, and the quantities and placement of structures on the respective buildings were directed by a pest control company.

Optical deterrents chosen were Eagle Eyes™ and Fire Flags. Eagle Eyes™, placed on Theo van Wijk building, are rotating prisms that reflects light within the ultra violet spectrum, designed to interfere with pigeons' line of flight as the light causes a distraction (Figure 33); while Fire Flags which are made from reflective gold and silver plastic designed to move with the wind to give the impression of fire and danger were placed on OR Tambo building (Eagle Eye, 2015a) (Figure 34).

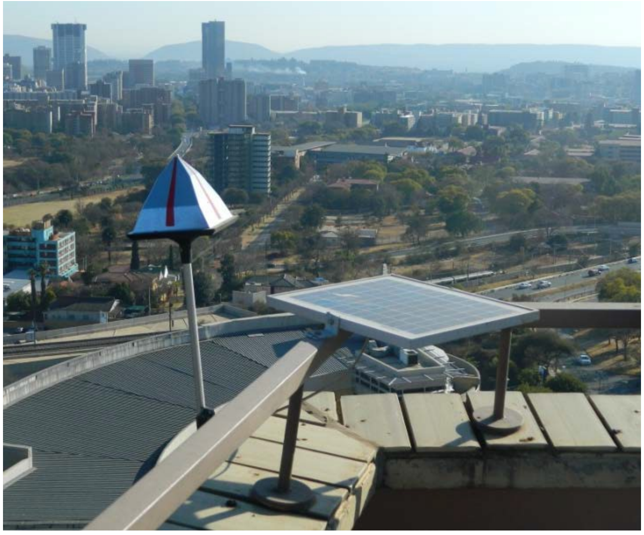


Figure 33: Eagle Eye^{TM} unit on Theo van Wijk building of the University of South Africa’s Muckleneuk campus

Figure 34: Fire Flags on OR Tambo building of the University of South Africa’s Muckleneuk campus

Physical barriers prevent or deter pigeons from buildings in varying degrees. Due to the lack of cabling ducts on the Cas van Vuuren building, dual pronged stainless steel bird spikes continuously placed along the ledge of balcony were implemented to deter pigeons from perching on the building (Figure 35).

Figure 35: Bird spikes on Cas van Vuuren building of the University of South Africa's Muckleneuk campus

Netting, excluding pigeons from the applied site, was placed on two minor areas of Theo van Wijk where exterior piping allowed for ideal roosting and breeding opportunities. This method provides total exclusion, as long as it remains intact - a factor which doesn't allow it to be a feasible option for the buildings on the Muckleneuk campus due to their designs and the requirement of maintenance staff to have ease of access. This was noted during the project as the two areas which were netted, did not remain intact due to human negligence and wind (Figure 36).

Figure 36: Redundant netting aimed at excluding pigeons from sections of the Theo van Wijk building on the University of South Africa's Muckleneuk campus

This in addition to the high expense and maintenance required an estimated cost of more than R5 million over 5 year period was quoted for the application of netting on the Muckleneuk campus (Westington, pers. comm. 2013).

The Samuel Pauw building was used for the implementation of the combination of control structures recommended by a prominent pest control company in South Africa. These included Eagle Eyes™, Fire Flags and bird spikes.

AJH van der Walt building was kept as a control (baseline) building without any pigeon control structures or strategies to determine if pigeons deterred from surrounding buildings simply moved to an untreated building as suggested by Mooallem (2006). Adult and juvenile pigeons were counted on the buildings at dawn and dusk once a week for a period of one year. The results were interpreted as an index of pigeon population size.

An educational campaign in the form of informative posters was implemented across the campus discouraging the active feeding of pigeons.

The study found that the pigeon population index declined by 50% as a result of the various control structures placed on the campus buildings.

Bird spikes indicated the highest reduction efficacy as pigeons were physically hindered from perching on the treated building. To ensure sustainable optimal results, alternative perching sites should be removed, whilst ongoing maintenance and monitoring of the bird spikes is essential as faeces and debris caught in the spikes can render them redundant and ineffective.

The study found visual scare devices to be disproportionally less effective at reducing the pigeon index on the campus than the physical exclusion and habitat modification of the bird spikes. Pigeons realised the lack of real threat and quickly learnt to ignore the flashes of light produced from the Eagle Eye^{TM} units. Due to the interdisciplinary nature of this study, the human component influenced the efficacy of the units as a number of units were removed and vandalised. A total of 21 of 42 Eagle Eye^{TM} units were removed due to staff complaints, and of the remaining Eagle

Eye^{TM} units six units had one/two shields applied to prevent flashes of light into staff offices. Nonetheless for this campus, the units worked at their optimal capacity, taking into account staff considerations.

Fire Flags were found to be the least efficient control structure on campus. Units placed on OR Tambo building were also subjected to vandalism by staff, and informational labels requesting staff to refrain from tampering with the units were subsequently attached to each Fire Flag.

As site specific environmental factors and ecological resource availability affects pigeon control, this is not to say that Fire Flags and Eagle Eyes^{TM} would not be effective on a different site or building. They simply had limited efficacy on the Muckleneuk campus at controlling the pigeon population.

The combination of Eagle Eyes^{TM}, Fire Flags and bird spikes is the recommendation of the pest control industry for maximum efficiency at reducing pigeon populations. According to the pest control company's literature a reduction of up to 80% of pigeon populations can be expected (Eagle Eye, 2015b). While this was not found to be true of the pigeon population on the Mucklenuek campus (58% pigeon population index reduction); the combination applied to the Samuel Pauw building was less efficient than the building that only had bird spikes applied. This is in contrast to the assumption that the combination should not be less effective than its individual parts. However the building on which the combination was applied had numerous open exterior cabling ducts and open or loose exterior ceiling boards. These provided the pigeons with alternative sites to the bird spikes which reduced the perching surface area of the balcony ledges, consequently limiting the effect of the control structure combination on the pigeon index.

The combination of control structures marketed at maximising pigeon reduction, would improve in efficacy if the open cabling ducts and ceiling boards that provided alternative perching sites were attended to. Research has found that the success and efficiency of control structures at reducing pigeon populations depends on the conditions of usage (Ryzhov & Mursejev, 2010). The success of control structures is therefore dependent on the context of application and factors influencing a site. Blanket statements on the expected percentage reduction of pigeon populations by control structures cannot be guaranteed as each site and pigeon index interaction is unique.

A further contributing factor which affects the effectiveness of pigeon control structures is seasonality. While the variability in climatic conditions, environmental changes and food availability influence the behaviour of pigeons and their subsequent tolerance of control structures.

The efficacy of all the control structures was found to increase during the warmer months corresponding with the natural pigeon index fluctuation on campus. Pigeons on the Muckleneuk campus which breed year round with a peak between July and October indicated a higher tenacity for tolerating the control structures in spring. Avian species have been recorded to trade off conflicting life sustaining demands. Pigeons on the campus were recorded to endure the discomfort of the deterrents to rear young. Wildlife regularly makes decisions that are crucial to their survival and fitness (Conradt & Roper, 2005), thus pigeons on campus rather directed their energy into foraging locally than travelling to surrounding agricultural areas in spring due to the limited crop availability (Harris, de Crom, Labuschagne & Wilson, unpublished data). In doing so, more pigeons were visible on the buildings. The higher spring pigeon population index observed with the visual deterrents may also imply that although the units presented an irritant to the pigeons inhabiting the buildings, pigeon behaviour was not severely impacted and individuals were willing to tolerate the discomfort.

All control structures on the campus buildings were found to be the least efficient during the autumn months. Due to the colder temperatures, pigeons were most likely hidden as a result of thermal factors (Lima, 1985) and consequentially also from the observer. Autumn also coincides with a biologically important season in pigeon anatomy; moulting. As costly energy is diverted for feather regrowth and plumage change (Murton, 1966; Johnston & Janiga, 1995), pigeons are relatively inactive as opposed to the rest of the year to conserve energy.

Though seasonality affects the efficacy of control structures, with spring and autumn indicating respective peaks and dips; pigeons did not move from the treated to untreated buildings as previously thought. This does not however imply that pigeons did not move between treated buildings to limit their exposure to a deterrent, but the study did not investigate this. For further information please refer to Chapter 5.4.

Audio bird scarer and falconry

Predation or the threat thereof is used to regulate prey populations in urban environments (Sorace, 2002). Alternative pigeon control methods include the implied or actual presence of predators through the use bioacoustics (species specific alarm/distress calls and bird of prey calls), and falconry to deter pigeons from making use of buildings and infrastructure. The choice of method depends on a variety of factors namely: pigeon population size, environmental conditions, cost and time implications, trained personnel, and pigeon resource availability. Each of the techniques are derived from the innate fear of pigeons and their need to avoid birds of prey presented in an audio or visual form, under the assumption that pigeons will respond accordingly. An audio bird scarer (BirdXPeller PRO™) and flying or perching raptors (Rock Kestrel (*Falco rupicolus*), African Goshawk (*Accipiter tachiro)* and Jackal Buzzard (*Buteo rufofuscus*) were tested as a form of pigeon control on the AJH van der Walt building (Figure 37 and 38).

Figure 37: BirdXPeller PRO™ unit used during the implied predator presence audio trial at University of South Africa's Muckleneuk campus)

Figure 38: Rock Kestrel (*Falco rupicolus*) flown during the actual predator presence visual trial at University of South Africa's Muckleneuk campus

For each of the respective control methods, scaring took place once a week at dawn and dusk for a period of four weeks (total eight weeks). Adult and juvenile pigeons were counted prior to scaring, recounted post-scaring, and then at 10 minute intervals for a period of 30 minutes thereafter. The results were interpreted as an index of pigeon population size on the AJH van der Walt building.

Prior to scaring the pigeon population on AJH van der Walt building indicated a natural outgoing trend at dawn to maximise on food availability, resulting in fewer pigeons remaining on the building. Conversely at dusk, pigeons indicated a natural incoming trend as they returned to roost, thus increasing the pigeon population index on the buildings. Pigeon populations on AJH van der Walt reacted differently to audio and raptor scares and their natural dawn and dusk trends were subsequently influenced.

Audio bird scarer

The study found that the audio bird scarer was ineffective at frightening and deterring pigeons from perching on AJH van der Walt building. At dawn the pigeon population continued to display a downward trend during the audio scare which paralleled the natural trend of pigeons leaving to forage. At dusk, pigeons increased substantially after the scare as individuals already on the building came out to investigate the unfamiliar noise as suggested by Fitzwater (1970). Once the 10 minutes post scare had lapsed the population index continued to increase on the building to roost similar to that of the incoming natural trend.

Behavioural and biological factors are responsible for the limited effect of audio on pigeons. This can be observed when pigeons are alarmed, their behavioural response is to remain stationary and instinctively cower down in roosts or nests (Hutton & Dobson, 1993; Hutton & Rostron, 2005). Furthermore pigeons lack of an alarm call (Boudreau, 1968; Inglis & Isaacson, 1984; Hutton & Dobson, 1993; Hutton & Rostron, 2005), and instead rely on open white wing bars to provide warning (Boudreau, 1972; Inglis & Isaacson, 1984). Additionally recorded raptor calls, to signal a predator is in the vicinity, is not biologically sound and portrays an unnatural representation of reality as predators hunt silently (Harris & Davies, 1998).

Resource abundance with regards to nesting and roosting sites as well as permanent food and water on the Muckleneuk campus, has resulted in higher tolerance levels of the pigeon population. Pigeons have developed a strong association with the campus and endure discomfort if the benefits of the site outweigh the intrusion of the audio device (Hamershock, 1992). Please refer to Chapter 5.5 for further information.

Falconry

The use of predators as a form of biological control of pigeons in urban environments, is considered to be humane and discrete (Ryzhov & Mursejev, 2010). Trained birds of prey can be flown by a falconer at certain times and frequencies to specifically target problem areas; or a resident raptor pair can be established to encourage the ongoing real predator presence at a site. Trained birds of prey were used for the purpose of this study, as the success of an introduced resident pair cannot be guaranteed. A raptor pair may not establish a territory at the site of introduction, and the turnaround time for fledglings to return to their place of birth to breed is up to three years (Freeman pers. comm. 2015). Also it has been recorded that only one kill may be necessary each day, leaving much time for the raptors to rest thus reducing the visible presence of the predators (Finch-Davies & Kemp,1980).

The visible presence of a bird of prey was found to be highly effective at frightening the pigeon population on AJH van der Walt, albeit temporarily. Pigeons on AJH van der Walt reacted as expected to avoid the presence of the raptors. In contrast to the natural decreasing trend at dawn, pigeon numbers on the building substantially declined directly after the raptor flight and then gradually increased over the 30 minute period post scare. Ryzhov and Mursejev (2010) found that pigeons changed their behaviour so as to avoid the discomfort of deliberate raptor presence; this was also found to be true of this study as pigeon flocks were observed perching on the buildings adjacent to AJH van der Walt during scare periods. Due to independent factors such as abundant roosting and nesting sites as found on the tested building, pigeons returned to AJH van der Walt once the threat was removed.

At dusk, the pigeon population index declined substantially again in response to the raptor presence. This decline was nonetheless short term as pigeons continued to follow the natural trend of returning to roost once the threat was removed.

Due to the evolutionary and biological basis, trained raptors are able to bring about short term behavioural change in pigeon populations to avoid a treated area, or eventual reduction in population size as individuals move away to establish new territories due to the constant real threat of being predated upon (Shochat, Lerman & Fernández-Jurcic, 2010). Considered to be a hands-on technique (Harris & Davies, 1998), the raptor and falconer are able to immediately adapt to environmental and populational fluctuations to maximise effect as opposed to automatic systems. Research has shown that raptors are highly effective at deterring pigeons; however the effect is temporary unless used consistently over a long period of time (Matyjasiak, 2008). To increase the temporal efficiency of the raptors on the pigeon population, wider application should be undertaken of the whole campus to minimise pigeon delaying behaviour (Ryzhov & Mursejev, 2010; Krimowa, 2012). Essentially trained birds of prey should be flown frequently over a long period of time to associate the campus with danger. Alternatively raptors can be flown selectively if an immediate reduction in pigeons at a site for a short period of time is required.

In addition, the effect of the raptor presence on the campus' pigeon population was intensified as wild avian predators of pigeons such as sparrowhawks and goshawks (*Accipiter sp*.) and Pied Crows (*Corvus albus*) have been seen to frequent the campus (Harris, 2014, pers. obs). With the increased presence of unfamiliar trained raptors, resident birds of prey investigate to determine whether there is a threat to their established territories (Freeman pers comm. 2015), consequently increasing the visible predator presence on campus. Please refer to Chapter 5.5 for further information.

SUPPLEMENTARY CONTROL STRATEGIES

Breeding space and food resources provide the ecological basis for pigeon populations in urban spaces. Therefore intervention which reduces reproductive output through the replacement of eggs and an anti-feeding educational campaign (Dobeic, Pintarič, Vlahović & Dovč, 2011) can result in the successful and sustainable reduction of a pigeon population (Geigenfeind, 2013) to socially acceptable standards whilst meeting animal welfare concerns (Ryan, 2011) on campus.

Nest boxes

Pigeon control does not remove or displace all the pigeons in a population, individuals with established territories will remain on the buildings and overcome any control system if the resources outweigh the discomfort of the management strategies. Those who remain will continue to breed, however their reproductive output can be controlled by providing them with designated breeding sites which are monitored and maintained.

Egg removal from designated nest boxes, which limits the hatching rate of pigeons, is considered to be a form of mechanical (Mooallem, 2006) and ethical birth control (Jacqui, Cazelles, Prévot-Julliard, Leboucher & Gasparini, 2010). Fertile eggs are systematically replaced with plastic dummy eggs which are then incubated by the parent for the remaining duration of the incubation period (Geigenfeind, 2013) until such a time as the viability is realised and the female lays again. This strategy not only decreases the birth rate (Geigenfeind, 2013) but also maintains a small and healthy pigeon population (Haag-Wackernagel, 2008; Jacquin *et al.* 2010; Dobeic, Pintarič, Vlahović & Dovč, 2011).

One hundred and thirty wooden and plastic artificial nest boxes were mounted on the cabling ductsof two of the buildings on campus; Theo van Wijk and OR Tambo. Each of the nest boxes contained a piece of carpet which was treated with a pigeon mite, tick, flea and fly insecticide (Dovastof). Nest boxes were checked once a week for nesting activity and eggs to prevent hatching. On finding an egg(s), it was removed and replaced with a white plastic pigeon dummy egg. The removed egg was subsequently taken to a local nature reserve as a food source for egg-eating mammals. Dovastof was reapplied onto the nest to manage ectoparasites on egg removal. As eggs are incubated for approximately 18 days before hatching (Krebs, 1974; Hetmański & Wołk, 2005; Jacquin *et al.* 2010), dummy eggs were removed from the nests after 14 days, to allow for the initiation of another laying cycle (Figure 39).

Figure 39: Pigeon eggs on a pigeon nest which are replaced by the dummy eggs with insecticide powder in a plastic artificial nest box on OR Tambo building

Of the 130nest boxes, 19 were actively used over the course of the management year. Pigeons indicated a preference towards the plastic nest boxes, with 181 incidents of nest activity recorded; this in comparison to the 37 incidents of nest activity recorded in the wooden boxes. However this was not an accurate representation of an ideal nest box application as the objective of controlling reproduction through egg removal can only be achieved if pigeons are excluded from alternative breeding sites thereby directing them to make use the nest boxes. This could not achieved on the Muckleneuk campus, as open cabling ducts and exterior ceiling boards which provide safe and sheltered breeding space, were not closed as agreed upon on the project’s commencement. The strategy was further constrained due to the irregular access to one of the executive level balconies on the OR Tambo building which housed nest boxes.

Educational campaign

Considered to be the most successful long term control for problem pigeon populations (Hutton & Rostron, 2005), an educational campaign was initiated on campus. Various colourful A3 posters designed to make staff aware of the pigeon population on campus and control thereof, as well as discouraging deliberate pigeon feeding on and around campus buildings in an effort to manage the pigeons were placed on the interior and exterior of all the buildings on campus. Posters requesting staff not to feed the pigeons were also strategically placed at the cafeterias and sites of social gathering. Studies have shown that the creation of a responsible feeding zone offers an alternative to prohibiting pigeon feeding on or near buildings (Haag-Wackernagel, 1995; Krimowa, 2012; Geigenfeind, 2013). The idea promotes campus greening (Alshuwaikhat & Abubakar, 2008) as people will be encouraged to feed responsibly while still being provided the opportunity for human-pigeon interaction (Haag-Wackernagel, 1995), which is often the initial reason for feeding. This concept was attempted at a site of natural vegetation on the far eastern side of the campus, however due to the consistent removal of the posters indicating the feeding zone the initiative was not able to take hold.

Placement approval for the posters to be uploaded onto the campus' digital e-notice boards was obtained, however this had not yet occurred on the conclusion of the project. The success of the educational campaign could not be measured as the posters were not placed in locked information cabinets, and as a result many were removed by staff to be replaced with more pressing matters at the time. Those that remained did so for the duration of the project. Judging by the extensive use of the project's email address, which was supplied on the posters, staff did read and take note of the information supplied on the posters.

Further research should be conducted to obtain reliable data on the effect of the educational campaign on staff members, as well as alternative educational methods directed at managing the pigeon population. Please refer to Chapter 5.6 for further information.

PIGEON RELATED COSTS

According to Giunchi *et al.* (2012), there has been limited research on the direct costs and economic losses relating to pigeons within urban environments. Cost estimates are generally calculated for large areas such as the 8.4% loss of sunflower seeds in South Africa due to pigeons (van Niekerk, 2009), or specific to sites (7–9 euros/pigeon/year in Italian cities (Zucconi, Galavotti & Deserti, 2003) or USD 9/pigeon/year in the United States of America (Haag-Wackernagel, 1995; Pimentel, Lach, Zuniga & Morrison, 1999); equivalent to approximately R127.00–R150.00/pigeon/year). However the cost estimates for pigeons in urban areas are often determined by the costs of deterring systems incurred to manage the pigeon populations (Giunchi *et al.* 2012). Direct and indirect costs due to pigeons and their associated activities on the Muckleneuk campus have not thus far been independently calculated. The primary passive managerial actions in response to pigeon problems prior to the study were the fumigation of offices and cleaning of balconies. However these actions occurred regularly and were not dependent on pigeon-related complaints, consequently the costs solely due to pigeons cannot be established. University Estates did however incur the majority of the costs of the pigeon control strategies tested in the research study, with the remaining costs provided by the Applied Behavioural Ecological & Ecosystem Research Unit (ABEERU). The costs per method, their respective efficiency and recommendation at reducing the pigeon population on campus are tabulated below (Table 7).

Table 7: Recommendation of pigeon control measures for pigeon control on the University of South Africa's Muckleneuk campus

BUILDING	CONTROL METHOD	COST PER CONTROL METHOD	TOTAL COST PER BUILDING	PIGEON POPULATION INDEX % REDUCTION	RECOMMENDATION
Theo van Wijk	Eagle Eyes™ & shields	R 458 679.00	R 474 835.67	51% reduction	Not recommended
	Nest boxes	R 1 755.12		N/A	Highly recommended
	Netting	R 14 401.55		N/A	Not recommended
OR Tambo	Fire Flags	R 125 582.40	R 127 040.90	42% reduction	Not recommended
	Nest boxes	R 1 458.50		N/A	Highly recommended
AJH van der Walt	Audio bird scarer (BirdXPeller PRO™)	R 3 437.21	R 3 437.21	7% reduction (dawn); 11% increase (dusk)	Not recommended
	Birds of prey	Included in project cost (Worth: R 14 158.80)		50% reduction (dawn); 30% reduction (dusk)	Highly recommended
Cas van Vuuren	Bird spikes	R 309 661.72	R 309 661.72	88% reduction	Highly recommended
Samuel Pauw	Eagle Eyes™ & shields	R 80 694.90	R 655 994.80	58% reduction	Not recommended
	Fire Flags	R 18 837.36			
	Bird spikes	R 556 462.50			
Campus	Educational campaign posters	R 300.00	-	N/A	Highly recommended
Campus	Attend to open trunking and ceiling boards	N/A	N/A	N/A	Highly recommended

ROLES AND RESPONSIBILITIES

The primary department responsible for the upkeep of the campus is University Estates. It is suggested that an IPM co-ordinator be identified to co-ordinate the implementation of pigeon management plan, provide leadership and co-ordination of all interested and affected parties, and collaborate efforts with building managers and departmental representatives.

This management plan serves to guide University Estates in sustainably managing the pigeons at a small and healthy population level. However a vital component of any management plan is the continued upkeep and maintenance of the recommended strategies, as well as the continued effort that management is willing to provide to such a plan.

It is proposed that a pigeon warden can fulfil this responsibility to ensure that the research, financial outlay and project will continue to successfully manage the pigeon population on campus. A pigeon warden would act as an intermediary between the University's staff members, the pigeons (and control structures) and the University Estates. He/she would assist in the revival and continuation of the educational campaign to promote awareness and understanding of IPM, assist in the evaluation of the plan's efficiency, co-ordinate, monitor and maintain the control strategies, conduct research regarding the pigeon population and control,or related topics; and report to the IPM co-ordinator on related issues.

This is a fairly novel concept with only a few countries partaking in such an approach (Mooallem, 2006). The Swiss Pigeon Action project founded in 1988, was a pioneer in involving pigeon wardens as part of their ecologically responsible and sustainable solution to their street pigeon problem whereby they halved the city's pigeon population in four years (Haag-Wackernagel, 1995). In the United Kingdom, the national Pigeon Control Advisory Service (Picas) is a leading influence in advising the use of pigeon wardens both in Britain and internationally (Mooallem, 2006; BBC News, 2003). Unemployed members of the public have been employed in Germany as pigeon wardens to construct and clean out public pigeon coops (Crossland, 2007). UNISA would be at the forefront of applying this concept in South Africa.

Although historically this position has typically been to persuade members of the public to feed only in designated pigeon feeding zones in collaboration with a broader pigeon control programme (Mooallem, 2006); the responsibility of such a person would extend into maintaining the low stable pigeon numbers on the Muckleneuk campus, ensuring continuation and maintenance of the already installed control structures, data collection for further research, and being a sounding board between staff and University Estates with regards to pigeon related complaints and concerns on campus.

UNISA currently partakes in various community engagement (CE) projects in Diepsloot to improve human capital through entrepreneurship skills. It is proposed that a member of the Diepsloot community could be involved and trained to fulfil such a position. This would attend to the challenges of poverty, unemployment and inequality by empowering an unemployed member of the public by providing them with skills and an education.

Training and employing a member of the community as a pigeon warden would be a revolving concept over a five year period. An individual would be chosen through the Diepsloot CE projects, provided with a uniform, trained in the necessary skills and employed at minimum wage for three days a week while being provided with the opportunity to complete a UNISA higher certificate in Life and Environmental Sciences within the stipulated time frame. On completion; the individual would, ideally, have achieved a qualification, health and safety training, a certificate in first aid, and new innovative skills and tools to have access to employment opportunities which would in turn provide empowerment and improved quality of life. A new individual will be chosen once the five year period has lapsed, and will be provided with the same opportunity. This concept will ensure that the control strategies implemented on campus will be efficient in their ability to provide control at an optimum, cost-effective and sustainable level.

To a lesser informal extent; building managers should be aware of the control strategies on campus and in particular on their buildings. Furthermore departmental representatives notified of pigeon-related issues affecting staff, and individual staff members on campus are equally responsible for the management of the pigeon population in collaboration with the IPM plan’s principles and purpose.

Relevant staff members need to be trained and informed of their responsibilities as insufficient training and lack of participation prevents the successful implementation and long term sustainability of the IPM and anticipated long term cost reduction. IPM record keeping is equally essential to ensure its effective outcome as trends overtime direct and influence future decisions. The IPM plan should be evaluated annually based on the data collected by the pigeon warden.

LIMITATIONS

As with any research, this project had limitations and constraints. These were minimised as much as possible and were taken into account throughout the duration of the study.

Due to the multi-faceted nature of the project, a number of delays relating to the pigeon control measures were experienced throughout the study. Budget approvals, organisational formalities, incorrect control structure quantities and staff complaints were the primary reasons for the six month commencement delay. Access restrictions impeded the day-to-day logistics during the initial control structures implementation and maintenance thereafter.

Due to the incorrect control structure quantities originally quoted, a secondary quote had to be requested and approved. This delay prevented the investigation of the habituation phase of the pigeons to the control structures as the buildings were not adequately covered providing pigeons with areas of no or minimal control. Once implemented, Eagle Eyes™, Fire Flags and netting were not regularly maintained which resulted in broken and ineffective units (Figure 40).

Figure 40: An ineffective broken Fire Flag on OR Tambo building at University of South Africa's Muckleneuk campus

As the control strategies could not be implemented independent of staff on campus, staff members who were not in support of the project took to vandalising and tampering with Eagle Eye^{TM} and Fire Flags units (Figure 41, 42 & 43). Eagle Eye^{TM} shields and or the removal of units which created light disturbances in offices were requested. Similarly the success of the educational campaign could not be measured through a questionnaire as the posters were not placed in locked information cabinets as previously requested, and as a result many were removed by staff to be replaced with more pressing matters at the time.

Figure 41: Fire Flag unit removed by staff members of OR Tambo building at the University of South Africa' Muckleneuk campus

Figure 42: Fire Flag with staff ‘please do not remove’ notice attached on OR Tambo building at the University of South Africa’ Muckleneuk campus

Figure 4 3: Eagle Eye^{TM} unit covered with a plastic bag by a member of staff to prevent the unit from reflecting light on Theo van Wijk building at the University of South Africa’ Muckleneuk campus

The use of ultrasound had previously been considered to be tested as an auditory control method. However due to staff members' complaints relating to the device and the perceived negative impact, this method was not included as part of the study.

Routine maintenance on campus in the form of asbestos ceiling board replacement on Samuel Pauw took place during the first year of the project (2013). For a limited time period, additional roosting and nesting space was made available to the pigeons.

Finally, the prevalence of open, loose and broken exterior ceiling boards and cabling ducts on the campus significantly impacted the study. The issue was highlighted regularly on formal and informal occasions prior to the project's commencement and throughout its duration. However ceiling boards and cabling ducts were not attended to prior to control structure implementation and a relatively insignificant ad-hoc attempt at attending to the problem was conducted towards the end of the study.

Health concerns, which initiated the project, are directly related to pigeons roosting and nesting in open ceiling boards and cabling ducts (Figure 44). The access to safe and sheltered roosting and nesting space provide the pigeons with an alternative site away from the control structures implemented on the balconies and roofs of the buildings. The additional breeding space compromised the nest box initiative which required the elimination of alternative sites.

Figure 44: Speckled Pigeon nesting in an open cabling duct (trunking) of AJH van der Walt building at the University of South Africa' Muckleneuk campus

According to management, various departments are responsible for opening the ceiling boards and cabling ducts to perform maintenance activities, but due to human negligence are not reclosed (Ntshoe pers comm. 2014). To a lesser extent, wind updrafts capable of lifting ceiling boards and cabling duct lids also plays a role. However there isn't a department formally responsible to monitor and attend to the problem, which results in an attitude of it being someone else's responsibility. Studies have shown that control strategies have limited capabilities at managing pigeon populations and is dependent on the amount of effort the user is willing to contribute (Boudreau, 1968; Harris & Davies, 1998). To achieve the best possible outcome problematic ceiling boards and cabling ducts needs to be attended to on an ongoing basis and as a matter of urgency.

SUMMARY

Humane non-lethal pigeon control on the University of South Africa's Muckleneuk campus is multi-disciplinary. Ecological, environmental and social aspects influence and determine the plan's outcome and therefore need to be considered from a management perspective.

Recommended measures for humane and non lethal pigeon management on the Muckleneuk campus

- Attend to loose, broken and missing cabling ducts and exterior ceiling boards
- Cleaning and fumigation
- Bird spikes
- Nest boxes
- Trained raptors
- Staff engagement

As with any pest management plan, initial precautionary measures are necessary to support the proposed action. The elimination of additional shelter resources is imperative for sustainable pigeon management. Open cabling ducts and loose, missing or broken exterior ceiling boards are evident on all buildings on campus. This ease of access has provided the pigeons with additional safe shelter for nesting and roosting. Identified cabling ducts and ceiling boards were not attended to, as requested prior to and during the study. Pigeons were therefore provided with alternative space to continue their existence on buildings that had control structures applied thus compromising the proposed outcome of the treatments.

Furthermore the ease of access into the structures of buildings has contributed to health concerns of staff relating to pigeon debris and faeces accumulation which may indirectly impact the working environment in staff offices.

Open access points should be considered as a priority by management. Until such a time as the cabling ducts and open ceiling boards are attended to and maintained regularly, measures directed at managing the pigeon population on campus will produce less than optimum results. This was evident in the nest boxes as pigeons which were deterred from control structures were not redirected to the boxes which would allow for the reduction of hatchling rate in the removal of laid eggs. Instead pigeons continued to make use of the open access points in the buildings. The continued use and maintenance of nest boxes as a means of managing the pigeons on the Muckleneuk campus is however recommended as the boxes that were used by pigeons produced successful results. The effectiveness of the nest boxes as a means to manage the pigeon population will improve once open cabling ducts and ceiling boards are attended to. A dedicated staff member (pigeon warden; see Role and responsibilities) should be responsible for the continuation of monitoring, cleaning and the replacement of dummy eggs in the nest boxes on campus.

Eagle Eye™ and Fire flag units applied independently and as components of the combination were found to have limited efficacy at deterring pigeons from the treated buildings on campus relative to the bird spikes. Furthermore the visual irritation of the flashes on staff members resulted in units being removed, tampered with and damaged. It has therefore been concluded that Eagle Eyes™, Fire Flags and the pest control industry's combination are inappropriate for pigeon control on the Muckleneuk campus and are not recommended.

Alternative pigeon control in the form of an audio bird scarer was found to be ineffective at frightening and or discouraging pigeons from the building that was used during the trial. Due to the lack of biological basis and an abundance of food, water and shelter resources supporting pigeons on campus, the use of the audio bird scarer is not recommended for pigeon control on the Muckleneuk campus.

Bird spikes, used independently and as a combination with other control structures, resulted in the highest efficacy at deterring pigeons from the treated buildings. Dual pronged, extra length bird spikes specific to discouraging pigeons from perching were found to be successful for the Muckleneuk campus. Minimal maintenance is required for the spikes to work at an optimal level and due to the structure's tidy and unobtrusive image, the spikes do not detract from the buildings' aesthetical value. Bird spikes, specific for pigeons, are therefore recommended for pigeon control as a long term solution to be applied to all affected buildings on the Muckleneuk campus.

Pigeons were found to be effectively deterred and discouraged from a site during the flights of trained raptors. In the event of function which requires that immediate exclusion of the pigeons from a specific area, raptors flown prior to the event will yield positive results. The impact on the pigeons' behaviour is however temporary; to ensure effective long term pigeon management raptors should be flown around the whole campus, at regular frequent intervals throughout the year to associate the campus with danger. Cost-implications present a constraint to this method. To minimise this restriction whilst obtaining positive results, raptors should be flown during autumn when the bird spike efficacy was found to be at its lowest and at dusk while pigeons are returning to roost. This will result in a long term behavioural change as individuals will choose to roost and nest elsewhere. Furthermore trained raptors flown on campus provide educational and ecological benefits, which combined with efficacy is recommended as a means of pigeon control on the Muckleneuk campus.

Staff engagement aimed at helping to change staff members' behaviour and highlighting their responsibility towards pigeon management on campus should continue to be achieved through a renewed educational campaign, a dedicated UNISA email address (unisapigeons@gmail.com) and regular e-notices. Staff members provide valuable insight at ground level which allows management to address potential and perceived pigeon problems timelessly.

General maintenance and precautionary measures such as the fumigation of offices and the cleaning of balconies and cabling ducts to remove accumulated debris and pigeon faeces should continue on a regular basis. These activities aim to reduce pathogen survival, potential disease transmission (Geigenfeind, 2013) and the removal of debris and droppings to minimise the feeling of social disorder (Douglas, 1966) and improve structural integrity (Belant, 1997). Protective clothing and dust masks should be worn when removing droppings to reduce health risks associated with fungal spores and mould transmission.

MONITORING PLAN

Monitoring is a fundamental requirement of wildlife management plans as various factors influence the promotion or reduction of animal populations within urban environments. Information relating to the progress and success of a management plan should be regularly collected to assess the measurable impact of expected outcomes, for the accountability of resources and to guide strategic planning.

Record keeping of ecological, environmental and social factors affecting the pigeon management plan should be systematic and routine as trends overtime direct and influence future decisions.

The following aspects should be monitored to ensure the continued success of the project:

Ecological

- Weekly pigeon population index fluctuation per building
- Species composition relative to the pigeon population index of pigeons on the Muckleneuk campus
- Weekly presence of breeding activity
- Bi-annual ectoparasite test of staff offices
- Deliberate feeding activity logged at dedicated feeding zone

Environmental

- Broken or ineffective control structures
- Open, loose or broken cabling ducts, exterior ceiling boards and access points
- Nest box use
- Pigeon-related cleaning and fumigation activity

Social

- Staff engagement relating to future pigeon management decisions
- Annual staff survey investigating their opinions relating to the pigeons and management thereof
- Maintaining the dedicated email address used by staff to convey pigeon-related information
- Pigeon related complaints received (when, where, what, remedial actions)
- Monthly int-com announcements relating to pigeon management
- Ongoing educational campaign

For the project to obtain an optimal level of success and sustainability, commitment from management needs to be practical to ensure appropriately directed funding, monitoring and maintenance of the management plan and the prioritisation of holistic pigeon control within the scope of protecting and enhancing the wellbeing of staff and the campus' natural environment.

REFERENCES

ACTS **see** SOUTH AFRICA

ADAMS, C., LINDSEY, K. & ASH, S. 2006. *Urban wildlife management*. CRC Press.

ALI, S., RAKHA, B.A., HUSSAIN, I., NADEEM, M.S. & RAFIQUE, M. 2013. Ecology of Feral Pigeon (*Columba livia*) in Urban Areas of Rawalpindi/Islamabad, Pakistan. *Pakistan Journal of Zoology*, 45(5): 1229 – 1234.

ALSHUWAIKHAT, H. M. & ABUBAKAR, I. 2008. An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. *Journal of Cleaner production,* 16:1777-1785.

ANDRZEJEWSKI, R., BABINSKA-WERKA, J., GLIWICZ, J., GOSZCZYNSKI, J. 1978. Synurbanisation processes in an urban population of *Apodemus agrarius*. I. Characteristics of population in urbanization gradient. *Acta theriologica,* 23, 341–358.

ANGIER N. 1991. New York's tough pigeons fight predators for survival. New York Times July 8: A1.

ANTCZAK, M. 2010. Winter Noctural Roost Selection by Solitary Passerine Bird, the Great Grey Shrike *Lanius excubitor*. *Ornis Fennica*, 87: 99 – 105.

AUSTRALIA. Department of Health. 2010. Environmental Health Practitioner Manual [Online] Avilable from: www.health.gov.au [Accessed: 05/08/2016].

BABINSKA-WERKA, J., GLIWICZ, J., GOSZCZYNSKI, J. 1979. Synurbanisation processes in an urban population of *Apodemus agrarius*. II. Habitats of the Striped Field Mouse in town. *Acta theriologica,* 26, 405-415.

BALDACCINI, N., GIUNCHI, D., MONGINI, E. & RAGIONIERI, L. 2000. Foraging flights of wild rock doves (Columba l. Livia): a spatio- temporal analysis. *Monitore Zoologico Italiano*, 67: 371 – 377.

BARBIERI, F. & DE ANDREIS, C. 1991. Indagine sulla presenza dei colombi (Columba livia forma domestica) nel centro storico di Pavia e nall'Oltrepó. *Suppl. Ric. Biol. Selvaggina*, 17: 195 – 198.

BARNES, T.G. 1997. *Managing urban pest bird problems in Kentucky*. University of Kentucky cooperative extension service.

BAXTER, A. 2000. Use of distress calls to deter birds from landfill sites near airports. *International Strike Committee*, Amsterdam, 17 – 21 April.

BBC NEWS. 2003. Pigeon warden takes to the streets [Online]. Available from: http://news.bbc.co.uk/go/pr/fr/-/2/hi/uk_news/england/west_midlands/3297117.stm. [Accessed: 13/01/2015].

BECH, C. & REINERTSEN, R.E. (eds.). 1989. *Physiology of Cold Adaptation in Birds*. Plenum Press: New York.

BELANT, J.P. 1997. Gulls in urban environments: landscape level management to reduce conflict. *Landscape Urban Plan*, 38: 245 – 258.

BELANT, J. L., WORONECKI, P.P., DOLBEER, R.A. & SEAMANS, T.W. 1998. Ineffectiveness of five commercial deterrents for nesting starlings. *Wildlife Society Bulletin*, 26: 264 - 268.

BELGUERMI, A., BOVET, D., PASCAL, A., PRÉVOT-JULLIARD, A., JALME, M.S., RAT-FISCHER. L. & LEBOUCHER, G. 2011. Pigeons discriminate between human feeders. *Animal Cognition,* 14:909-914.

BEVAN, R.D.R. 1990. The costs of feral pigeon. In: *British Ornithological Union: proceedings of a symposium in October 1990.* London: ADAS/British Ornithologists' Union: 10-11.

BENNETT, A.T.D. & CUTHILL, I.C. 1994. Ultraviolet vision in birds: What is its function. *Vision Research*, 34: 1471–1478.

BIRD STOP, 2015. BirdXPeller Pro Digital 1-Channel Bird Scarer [Online]. Available from: http://www.birdstop.co.uk/birdxpeller_pro_digital_1-channel_bird_scarer.asp [Accessed: 05/04/2014].

BIRDSTOP. 2016. BirdXPeller Pro Digital 1 Channel Bird Scarer Version [Online]. Available from: http://www.birdstop.co.uk/birdxpeller_pro_digital_1_channel_bird_scarer_version_1.asp [Accessed: 16.03.2014].

BLACKWELL, B.F., BERNHARDT, G.E. & DOLBEER, R.A. 2002. Lasers as nonlethal avian repellents. *Journal of Wildlife Management*, 66: 250 – 258.

BOLGER, D.T. 2001. Urban Birds: Population, Community and Landscape Approaches. In: Marzluff, J.M. (ed.). Avian ecology and conservation in an urbanizing world. Kluwer Academic Publ., Boston: 155 – 177.

BOOTH, T.W. 1994. *Bird dispersal techniques*. The handbook: prevention and control of wildlife damage: 58.

BOTKIN, D. 2012. *The moon in the nautilus shell*. New York: Oxford University Press.

BOUDREAU, G.W. 1968a. Alarm sounds and responses of birds and their application in controlling problem species. *The Living Bird*, 7: 27 - 46.

BOUDREAU, G.W. 1968b. Status of bio-sonics in pest bird control. In: *Bird Control Seminars Proceedings*: 145: 38 – 43.

BOUDREAU, G.W. 1972. Factors relating to alarm stimuli in bird control. In: *Proceedings of Vertebrate Pest Conference*, 5: 121 - 123.

BRAMBILLA, M., RUBOLINI, D. & GUIDALI, F. 2006. Factors affecting Breeding Habitat Selection in a Cliff-Nesting Peregrine *Falco peregrinus* population. *Journal of Ornithology,* 147: 428 – 435.

BRAUN, V. & CLARKE, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology, 3* (2):77-101.

BREMNER, A. & PARK, K. 2007. Public attitudes to the management of non-native species in Scotland. *Biological Conservation,* 139:306 - 314.

BRIDGMAN, C.J. 1976. Bio-acoustic bird scaring in Britain. In: *Proceedings of Pan-Africa Ornithological Congress*, 4:383 – 387

BRIX, A., BRYDON, T., DAVIDIAN,E., DINSE, K. & VIDYARTHI, S. 2006. Toward sustainable campus communities: evaluating alternative development scenarios. MSc University of Michigan: Michigan.

BROOKE, R.K. 1981. The feral pigeon – a 'new' bird for the South African list. *Bokmakierie*, 33: 37 – 40.

BROWN, R.G.B. 1969. Seed Selection by Pigeons. *Behaviour*, 34(3): 115 – 131

BRUGGERS, R.L., BROOKS, J.E., DOLBEER, R.A., WORONECKI, P.P., PANDIT, R.K., TARIMO, T. & HOQUE, M. 1986. Responses of pest birds to reflecting tape in agriculture. *Wildlife Society Bulletin*, 14: 161 – 170.

BRUNET, S. & HOUBERT, P. 2007. Involving stakeholders: The Belgian Fowl Pest Crisis. *Journal of Risk Research*, 10(5):643 - 660.

BRYANT, D.M. 1997. Energy Expenditure in Wild Birds. *Proceedings of Nutrition Society,* 56: 1025 – 1039.

BUIJS, J.A. & VAN WIJNEN, J.H. 2001. Survey of feral rock doves (*Columba livia*) in Amsterdam, a bird-human association. *Urban Ecosystems*, 5: 235 – 241.

BUYS, W. (buyswj@unisa.ac.za). 2013. Report. [Email to:] Harris, E. (emmaharris09@gmail.com) July 15.

CARLE, R. 1959. Die Vorbereitung zur Bestandsregelung unter den verwilderten Haustauben in den Städten. Städtehygiene 8:164 –168. In: DEL MONTE, M. & SABBIONI, C. 1986. Chemical and biological weathering of an historical building: Reggio Emilia Cathedral. *Science of the Total Environment*, 50: 165 – 18.

CHANDLER, C.R., KETTERSON, E.D. & VAL NOLAN, J.R. 1995. Spatial Aspects of Roost-Site Selection in Breeding Male Dark-Eyed Juncos. *The Condor*, 97: 279 – 282.

CHARLES, K.E. & LINKLATER, W.L. 2015. The role of environmental engagement in tolerating urban bird problems. *Human Dimensions of Wildlife: An International Journal*, 20 (2): 99 – 111.

CHRISTENSEN, W. 1996. Creative pigeon management. *New Hampshire Audubon*, 32(6): 11.

CLAYTON, D.H. & TOMPKINS, D.M. 1995. Comparative effects of mites and lice on the reproductive success of rock doves (Columba livia). *Parasitology*, 110: 195 – 206.

COLLETT, A. (AnnelizaC@daff.gov.za). 2015. Agricultural crop list. [Email to:] Harris, E. (emmaharris09@gmail.com) Oct. 21.

CONKLIN, J.S., DELWICHE, M.J., GORENZEL, W.P. & COATES, R.W. 2009. Deterring cliff swallow nesting on highway structures using bioacoustics and surface modifications. *Human-Wildlife Conflicts*, 3: 93 – 102.

CONRADT, L. & ROPER, T.J. 2005. Consensus decision making in animals. *Trends in Ecology and Evolution*, 20(8): 449 – 456.

COOK, A., RUSHTON, S., ALLAN, J. & BAXTER, A. 2008. An evaluation of techniques to control problem bird species on landfill sites. *Environmental Management*, 41: 834 – 843.

CORDANO, M., FRIEZE, I., & ELLIS, K. 2004. Entangled affiliations and attitudes: an analysis of the influences on environmental policy stakeholders' behavioural intentions. *Journal of Business Ethics,* 49(1), 27–40.

COUNSILMAN, J.J. 1974. Waking and Roosting Behaviour of the Indian Myna. *Emu*, 74: 135 – 148.

CROSSLAND, D. 2007. To kill or not to kill: cities tackle surge in global pigeon population. Spiegel International [Online]. Available from: http://www.spiegel.de/international/germany/to-kill-or-not-to-kill-cities-tackle-surge-in-global-pigeon-population-a-515713.html. [Accessed: 13/01/2015].

CURIO, E.K. & REGELMANN, K. 1983. An anti-predator response in the Great Tit *(Parus major):* is it tuned to predator risk? *Oecologia* (Berlin) 60:83 – 88.

DAVIS, P.J. 1974. Fundamentals of bird scaring – a laboratory approach. *Annals of Applied Biology*, 76(3): 353 – 358.

DE MENT, S. 1987. Toxic lead exposure in the urban rock dove. *Journal of Wildlife Diseases*, 23(2): 273 – 278.

DE MENT, S. & CHISOLM, J. 1986. Lead exposure in an urban peregrine falcon and its avian prey. *Journal of Wildlife Diseases*, 22: 238 – 244.

DECHILLO, S. 1986. Owl decoys face off against pigeons. *New York Times*, Nov. 2.

DEIS, R. 1986. Is bird feeding a no-no? *Defenders,* 54, 17-18.

DEPARTMENT of Cooperative Governance and Traditional Affairs **see** SOUTH AFRICA. Department of Cooperative Governance and Traditional Affairs.

DEPARTMENT of Environmental Affairs **see** SOUTH AFRICA. Department of Environmental Affairs.

DEPARTMENT of Health **see** AUSTRALIA. Department of Health.

DINETTI, M. 2006. Urban avifauna: is it possible to live together? *Veterinary Research Communications*, 30 (Supple. 1): 3 – 7.

DITCHKOFF, S.S., SAALFELD, S.T. & GIBSON, C.J. 2006. Animal Behaviour in Urban Ecosystems: Modifications due to human-induced stress. *Urban Ecosystem,* 9: 5 – 12.

DOBEIC, M., PINTARIČ, S., VLAHOVIĆ, K. & DOVČ, A. 2011. Feral pigeon (Columba livia) population management in Ljubljana. *Veterinarski Arhiv*, 81(2): 285 – 298.

DOUGLAS, M. 1966. *Purity and Danger*. London: Penguin.

DRISCOLL, C.A., MACDONALD, D.W., O'BRIEN, S.J. 2009. From wild animals to domestic pets, an evolutionary view of domestication. *Proceedings of the National Academy of Sciences*,106 (Suppl 1) :9971–9978.

DUNN, R.R., GAVIN, M.C., SANCHEZ, M. & SOLOMON, J.N. 2006. The pigeon paradox: dependence of global conservation on urban nature. *Conservation Biology*, 20(6):1814-1816.

EAGLE EYE. 2015a. Eagle Eye bird control [Online]. Available from: http://www.eagleeye.co.za/popular-bird-control-products. [Accessed: 08/12/2015].

EAGLE EYE. 2015b. Eagle Eye placement guidelines [Online]. Available from: file:///C:/Users/Downloads/Eagle_Eye_placement_guidelines_metric_1.pdf. [Accessed: 08/12/2015].

EARLE, R.A. & LITTLE, R.M. 1993. Hematozoa of Feral Rock Doves and Rock Pigeons in Mixed Flocks. *South African Journal of Wildlife*, 23: 98 – 100.

EISERER, L.A. 1984. Communal Roosting in Birds. *Bird Behavior*. 5: 61 – 80.

ENVIRONMENTAL HEALTH DIRECTORATE, 2006. *Feral Pigeon Control Environmental Health Guide* [Online]. Available from: http://www.public.health.wa.gov.au/cproot/1408/2/feral_pigeon_control.pdf [Accessed: 01/06/2013].

FINCH-DAVIES, C.G. & KEMP, A.C. 1980 The Birds of Prey of Southern Africa. Johannesburg: Winchester Press.

FISHER, R.J., FLETCHER, Q.F., WILLIS, C.K.R. & BRIGHAM, R.M. 2004. Roost Selection and Roosting Behaviour of Male Common Nighthawks. *American Midland Naturalist Journal.,* 151: 79 – 87.

FITZWATER, W.D. 1970. Sonic Systems for Controlling Bird Depredations. In: *Bird Control Seminars Proceedings*: 203.

FITZWATER, W.D. 1988. Solutions to Urban Bird Problems. In: *Proceedings of the Thirteenth Vertebrate Pest Conference*: 254 – 259.

FLANNERY, M.C. 2009. The Value of Pigeons. *The American Biology Teacher 71(7): 430-431.*

FRANSSON, N., & GÄRLING, T. 1999. Environmental concern: Conceptual definitions, measurement methods, and research findings. *Journal of Environmental Psychology*, 19(4), 369–382.

FRASER, W. 2001. Introduced wildlife in New Zealand: A survey of general public views. *Landcare 466 Research Science Series No. 23*, Manaaki Whenua Press, Canterbury, New Zealand: 467 468

FRASER, A. 2006. Public attitudes to pest control: a literature review. Department of Conservation, 469 Wellington, New Zealand: 36

FREEMAN, D. 2015b. Falconer, Top Turf, Bidvest Steiner. Personal communication.

FREEMAN, D. (dylfreeman1@yahoo.com). 2015a. Pest Control Write up. [Email to:] Harris, E. (emmaharris09@gmail.com) Jun. 8.

FRINGS, H. 1964. Sound in vertebrate pest control. *Vertebrate Pest Conference*, 2: 50 – 56.

FUKUDA, Y., FRAMPTON, C.M. & HICKLING, G.J. 2008. Evaluation of two visual birdscarers, the Peaceful Pyramid® and an eye-spot balloon, in two vineyards. *New Zealand Journal of Zoology*, 35(3): 217 – 224.

GEIGENFEIND, I. 2013. On the biology and epidemiology of the feral pigeon (*Columba livia*). PhD University of Basel: Basel.

GILSDORF, J.M., HYGNSTOM, S.E. & VERCAUTEREN, K.C. 2003. Use of frightening devices in wildlife damage management. *Integrated Pest Management Reviews*, 7: 29 – 45.

GIUNCHI, D, BALDACCINI, N.E., SBRAGIA, G. & SOLDATINI, C. 2007. On the Use of Pharmacological Sterilisation to Control Feral Pigeon Populations. *Wildlife Research*, 34: 306 – 318.

GIUNCHI, D. & GAGGINI, V. 2007. Distance sampling as an effective method for monitoring feral pigeon (*Columba livia* f. *domestica*) urban populations. *Urban*

Ecosystem, 10: 397 – 412.

GIUNCHI, D., ALBORES-BARAJAS, Y.V., BALDACCINI, N.E., VANNI, L. & SOLDATINI, C. (2012). *Feral Pigeons: Problems, Dynamics and Control Methods*. In: Larramendy, M.L. & Soloneski, S. (eds.). Integrated Pest Management and Pest Control - Current and Future Tactics. Intech Open Science: Rijeka, Croatia: 215-240.

GIUNCHI, D., GAGGINI, V. & BALDACCINI, N.E. 2007. Distance sampling as an effective method for monitoring feral pigeon (*Columba livia* f. *domestica*) urban populations. *Urban Ecosystem*, 10: 397 – 412.

GODIN, A.J. 1994. *Birds at airports*. The handbook: prevention and control of wildlife damage: 56

GOODWIN, D. 1983. Behaviour. In: Wright, E.N. (ed.). *Physiology and Behaviour of the Pigeon*. Academic Press, London: 285 – 308.

GOOGLE MAPS, 2015. University of South Africa Muckleneuk campus [Online]. Available from: https://www.google.co.za/maps/dir//-25.756165,28.200316/@-25.7681391,28.1981992,730m/data=!3m1!1e3?hl=en. [Accessed: 05/10/2015].

GORENZEL, W.P. & SALMON, T.P. 1993. Tape-recorded calls disperse American crows from urban roosts. *Wildlife Society Bulletin*, 21: 334 – 338.

GŎRSKI, W. 1997. Urban and Rural Populations of the Magpie *Pica pica* in the

Koszalin Region, NW Poland. *Acta Ornithologica*., 32: 51 – 59.

GREGORY, R.D. & MARCHANT, J.H. 1995. Population trends of Jays, Magpies, Jackdaws and Carrion Crows in the United Kingdom. *Bird Study*, 43: 28 – 37.

GROBLER, N. ngrobler@unisa.ac.za 2013. AJH mite report. [Email to:] Harris, E. (emmaharris09@gmail.com) July 15.

HAAG-WACKERNAGEL, D. 1984. Ein Beitrag zur ökologie der Stadttaube. PhD Universität Basel: Basel.

HAAG-WACKERNAGEL, D. 1995. Regulation of the Street Pigeon in Basel. *Wildlife Society Bulletin,* 23(2): 256 – 260.

HAAG-WACKERNAGEL, D. 1998. Ecology of Feral Pigeons in Basel, Switzerland. In: Farina, A., Kennedy, J. & Bossu, V. (eds.). *INTECOL, VII International Congress of Ecology*, July 19-25, 1998, Florence.

HAAG-WACKERNAGEL, D. 2006. Human diseases caused by feral pigeons. In Advances in Vertebrate Pest Management, edited by C.J. Feare and D.P. Cowan. Filander Verlag, Fűrth 4, pp. 31-58.

HAAG-WACKERNAGEL, D. 2008. *Feral Pigeon Management* [Online]. Available from: www.Anatomie.unibas.ch/integrativeBiology/hag/Feral-Pigeon Strassentauben/pigeon-management.html [Accessed: 12/02/2013].
HAAG-WACKERNAGEL, D. & BIRCHER, A.J. 2009. Ectoparasites from feral

pigeons affecting humans. *Dermatology,* 220: 82 – 92.

HAAG-WACKERNAGEL, D. & GEIGENFEIND, I. 2008. Protecting buildings against feral pigeons. *European Journal of Wildlife Research*, 54:715-721.

HAAG-WACKERNAGEL, D., HEEDB, P. & LEISS, A. 2006. Phenotype-dependent selection of juvenile urban feral pigeons Columba livia: Capsule we suggest the existence of colour-based selection processes on juvenile feral pigeons in an urban environment. *Bird Study*, 53(2):163-170.

HAAG-WACKERNAGEL, D. & MOCH, H. 2004. Health hazards posed by feral pigeons. *Journal of Infection*, 48: 307 – 313.

HADIDIAN, J. 2007. *Wild Neighbours: The Humane Approach to Living with Wildlife.* 2nd ed. Humane Society Press, Washington DC.

HAMERSHOCK, D.M. 1992. Ultrasonics as a method of bird control. Wright Laboratory. Internal document.

HARRIS, E., DE CROM, E.P., LABUSCHAGNE, J.P. & WILSON, A. unpublished data. The use of an urban environment by Speckled Pigeons (*Columba guinea*) and feral pigeons (*Columba livia*) with special reference to the University of South Africa's Muckleneuk campus.

HARRIS, R.E. & DAVIES, R.A. 1998. *Evaluation of the efficacy of products and* *techniques for airport bird control*. Aerodrome Safety Branch Transport Canada: Ontario.

HASKELL, D.G., KNUPP, A.M. & SCHNEIDER, M.C. 2001. Nest predator abundance and urbanisation. In: Marzluff, J.M., Bowman, R. & Donnelly, R. (eds.). *Avian ecology and conservation in an urbanising world*. Kluwer Academic: Norwell, 243 – 258.

HEALTH PROTECTION PROGRAMS, 2011. *Public health fact sheet feral pigeons: management and control* [Online]. Available from: https://www.lga.sa.gov.au/webdata/resources/files/F35%20-%20Feral%20pigeons_management%20and%20control%20fact%20sheet.pdf [Accessed: 01/06/2013].

HELEN, B. 2001. "City Pigeons: Coo or Shoo?" *The Dominion (Wellington)* Feb, 6, 9.

HETMAŃSKI, T. & WOŁK, E. 2005. The Effect of Environmental Factors and Nesting Conditions on Clutch Overlap in the Feral Pigeon *Columba livia f. urbana* (GM.). *Polish Journal of Ecology*, 53(4): 523 – 534.

HETMAŃSKI, T. 2004. Timing of Breeding in the Feral Pigeon *Columba livia f.* domestica in Słupsk (NW Poland). *Acta Ornithologica*, 39(2): 105 – 110.

HETMAŃSKI, T. 2007. Dispersion Asymmetry within a Feral Pigeon *Columba livia* population. *Acta Ornithologica*, 42(1): 23 – 31.

HEWSON, R. 1967. The Rock Dove in Scotland in 1965. *Scott Birds,* 4:359–371

HURST, W. 2006. Watch the birdie! [Online]. Available from: www.building.co.uk [Accessed: 06/05/2013].

HUTTON, R. 2005. *Method statement for the control of feral pigeons* [Online]. Available from: http://www.handr.co.uk/literature/feral_pigeons.htm. [Accessed: 05/08/2014].

HUTTON & ROSTRON. 2005. Method statement for the control of feral pigeons [Online]. Available from: http://www.handr.co.uk/literature/feral_pigeons.htm. [Accessed: 05/12/2012].

HUTTON, T.C. & DOBSON, J. 1993. The control of feral pigeons: an independent approach. *Structural Survey*, 11(2): 159 – 167.

HUTTON, M. & GOODMAN, G.T. 1980. Metal contamination of feral pigeons *Columba livia* from the London area. 1. Tissue accumulation of lead, cadmium, and zinc. *Environmental Pollution Series a-Ecological and Biological*, 22: 207 – 217.

INGLIS, I.R. & ISAACSON, A.J. 1984. The responses of Woodpigeons (*Columba palumbus*) to pigeon decoys in various postures: a quest for a super-normal alarm stimulus. *Behaviour*, 90(4): 224 – 240.

ISHIGAME, G., & BAXTER, G.S. 2007. Practice and attitudes of suburban and rural dwellers to feeding wild birds in Southeast Queensland, Australia. *Ornithological Science,* 6, 11–19.

JACOBS, G.H. 1992. Ultraviolet vision in vertebrates. *American Zoologist*, 32: 544 – 554.

JACQUIN, L., CAZELLES, B., PRÉVOT-JULLIARD, A., LEBOUCHER, G. & GASPARINI, J. 2010. Reproduction management affects breeding ecology and reproduction costs in feral urban pigeons (*Columba livia*). *Canadian Journal of Zoology,* 88, Aug: 781 – 787.

JENNINGS, G. 2001. *Tourism Research*. John Wiley and Sons: Queensland.

JEROLMACK, C. 2008. How pigeons became rats: The cultural-spatial logic of problem animals. *Social problems,* 55(2):77-94.

JOHNSTON, R.F. 1992a. Evolution in the Rock Dove: Skeletal Morphology. *The Auk*, 109: 530 – 542.

JOHNSTON, R.F. 1992b. Rock Dove. In: Poole, A., Stettenheim, P. & Gill, F. (eds.). *The Birds of North America*. The American Ornithologists' Union: Washington.

JOHNSON, R.J., 2000. Management of pest birds in urban environments. *Other Publications in Wildlife Management*: 16.

JOHNSTON, R.F. & JANIGA, M. 1995. *Feral pigeons.* New York: Oxford University Press.

JOKIMÄKI, J., KAISANLAHTI-JOKIMÄKI, M., SORACE, A., FERNÁNDEZ-JURICIC, E., RODRIGUEZ-PRIETO, I. & JIMENEZ, M.D. 2005. Evaluation of the "Safe Nesting Zone" Hypothesis across an Urban Gradient: a multi-scale study. *Ecography*, 28: 59 – 70.

JONES, J. 2001. Habitat Selection Studies in Avian Ecology: A Critical Review. *The Auk*, 118(2): 557 – 562.

KAUTZ, E.J. 1985. Effects of harvest on feral rock pigeon survival, nest success, and population size. PhD University of Cornell: Ithaca.

KAUTZ, E.J. 1990. Testing for compensatory responses to removals from wildlife populations. In: *Proceedings of the Trans 55th North American Wildlife. & Natural. Resources. Conference*.: 527 – 533.

KEENAN, K. 2000. Town to roust birds from roost. *Worcester Telegram & Gazette*, Jan. 17: B1.

KEIDAR, H., MORAN, S. & WOLF, J. 1975. Playback of distress calls as a means of preventing losses to agriculture by birds. I. Playback experiment with larks (1970-1974). Rep. for Israeli Ministry of Agriculture: 24.

KENIGER, L.E., GASTON, K.J., IRVINE, K.N. & FULLER, R.A. 2013. Whatr are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health*, 10(3): 913 – 935.

KENWARD, R.E. 1978. The influence of human and Goshawk (*Accipiter gentilis*) activity on Wood Pigeons (*Columba palumbus*) at Brassica feeding sites. *Annals of Applied Biology*, 89: 277 - 286.

KOCHERT, M.N. 1972. Population Status and Chemical Contamination in Golden Eagles in Southwestern Idaho. M.Sc. University of Idaho, Moscow, USA.

KOEN, J. & JENKINS, A. 2011. Raptors and racing pigeons [Online]. Available from: HAAG-WACKERNAGEL, D. 2008. *Feral Pigeon Management* [Online]. Available from: http://www.andersonafrica.co.za/pamphlets/Raptors_and_pigeons.pdf [Accessed: 01/05/2012].

KŐRTNER, G. & GEISER, F. 1999. Roosting Behaviour of the Tawny Frogmouth (*Podargus strignides*). *Journal of Zoology,* 248: 501 – 507.

KREBS, L.B. 1974. Feral Pigeon Control. In: *Proceedings of the 6th Vertebrate Pest Conference*: 257 – 262.

KREBS, J.R. & DAVIES, N.B. 1993. *An introduction to behavioural ecology*. Oxford: Blackwell Scientific

KRIMOWA, S. 2012. Pigeons and People: Resource Ecology and Human Dimensions of Urban Wildlife. M.Sc. Victoria University of Wellington, Wellington.

KRUGER, A. C. 2004. *Climate of South Africa. Climate Regions. WS45*. South African Weather Service. Pretoria. South Africa.

KRUGER, B. (krugebj@unisa.ac.za). 2015. Request for information for research purposes. [Email to:] Harris, E (emmaharris09@gmail.com) Dec. 7.

LANGEMANN, U., HAMANN, I. & FRIEB, A. 1999. A behavioral test of presbycusis in the bird auditory system. *Hearing Research,* 137: 68–76.

LATOUR, B. 2004. *Politics of nature*. Cambridge: Harvard University Press.

LAWTON, J.H. 1998. Pigeons, peregrines and people. *Oikos,* 83: 209 - 211.

LEONARD, J.P. 1998. Nesting and Foraging Ecology of Band-tailed Pigeons in Western Oregon. PhD Oregon State University, Oregon.

LEVER , C. 1987. *Naturalised Birds of the World*. New York: Wiley.

LEVI, W.M. 1963 [1941]. *The Pigeon*. Sumter: Levi Publishing Co.

LIMA, S. L. 1985. Maximizing feeding efficiency and minimizing time exposed to predators: a trade-off in the black-capped chickadee. *Oecologia* (Berlin), 66: 60 – 67.

LIMA, S.L. & Dill, L.M. 1990. Behavioral decisions made under risk of predation: a review and prospectus. *Canadian Journal of Zoology*, 68: 619 – 640.

LINZ, G.M., HOMAN, H.J. & BLEIER, W.J. S.a. *Control of bird pests in sunflower crops: options and limitations* [Online]. Available from: www.asagir.org.ar [Accessed: 07/09/2014].

LITTLE, R.M. 1994. Marked Dietary Differences between Sympatric Feral Rock Dives and Rock Pigeons. *South African Journal of Zoology*, 29(1): 33 – 35.

LOFTS, B., MURTON, R.K. & WESTWOOD, N.J. 1966. Gonadal Cycles and the Evolution of Breeding Seasons in British Columbidae. *Journal ofZoology*, 150: 249 – 272.

LÓPEZ-LÓPEZ, P., VERDEJO, J. & BARBA, E. 2009. The role of pigeon consumption in the population dynamics and breeding performance of a peregrine falcon (*Falco peregrinus*) population: conservation implications. *European Journal of Wildlife Research*, 55: 125 – 132.

LORANGER, S., DEMERS, G., KENNEDY, G., FORGET, E. & ZAYED, J. 1994. The pigeon (*Columba livia*) as a monitor for manganese contamination from motor vehicles. *Archives of Environmental Contamination and Toxicology*, 27: 311 – 317.

LUNIAK, M. 2004. Synurbanization – adaptation of animal wildlife to urban development. In: Shaw, W.W., Harris, L.K., Vandruff, L. (eds.). *Proceedings of the 4th International Symposium on Urban Wildlife Conservation*. Arizona: Tucson: 50–

55.

MAGNINO, S., HAAG-WACKERNAGEL, D., GEIGENFEIND, I., HELMECKE, S., DOVC, A., PRUKNER-RADOVCIC, E., RESIDBEGOVIC, E., ILIESKI, V., LAROUCAU, K., DONATI, M., MARTINOV, S., & KALETA, E.F. 2009. Chlamydial infections in feral pigeons in Europe: Review of data and focus on public health implications. *Veterinary Microbiology,* 135, 54-67.

MALAN, J. 2014. Pigeon fancier and racer. Personal communication.

MARTIN, T.E. 1993. Nest Predation and Nest Sites: New Perspectives on Old Patterns. *BioScience*, 43: 523 – 532.

MATUSOKA, R. H. & KAPLAN, R. 2008. People needs in the urban landscape: Analysis of Landscape and Urban Planning contributions. *Landscape and Urban Planning,* 84: 7-19.

MATYJASIAK, P. 2008. Methods of bird control at airports. In: Uchmański, J. (ed.) *Theoretical and applied aspects of modern ecology*. Cardinal Stefan Wyszyński University Press: Warsaw: 171 – 203.

MCCLEERY, R.H. 1978. Optimal behaviour sequences and decision making. In: Krebs, J.R. & Davies, N.B. (eds.). *Behavioural ecology: an evolutionary approach*. Blackwell: Oxford: 377-410.

MCCOLLIN, D. 1998. Forest Edges and Habitat Selection in Birds: A Functional Approach. *Ecography*, 21: 247 – 260.

MCKEOWN, D. 2008. Toronto Pigeon feeding. Internal Document.

MICHAEL, M. 2004. Roadkill: Between humans, nonhuman animals and technologies. *Society and Animals*, 12(4): 278 – 298.

MOOALLEM, J. 2006. Pigeon Wars. *New York Times Magazine*, Oct. 15:54.

MOSHER, J.A. & WHITE, C.M. 1976. Directional Exposure of Golden Eagle Nests. *Canadian Field-Naturalist.,* 90: 356 – 359.

MOTT, D.F. & TIMBROOK, S.K. 1988. Alleviating nuisance Canada goose problems with acoustical stimuli. *Vertebrate Pest Conference*, 13: 301 – 304.

MURTON, R.K. 1966. Natural Selection and the Breeding Seasons of the Stock Dove and Wood Pigeon. *Bird Study*, 13(4): 311 – 327.

MURTON, R.K., THEARLE, R.J.P. & COOMBS, C.F.B. 1972. Ecological studies of the feral pigeon Columba livia var. lll. Reproduction and plumage polymorphism. *Journal of. Applied Ecology,* 9, 841 – 853.

MURTON, R.K., THEARLE, R.J.P. & THOMPSON, R.J.P. 1972. Ecological studies of the feral pigeon Columba livia var. l. Population, breeding biology and methods of control. Journal of Applied Ecology,. 9, 835 - 874.

NAYLOR, A.J. 2015. The occurrence, behaviour and public perception of rock hyraxes, *Procavia capensis*, in urban areas. M.Sc. University of the Witwatersrand, Johannesburg

NTSHOE, L. 2013. Catering and Cleaning manager, University Estates, UNISA. Personal communication.

O'REGAN, S.M., FLYNN, D., KELLY, T.C., O'CALLAGHAN, M.J.A., POKROVSKII, A.V. & RACHINSKII, D. 2012. The response of the woodpigeon (Columba palumbus) to relaxation of intraspecific competition: A hybrid approach. *Ecological Modelling*, 224: 54 – 64.

ONTIVEROS, D. 1999. Selection of Nest Cliffs by Bonelli's Eagle (*Hieraaetus fasciatus*) in South-eastern Spain. *Journal of Raptor Research,* 33(2): 110 – 116.

OXLEY, J.A. 2013.Feral pigeon control and welfare. *Veterinary Record:* 172

PETER COX. 2013. Commercial bird deterrence [Online]. Available from: https://www.petercox.com/commercial/bird-deterrence/ [Accessed: 05/11/2013].

PHILLIPS, R.B., SNELL, H.L. & VARGAS, H. 2003. Feral rock doves in the Galápagos Islands: Biological and economic threats. *Noticias de Galápagos*, 62:6-10.

PHILO, C. 1995. Animals, Geography, and the City: Notes on Inclusions and Exclusions. *Environment and Planning D: Society and Space* 13: 655-681.

PHILO, C. & WILBERT, C. (eds.). 2000. *Animal Spaces, Beastly Places: New Geographies of Human-Animal Relations*. Psychology Press, New York.

PICKETT, S.T.A, CADENASSO, M.L., GROVE, J.M., BOONE, C.G., IRWIN, E., GROFFMAN, P.M., KAUSHAL, S.S., MARSHALL, V., MCGRATH, B.P., NILON, C.H., POUYAT, R.V., SZLAVECZ, K., TROY, A., & WARREN, P. 2011. Urban ecological systems: a decade of progress. *Journal of Environmental Management,* 92,331–362.

PIGEON CONTROL RESOURCE CENTRE. 2016. Sonic and bio-acoustic pigeon and bird control [Online]. Available from: http://www.pigeoncontrolresourcecentre.org/html/reviews/sonic-pigeon-and-bird-control.html [Accessed: 05/08/2014].

PIMENTEL, D., LACH, L., ZUNIGA, R. & MORRISON, D. , 1999. Environmental and economic costs associated with non-indigenous species in the United States. *Cornell Chronicle*, June 12.

PLAYER, I. 2007. *Zululand wilderness shadow and soul*. Cape Town: David Philip Publishers.

PLUTA, A. 2012. Integrated well-being: positive psychology and the natural world. MAPP. dissertation, Pennsylvania: University of Pennsylvania.

PRIEGO, C., BREUSTE, J.H., & ROJAS, J. 2008. Perception and value of nature in urban landscapes: a comparative analysis of cities in Germany, Chile and Spain. *Landscape Online* 7:1-22.

PULLIAM, H.R. 1976. The principle of optimal behaviour and the theory of communities. In: Bateson, P.P.G. & Klopfer, P.H. (eds.). *Perspectives in ethology, vol 2*. Plenum Press: New York: 311 – 332

RATCLIFFE, D.A. 1993. *The Peregrine Falcon*, 2nd ed. Poyser, London.

REINKE, E. 1959. Die verwilderten Haustauben im Hamburg. Zeitschrift für angerwandte Zoologie. 46:285 – 301.

REITER, D.K., BRUNSON, M.W. & SCHMIDT, R.H. 1999. Public attitudes toward wildlife damage management and policy. *Wildlife Society Bulletin*, 27:746 - 758.

REYNOLDS, E. 2013. Fowl friends. Socialist explores the love-hate relationship between people and pigeons. *NYU Alumuni Magazine* [Online] 20:Spring. Available from: https://www.nyu.edu/alumni.magazine/issue20/nyc_1.html [Accessed: 04/09/2014].

ROBBINS, C.S. 1995. Non-native birds. In: LaRoe, E.T., Farris, G.S., Puckett, C.E., Doran, P.D. & Mac M.J. (eds.). *Our Living Resources: a Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals and Ecosystems.* U.S. Department of the Interior, National Biological Service: Washington, DC: 437 – 440.

ROLLINSON, D., O'LEARY, R. & JONES, D.N. 2003. The practice of wildlife feeding in suburban Brisbane. *Corella*, 27:52–58.

ROSE, E., NAGEL, P. & HAAG-WACKERNAGEL, D. 2006. Spatio-temporal use of the urban habitat by feral pigeons (*Columba livia*). *Behavioral Ecological Sociobiology*, 60: 242 – 254.

RUTZ, C. 2012. Predator fitness increases with selectivity for odd prey. *Current Biology*, 22: 820 – 824.

RYAN, A.C. 2011. The distribution, density, and movements of feral pigeons *Columba livia* and their relationship with people. M.Sc. Victoria University of Wellington, Wellington.

RYZHOV, S.K. & MURSEJEV, M.R. 2010. Trained goshawks against pigeons. *Raptors Conservation*, 20: 25 – 34.

SA **see** SOUTH AFRICA.

SABLOFF, A. 2001. *Reordering the natural world*. Toronto: University of Toronto Press.

SACCHI, R., GENTILLI, A., RAZZETTI, E. & BARBERI, F. 2002. Effects of Building Features on Density and Flock Distribution of Feral Pigeons *Columba livia var.domestica* in an Urban Environment. *Canadian Journal of Zoology*. 80: 48 – 54.

SANDERS, C.R. 2003. Actions speak louder than words: close relationships between humans and nonhuman animals. *Symbolic Interaction*, 26(3): 405 – 426.

SANTA BARBARA CITY COLLEGE. 2012. Integrated Pest Management Plan. Internal document.

SARVARD, J.L., CLERGEAU, P. & MENNECHEZ, G. 2000. Biodiversity concepts and urban ecosystems. *Landscape Urban Planning*, 48: 131 – 142.

SEAMANS, T.W., BARRAS, S.C. & BERNHARDT, G.E. 2007. Evaluation of two perch deterrents for starlings, blackbirds and pigeons. *International Journal of Pest Management,* 53: 45 – 51.

SEAMANS, T.W., BARRAS, S.C. & PATTON, Z.J. 2007. Are birds scared by rotating mirrors? In: *Proceedings of the Bird Strike Committee USA Canada 5th Annual Meetin, held in Toronto on 18 – 21 August, 2003*. Ontario: Toronto.

SEAMANS, T.W. & BLACKWELL, B.F. 2011. Electric Shock Strips as Bird Deterrents: Does Experience Count? *International Journal of Pest Management*, 57(4): 357 – 362.

SEAMANS, T. W., LOVELL, C.D., DOLBEER, R.A., CEPEK, J.D. 2001. Evaluation of mirrors to deter nesting Starlings. *USDA National Wildlife Research Centre:* 613.

SEAMANS, T.W., MARTIN, J.A. & BELANT, J.L. 2013. Tactile and auditory repellents to reduce wildlife hazards to aircraft. *Wildlife Management Techniques*.

SHEA, K., THRALL, P.H. & BURDON, J.J. 2000. An integrated approach to management in epidemiology and pest control. *Ecology letters*, 3: 150 – 158.

SHETTY, S., BHARATHI, L., SHENOY, K.B & HEGDE, S.N. 1992. Biochemical properties of pigeon milk and its effect on growth. *Journal of Comparative Physiology*, 162: 632 – 636.

SHOCHAT, E., LERMAN, S. & FERNÁNDEZ-JURICIC, E. 2010. Birds in Urban Ecosystems: Population Dynamics, Community Structure, Biodiversity and Conservation. *Urban Ecosystem Ecology*: 75 – 86.

SHOCHAT, E., LERMAN, S.B., KATTI, M., & LEWIS, D.B. 2004. Linking optimal foraging behavior to bird community structure in an urban-desert landscape: Field experiments with artificial feeding patches. *American Naturalist,* 164, 232-243.

SHOCHAT, E., WARREN, P.S., FAETH, S.H., MCINTYRE, N.E. & HOPE, D. 2006. From patterns to emerging processes in urban evolutionary ecology. *Trends in Ecology & Evolution,* 21:186-191.

SHOTTER, R.A. 1978. Aspects of the Biology and Paraistology of the Speckled Pigeon *Columba guinea* L. from Ahmadu Bello University Campus, Zaria, North Central State, Nigeria. *Zoological Journal of the Linnean Society*, 62: 193 – 203.

SKEAD, D.M. 1969. A Study of the Rock Pigeon *Columba guinea*. *Ostrich*, 42(1): 65 – 69.

SMYTHE, R.H. 1975. *Vision in the Animal World*, New York, USA: The Macmillan Press Ltd.

SOL, D. & SENAR, J.C. 1995. Urban pigeon populations: stability, home range, and the effect of removing individuals. *Canadian Journal of Zoology*, 73: 1154 – 1160.

SOL, D., SANTOS, D.M., GARCIA, J., CUADRADO, M. (1998). Competition for food in urban pigeons: the cost of being juvenile. *Cooper Ornithological Society,* 100:298-304.

SOLDATINI, C., MAINARDI, D., BALDACCINI, N.E. & GIUNCHI, D. 2006. A Temporal Analysis of the Foraging Flights of Feral Pigeons (Columba livia f. Domestica) from Three Italian Cities. *Italian Journal of Zoology*, 73(1): 83 – 92.

SORACE, A. 2002. High density of bird and pest species in urban habitats and the role of predator abundance. *Ornis Fennica*, 79: 60 – 71.

SOSSINKA, K. 1982. Domestication in birds. *Avian Biology*, 6: 373 – 403.

SOUTH AFRICA. 2010. National Environmental Management: Biodiveristy Act, 2004 (Act No. 10 of 2004). *General Notice of the Department of Environmental Affairs*, 1084(2010), Nov. 26.

SOUTH AFRICA. 2015. National Environmental Management: Biodiversity Act 2004 (Act No, 10 of 2004) Draft Amendments to the Alien and Invasive Species Lists, 2015. Government Gazette, 493, May 29. (Regulation Gazette No. 38833).

SOUTH AFRICA. Department of Cooperative Governance and Traditional Affairs. 2014. Towards an integrated urban development framework [Online]. Available from: http://sacitiesnetwork.co.za/wp-content/uploads/2014/08/urban-policy.pdf [Accessed: 29/01/2016].

SOUTH AFRICA. Department of Environmental Affairs. 2015. Feral pigeon invasive species [Online]. Available from: https://www.environment.gov.za/mediarelease/feralpigeon_invasivespecies [Accessed: 10/12/2015].

SOUTH AFRICAN WEATHER SERVICE, 2010. Climate of South Africa. WB42 Climate Statistics 0513465. *University of Pretoria Proefplaas*.

SPANIER, E. 1980. The use of distress calls to repel night herons (*Nycticorax nycticorax*) from fish ponds. *Journal of Applied Ecology*, 17: 287 – 294.

STERN, P., KALOF, L., DIETZ, T., & GUAGNANO, G. 1995. Values, beliefs, and pro environmental action: attitude formation toward emergent attitude objects. *Journal of Applied Social Psychology,* 25(18),1611-1636.

STRINGHAM, S.A, MULROY, E.E, XING, J., RECORD, D., GUERNSEY, M.W., ALDENHOVEN, J.T., OSBORNEE, J. & SHAPIRO, M.D. 2012. Divergence, convergence, and the ancestry of feral populations in the domestic rock pigeon. *Current Biology*, 22: 1 – 7.

SUMMERS, R.W. 1985. The effect of scarers on the presence of starlings (*Sturnus vulgaris*) in cherry orchards. *Crop Protection*, 4: 520 – 528.

SURVEY MONKEY. 2015. *Survey Monkey* [Online]. Available from: https://www.surveymonkey.com/ *[Accessed: 28/01/2015].*

TEMBY, I. 2004. Urban wildlife issues in Australia. In: *4th International Urban Wildlife Symposium*, University of Arizona, Tuscon.

TERRE BLANCHE, M., DURRHEIM, K., & PAINTER, D. 2006. *Research in practice: Applied methods for the social sciences* (2nd ed.). Cape Town: University of Cape Town Press.

TIGAS, L.A., VAN VUREN, D.H. & SAUVAJOT, R.M. 2002. Behavioural responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. *Biological Conservation*, 108: 299 – 306.

TOBIN, M.E., WORONECKI, P.P., DOLBEER, R.A. & BRUGGERS, R.L. 1988. Reflecting tape fails to protect ripening blueberries from bird damage. *Wildlife Society Bulletin*, 16: 300 – 303.

TREVES, A. & NOUGHTON-TREVES, L. 2005. Evaluating lethal control in the management of human-wildlife conflict. In: WOODROFFE, R., THIEGOOD, S. & RABINOWITZ, A. *People and Wildlife, Conflict or Co-existence?* Cambridge University Press: New York.

TSURIM, I., ABRAMSKY, Z. & KOTLER, B.P. 2008. Foraging Behaviour of Urban Birds: Are human commensals less sensitive to predation risk that their nonurban counterparts? *The Condor*, 110(4): 772 – 776.

UNISA. 2015. *UNCG* [Online]. Available from: http://unisa.ac.za/ungc/index.html [Accessed: 11/02/2015].

UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION. 2014. *World urbanization prospects: the 2014 revision, highlights.*

VAN NIEKERK, J.H. 2003. Grain Selection and Flocking of Rock Pigeons at a Cattle Feedlot in Gauteng Province, South Africa. *South African Journal of Wildlife Research*, 33(2): 138 – 141.

VAN NIEKERK, J.H. 2009. Loss of Sunflower Seeds to Columbids in South Africa: Economic Implications and Control Measures. *Ostrich*, 80(1): 47 – 52.

VAN NIEKERK, J.H. & VAN GINKEL, C.M. 2004. The Feeding Behaviour of Pigeons and Doves on Sown Grain Crops on the South African Highveld. *Ostrich*, 75(1&2): 39 – 43.

WALSBERG, G.E. 1986. Thermal Consequences of Roost-Site Selection: The Relative Importance of Three Modes of Heat Conservation. *The Auk*, 103: 1 – 7.

WALSBERG, G.E. & KING, J.R. 1980. The Thermoregulatory Significance of the Winter Roost-sites selected by Robins in Eastern Washington. *Wilson Bulletin*, 92: 33 – 39.

WANLESS, R.M. & JUPITER, T.A. 2002. Predation on Doves by Pied Crows, *Corvus albus*, on Aldabra Atoll. *Ostrich*, 73(1&2): 59 – 78.

WARWICK, C. 2003. Save The Trafalgar Square Pigeons [Online]. Available from: http://www.savethepigeons.org/HawkReportP1.pdf. [Accessed: 18/11/2013].

WEBER, J., HAAG-WACKERNAGEL, D. & DURRER, H. 1994. Interactions between humans and pigeons. *Anthrozoös*, 1: 55 - 59.

WESTINGTON, J. 2013. Pest control manager, UNISA. Personal communication.

WETHERBEE, D.K., COPPINGER, R.P., WENTWORTH, B.C. & WALSH, R.E. 1964. Antifecundity effects of sudan black B and transovarian intravital staining in avian population control. *Experimental Station Bulletin* 543, College of Agriculture, University of Massachusettes Amherst, USA.

WOLCH, J., & EMEL, J. (eds.). 1998. *Animal geographies*. New York: Verso.

ZUCCONI, S., GALAVOTTI, S. & DESERTI, R. 2003. I colombi in ambiente urbano

– Sintesi del progetto di ricerca Nomisma. *Disinfestazione*, Nov/Dec.: 9 – 21.

ZWARTJIES, P.W. & NORDELL, S.E. 1998. Patterns of Cavity-Entrance Orientation by Glided Flickers (*Colaptes chrysoides*) in cardŏn cactus. *The Auk*, 115: 119 – 126

<u>Note:</u> All photographs in the dissertation were taken by the author unless otherwise indicated.

APPENDICES

APPENDIX A

Online Survey Monkey questionnaire

Perceptions of pigeons

---

1. Please rate the following statements: *(circle one)*

"Pigeons are flying rats"	1. Strongly disagree
	2. Disagree
	3. Undecided
	4. Agree
	5. Strongly agree
"Pigeons allow a connection to nature"	1. Strongly disagree
	2. Disagree
	3. Undecided
	4. Agree
	5. Strongly agree

2. What is your view or perception on pigeons?

____

____

3. Where did these perceptions originate? *(check appropriate categories)*

□ Friends

□ Family

□ Media / internet

□ Pest control groups

□ Health authorities

□ Other. Please specify: ____

4. Have your perceptions of pigeons changed over time? Yes / No

If yes, why and how?____

If no, are you willing to change your perceptions? Why or why not?

____

Pigeon populations on campus

5. How do you feel about the various pigeon activities on campus: *(circle one)*

	Strongly oppose	Oppose	Undecided	Encourage	Strongly encourage
a) Feeding (artificially by humans)	1	2	3	4	5

	Strongly oppose	Oppose	Undecided	Encourage	Strongly encourage
b) Roosting	1	2	3	4	5

	Strongly oppose	Oppose	Undecided	Encourage	Strongly encourage
	1	2	3	4	5

c) Nesting and breeding

6. In your opinion how do the following pigeon-related aspects impact people on campus?

(circle one each)

6.1 Nesting material

Extremely negative	Negative	Undecided	Positive	Extremely positive
1	2	3	4	5

6.2 Ectoparasites (lice and or ticks)

Extremely negative	Negative	Undecided	Positive	Extremely positive
1	2	3	4	5

6.3 Viewing of chicks in nests

Extremely negative	Negative	Undecided	Positive	Extremely positive
1	2	3	4	5

6.4 Feeding the pigeons

Extremely negative	Negative	Undecided	Positive	Extremely positive
1	2	3	4	5

6.5 Daily interaction with pigeons

Extremely negative	Negative	Undecided	Positive	Extremely positive
1	2	3	4	5

7. Do you consider the pigeons on campus to be a problem? Yes / No

If yes, what would you like to see done about it? ___________________________

8. Have you complained about the pigeons on campus? Yes / No

If yes, about what, when and to whom? __________________________________

9. Should pigeon populations at the campuses be: a). managed or b). eradicated? or c). other? *(choose one)* ______________

10. How do you feel about pigeon management on the campuses? *(check one)*

□ A necessity; □ A solution; □ An unsustainable solution; □ A waste of time; □ Can't be bothered

11. Which of the pigeon management options below do you think would have the most impact for a sustainable period of time? *(Check appropriate categories)*

□ Trapping and removal

□ Killing (shooting or poisoned baits)

□ Bird spikes (a physical barrier which prevents pigeons from roosting or nesting)

□ Falcons

□ Netting on buildings

□ Clearing of nests

□ Scare devices (eg. eagle eyes)

□ Contraceptives

□ None

Human aspect

---

12. Do you think humans are the cause of the pigeon population problems in urban environments? Yes / No.

Reason: ____

13. Whose responsibility should it be to control the pigeons in urban environments? *(circle one)*

a) Municipality

b) Building management departments

c) Non-profit organisations

d) Animal welfare societies

e) Public

f) Other (please specify): ____

14. Are you involved or interested in conservation related topics and activities?

Yes / No. If yes, what? ____

15. Please provide any comments or opinions you may have regarding this project or pigeons populations in urban environments:

____

____

Thank you for your time to complete this questionnaire

If you have any further questions or comments please do not hesitate to contact the primary researcher at unisapigeons@gmail.com. Thank you, Emma Harris

APPENDIX B

Four e-notices sent to all UNISA staff members throughout the year (September 2013 – September 2014) informing them about the online survey and encouraging their participation

1. The Muckleneuk Campus and its pigeons. What is happening? https://staff.unisa.ac.za/e-connect/e-notice/2014/04/25/the-muckleneuk-campus-and-its-pigeons-what-is-happening/

The Muckleneuk Campus and its pigeons. What is happening?

There has been an issue with the pigeons on the Muckleneuk Campus for many years. In response to numerous and varied complaints, a research project was identified in 2012 to develop a holistic, integrated and humane pigeon management control plan to specifically meet the needs of Unisa's Muckleneuk Campus ("Unisa" being defined as all its staff and its infrastructure). This is the first time that a "pest" control programme has ever considered members of staff at the site of the problem, and Unisa and the research team are to be acknowledged for their forward thinking approach to the situation. This research is the topic of a Unisa MSc Environmental Sciences student, within the College of Agriculture and Environmental Sciences.

Ms Emma Harris, the student in question, has for one year counted the number of pigeons on every ledge of every building every week – no small task. Now that she has her baseline data, we are excited at installing the various control structures around the campus. The types of control structures and their placement have been carefully considered and guided by literature, pest control specialists and Emma's findings. These structures have, however, been eliciting some responses and concerns from various staff members. Firstly, they are not permanent. They are to be in place for a period of one year. Part of Emma's research is to compare the efficiency of the various humane control measures implemented. A final decision will only be made after one year of data collection, and the decision will be based on efficiency and other factors.

Unfortunately, the research has already been delayed by five months for several reasons; the latest is the annoyance expressed about the presence of the structures. In an effort to address staff with issues and concerns, University Estates who deal with all the complaints, and of course Emma who has already spent 1½ years on this research, we are requesting the following in an effort to expedite the implementation phase and appease all concerned:

How can you have your say?

- Last year a questionnaire was sent out to assess the effects, both positive and negative, of the pigeons on members of staff and the campus. Unfortunately, only a small number of people responded and a larger data set is required for research purposes. So if you did not participate in that survey, please feel free to log onto **https://www.surveymonkey.com/s/UNISApigeons** and complete it there. Unisa ethical clearance has been granted for the questionnaire, and it is of course anonymous and voluntary.
- If any control structures are negatively affecting you and you are unable to cope with their presence for one year, then please notify Emma by no later than 9 May 2014, as she would like to address the issues sooner rather than later so that her next year of data collection can begin!
- If you have any questions, we would be more than happy to answer them! This research project started as an initiative to include members of staff in decision making on issues pertaining to the pigeons on the campus, and we still hold true to

that ideal and would be very happy to interact with any member of staff interested in doing so. Emma can be contacted at **unisapigeons@gmail.com** and her supervisor Ms Ann Wilson in the Department of Environmental Sciences at **cheata@unisa.ac.za**

Thanking you all for your time and hoping to work with you to reach a common goal!

Kind regards

The research team

April 25th, 2014 | Category: Academic

2. An update on the Muckleneuk Pigeon Research Project https://staff.unisa.ac.za/e-connect/e-notice/2014/06/27/an-update-on-the-muckleneuk-pigeon-research-project/

An update on the Muckleneuk Pigeon Research Project

A short background for those not yet familiar with the research

There has been an issue with the pigeons on the Muckleneuk Campus for many years. In response to numerous and varied complaints, a research project was identified in 2012 to develop a holistic, integrated and humane pigeon management control plan to specifically meet the needs of Unisa's Muckleneuk Campus ("Unisa" being defined as all its staff and its infrastructure). This is the first time that a "pest" control programme has ever considered members of staff at the site of the problem, and Unisa and the research team are to be acknowledged for their forward thinking approach to the situation. This research is the topic of a Unisa MSc Environmental Sciences student, within the College of Agriculture and Environmental Sciences.

Phase 1 was the control year and ran from 1 February 2013 to 31 January 2014. This required Ms Emma Harris, the student in question, to count the number of pigeons on every ledge of every building every week.

Phase 2 is the interview phase and is currently underway. Many of you have been kind enough to respond to our electronic questionnaires and some of you are currently answering face-to-face questionnaires with Emma. If you have not yet completed the questionnaire, may we please request that you do, as we would love to have your opinion reflected in our study. Simply follow this link:**https://www.surveymonkey.com/s/UNISApigeons**

Phase 3 is the exciting phase which will see the various structures (some of which you may have seen go up already) being monitored for a year. This phase was delayed for a few months due to the various and very different responses which they elicited. After our e-notice message (in which we urged affected parties to contact us) we managed to liaise with everyone affected and or concerned, and after several discussions and meetings, managed to map a way forward

Where we are now?

We are happy to announce that a middle ground with regard to the control structures has been reached! Flashes from the eagle eyes, which have been causing irritation to staff, and which have since been turned off and covered, will be attended to through the implementation of strategically placed shields. The installation of the flash shields on existing eagle eyes will commence immediately, and once completed the flash flags and eagle eyes will be uncovered and turned on to commence this phase of the research. The project has been amended to reduce staff impact as much as possible. We request staff to please tolerate the flash flags and eagle eyes for the finite period of one year for phase 3, which will allow the researcher to test the effectiveness of the various control structures. The researcher will continue to take staff concerns into consideration throughout the testing phase.

Thank you to all who have contributed and shown interest in the project thus far. The project's progress has been shaped by your input and direction. Should you have any comments and queries regarding the project please contact the researcher, Ms Emma Harris at **unisapigeons@gmail.com**.

Kind regards

The research team

June 27th, 2014 | Category: General

3. An update on the Muckleneuk Pigeon Research Project https://staff.unisa.ac.za/e-connect/e-notice/2014/09/29/an-update-on-the-muckleneuk-pigeon-research-project-2/

An update on the Muckleneuk Pigeon Research Project

A short background introduction for those not yet familiar with the research:

There has been an issue with the pigeons on the Muckleneuk Campus for many years. In response to numerous and varied complaints, a research project was identified in 2012 to develop a holistic, integrated and humane pigeon management control plan to specifically meet the needs of Unisa's Muckleneuk Campus ("Unisa" being defined as all its staff and its infrastructure). This is the first time that a "pest" control programme has ever considered members of staff at the site of the problem, and Unisa and the research team are to be acknowledged for their forward thinking approach to the situation. This research is the topic of a Unisa MSc Environmental Sciences student, within the College of Agriculture and Environmental Sciences.

The project's final phase is currently underway. Various control structures and or strategies have been implemented on the various buildings on campus. Ms Emma Harris, the student in question, counts the number of pigeons on every ledge of every building every week. It has been noted that since the implementation of the control structures, there has been a drop in the number of pigeons on campus. The remaining pigeons have started to make use of the nest boxes, installed on Theo van Wijk and Or Tambo, this in an effort to manage a smaller, healthy pigeon population. The effectiveness of the specific structures and strategies will continue to be monitored for the duration of this phase which will come to an end in August 2015.

Thank you to all who have contributed and shown interest in the project thus far. This project would not have been possible without the substantial support, assistance and guidance of the following people and institutions (we would like to apologise now for the omission of the vote of thanks, in the upcoming Focus magazine August issue)

- Prof L Brown
  Applied Behavioural Ecology and Ecosystem Research Unit (ABEERU)
  Department of Environmental Science
  College of Agriculture and Environmental Science
- Mr I Mogomotsi, Executive Director of University Estates
- Ms A Wilson (supervisor)
  Department of Environmental Science
  College of Agriculture and Environmental Science

- Dr EP de Crom (co-supervisor)
  Department of Nature Conservation
  Faculty of Science
  Tshwane University of Technology
- The University and all its staff
- Unisa Postgraduate bursary
- NRF Master's scholarship

Should you have any comments and queries regarding the project please contact the researcher, Ms Emma Harris at **unisapigeons@gmail.com**.

September 29th, 2014 | Category: General

4. An update on the Muckleneuk Pigeon Research Project https://staff.unisa.ac.za/e-connect/e-notice/2014/10/02/an-update-on-the-muckleneuk-pigeon-research-project-3/

An update on the Muckleneuk Pigeon Research Project

A short background introduction for those not yet familiar with the research:

There has been an issue with the pigeons on the Muckleneuk Campus for many years. In response to numerous and varied complaints, a research project was identified in 2012 to develop a holistic, integrated and humane pigeon management control plan to specifically meet the needs of Unisa's Muckleneuk Campus ("Unisa" being defined as all its staff and its infrastructure). This is the first time that a "pest" control programme has ever considered members of staff at the site of the problem, and Unisa and the research team are to be acknowledged for their forward thinking approach to the situation. This research is the topic of a Unisa MSc Environmental Sciences student, within the College of Agriculture and Environmental Sciences.

The project’s final phase is currently underway. Various control structures and or strategies have been implemented on the various buildings on campus. Ms Emma Harris, the student in question, counts the number of pigeons on every ledge of every building every week. It has been noted that since the implementation of the control structures, there has been a drop in the number of pigeons on campus. The remaining pigeons have started to make use of the nest boxes, installed on Theo van Wijk and Or Tambo, this in an effort to manage a smaller, healthy pigeon population. The effectiveness of the specific structures and strategies will continue to be monitored for the duration of this phase which will come to an end in August 2015.

Thank you to all who have contributed and shown interest in the project thus far. This project would not have been possible without the substantial support, assistance and guidance of the following people and institutions (we would like to apologise now for the omission of the vote of thanks, in the upcoming Focus magazine August issue)

- Prof L Brown
  Applied Behavioural Ecology and Ecosystem Research Unit (ABEERU)
  Department of Environmental Science
  College of Agriculture and Environmental Science
- Mr I Mogomotsi, Executive Director of University Estates
- Ms A Wilson (supervisor)
  Department of Environmental Science
  College of Agriculture and Environmental Science
- Dr EP de Crom (co-supervisor)
  Department of Nature Conservation

Faculty of Science

Tshwane University of Technology

- The University and all its staff
- Unisa Postgraduate bursary
- NRF Master's scholarship

Should you have any comments and queries regarding the project please contact the researcher, Ms Emma Harris at **unisapigeons@gmail.com**.

October 2nd, 2014 | Category: General

APPENDIX C

Interview questionnaire

Perceptions of pigeons

---

1. Are pigeons are flying rats? Yes / No.

Reason:____

2. Do pigeons allow a connection to nature? Yes / No.

Reason:____

3. What is your view or perception on pigeons?

____

4. Where did these perceptions originate?_____________________________

5. Have your perceptions of pigeons changed over time? Yes / No

5.1 If yes, why and how?____

5.2 If no, are you willing to change your perceptions? Why or why not?_________

Pigeon populations on campus

---

6. How do you feel about the various pigeon activities on campus?

a) Feeding (artificially by humans)

b) Roosting

c) Nesting and breeding

7. In your opinion how do the following pigeon-related aspects impact people on campus?

7.1 Nesting material

7.2 Ectoparasites (lice and or ticks)

7.3 Viewing of chicks in nests

7.4 Feeding the pigeons

7.5 Daily interaction with pigeons

8. Do you consider the pigeons on campus to be a problem? Yes / No

Reason:____

If yes, what would you like to see done about it?______________________________

9. Have you complained about the pigeons on campus? Yes / No

If yes, about what, when and to whom?___________________________________

9. Should pigeon populations at the campuses be:

a). managed, b). eradicated, or c). other

Reason:____

10. How do you feel about pigeon management on the campuses?

□ A necessity; □ A solution; □ An unsustainable solution; □ A waste of time;

□ Can't be bothered. Reason:____

11. Do you think the pigeon management options below would have a significant impact for a sustainable period of time?

□ Trapping and removal: Yes / No / Undecided

□ Killing (shooting or poisoned baits): Yes / No / Undecided

□ Bird spikes: Yes / No / Undecided

□ Falcons: Yes / No / Undecided

□ Netting on buildings: Yes / No / Undecided

□ Clearing of nests: Yes / No / Undecided

□ Scare devices: Yes / No / Undecided

□ Contraceptives: Yes / No / Undecided

□ Other: Yes / No / Undecided. Such as:___________________________________

Human aspect

12. Do you think humans are the cause of the pigeon population problems in urban environments? Yes / No.

Reason:____

13. Whose responsibility should it be to control the pigeons in urban environments?

14. Are you involved or interested in conservation related topics and activities?

Yes / No. If yes, what? ____

15. Please provide any comments or questions you may have regarding this project or pigeons populations in urban environments:

____

____

Thank you for your time to participate in this interview

If you have any further questions or comments please do not hesitate to contact the primary researcher at unisapigeons@gmail.com. Thank you, Emma Harris

APPENDIX D

CONSENT FORM

TITLE OF RESEARCH PROJECT

An integrated management approach to non-lethal pigeon control on the University of South Africa's Muckelneuk campus

Dear Sir / Madam Date..…/..…/2013

NATURE AND PURPOSE OF THE STUDY

The purpose of this research project is to investigate a holistic approach to pigeon management and control on the Muckleneuk campus of UNISA through the use of non-lethal techniques. This study will integrate information from scientific and human-related disciplines in an effort to sustainably and holistically manage pigeon populations in the urban environments. Feral pigeons (*Columba livia)* and Speckled pigeons (*Columba guinea)* living on the buildings on the Muckleneuk Campus will be monitored to accurately assess the current problem and to determine the most effective methods of control, while structured questionnaires will be distributed to UNISA staff to gather information regarding their opinions, attitudes and awareness to the pigeon problem/s, management of the birds and associated health risks.

RESEARCH PROCESS

1. Counting of the Feral pigeons and Speckled pigeons will take place weekly for the duration of 2013 to determine a control index of pigeon numbers inhabiting the buildings comprising the Muckleneuk campus.

2. Monitoring of staff complaints regarding pigeon associated issues will take place weekly for the duration of 2013 and 2014.

3. This study requires your participation during mid 2013, in the completion of the consent form and structured questionnaire to determine your opinions, attitudes and awareness of the pigeons and associated topics.

4. The structured questionnaire and consent form will be sent to the UNISA staff electronically through the online programme SurveyMonkey.

5. There are no right or wrong answers and all opinions will be valued.

6. Implementation of the pigeon control techniques and furthering monitoring of the Feral pigeons and Speckled pigeons numbers will take place weekly for the duration of 2014 to determine the controls' effectiveness.

7. A holistic, interdisciplinary management plan will be submitted to UNISA management to assist in further control of pigeon numbers.

NOTIFICATION THAT PHOTOGRAPHIC MATERIAL, TAPE RECORDINGS, ETC WILL BE REQUIRED

No tape recordings or photographic material of participants will be required.

CONFIDENTIALITY

The opinions of the structured questionnaires are viewed as strictly confidential, and only the primary researcher, supervisor and co-supervisor will have access to the information. No data published in dissertations and journals will contain any information by which the participants may be identified. Your anonymity is therefore ensured.

WITHDRAWAL CLAUSE

I understand that I may withdraw from the study at any time. I therefore participate voluntarily until such time as I request otherwise.

POTENTIAL BENEFITS OF THE STUDY

In light of the purpose of the study, pigeon management and control has previously been implemented using ineffective and often lethal methods on an ad hoc basis without the input of the people affected, either negatively or positively, by the pigeons. Through this study, it is hoped that an interdisciplinary management plan for the control of pigeon populations over a sustained period of time can be established and implemented without the need for lethal and inhumane methods of control, whilst taking into account the opinions and attitudes of the people affected by the pigeons.

INFORMATION

If you have any queries regarding the study please contact the supervisor Ms A Wilson at 011 471 3222 or co-supervisor Dr EP de Crom at 012 382 4194.

CONSENT

I, the undersigned, ………………………………………………………………. (full name) have read the above information relating to the project and have, if necessary, heard the verbal version, and declare that I understand it. I have been afforded the opportunity to discuss relevant aspects of the project with the project leader, and hereby declare that I agree voluntarily to participate in the project.

I indemnify the university and any employee or student of the university against any liability that I may incur during the course of the project.

I further undertake to make no claim against the university in respect of damages to my person or reputation that may be incurred as a result of the project/trial or through the fault of other participants, unless resulting from negligence on the part of the university, its employees or students.

I have received a signed copy of this consent form.

Signature of participant: .... Signed at ………………………………… on ………………………………. WITNESSES

1 ....

2 ....

APPENDIX E

Weekly pigeon population index on the Muckleneuk campus prior to control (March 2013 – February 2014)

Table 1: Month codes for pigeon population index table

Code	Month
1	January
2	February
3	March
4	April
5	May
6	June
7	July
8	August
9	September
10	October
11	November
12	December

Table 2: Seasonal codes for pigeon population index table

Season	Months
Spring = 1	September - November
Summer = 2	December - February
Autumn = 3	March - May
Winter = 4	June - August

Table 3: Weekly pigeon population index on the Muckleneuk campus prior to control (March 2013 – February 2014)

WEEK	MONTH	SEASON	SPECKLED PIGEON	FERAL PIGEON	TOTAL CAMPUS INDEX
1	1	2	316	47	363
2	1	2	287	85	372
3	1	2	260	75	335
4	1	2	261	58	319
5	1	2	264	81	345
6	2	2	271	53	324
7	2	2	288	78	366
8	2	2	294	83	377
9	2	2	312	45	357
10	3	3	355	63	418
11	3	3	285	84	369
12	3	3	299	38	337
13	3	3	264	53	317
14	4	3	220	72	292
15	4	3	334	71	405
16	4	3	274	79	353
17	4	3	289	59	348
18	5	3	314	38	352

19	5	3	240	67	307
20	5	3	232	63	295
21	5	3	285	56	341
22	5	3	246	39	285
23	6	4	265	42	307
24	6	4	287	38	325
25	6	4	246	43	289
26	6	4	258	37	295
27	7	4	296	30	326
28	7	4	264	34	298
29	7	4	289	29	318
30	7	4	245	43	288
31	8	4	278	37	315
32	8	4	239	49	288
33	8	4	253	27	280
34	8	4	218	45	263
35	8	4	258	42	300
36	9	1	296	46	342
37	9	1	250	63	313
38	9	1	292	43	335
39	9	1	345	75	420
40	10	1	317	69	386
41	10	1	363	61	424
42	10	1	315	30	345

43	10	1	319	54	373
44	10	1	321	51	372
45	11	1	325	41	366
46	11	1	305	50	355
47	11	1	343	51	394
48	11	1	325	44	369
49	12	2	321	66	387
50	12	2	329	80	409
51	12	2	331	49	380
52	12	2	333	77	410

APPENDIX F

Weekly pigeon population index on OR Tambo building with relation to aspect and level height prior to control (March 2013 – February 2014)

Table 1: Seasonal and monthly coding for pigeon population index table

Season	**Months**
Spring = 1	September - November
Summer = 2	December - February
Autumn = 3	March - May
Winter = 4	June - August

Table 2: Weekly pigeon population index on the ledges of balconies on the north and south side of OR Tambo building prior to control (March 2013 – February 2014)

WEEK	**SEASON**	**NORTH INDEX**	**SOUTH INDEX**
1	2	18	27
2	2	18	33
3	2	24	25
4	2	23	20
5	2	21	26
6	2	25	31
7	2	28	29

8	2	25	34
9	2	20	40
10	3	42	47
11	3	31	40
12	3	24	38
13	3	22	32
14	3	16	28
15	3	25	39
16	3	25	22
17	3	24	29
18	3	25	40
19	3	11	28
20	3	19	31
21	3	28	26
22	3	16	19
23	4	21	33
24	4	27	24
25	4	32	23
26	4	31	23
27	4	26	23
28	4	22	29
29	4	12	32
30	4	19	25
31	4	15	25

32	4	22	16
33	4	29	24
34	4	31	19
35	4	27	32
36	1	35	25
37	1	22	28
38	1	26	23
39	1	42	29
40	1	35	24
41	1	63	33
42	1	41	43
43	1	42	27
44	1	35	37
45	1	37	36
46	1	32	36
47	1	40	37
48	1	30	40
49	2	37	44
50	2	50	38
51	2	39	36
52	2	21	35

Table 3: Aspect coding for pigeon population index table

Aspect	
1	North
2	South

Table 4: Pigeon population index on the northern and southern aspects of each level (4 – 15) on OR Tambo building

LEVEL 4						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	4.0	3.0
1	2.0	3.0	3.0	31.0	4.0	0.0
1	3.0	3.0	3.0	24.0	4.0	0.0
1	4.0	3.0	3.0	22.0	4.0	0.0
1	5.0	4.0	3.0	16.0	4.0	1.0
1	6.0	4.0	3.0	25.0	4.0	1.0
1	7.0	4.0	3.0	25.0	4.0	2.0
1	8.0	4.0	3.0	24.0	4.0	3.0
1	9.0	5.0	4.0	25.0	4.0	2.0
1	10.0	5.0	4.0	11.0	4.0	0.0
1	11.0	5.0	4.0	19.0	4.0	1.0
1	12.0	5.0	4.0	28.0	4.0	4.0
1	13.0	5.0	4.0	16.0	4.0	0.0
1	14.0	6.0	4.0	21.0	4.0	2.0
1	15.0	6.0	4.0	27.0	4.0	1.0
1	16.0	6.0	4.0	32.0	4.0	0.0

1	17.0	6.0	4.0	31.0	4.0	3.0
1	18.0	7.0	4.0	26.0	4.0	1.0
1	19.0	7.0	4.0	22.0	4.0	0.0
1	20.0	7.0	4.0	12.0	4.0	0.0
1	21.0	7.0	4.0	19.0	4.0	1.0
1	22.0	8.0	4.0	15.0	4.0	0.0
1	23.0	8.0	4.0	22.0	4.0	1.0
1	24.0	8.0	4.0	29.0	4.0	3.0
1	25.0	8.0	4.0	31.0	4.0	4.0
1	26.0	8.0	4.0	27.0	4.0	1.0
1	27.0	9.0	1.0	35.0	4.0	4.0
1	28.0	9.0	1.0	22.0	4.0	4.0
1	29.0	9.0	1.0	26.0	4.0	5.0
1	30.0	9.0	1.0	42.0	4.0	3.0
1	31.0	10.0	1.0	35.0	4.0	2.0
1	32.0	10.0	1.0	63.0	4.0	3.0
1	33.0	10.0	1.0	41.0	4.0	2.0
1	34.0	10.0	1.0	42.0	4.0	1.0
1	35.0	10.0	1.0	35.0	4.0	2.0
1	36.0	11.0	2.0	37.0	4.0	2.0
1	37.0	11.0	2.0	32.0	4.0	0.0
1	38.0	11.0	2.0	40.0	4.0	7.0
1	39.0	11.0	2.0	30.0	4.0	0.0
1	40.0	12.0	2.0	37.0	4.0	2.0
1	41.0	12.0	2.0	50.0	4.0	1.0

1	42.0	12.0	2.0	39.0	4.0	2.0
1	43.0	12.0	2.0	21.0	4.0	0.0
1	44.0	1.0	2.0	18.0	4.0	2.0
1	45.0	1.0	2.0	18.0	4.0	0.0
1	46.0	1.0	2.0	24.0	4.0	2.0
1	47.0	1.0	2.0	23.0	4.0	2.0
1	48.0	1.0	2.0	21.0	4.0	0.0
1	49.0	2.0	2.0	25.0	4.0	0.0
1	50.0	2.0	2.0	28.0	4.0	2.0
1	51.0	2.0	2.0	25.0	4.0	0.0
1	52.0	2.0	2.0	20.0	4.0	0.0
2	1.0	3.0	3.0	47.0	4.0	1.0
2	2.0	3.0	3.0	40.0	4.0	3.0
2	3.0	3.0	3.0	38.0	4.0	6.0
2	4.0	3.0	3.0	32.0	4.0	7.0
2	5.0	4.0	3.0	28.0	4.0	5.0
2	6.0	4.0	3.0	39.0	4.0	4.0
2	7.0	4.0	3.0	22.0	4.0	3.0
2	8.0	4.0	3.0	29.0	4.0	1.0
2	9.0	5.0	4.0	40.0	4.0	0.0
2	10.0	5.0	4.0	28.0	4.0	0.0
2	11.0	5.0	4.0	31.0	4.0	1.0
2	12.0	5.0	4.0	26.0	4.0	1.0
2	13.0	5.0	4.0	19.0	4.0	2.0

2	14.0	6.0	4.0	33.0	4.0	1.0
2	15.0	6.0	4.0	24.0	4.0	5.0
2	16.0	6.0	4.0	23.0	4.0	0.0
2	17.0	6.0	4.0	23.0	4.0	0.0
2	18.0	7.0	4.0	23.0	4.0	3.0
2	19.0	7.0	4.0	29.0	4.0	5.0
2	20.0	7.0	4.0	32.0	4.0	2.0
2	21.0	7.0	4.0	25.0	4.0	3.0
2	22.0	8.0	4.0	25.0	4.0	0.0
2	23.0	8.0	4.0	16.0	4.0	2.0
2	24.0	8.0	4.0	24.0	4.0	2.0
2	25.0	8.0	4.0	19.0	4.0	0.0
2	26.0	8.0	4.0	32.0	4.0	2.0
2	27.0	9.0	1.0	25.0	4.0	3.0
2	28.0	9.0	1.0	28.0	4.0	2.0
2	29.0	9.0	1.0	23.0	4.0	0.0
2	30.0	9.0	1.0	29.0	4.0	4.0
2	31.0	10.0	1.0	24.0	4.0	3.0
2	32.0	10.0	1.0	33.0	4.0	4.0
2	33.0	10.0	1.0	43.0	4.0	2.0
2	34.0	10.0	1.0	27.0	4.0	3.0
2	35.0	10.0	1.0	37.0	4.0	1.0
2	36.0	11.0	2.0	36.0	4.0	0.0
2	37.0	11.0	2.0	36.0	4.0	1.0

2	38.0	11.0	2.0	37.0	4.0	0.0
2	39.0	11.0	2.0	40.0	4.0	2.0
2	40.0	12.0	2.0	44.0	4.0	1.0
2	41.0	12.0	2.0	38.0	4.0	4.0
2	42.0	12.0	2.0	36.0	4.0	3.0
2	43.0	12.0	2.0	35.0	4.0	2.0
2	44.0	1.0	2.0	27.0	4.0	1.0
2	45.0	1.0	2.0	33.0	4.0	0.0
2	46.0	1.0	2.0	25.0	4.0	2.0
2	47.0	1.0	2.0	20.0	4.0	3.0
2	48.0	1.0	2.0	26.0	4.0	4.0
2	49.0	2.0	2.0	31.0	4.0	0.0
2	50.0	2.0	2.0	29.0	4.0	2.0
2	51.0	2.0	2.0	34.0	4.0	3.0
2	52.0	2.0	2.0	40.0	4.0	3.0

LEVEL 5						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	5.0	0.0
1	2.0	3.0	3.0	31.0	5.0	0.0
1	3.0	3.0	3.0	24.0	5.0	1.0
1	4.0	3.0	3.0	22.0	5.0	0.0
1	5.0	4.0	3.0	16.0	5.0	0.0
1	6.0	4.0	3.0	25.0	5.0	2.0

1	7.0	4.0	3.0	25.0	5.0	0.0
1	8.0	4.0	3.0	24.0	5.0	0.0
1	9.0	5.0	4.0	25.0	5.0	0.0
1	10.0	5.0	4.0	11.0	5.0	0.0
1	11.0	5.0	4.0	19.0	5.0	0.0
1	12.0	5.0	4.0	28.0	5.0	0.0
1	13.0	5.0	4.0	16.0	5.0	1.0
1	14.0	6.0	4.0	21.0	5.0	0.0
1	15.0	6.0	4.0	27.0	5.0	0.0
1	16.0	6.0	4.0	32.0	5.0	0.0
1	17.0	6.0	4.0	31.0	5.0	0.0
1	18.0	7.0	4.0	26.0	5.0	0.0
1	19.0	7.0	4.0	22.0	5.0	0.0
1	20.0	7.0	4.0	12.0	5.0	1.0
1	21.0	7.0	4.0	19.0	5.0	0.0
1	22.0	8.0	4.0	15.0	5.0	4.0
1	23.0	8.0	4.0	22.0	5.0	2.0
1	24.0	8.0	4.0	29.0	5.0	2.0
1	25.0	8.0	4.0	31.0	5.0	1.0
1	26.0	8.0	4.0	27.0	5.0	3.0
1	27.0	9.0	1.0	35.0	5.0	5.0
1	28.0	9.0	1.0	22.0	5.0	0.0
1	29.0	9.0	1.0	26.0	5.0	0.0
1	30.0	9.0	1.0	42.0	5.0	0.0

1	31.0	10.0	1.0	35.0	5.0	0.0
1	32.0	10.0	1.0	63.0	5.0	0.0
1	33.0	10.0	1.0	41.0	5.0	0.0
1	34.0	10.0	1.0	42.0	5.0	2.0
1	35.0	10.0	1.0	35.0	5.0	0.0
1	36.0	11.0	2.0	37.0	5.0	0.0
1	37.0	11.0	2.0	32.0	5.0	0.0
1	38.0	11.0	2.0	40.0	5.0	0.0
1	39.0	11.0	2.0	30.0	5.0	0.0
1	40.0	12.0	2.0	37.0	5.0	0.0
1	41.0	12.0	2.0	50.0	5.0	0.0
1	42.0	12.0	2.0	39.0	5.0	1.0
1	43.0	12.0	2.0	21.0	5.0	0.0
1	44.0	1.0	2.0	18.0	5.0	0.0
1	45.0	1.0	2.0	18.0	5.0	0.0
1	46.0	1.0	2.0	24.0	5.0	0.0
1	47.0	1.0	2.0	23.0	5.0	0.0
1	48.0	1.0	2.0	21.0	5.0	0.0
1	49.0	2.0	2.0	25.0	5.0	1.0
1	50.0	2.0	2.0	28.0	5.0	2.0
1	51.0	2.0	2.0	25.0	5.0	0.0
1	52.0	2.0	2.0	20.0	5.0	0.0
2	1.0	3.0	3.0	47.0	5.0	3.0
2	2.0	3.0	3.0	40.0	5.0	3.0

2	3.0	3.0	3.0	38.0	5.0	0.0
2	4.0	3.0	3.0	32.0	5.0	1.0
2	5.0	4.0	3.0	28.0	5.0	2.0
2	6.0	4.0	3.0	39.0	5.0	4.0
2	7.0	4.0	3.0	22.0	5.0	0.0
2	8.0	4.0	3.0	29.0	5.0	1.0
2	9.0	5.0	4.0	40.0	5.0	3.0
2	10.0	5.0	4.0	28.0	5.0	1.0
2	11.0	5.0	4.0	31.0	5.0	1.0
2	12.0	5.0	4.0	26.0	5.0	1.0
2	13.0	5.0	4.0	19.0	5.0	1.0
2	14.0	6.0	4.0	33.0	5.0	1.0
2	15.0	6.0	4.0	24.0	5.0	0.0
2	16.0	6.0	4.0	23.0	5.0	0.0
2	17.0	6.0	4.0	23.0	5.0	0.0
2	18.0	7.0	4.0	23.0	5.0	0.0
2	19.0	7.0	4.0	29.0	5.0	2.0
2	20.0	7.0	4.0	32.0	5.0	5.0
2	21.0	7.0	4.0	25.0	5.0	0.0
2	22.0	8.0	4.0	25.0	5.0	2.0
2	23.0	8.0	4.0	16.0	5.0	0.0
2	24.0	8.0	4.0	24.0	5.0	0.0
2	25.0	8.0	4.0	19.0	5.0	0.0
2	26.0	8.0	4.0	32.0	5.0	0.0

2	27.0	9.0	1.0	25.0	5.0	1.0
2	28.0	9.0	1.0	28.0	5.0	0.0
2	29.0	9.0	1.0	23.0	5.0	0.0
2	30.0	9.0	1.0	29.0	5.0	3.0
2	31.0	10.0	1.0	24.0	5.0	1.0
2	32.0	10.0	1.0	33.0	5.0	3.0
2	33.0	10.0	1.0	43.0	5.0	1.0
2	34.0	10.0	1.0	27.0	5.0	0.0
2	35.0	10.0	1.0	37.0	5.0	0.0
2	36.0	11.0	2.0	36.0	5.0	1.0
2	37.0	11.0	2.0	36.0	5.0	3.0
2	38.0	11.0	2.0	37.0	5.0	2.0
2	39.0	11.0	2.0	40.0	5.0	2.0
2	40.0	12.0	2.0	44.0	5.0	1.0
2	41.0	12.0	2.0	38.0	5.0	0.0
2	42.0	12.0	2.0	36.0	5.0	0.0
2	43.0	12.0	2.0	35.0	5.0	3.0
2	44.0	1.0	2.0	27.0	5.0	2.0
2	45.0	1.0	2.0	33.0	5.0	3.0
2	46.0	1.0	2.0	25.0	5.0	1.0
2	47.0	1.0	2.0	20.0	5.0	0.0
2	48.0	1.0	2.0	26.0	5.0	0.0
2	49.0	2.0	2.0	31.0	5.0	1.0
2	50.0	2.0	2.0	29.0	5.0	1.0

2	51.0	2.0	2.0	34.0	5.0	0.0
2	52.0	2.0	2.0	40.0	5.0	5.0

LEVEL 6						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	6.0	6.0
1	2.0	3.0	3.0	31.0	6.0	2.0
1	3.0	3.0	3.0	24.0	6.0	1.0
1	4.0	3.0	3.0	22.0	6.0	3.0
1	5.0	4.0	3.0	16.0	6.0	2.0
1	6.0	4.0	3.0	25.0	6.0	3.0
1	7.0	4.0	3.0	25.0	6.0	0.0
1	8.0	4.0	3.0	24.0	6.0	0.0
1	9.0	5.0	4.0	25.0	6.0	2.0
1	10.0	5.0	4.0	11.0	6.0	1.0
1	11.0	5.0	4.0	19.0	6.0	3.0
1	12.0	5.0	4.0	28.0	6.0	0.0
1	13.0	5.0	4.0	16.0	6.0	0.0
1	14.0	6.0	4.0	21.0	6.0	2.0
1	15.0	6.0	4.0	27.0	6.0	3.0
1	16.0	6.0	4.0	32.0	6.0	6.0
1	17.0	6.0	4.0	31.0	6.0	3.0
1	18.0	7.0	4.0	26.0	6.0	5.0
1	19.0	7.0	4.0	22.0	6.0	5.0

1	20.0	7.0	4.0	12.0	6.0	4.0
1	21.0	7.0	4.0	19.0	6.0	2.0
1	22.0	8.0	4.0	15.0	6.0	2.0
1	23.0	8.0	4.0	22.0	6.0	1.0
1	24.0	8.0	4.0	29.0	6.0	6.0
1	25.0	8.0	4.0	31.0	6.0	4.0
1	26.0	8.0	4.0	27.0	6.0	2.0
1	27.0	9.0	1.0	35.0	6.0	1.0
1	28.0	9.0	1.0	22.0	6.0	1.0
1	29.0	9.0	1.0	26.0	6.0	0.0
1	30.0	9.0	1.0	42.0	6.0	0.0
1	31.0	10.0	1.0	35.0	6.0	1.0
1	32.0	10.0	1.0	63.0	6.0	20.0
1	33.0	10.0	1.0	41.0	6.0	4.0
1	34.0	10.0	1.0	42.0	6.0	3.0
1	35.0	10.0	1.0	35.0	6.0	3.0
1	36.0	11.0	2.0	37.0	6.0	8.0
1	37.0	11.0	2.0	32.0	6.0	1.0
1	38.0	11.0	2.0	40.0	6.0	3.0
1	39.0	11.0	2.0	30.0	6.0	0.0
1	40.0	12.0	2.0	37.0	6.0	2.0
1	41.0	12.0	2.0	50.0	6.0	0.0
1	42.0	12.0	2.0	39.0	6.0	0.0
1	43.0	12.0	2.0	21.0	6.0	0.0

1	44.0	1.0	2.0	18.0	6.0	1.0
1	45.0	1.0	2.0	18.0	6.0	0.0
1	46.0	1.0	2.0	24.0	6.0	0.0
1	47.0	1.0	2.0	23.0	6.0	0.0
1	48.0	1.0	2.0	21.0	6.0	0.0
1	49.0	2.0	2.0	25.0	6.0	0.0
1	50.0	2.0	2.0	28.0	6.0	1.0
1	51.0	2.0	2.0	25.0	6.0	0.0
1	52.0	2.0	2.0	20.0	6.0	0.0
2	1.0	3.0	3.0	47.0	6.0	6.0
2	2.0	3.0	3.0	40.0	6.0	0.0
2	3.0	3.0	3.0	38.0	6.0	1.0
2	4.0	3.0	3.0	32.0	6.0	0.0
2	5.0	4.0	3.0	28.0	6.0	3.0
2	6.0	4.0	3.0	39.0	6.0	3.0
2	7.0	4.0	3.0	22.0	6.0	1.0
2	8.0	4.0	3.0	29.0	6.0	3.0
2	9.0	5.0	4.0	40.0	6.0	3.0
2	10.0	5.0	4.0	28.0	6.0	0.0
2	11.0	5.0	4.0	31.0	6.0	1.0
2	12.0	5.0	4.0	26.0	6.0	0.0
2	13.0	5.0	4.0	19.0	6.0	0.0
2	14.0	6.0	4.0	33.0	6.0	6.0
2	15.0	6.0	4.0	24.0	6.0	0.0

2	16.0	6.0	4.0	23.0	6.0	2.0
2	17.0	6.0	4.0	23.0	6.0	1.0
2	18.0	7.0	4.0	23.0	6.0	2.0
2	19.0	7.0	4.0	29.0	6.0	4.0
2	20.0	7.0	4.0	32.0	6.0	3.0
2	21.0	7.0	4.0	25.0	6.0	1.0
2	22.0	8.0	4.0	25.0	6.0	3.0
2	23.0	8.0	4.0	16.0	6.0	0.0
2	24.0	8.0	4.0	24.0	6.0	0.0
2	25.0	8.0	4.0	19.0	6.0	2.0
2	26.0	8.0	4.0	32.0	6.0	5.0
2	27.0	9.0	1.0	25.0	6.0	0.0
2	28.0	9.0	1.0	28.0	6.0	5.0
2	29.0	9.0	1.0	23.0	6.0	2.0
2	30.0	9.0	1.0	29.0	6.0	3.0
2	31.0	10.0	1.0	24.0	6.0	2.0
2	32.0	10.0	1.0	33.0	6.0	0.0
2	33.0	10.0	1.0	43.0	6.0	1.0
2	34.0	10.0	1.0	27.0	6.0	0.0
2	35.0	10.0	1.0	37.0	6.0	1.0
2	36.0	11.0	2.0	36.0	6.0	0.0
2	37.0	11.0	2.0	36.0	6.0	3.0
2	38.0	11.0	2.0	37.0	6.0	6.0
2	39.0	11.0	2.0	40.0	6.0	4.0

2	40.0	12.0	2.0	44.0	6.0	2.0
2	41.0	12.0	2.0	38.0	6.0	0.0
2	42.0	12.0	2.0	36.0	6.0	1.0
2	43.0	12.0	2.0	35.0	6.0	1.0
2	44.0	1.0	2.0	27.0	6.0	7.0
2	45.0	1.0	2.0	33.0	6.0	3.0
2	46.0	1.0	2.0	25.0	6.0	3.0
2	47.0	1.0	2.0	20.0	6.0	5.0
2	48.0	1.0	2.0	26.0	6.0	4.0
2	49.0	2.0	2.0	31.0	6.0	3.0
2	50.0	2.0	2.0	29.0	6.0	4.0
2	51.0	2.0	2.0	34.0	6.0	2.0
2	52.0	2.0	2.0	40.0	6.0	2.0

LEVEL 7						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	7.0	1.0
1	2.0	3.0	3.0	31.0	7.0	1.0
1	3.0	3.0	3.0	24.0	7.0	2.0
1	4.0	3.0	3.0	22.0	7.0	2.0
1	5.0	4.0	3.0	16.0	7.0	0.0
1	6.0	4.0	3.0	25.0	7.0	0.0
1	7.0	4.0	3.0	25.0	7.0	2.0
1	8.0	4.0	3.0	24.0	7.0	3.0

1	9.0	5.0	4.0	25.0	7.0	0.0
1	10.0	5.0	4.0	11.0	7.0	1.0
1	11.0	5.0	4.0	19.0	7.0	0.0
1	12.0	5.0	4.0	28.0	7.0	6.0
1	13.0	5.0	4.0	16.0	7.0	1.0
1	14.0	6.0	4.0	21.0	7.0	1.0
1	15.0	6.0	4.0	27.0	7.0	2.0
1	16.0	6.0	4.0	32.0	7.0	5.0
1	17.0	6.0	4.0	31.0	7.0	4.0
1	18.0	7.0	4.0	26.0	7.0	3.0
1	19.0	7.0	4.0	22.0	7.0	1.0
1	20.0	7.0	4.0	12.0	7.0	1.0
1	21.0	7.0	4.0	19.0	7.0	3.0
1	22.0	8.0	4.0	15.0	7.0	0.0
1	23.0	8.0	4.0	22.0	7.0	4.0
1	24.0	8.0	4.0	29.0	7.0	3.0
1	25.0	8.0	4.0	31.0	7.0	3.0
1	26.0	8.0	4.0	27.0	7.0	6.0
1	27.0	9.0	1.0	35.0	7.0	0.0
1	28.0	9.0	1.0	22.0	7.0	2.0
1	29.0	9.0	1.0	26.0	7.0	1.0
1	30.0	9.0	1.0	42.0	7.0	2.0
1	31.0	10.0	1.0	35.0	7.0	2.0
1	32.0	10.0	1.0	63.0	7.0	5.0

1	33.0	10.0	1.0	41.0	7.0	3.0
1	34.0	10.0	1.0	42.0	7.0	7.0
1	35.0	10.0	1.0	35.0	7.0	2.0
1	36.0	11.0	2.0	37.0	7.0	1.0
1	37.0	11.0	2.0	32.0	7.0	1.0
1	38.0	11.0	2.0	40.0	7.0	5.0
1	39.0	11.0	2.0	30.0	7.0	2.0
1	40.0	12.0	2.0	37.0	7.0	4.0
1	41.0	12.0	2.0	50.0	7.0	3.0
1	42.0	12.0	2.0	39.0	7.0	5.0
1	43.0	12.0	2.0	21.0	7.0	0.0
1	44.0	1.0	2.0	18.0	7.0	1.0
1	45.0	1.0	2.0	18.0	7.0	4.0
1	46.0	1.0	2.0	24.0	7.0	4.0
1	47.0	1.0	2.0	23.0	7.0	2.0
1	48.0	1.0	2.0	21.0	7.0	2.0
1	49.0	2.0	2.0	25.0	7.0	4.0
1	50.0	2.0	2.0	28.0	7.0	1.0
1	51.0	2.0	2.0	25.0	7.0	3.0
1	52.0	2.0	2.0	20.0	7.0	1.0
2	1.0	3.0	3.0	47.0	7.0	10.0
2	2.0	3.0	3.0	40.0	7.0	2.0
2	3.0	3.0	3.0	38.0	7.0	10.0
2	4.0	3.0	3.0	32.0	7.0	5.0

2	5.0	4.0	3.0	28.0	7.0	5.0
2	6.0	4.0	3.0	39.0	7.0	11.0
2	7.0	4.0	3.0	22.0	7.0	10.0
2	8.0	4.0	3.0	29.0	7.0	7.0
2	9.0	5.0	4.0	40.0	7.0	6.0
2	10.0	5.0	4.0	28.0	7.0	8.0
2	11.0	5.0	4.0	31.0	7.0	10.0
2	12.0	5.0	4.0	26.0	7.0	6.0
2	13.0	5.0	4.0	19.0	7.0	2.0
2	14.0	6.0	4.0	33.0	7.0	4.0
2	15.0	6.0	4.0	24.0	7.0	4.0
2	16.0	6.0	4.0	23.0	7.0	2.0
2	17.0	6.0	4.0	23.0	7.0	2.0
2	18.0	7.0	4.0	23.0	7.0	7.0
2	19.0	7.0	4.0	29.0	7.0	3.0
2	20.0	7.0	4.0	32.0	7.0	7.0
2	21.0	7.0	4.0	25.0	7.0	4.0
2	22.0	8.0	4.0	25.0	7.0	6.0
2	23.0	8.0	4.0	16.0	7.0	5.0
2	24.0	8.0	4.0	24.0	7.0	6.0
2	25.0	8.0	4.0	19.0	7.0	2.0
2	26.0	8.0	4.0	32.0	7.0	4.0
2	27.0	9.0	1.0	25.0	7.0	2.0
2	28.0	9.0	1.0	28.0	7.0	5.0

2	29.0	9.0	1.0	23.0	7.0	5.0
2	30.0	9.0	1.0	29.0	7.0	5.0
2	31.0	10.0	1.0	24.0	7.0	3.0
2	32.0	10.0	1.0	33.0	7.0	7.0
2	33.0	10.0	1.0	43.0	7.0	10.0
2	34.0	10.0	1.0	27.0	7.0	1.0
2	35.0	10.0	1.0	37.0	7.0	3.0
2	36.0	11.0	2.0	36.0	7.0	10.0
2	37.0	11.0	2.0	36.0	7.0	2.0
2	38.0	11.0	2.0	37.0	7.0	4.0
2	39.0	11.0	2.0	40.0	7.0	1.0
2	40.0	12.0	2.0	44.0	7.0	8.0
2	41.0	12.0	2.0	38.0	7.0	5.0
2	42.0	12.0	2.0	36.0	7.0	8.0
2	43.0	12.0	2.0	35.0	7.0	2.0
2	44.0	1.0	2.0	27.0	7.0	1.0
2	45.0	1.0	2.0	33.0	7.0	6.0
2	46.0	1.0	2.0	25.0	7.0	1.0
2	47.0	1.0	2.0	20.0	7.0	0.0
2	48.0	1.0	2.0	26.0	7.0	1.0
2	49.0	2.0	2.0	31.0	7.0	1.0
2	50.0	2.0	2.0	29.0	7.0	4.0
2	51.0	2.0	2.0	34.0	7.0	4.0
2	52.0	2.0	2.0	40.0	7.0	1.0

LEVEL 8						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	8.0	3.0
1	2.0	3.0	3.0	31.0	8.0	2.0
1	3.0	3.0	3.0	24.0	8.0	1.0
1	4.0	3.0	3.0	22.0	8.0	1.0
1	5.0	4.0	3.0	16.0	8.0	2.0
1	6.0	4.0	3.0	25.0	8.0	2.0
1	7.0	4.0	3.0	25.0	8.0	1.0
1	8.0	4.0	3.0	24.0	8.0	2.0
1	9.0	5.0	4.0	25.0	8.0	2.0
1	10.0	5.0	4.0	11.0	8.0	0.0
1	11.0	5.0	4.0	19.0	8.0	0.0
1	12.0	5.0	4.0	28.0	8.0	0.0
1	13.0	5.0	4.0	16.0	8.0	0.0
1	14.0	6.0	4.0	21.0	8.0	0.0
1	15.0	6.0	4.0	27.0	8.0	0.0
1	16.0	6.0	4.0	32.0	8.0	0.0
1	17.0	6.0	4.0	31.0	8.0	1.0
1	18.0	7.0	4.0	26.0	8.0	1.0
1	19.0	7.0	4.0	22.0	8.0	2.0
1	20.0	7.0	4.0	12.0	8.0	0.0
1	21.0	7.0	4.0	19.0	8.0	1.0
1	22.0	8.0	4.0	15.0	8.0	0.0

1	23.0	8.0	4.0	22.0	8.0	3.0
1	24.0	8.0	4.0	29.0	8.0	0.0
1	25.0	8.0	4.0	31.0	8.0	3.0
1	26.0	8.0	4.0	27.0	8.0	1.0
1	27.0	9.0	1.0	35.0	8.0	0.0
1	28.0	9.0	1.0	22.0	8.0	3.0
1	29.0	9.0	1.0	26.0	8.0	2.0
1	30.0	9.0	1.0	42.0	8.0	0.0
1	31.0	10.0	1.0	35.0	8.0	1.0
1	32.0	10.0	1.0	63.0	8.0	3.0
1	33.0	10.0	1.0	41.0	8.0	2.0
1	34.0	10.0	1.0	42.0	8.0	3.0
1	35.0	10.0	1.0	35.0	8.0	5.0
1	36.0	11.0	2.0	37.0	8.0	7.0
1	37.0	11.0	2.0	32.0	8.0	6.0
1	38.0	11.0	2.0	40.0	8.0	1.0
1	39.0	11.0	2.0	30.0	8.0	2.0
1	40.0	12.0	2.0	37.0	8.0	0.0
1	41.0	12.0	2.0	50.0	8.0	2.0
1	42.0	12.0	2.0	39.0	8.0	3.0
1	43.0	12.0	2.0	21.0	8.0	0.0
1	44.0	1.0	2.0	18.0	8.0	0.0
1	45.0	1.0	2.0	18.0	8.0	3.0
1	46.0	1.0	2.0	24.0	8.0	3.0

1	47.0	1.0	2.0	23.0	8.0	1.0
1	48.0	1.0	2.0	21.0	8.0	2.0
1	49.0	2.0	2.0	25.0	8.0	2.0
1	50.0	2.0	2.0	28.0	8.0	3.0
1	51.0	2.0	2.0	25.0	8.0	1.0
1	52.0	2.0	2.0	20.0	8.0	1.0
2	1.0	3.0	3.0	47.0	8.0	4.0
2	2.0	3.0	3.0	40.0	8.0	1.0
2	3.0	3.0	3.0	38.0	8.0	1.0
2	4.0	3.0	3.0	32.0	8.0	0.0
2	5.0	4.0	3.0	28.0	8.0	0.0
2	6.0	4.0	3.0	39.0	8.0	2.0
2	7.0	4.0	3.0	22.0	8.0	1.0
2	8.0	4.0	3.0	29.0	8.0	0.0
2	9.0	5.0	4.0	40.0	8.0	6.0
2	10.0	5.0	4.0	28.0	8.0	2.0
2	11.0	5.0	4.0	31.0	8.0	2.0
2	12.0	5.0	4.0	26.0	8.0	1.0
2	13.0	5.0	4.0	19.0	8.0	2.0
2	14.0	6.0	4.0	33.0	8.0	0.0
2	15.0	6.0	4.0	24.0	8.0	0.0
2	16.0	6.0	4.0	23.0	8.0	3.0
2	17.0	6.0	4.0	23.0	8.0	1.0
2	18.0	7.0	4.0	23.0	8.0	1.0

2	19.0	7.0	4.0	29.0	8.0	3.0
2	20.0	7.0	4.0	32.0	8.0	0.0
2	21.0	7.0	4.0	25.0	8.0	1.0
2	22.0	8.0	4.0	25.0	8.0	3.0
2	23.0	8.0	4.0	16.0	8.0	4.0
2	24.0	8.0	4.0	24.0	8.0	2.0
2	25.0	8.0	4.0	19.0	8.0	1.0
2	26.0	8.0	4.0	32.0	8.0	4.0
2	27.0	9.0	1.0	25.0	8.0	5.0
2	28.0	9.0	1.0	28.0	8.0	0.0
2	29.0	9.0	1.0	23.0	8.0	0.0
2	30.0	9.0	1.0	29.0	8.0	2.0
2	31.0	10.0	1.0	24.0	8.0	2.0
2	32.0	10.0	1.0	33.0	8.0	3.0
2	33.0	10.0	1.0	43.0	8.0	4.0
2	34.0	10.0	1.0	27.0	8.0	2.0
2	35.0	10.0	1.0	37.0	8.0	11.0
2	36.0	11.0	2.0	36.0	8.0	6.0
2	37.0	11.0	2.0	36.0	8.0	5.0
2	38.0	11.0	2.0	37.0	8.0	4.0
2	39.0	11.0	2.0	40.0	8.0	2.0
2	40.0	12.0	2.0	44.0	8.0	2.0
2	41.0	12.0	2.0	38.0	8.0	5.0
2	42.0	12.0	2.0	36.0	8.0	4.0

2	43.0	12.0	2.0	35.0	8.0	2.0
2	44.0	1.0	2.0	27.0	8.0	3.0
2	45.0	1.0	2.0	33.0	8.0	2.0
2	46.0	1.0	2.0	25.0	8.0	2.0
2	47.0	1.0	2.0	20.0	8.0	4.0
2	48.0	1.0	2.0	26.0	8.0	2.0
2	49.0	2.0	2.0	31.0	8.0	2.0
2	50.0	2.0	2.0	29.0	8.0	1.0
2	51.0	2.0	2.0	34.0	8.0	6.0
2	52.0	2.0	2.0	40.0	8.0	5.0

LEVEL 9						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	9.0	6.0
1	2.0	3.0	3.0	31.0	9.0	4.0
1	3.0	3.0	3.0	24.0	9.0	0.0
1	4.0	3.0	3.0	22.0	9.0	0.0
1	5.0	4.0	3.0	16.0	9.0	0.0
1	6.0	4.0	3.0	25.0	9.0	2.0
1	7.0	4.0	3.0	25.0	9.0	0.0
1	8.0	4.0	3.0	24.0	9.0	0.0
1	9.0	5.0	4.0	25.0	9.0	2.0
1	10.0	5.0	4.0	11.0	9.0	1.0

1	11.0	5.0	4.0	19.0	9.0	1.0
1	12.0	5.0	4.0	28.0	9.0	3.0
1	13.0	5.0	4.0	16.0	9.0	0.0
1	14.0	6.0	4.0	21.0	9.0	0.0
1	15.0	6.0	4.0	27.0	9.0	0.0
1	16.0	6.0	4.0	32.0	9.0	2.0
1	17.0	6.0	4.0	31.0	9.0	1.0
1	18.0	7.0	4.0	26.0	9.0	2.0
1	19.0	7.0	4.0	22.0	9.0	0.0
1	20.0	7.0	4.0	12.0	9.0	0.0
1	21.0	7.0	4.0	19.0	9.0	0.0
1	22.0	8.0	4.0	15.0	9.0	0.0
1	23.0	8.0	4.0	22.0	9.0	1.0
1	24.0	8.0	4.0	29.0	9.0	2.0
1	25.0	8.0	4.0	31.0	9.0	0.0
1	26.0	8.0	4.0	27.0	9.0	0.0
1	27.0	9.0	1.0	35.0	9.0	0.0
1	28.0	9.0	1.0	22.0	9.0	2.0
1	29.0	9.0	1.0	26.0	9.0	1.0
1	30.0	9.0	1.0	42.0	9.0	2.0
1	31.0	10.0	1.0	35.0	9.0	7.0
1	32.0	10.0	1.0	63.0	9.0	4.0
1	33.0	10.0	1.0	41.0	9.0	5.0
1	34.0	10.0	1.0	42.0	9.0	0.0

1	35.0	10.0	1.0	35.0	9.0	0.0
1	36.0	11.0	2.0	37.0	9.0	0.0
1	37.0	11.0	2.0	32.0	9.0	2.0
1	38.0	11.0	2.0	40.0	9.0	3.0
1	39.0	11.0	2.0	30.0	9.0	3.0
1	40.0	12.0	2.0	37.0	9.0	2.0
1	41.0	12.0	2.0	50.0	9.0	2.0
1	42.0	12.0	2.0	39.0	9.0	0.0
1	43.0	12.0	2.0	21.0	9.0	1.0
1	44.0	1.0	2.0	18.0	9.0	1.0
1	45.0	1.0	2.0	18.0	9.0	0.0
1	46.0	1.0	2.0	24.0	9.0	0.0
1	47.0	1.0	2.0	23.0	9.0	1.0
1	48.0	1.0	2.0	21.0	9.0	2.0
1	49.0	2.0	2.0	25.0	9.0	0.0
1	50.0	2.0	2.0	28.0	9.0	0.0
1	51.0	2.0	2.0	25.0	9.0	1.0
1	52.0	2.0	2.0	20.0	9.0	0.0
2	1.0	3.0	3.0	47.0	9.0	4.0
2	2.0	3.0	3.0	40.0	9.0	1.0
2	3.0	3.0	3.0	38.0	9.0	2.0
2	4.0	3.0	3.0	32.0	9.0	4.0
2	5.0	4.0	3.0	28.0	9.0	2.0
2	6.0	4.0	3.0	39.0	9.0	1.0

2	7.0	4.0	3.0	22.0	9.0	1.0
2	8.0	4.0	3.0	29.0	9.0	4.0
2	9.0	5.0	4.0	40.0	9.0	2.0
2	10.0	5.0	4.0	28.0	9.0	1.0
2	11.0	5.0	4.0	31.0	9.0	1.0
2	12.0	5.0	4.0	26.0	9.0	2.0
2	13.0	5.0	4.0	19.0	9.0	1.0
2	14.0	6.0	4.0	33.0	9.0	0.0
2	15.0	6.0	4.0	24.0	9.0	1.0
2	16.0	6.0	4.0	23.0	9.0	0.0
2	17.0	6.0	4.0	23.0	9.0	2.0
2	18.0	7.0	4.0	23.0	9.0	2.0
2	19.0	7.0	4.0	29.0	9.0	2.0
2	20.0	7.0	4.0	32.0	9.0	1.0
2	21.0	7.0	4.0	25.0	9.0	1.0
2	22.0	8.0	4.0	25.0	9.0	0.0
2	23.0	8.0	4.0	16.0	9.0	0.0
2	24.0	8.0	4.0	24.0	9.0	0.0
2	25.0	8.0	4.0	19.0	9.0	1.0
2	26.0	8.0	4.0	32.0	9.0	1.0
2	27.0	9.0	1.0	25.0	9.0	2.0
2	28.0	9.0	1.0	28.0	9.0	1.0
2	29.0	9.0	1.0	23.0	9.0	0.0
2	30.0	9.0	1.0	29.0	9.0	1.0

2	31.0	10.0	1.0	24.0	9.0	0.0
2	32.0	10.0	1.0	33.0	9.0	2.0
2	33.0	10.0	1.0	43.0	9.0	1.0
2	34.0	10.0	1.0	27.0	9.0	1.0
2	35.0	10.0	1.0	37.0	9.0	3.0
2	36.0	11.0	2.0	36.0	9.0	0.0
2	37.0	11.0	2.0	36.0	9.0	1.0
2	38.0	11.0	2.0	37.0	9.0	2.0
2	39.0	11.0	2.0	40.0	9.0	1.0
2	40.0	12.0	2.0	44.0	9.0	4.0
2	41.0	12.0	2.0	38.0	9.0	2.0
2	42.0	12.0	2.0	36.0	9.0	4.0
2	43.0	12.0	2.0	35.0	9.0	2.0
2	44.0	1.0	2.0	27.0	9.0	2.0
2	45.0	1.0	2.0	33.0	9.0	1.0
2	46.0	1.0	2.0	25.0	9.0	0.0
2	47.0	1.0	2.0	20.0	9.0	1.0
2	48.0	1.0	2.0	26.0	9.0	3.0
2	49.0	2.0	2.0	31.0	9.0	4.0
2	50.0	2.0	2.0	29.0	9.0	1.0
2	51.0	2.0	2.0	34.0	9.0	2.0
2	52.0	2.0	2.0	40.0	9.0	5.0

LEVEL 10

Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	10.0	2.0
1	2.0	3.0	3.0	31.0	10.0	6.0
1	3.0	3.0	3.0	24.0	10.0	4.0
1	4.0	3.0	3.0	22.0	10.0	5.0
1	5.0	4.0	3.0	16.0	10.0	4.0
1	6.0	4.0	3.0	25.0	10.0	2.0
1	7.0	4.0	3.0	25.0	10.0	4.0
1	8.0	4.0	3.0	24.0	10.0	2.0
1	9.0	5.0	4.0	25.0	10.0	4.0
1	10.0	5.0	4.0	11.0	10.0	3.0
1	11.0	5.0	4.0	19.0	10.0	2.0
1	12.0	5.0	4.0	28.0	10.0	5.0
1	13.0	5.0	4.0	16.0	10.0	1.0
1	14.0	6.0	4.0	21.0	10.0	2.0
1	15.0	6.0	4.0	27.0	10.0	3.0
1	16.0	6.0	4.0	32.0	10.0	4.0
1	17.0	6.0	4.0	31.0	10.0	3.0
1	18.0	7.0	4.0	26.0	10.0	0.0
1	19.0	7.0	4.0	22.0	10.0	1.0
1	20.0	7.0	4.0	12.0	10.0	0.0
1	21.0	7.0	4.0	19.0	10.0	0.0
1	22.0	8.0	4.0	15.0	10.0	1.0
1	23.0	8.0	4.0	22.0	10.0	3.0

1	24.0	8.0	4.0	29.0	10.0	1.0
1	25.0	8.0	4.0	31.0	10.0	1.0
1	26.0	8.0	4.0	27.0	10.0	0.0
1	27.0	9.0	1.0	35.0	10.0	5.0
1	28.0	9.0	1.0	22.0	10.0	2.0
1	29.0	9.0	1.0	26.0	10.0	4.0
1	30.0	9.0	1.0	42.0	10.0	3.0
1	31.0	10.0	1.0	35.0	10.0	4.0
1	32.0	10.0	1.0	63.0	10.0	2.0
1	33.0	10.0	1.0	41.0	10.0	3.0
1	34.0	10.0	1.0	42.0	10.0	1.0
1	35.0	10.0	1.0	35.0	10.0	2.0
1	36.0	11.0	2.0	37.0	10.0	1.0
1	37.0	11.0	2.0	32.0	10.0	4.0
1	38.0	11.0	2.0	40.0	10.0	4.0
1	39.0	11.0	2.0	30.0	10.0	1.0
1	40.0	12.0	2.0	37.0	10.0	2.0
1	41.0	12.0	2.0	50.0	10.0	6.0
1	42.0	12.0	2.0	39.0	10.0	5.0
1	43.0	12.0	2.0	21.0	10.0	5.0
1	44.0	1.0	2.0	18.0	10.0	0.0
1	45.0	1.0	2.0	18.0	10.0	1.0
1	46.0	1.0	2.0	24.0	10.0	1.0
1	47.0	1.0	2.0	23.0	10.0	1.0

1	48.0	1.0	2.0	21.0	10.0	1.0
1	49.0	2.0	2.0	25.0	10.0	1.0
1	50.0	2.0	2.0	28.0	10.0	1.0
1	51.0	2.0	2.0	25.0	10.0	2.0
1	52.0	2.0	2.0	20.0	10.0	2.0
2	1.0	3.0	3.0	47.0	10.0	1.0
2	2.0	3.0	3.0	40.0	10.0	5.0
2	3.0	3.0	3.0	38.0	10.0	3.0
2	4.0	3.0	3.0	32.0	10.0	1.0
2	5.0	4.0	3.0	28.0	10.0	1.0
2	6.0	4.0	3.0	39.0	10.0	3.0
2	7.0	4.0	3.0	22.0	10.0	0.0
2	8.0	4.0	3.0	29.0	10.0	6.0
2	9.0	5.0	4.0	40.0	10.0	3.0
2	10.0	5.0	4.0	28.0	10.0	4.0
2	11.0	5.0	4.0	31.0	10.0	5.0
2	12.0	5.0	4.0	26.0	10.0	3.0
2	13.0	5.0	4.0	19.0	10.0	2.0
2	14.0	6.0	4.0	33.0	10.0	6.0
2	15.0	6.0	4.0	24.0	10.0	2.0
2	16.0	6.0	4.0	23.0	10.0	1.0
2	17.0	6.0	4.0	23.0	10.0	5.0
2	18.0	7.0	4.0	23.0	10.0	0.0
2	19.0	7.0	4.0	29.0	10.0	1.0

2	20.0	7.0	4.0	32.0	10.0	2.0
2	21.0	7.0	4.0	25.0	10.0	3.0
2	22.0	8.0	4.0	25.0	10.0	1.0
2	23.0	8.0	4.0	16.0	10.0	0.0
2	24.0	8.0	4.0	24.0	10.0	4.0
2	25.0	8.0	4.0	19.0	10.0	2.0
2	26.0	8.0	4.0	32.0	10.0	3.0
2	27.0	9.0	1.0	25.0	10.0	1.0
2	28.0	9.0	1.0	28.0	10.0	0.0
2	29.0	9.0	1.0	23.0	10.0	0.0
2	30.0	9.0	1.0	29.0	10.0	0.0
2	31.0	10.0	1.0	24.0	10.0	0.0
2	32.0	10.0	1.0	33.0	10.0	1.0
2	33.0	10.0	1.0	43.0	10.0	2.0
2	34.0	10.0	1.0	27.0	10.0	3.0
2	35.0	10.0	1.0	37.0	10.0	2.0
2	36.0	11.0	2.0	36.0	10.0	4.0
2	37.0	11.0	2.0	36.0	10.0	2.0
2	38.0	11.0	2.0	37.0	10.0	4.0
2	39.0	11.0	2.0	40.0	10.0	4.0
2	40.0	12.0	2.0	44.0	10.0	3.0
2	41.0	12.0	2.0	38.0	10.0	4.0
2	42.0	12.0	2.0	36.0	10.0	4.0
2	43.0	12.0	2.0	35.0	10.0	6.0

2	44.0	1.0	2.0	27.0	10.0	1.0
2	45.0	1.0	2.0	33.0	10.0	1.0
2	46.0	1.0	2.0	25.0	10.0	3.0
2	47.0	1.0	2.0	20.0	10.0	0.0
2	48.0	1.0	2.0	26.0	10.0	2.0
2	49.0	2.0	2.0	31.0	10.0	4.0
2	50.0	2.0	2.0	29.0	10.0	2.0
2	51.0	2.0	2.0	34.0	10.0	3.0
2	52.0	2.0	2.0	40.0	10.0	3.0

LEVEL 11						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	11.0	4.0
1	2.0	3.0	3.0	31.0	11.0	1.0
1	3.0	3.0	3.0	24.0	11.0	3.0
1	4.0	3.0	3.0	22.0	11.0	2.0
1	5.0	4.0	3.0	16.0	11.0	1.0
1	6.0	4.0	3.0	25.0	11.0	1.0
1	7.0	4.0	3.0	25.0	11.0	3.0
1	8.0	4.0	3.0	24.0	11.0	5.0
1	9.0	5.0	4.0	25.0	11.0	3.0
1	10.0	5.0	4.0	11.0	11.0	0.0
1	11.0	5.0	4.0	19.0	11.0	0.0
1	12.0	5.0	4.0	28.0	11.0	2.0

1	13.0	5.0	4.0	16.0	11.0	3.0
1	14.0	6.0	4.0	21.0	11.0	4.0
1	15.0	6.0	4.0	27.0	11.0	2.0
1	16.0	6.0	4.0	32.0	11.0	1.0
1	17.0	6.0	4.0	31.0	11.0	3.0
1	18.0	7.0	4.0	26.0	11.0	1.0
1	19.0	7.0	4.0	22.0	11.0	3.0
1	20.0	7.0	4.0	12.0	11.0	0.0
1	21.0	7.0	4.0	19.0	11.0	1.0
1	22.0	8.0	4.0	15.0	11.0	0.0
1	23.0	8.0	4.0	22.0	11.0	1.0
1	24.0	8.0	4.0	29.0	11.0	4.0
1	25.0	8.0	4.0	31.0	11.0	1.0
1	26.0	8.0	4.0	27.0	11.0	4.0
1	27.0	9.0	1.0	35.0	11.0	2.0
1	28.0	9.0	1.0	22.0	11.0	1.0
1	29.0	9.0	1.0	26.0	11.0	1.0
1	30.0	9.0	1.0	42.0	11.0	2.0
1	31.0	10.0	1.0	35.0	11.0	0.0
1	32.0	10.0	1.0	63.0	11.0	4.0
1	33.0	10.0	1.0	41.0	11.0	1.0
1	34.0	10.0	1.0	42.0	11.0	6.0
1	35.0	10.0	1.0	35.0	11.0	4.0
1	36.0	11.0	2.0	37.0	11.0	2.0

1	37.0	11.0	2.0	32.0	11.0	3.0
1	38.0	11.0	2.0	40.0	11.0	3.0
1	39.0	11.0	2.0	30.0	11.0	6.0
1	40.0	12.0	2.0	37.0	11.0	1.0
1	41.0	12.0	2.0	50.0	11.0	2.0
1	42.0	12.0	2.0	39.0	11.0	4.0
1	43.0	12.0	2.0	21.0	11.0	4.0
1	44.0	1.0	2.0	18.0	11.0	2.0
1	45.0	1.0	2.0	18.0	11.0	3.0
1	46.0	1.0	2.0	24.0	11.0	4.0
1	47.0	1.0	2.0	23.0	11.0	3.0
1	48.0	1.0	2.0	21.0	11.0	5.0
1	49.0	2.0	2.0	25.0	11.0	4.0
1	50.0	2.0	2.0	28.0	11.0	4.0
1	51.0	2.0	2.0	25.0	11.0	2.0
1	52.0	2.0	2.0	20.0	11.0	3.0
2	1.0	3.0	3.0	47.0	11.0	2.0
2	2.0	3.0	3.0	40.0	11.0	2.0
2	3.0	3.0	3.0	38.0	11.0	3.0
2	4.0	3.0	3.0	32.0	11.0	2.0
2	5.0	4.0	3.0	28.0	11.0	4.0
2	6.0	4.0	3.0	39.0	11.0	1.0
2	7.0	4.0	3.0	22.0	11.0	1.0
2	8.0	4.0	3.0	29.0	11.0	2.0

2	9.0	5.0	4.0	40.0	11.0	3.0
2	10.0	5.0	4.0	28.0	11.0	0.0
2	11.0	5.0	4.0	31.0	11.0	1.0
2	12.0	5.0	4.0	26.0	11.0	2.0
2	13.0	5.0	4.0	19.0	11.0	3.0
2	14.0	6.0	4.0	33.0	11.0	2.0
2	15.0	6.0	4.0	24.0	11.0	5.0
2	16.0	6.0	4.0	23.0	11.0	3.0
2	17.0	6.0	4.0	23.0	11.0	6.0
2	18.0	7.0	4.0	23.0	11.0	0.0
2	19.0	7.0	4.0	29.0	11.0	2.0
2	20.0	7.0	4.0	32.0	11.0	0.0
2	21.0	7.0	4.0	25.0	11.0	0.0
2	22.0	8.0	4.0	25.0	11.0	1.0
2	23.0	8.0	4.0	16.0	11.0	0.0
2	24.0	8.0	4.0	24.0	11.0	3.0
2	25.0	8.0	4.0	19.0	11.0	4.0
2	26.0	8.0	4.0	32.0	11.0	1.0
2	27.0	9.0	1.0	25.0	11.0	2.0
2	28.0	9.0	1.0	28.0	11.0	1.0
2	29.0	9.0	1.0	23.0	11.0	4.0
2	30.0	9.0	1.0	29.0	11.0	0.0
2	31.0	10.0	1.0	24.0	11.0	1.0
2	32.0	10.0	1.0	33.0	11.0	2.0

2	33.0	10.0	1.0	43.0	11.0	3.0
2	34.0	10.0	1.0	27.0	11.0	2.0
2	35.0	10.0	1.0	37.0	11.0	4.0
2	36.0	11.0	2.0	36.0	11.0	3.0
2	37.0	11.0	2.0	36.0	11.0	4.0
2	38.0	11.0	2.0	37.0	11.0	0.0
2	39.0	11.0	2.0	40.0	11.0	2.0
2	40.0	12.0	2.0	44.0	11.0	4.0
2	41.0	12.0	2.0	38.0	11.0	2.0
2	42.0	12.0	2.0	36.0	11.0	4.0
2	43.0	12.0	2.0	35.0	11.0	2.0
2	44.0	1.0	2.0	27.0	11.0	2.0
2	45.0	1.0	2.0	33.0	11.0	5.0
2	46.0	1.0	2.0	25.0	11.0	5.0
2	47.0	1.0	2.0	20.0	11.0	3.0
2	48.0	1.0	2.0	26.0	11.0	3.0
2	49.0	2.0	2.0	31.0	11.0	5.0
2	50.0	2.0	2.0	29.0	11.0	3.0
2	51.0	2.0	2.0	34.0	11.0	1.0
2	52.0	2.0	2.0	40.0	11.0	2.0

LEVEL 12						
Aspect	Week	Month	Season	Index	Level	Count

1	1.0	3.0	3.0	42.0	12.0	6.0
1	2.0	3.0	3.0	31.0	12.0	4.0
1	3.0	3.0	3.0	24.0	12.0	9.0
1	4.0	3.0	3.0	22.0	12.0	5.0
1	5.0	4.0	3.0	16.0	12.0	3.0
1	6.0	4.0	3.0	25.0	12.0	4.0
1	7.0	4.0	3.0	25.0	12.0	4.0
1	8.0	4.0	3.0	24.0	12.0	6.0
1	9.0	5.0	4.0	25.0	12.0	8.0
1	10.0	5.0	4.0	11.0	12.0	1.0
1	11.0	5.0	4.0	19.0	12.0	4.0
1	12.0	5.0	4.0	28.0	12.0	3.0
1	13.0	5.0	4.0	16.0	12.0	5.0
1	14.0	6.0	4.0	21.0	12.0	2.0
1	15.0	6.0	4.0	27.0	12.0	8.0
1	16.0	6.0	4.0	32.0	12.0	6.0
1	17.0	6.0	4.0	31.0	12.0	5.0
1	18.0	7.0	4.0	26.0	12.0	4.0
1	19.0	7.0	4.0	22.0	12.0	4.0
1	20.0	7.0	4.0	12.0	12.0	3.0
1	21.0	7.0	4.0	19.0	12.0	2.0
1	22.0	8.0	4.0	15.0	12.0	4.0
1	23.0	8.0	4.0	22.0	12.0	3.0
1	24.0	8.0	4.0	29.0	12.0	2.0

1	25.0	8.0	4.0	31.0	12.0	2.0
1	26.0	8.0	4.0	27.0	12.0	6.0
1	27.0	9.0	1.0	35.0	12.0	9.0
1	28.0	9.0	1.0	22.0	12.0	6.0
1	29.0	9.0	1.0	26.0	12.0	6.0
1	30.0	9.0	1.0	42.0	12.0	15.0
1	31.0	10.0	1.0	35.0	12.0	8.0
1	32.0	10.0	1.0	63.0	12.0	8.0
1	33.0	10.0	1.0	41.0	12.0	8.0
1	34.0	10.0	1.0	42.0	12.0	13.0
1	35.0	10.0	1.0	35.0	12.0	14.0
1	36.0	11.0	2.0	37.0	12.0	8.0
1	37.0	11.0	2.0	32.0	12.0	9.0
1	38.0	11.0	2.0	40.0	12.0	9.0
1	39.0	11.0	2.0	30.0	12.0	4.0
1	40.0	12.0	2.0	37.0	12.0	14.0
1	41.0	12.0	2.0	50.0	12.0	21.0
1	42.0	12.0	2.0	39.0	12.0	9.0
1	43.0	12.0	2.0	21.0	12.0	7.0
1	44.0	1.0	2.0	18.0	12.0	6.0
1	45.0	1.0	2.0	18.0	12.0	3.0
1	46.0	1.0	2.0	24.0	12.0	3.0
1	47.0	1.0	2.0	23.0	12.0	5.0
1	48.0	1.0	2.0	21.0	12.0	6.0

1	49.0	2.0	2.0	25.0	12.0	6.0
1	50.0	2.0	2.0	28.0	12.0	8.0
1	51.0	2.0	2.0	25.0	12.0	11.0
1	52.0	2.0	2.0	20.0	12.0	8.0
2	1.0	3.0	3.0	47.0	12.0	5.0
2	2.0	3.0	3.0	40.0	12.0	6.0
2	3.0	3.0	3.0	38.0	12.0	6.0
2	4.0	3.0	3.0	32.0	12.0	3.0
2	5.0	4.0	3.0	28.0	12.0	3.0
2	6.0	4.0	3.0	39.0	12.0	1.0
2	7.0	4.0	3.0	22.0	12.0	3.0
2	8.0	4.0	3.0	29.0	12.0	1.0
2	9.0	5.0	4.0	40.0	12.0	4.0
2	10.0	5.0	4.0	28.0	12.0	2.0
2	11.0	5.0	4.0	31.0	12.0	1.0
2	12.0	5.0	4.0	26.0	12.0	3.0
2	13.0	5.0	4.0	19.0	12.0	0.0
2	14.0	6.0	4.0	33.0	12.0	5.0
2	15.0	6.0	4.0	24.0	12.0	3.0
2	16.0	6.0	4.0	23.0	12.0	3.0
2	17.0	6.0	4.0	23.0	12.0	5.0
2	18.0	7.0	4.0	23.0	12.0	0.0
2	19.0	7.0	4.0	29.0	12.0	1.0
2	20.0	7.0	4.0	32.0	12.0	4.0

2	21.0	7.0	4.0	25.0	12.0	3.0
2	22.0	8.0	4.0	25.0	12.0	1.0
2	23.0	8.0	4.0	16.0	12.0	0.0
2	24.0	8.0	4.0	24.0	12.0	2.0
2	25.0	8.0	4.0	19.0	12.0	1.0
2	26.0	8.0	4.0	32.0	12.0	1.0
2	27.0	9.0	1.0	25.0	12.0	0.0
2	28.0	9.0	1.0	28.0	12.0	3.0
2	29.0	9.0	1.0	23.0	12.0	4.0
2	30.0	9.0	1.0	29.0	12.0	2.0
2	31.0	10.0	1.0	24.0	12.0	3.0
2	32.0	10.0	1.0	33.0	12.0	3.0
2	33.0	10.0	1.0	43.0	12.0	6.0
2	34.0	10.0	1.0	27.0	12.0	3.0
2	35.0	10.0	1.0	37.0	12.0	3.0
2	36.0	11.0	2.0	36.0	12.0	5.0
2	37.0	11.0	2.0	36.0	12.0	5.0
2	38.0	11.0	2.0	37.0	12.0	1.0
2	39.0	11.0	2.0	40.0	12.0	6.0
2	40.0	12.0	2.0	44.0	12.0	7.0
2	41.0	12.0	2.0	38.0	12.0	4.0
2	42.0	12.0	2.0	36.0	12.0	3.0
2	43.0	12.0	2.0	35.0	12.0	3.0
2	44.0	1.0	2.0	27.0	12.0	4.0

2	45.0	1.0	2.0	33.0	12.0	2.0
2	46.0	1.0	2.0	25.0	12.0	3.0
2	47.0	1.0	2.0	20.0	12.0	1.0
2	48.0	1.0	2.0	26.0	12.0	1.0
2	49.0	2.0	2.0	31.0	12.0	4.0
2	50.0	2.0	2.0	29.0	12.0	3.0
2	51.0	2.0	2.0	34.0	12.0	3.0
2	52.0	2.0	2.0	40.0	12.0	1.0

LEVEL 13						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	13.0	5.0
1	2.0	3.0	3.0	31.0	13.0	5.0
1	3.0	3.0	3.0	24.0	13.0	2.0
1	4.0	3.0	3.0	22.0	13.0	3.0
1	5.0	4.0	3.0	16.0	13.0	3.0
1	6.0	4.0	3.0	25.0	13.0	6.0
1	7.0	4.0	3.0	25.0	13.0	1.0
1	8.0	4.0	3.0	24.0	13.0	1.0
1	9.0	5.0	4.0	25.0	13.0	1.0
1	10.0	5.0	4.0	11.0	13.0	1.0
1	11.0	5.0	4.0	19.0	13.0	0.0
1	12.0	5.0	4.0	28.0	13.0	3.0
1	13.0	5.0	4.0	16.0	13.0	3.0

1	14.0	6.0	4.0	21.0	13.0	0.0
1	15.0	6.0	4.0	27.0	13.0	3.0
1	16.0	6.0	4.0	32.0	13.0	2.0
1	17.0	6.0	4.0	31.0	13.0	4.0
1	18.0	7.0	4.0	26.0	13.0	3.0
1	19.0	7.0	4.0	22.0	13.0	2.0
1	20.0	7.0	4.0	12.0	13.0	2.0
1	21.0	7.0	4.0	19.0	13.0	4.0
1	22.0	8.0	4.0	15.0	13.0	2.0
1	23.0	8.0	4.0	22.0	13.0	2.0
1	24.0	8.0	4.0	29.0	13.0	2.0
1	25.0	8.0	4.0	31.0	13.0	3.0
1	26.0	8.0	4.0	27.0	13.0	2.0
1	27.0	9.0	1.0	35.0	13.0	4.0
1	28.0	9.0	1.0	22.0	13.0	0.0
1	29.0	9.0	1.0	26.0	13.0	4.0
1	30.0	9.0	1.0	42.0	13.0	6.0
1	31.0	10.0	1.0	35.0	13.0	2.0
1	32.0	10.0	1.0	63.0	13.0	4.0
1	33.0	10.0	1.0	41.0	13.0	6.0
1	34.0	10.0	1.0	42.0	13.0	2.0
1	35.0	10.0	1.0	35.0	13.0	3.0
1	36.0	11.0	2.0	37.0	13.0	4.0
1	37.0	11.0	2.0	32.0	13.0	3.0

1	38.0	11.0	2.0	40.0	13.0	5.0
1	39.0	11.0	2.0	30.0	13.0	11.0
1	40.0	12.0	2.0	37.0	13.0	6.0
1	41.0	12.0	2.0	50.0	13.0	8.0
1	42.0	12.0	2.0	39.0	13.0	8.0
1	43.0	12.0	2.0	21.0	13.0	4.0
1	44.0	1.0	2.0	18.0	13.0	0.0
1	45.0	1.0	2.0	18.0	13.0	4.0
1	46.0	1.0	2.0	24.0	13.0	0.0
1	47.0	1.0	2.0	23.0	13.0	3.0
1	48.0	1.0	2.0	21.0	13.0	2.0
1	49.0	2.0	2.0	25.0	13.0	2.0
1	50.0	2.0	2.0	28.0	13.0	2.0
1	51.0	2.0	2.0	25.0	13.0	2.0
1	52.0	2.0	2.0	20.0	13.0	1.0
2	1.0	3.0	3.0	47.0	13.0	1.0
2	2.0	3.0	3.0	40.0	13.0	7.0
2	3.0	3.0	3.0	38.0	13.0	5.0
2	4.0	3.0	3.0	32.0	13.0	5.0
2	5.0	4.0	3.0	28.0	13.0	2.0
2	6.0	4.0	3.0	39.0	13.0	4.0
2	7.0	4.0	3.0	22.0	13.0	2.0
2	8.0	4.0	3.0	29.0	13.0	3.0
2	9.0	5.0	4.0	40.0	13.0	1.0

2	10.0	5.0	4.0	28.0	13.0	4.0
2	11.0	5.0	4.0	31.0	13.0	6.0
2	12.0	5.0	4.0	26.0	13.0	3.0
2	13.0	5.0	4.0	19.0	13.0	2.0
2	14.0	6.0	4.0	33.0	13.0	6.0
2	15.0	6.0	4.0	24.0	13.0	2.0
2	16.0	6.0	4.0	23.0	13.0	5.0
2	17.0	6.0	4.0	23.0	13.0	1.0
2	18.0	7.0	4.0	23.0	13.0	4.0
2	19.0	7.0	4.0	29.0	13.0	2.0
2	20.0	7.0	4.0	32.0	13.0	3.0
2	21.0	7.0	4.0	25.0	13.0	5.0
2	22.0	8.0	4.0	25.0	13.0	0.0
2	23.0	8.0	4.0	16.0	13.0	3.0
2	24.0	8.0	4.0	24.0	13.0	3.0
2	25.0	8.0	4.0	19.0	13.0	3.0
2	26.0	8.0	4.0	32.0	13.0	5.0
2	27.0	9.0	1.0	25.0	13.0	1.0
2	28.0	9.0	1.0	28.0	13.0	7.0
2	29.0	9.0	1.0	23.0	13.0	5.0
2	30.0	9.0	1.0	29.0	13.0	4.0
2	31.0	10.0	1.0	24.0	13.0	3.0
2	32.0	10.0	1.0	33.0	13.0	3.0
2	33.0	10.0	1.0	43.0	13.0	8.0

2	34.0	10.0	1.0	27.0	13.0	6.0
2	35.0	10.0	1.0	37.0	13.0	4.0
2	36.0	11.0	2.0	36.0	13.0	3.0
2	37.0	11.0	2.0	36.0	13.0	4.0
2	38.0	11.0	2.0	37.0	13.0	5.0
2	39.0	11.0	2.0	40.0	13.0	8.0
2	40.0	12.0	2.0	44.0	13.0	5.0
2	41.0	12.0	2.0	38.0	13.0	8.0
2	42.0	12.0	2.0	36.0	13.0	4.0
2	43.0	12.0	2.0	35.0	13.0	2.0
2	44.0	1.0	2.0	27.0	13.0	3.0
2	45.0	1.0	2.0	33.0	13.0	2.0
2	46.0	1.0	2.0	25.0	13.0	3.0
2	47.0	1.0	2.0	20.0	13.0	1.0
2	48.0	1.0	2.0	26.0	13.0	3.0
2	49.0	2.0	2.0	31.0	13.0	2.0
2	50.0	2.0	2.0	29.0	13.0	2.0
2	51.0	2.0	2.0	34.0	13.0	5.0
2	52.0	2.0	2.0	40.0	13.0	3.0

LEVEL 14						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42.0	14.0	6.0

1	2.0	3.0	3.0	31.0	14.0	2.0
1	3.0	3.0	3.0	24.0	14.0	0.0
1	4.0	3.0	3.0	22.0	14.0	1.0
1	5.0	4.0	3.0	16.0	14.0	0.0
1	6.0	4.0	3.0	25.0	14.0	2.0
1	7.0	4.0	3.0	25.0	14.0	2.0
1	8.0	4.0	3.0	24.0	14.0	2.0
1	9.0	5.0	4.0	25.0	14.0	1.0
1	10.0	5.0	4.0	11.0	14.0	3.0
1	11.0	5.0	4.0	19.0	14.0	2.0
1	12.0	5.0	4.0	28.0	14.0	2.0
1	13.0	5.0	4.0	16.0	14.0	2.0
1	14.0	6.0	4.0	21.0	14.0	6.0
1	15.0	6.0	4.0	27	14	3
1	16.0	6.0	4.0	32	14	6
1	17.0	6.0	4.0	31	14	4
1	18.0	7.0	4.0	26	14	6
1	19.0	7.0	4.0	22	14	1
1	20.0	7.0	4.0	12	14	0
1	21.0	7.0	4.0	19	14	0
1	22.0	8.0	4.0	15	14	2
1	23.0	8.0	4.0	22	14	0
1	24.0	8.0	4.0	29	14	1
1	25.0	8.0	4.0	31	14	3

1	26.0	8.0	4.0	27	14	2
1	27.0	9.0	1.0	35	14	4
1	28.0	9.0	1.0	22	14	1
1	29.0	9.0	1.0	26	14	1
1	30.0	9.0	1.0	42	14	9
1	31.0	10.0	1.0	35	14	3
1	32.0	10.0	1.0	63	14	8
1	33.0	10.0	1.0	41	14	4
1	34.0	10.0	1.0	42	14	4
1	35.0	10.0	1.0	35	14	0
1	36.0	11.0	2.0	37	14	1
1	37.0	11.0	2.0	32	14	2
1	38.0	11.0	2.0	40	14	0
1	39.0	11.0	2.0	30	14	1
1	40.0	12.0	2.0	37	14	0
1	41.0	12.0	2.0	50	14	0
1	42.0	12.0	2.0	39	14	0
1	43.0	12.0	2.0	21	14	0
1	44.0	1.0	2.0	18	14	4
1	45.0	1.0	2.0	18	14	0
1	46.0	1.0	2.0	24	14	5
1	47.0	1.0	2.0	23	14	3
1	48.0	1.0	2.0	21	14	1
1	49.0	2.0	2.0	25	14	3

1	50.0	2.0	2.0	28	14	4
1	51.0	2.0	2.0	25	14	3
1	52.0	2.0	2.0	20	14	3
2	1.0	3.0	3.0	47	14	5
2	2.0	3.0	3.0	40	14	5
2	3.0	3.0	3.0	38	14	1
2	4.0	3.0	3.0	32	14	1
2	5.0	4.0	3.0	28	14	1
2	6.0	4.0	3.0	39	14	4
2	7.0	4.0	3.0	22	14	0
2	8.0	4.0	3.0	29	14	1
2	9.0	5.0	4.0	40	14	3
2	10.0	5.0	4.0	28	14	2
2	11.0	5.0	4.0	31	14	2
2	12.0	5.0	4.0	26	14	4
2	13.0	5.0	4.0	19	14	4
2	14.0	6.0	4.0	33	14	2
2	15.0	6.0	4.0	24	14	2
2	16.0	6.0	4.0	23	14	4
2	17.0	6.0	4.0	23	14	0
2	18.0	7.0	4.0	23	14	3
2	19.0	7.0	4.0	29	14	4
2	20.0	7.0	4.0	32	14	5
2	21.0	7.0	4.0	25	14	2

2	22.0	8.0	4.0	25	14	4
2	23.0	8.0	4.0	16	14	1
2	24.0	8.0	4.0	24	14	2
2	25.0	8.0	4.0	19	14	3
2	26.0	8.0	4.0	32	14	2
2	27.0	9.0	1.0	25	14	6
2	28.0	9.0	1.0	28	14	4
2	29.0	9.0	1.0	23	14	2
2	30.0	9.0	1.0	29	14	5
2	31.0	10.0	1.0	24	14	6
2	32.0	10.0	1.0	33	14	3
2	33.0	10.0	1.0	43	14	4
2	34.0	10.0	1.0	27	14	4
2	35.0	10.0	1.0	37	14	5
2	36.0	11.0	2.0	36	14	2
2	37.0	11.0	2.0	36	14	5
2	38.0	11.0	2.0	37	14	5
2	39.0	11.0	2.0	40	14	4
2	40.0	12.0	2.0	44	14	4
2	41.0	12.0	2.0	38	14	2
2	42.0	12.0	2.0	36	14	0
2	43.0	12.0	2.0	35	14	2
2	44.0	1.0	2.0	27	14	1
2	45.0	1.0	2.0	33	14	4

2	46.0	1.0	2.0	25	14	2
2	47.0	1.0	2.0	20	14	2
2	48.0	1.0	2.0	26	14	1
2	49.0	2.0	2.0	31	14	2
2	50.0	2.0	2.0	29	14	5
2	51.0	2.0	2.0	34	14	4
2	52.0	2.0	2.0	40	14	7

LEVEL 15 (ROOF EXCLUDED FROM ANALYSIS)						
Aspect	Week	Month	Season	Index	Level	Count
1	1.0	3.0	3.0	42	15	0
1	2.0	3.0	3.0	31	15	4
1	3.0	3.0	3.0	24	15	1
1	4.0	3.0	3.0	22	15	0
1	5.0	4.0	3.0	16	15	0
1	6.0	4.0	3.0	25	15	0
1	7.0	4.0	3.0	25	15	6
1	8.0	4.0	3.0	24	15	0
1	9.0	5.0	4.0	25	15	0
1	10.0	5.0	4.0	11	15	0
1	11.0	5.0	4.0	19	15	6
1	12.0	5.0	4.0	28	15	0
1	13.0	5.0	4.0	16	15	0
1	14.0	6.0	4.0	21	15	2

1	15.0	6.0	4.0	27	15	2
1	16.0	6.0	4.0	32	15	0
1	17.0	6.0	4.0	31	15	0
1	18.0	7.0	4.0	26	15	0
1	19.0	7.0	4.0	22	15	3
1	20.0	7.0	4.0	12	15	1
1	21.0	7.0	4.0	19	15	5
1	22.0	8.0	4.0	15	15	0
1	23.0	8.0	4.0	22	15	1
1	24.0	8.0	4.0	29	15	3
1	25.0	8.0	4.0	31	15	6
1	26.0	8.0	4.0	27	15	0
1	27.0	9.0	1.0	35	15	1
1	28.0	9.0	1.0	22	15	0
1	29.0	9.0	1.0	26	15	1
1	30.0	9.0	1.0	42	15	0
1	31.0	10.0	1.0	35	15	5
1	32.0	10.0	1.0	63	15	2
1	33.0	10.0	1.0	41	15	3
1	34.0	10.0	1.0	42	15	0
1	35.0	10.0	1.0	35	15	0
1	36.0	11.0	2.0	37	15	3
1	37.0	11.0	2.0	32	15	1
1	38.0	11.0	2.0	40	15	0

1	39.0	11.0	2.0	30	15	0
1	40.0	12.0	2.0	37	15	4
1	41.0	12.0	2.0	50	15	5
1	42.0	12.0	2.0	39	15	2
1	43.0	12.0	2.0	21	15	0
1	44.0	1.0	2.0	18	15	1
1	45.0	1.0	2.0	18	15	0
1	46.0	1.0	2.0	24	15	2
1	47.0	1.0	2.0	23	15	2
1	48.0	1.0	2.0	21	15	0
1	49.0	2.0	2.0	25	15	2
1	50.0	2.0	2.0	28	15	0
1	51.0	2.0	2.0	25	15	0
1	52.0	2.0	2.0	20	15	1
2	1.0	3.0	3.0	47	15	5
2	2.0	3.0	3.0	40	15	5
2	3.0	3.0	3.0	38	15	0
2	4.0	3.0	3.0	32	15	3
2	5.0	4.0	3.0	28	15	0
2	6.0	4.0	3.0	39	15	1
2	7.0	4.0	3.0	22	15	0
2	8.0	4.0	3.0	29	15	0
2	9.0	5.0	4.0	40	15	6
2	10.0	5.0	4.0	28	15	4

2	11.0	5.0	4.0	31	15	0
2	12.0	5.0	4.0	26	15	0
2	13.0	5.0	4.0	19	15	0
2	14.0	6.0	4.0	33	15	0
2	15.0	6.0	4.0	24	15	0
2	16.0	6.0	4.0	23	15	0
2	17.0	6.0	4.0	23	15	0
2	18.0	7.0	4.0	23	15	1
2	19.0	7.0	4.0	29	15	0
2	20.0	7.0	4.0	32	15	0
2	21.0	7.0	4.0	25	15	2
2	22.0	8.0	4.0	25	15	4
2	23.0	8.0	4.0	16	15	1
2	24.0	8.0	4.0	24	15	0
2	25.0	8.0	4.0	19	15	0
2	26.0	8.0	4.0	32	15	4
2	27.0	9.0	1.0	25	15	2
2	28.0	9.0	1.0	28	15	0
2	29.0	9.0	1.0	23	15	1
2	30.0	9.0	1.0	29	15	0
2	31.0	10.0	1.0	24	15	0
2	32.0	10.0	1.0	33	15	2
2	33.0	10.0	1.0	43	15	1
2	34.0	10.0	1.0	27	15	2

2	35.0	10.0	1.0	37	15	0
2	36.0	11.0	2.0	36	15	2
2	37.0	11.0	2.0	36	15	1
2	38.0	11.0	2.0	37	15	4
2	39.0	11.0	2.0	40	15	4
2	40.0	12.0	2.0	44	15	3
2	41.0	12.0	2.0	38	15	2
2	42.0	12.0	2.0	36	15	1
2	43.0	12.0	2.0	35	15	8
2	44.0	1.0	2.0	27	15	0
2	45.0	1.0	2.0	33	15	4
2	46.0	1.0	2.0	25	15	0
2	47.0	1.0	2.0	20	15	0
2	48.0	1.0	2.0	26	15	2
2	49.0	2.0	2.0	31	15	3
2	50.0	2.0	2.0	29	15	1
2	51.0	2.0	2.0	34	15	1
2	52.0	2.0	2.0	40	15	3

Table 5: Seasonal difference in balcony ledge use by pigeons on the north and south side of the OR Tambo building

<table>
<tr><td></td><td>Summer</td><td>Autumn</td><td>Winter</td><td>Spring</td></tr>
<tr><td>*Chi Square statistic</td><td>6.02</td><td>16.95</td><td>0.26</td><td>4.14</td></tr>
<tr><td>Df</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>*P-value</td><td>0.014</td><td><0.0001</td><td>0.6101</td><td>0.0419</td></tr>
<tr><td colspan="5">*[Note that for df=1, the calculated value of chi-square is corrected for continuity.]</td></tr>
</table>

Table 6: Correlation between number of perched pigeons and level height on OR Tambo building

<table>
<tr><td rowspan="6">Spearman's rho</td><td rowspan="3">Level</td><td>Correlation Coefficient</td><td>1.000</td><td>.636*</td></tr>
<tr><td>Sig. (2-tailed)</td><td></td><td>.035</td></tr>
<tr><td>N</td><td>11</td><td>11</td></tr>
<tr><td rowspan="3">Count</td><td>Correlation Coefficient</td><td>.636*</td><td>1.000</td></tr>
<tr><td>Sig. (2-tailed)</td><td>.035</td><td></td></tr>
<tr><td>N</td><td>11</td><td>11</td></tr>
</table>

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX G

Weekly pigeon population index during the management year on the Muckleneuk campus (August 2014 – August 2015)

Table 1: Monthly, seasonal and treatment coding for pigeon population index table

Month	
1	January
2	February
3	March
4	April
5	May
6	June
7	July
8	August
9	September
10	October
11	November
12	December

Season	
1	Spring
2	Summer
3	Autumn
4	Winter

Treatment	
1	Eagle eyes
2	Fire flags
3	Combination
4	Bird spikes

The index was calculated as (Baseline study year - Management year) / Management year * 100)

Table 2: Population index in response to the different treatments during the management year (August 2014 – August 2015)

Week	Month	Season	Treatment	Count	Weight	Adjusted Count	Index	Absolute Index
49	12	1	1	-50.1292	0.764901	-38.34388013	38.34388	38.34388013
50	12	1	1	-54.5232	0.764901	-41.70487736	41.70488	41.70487736
51	12	1	1	-47.6316	0.764901	-36.43344779	36.43345	36.43344779
52	12	1	1	-56.3415	0.764901	-43.09564812	43.09565	43.09564812
1	1	1	1	-49.0358	0.764901	-37.50754773	37.50755	37.50754773
2	1	1	1	-52.957	0.764901	-40.50686006	40.50686	40.50686006
3	1	1	1	-50.1493	0.764901	-38.35922004	38.35922	38.35922004
4	1	1	1	-45.768	0.764901	-35.00801336	35.00801	35.00801336
5	1	1	1	-56.2319	0.764901	-43.01183075	43.01183	43.01183075
6	2	1	1	-46.9136	0.764901	-35.88424979	35.88425	35.88424979
7	2	1	1	-56.2842	0.764901	-43.05181133	43.05181	43.05181133
8	2	1	1	-53.5809	0.764901	-40.98409151	40.98409	40.98409151
9	2	1	1	-50.4202	0.764901	-38.56644272	38.56644	38.56644272
10	3	2	1	-50.7177	0.624484	-31.67237622	31.67238	31.67237622
11	3	2	1	-54.2005	0.624484	-33.84735199	33.84735	33.84735199
12	3	2	1	-50.7418	0.624484	-31.68744901	31.68745	31.68744901

13	3	2	1	-46.6877	0.624484	-29.15570327	29.1557	29.15570327
14	4	2	1	-47.9452	0.624484	-29.94099664	29.941	29.94099664
15	4	2	1	-64.9383	0.624484	-40.55288851	40.55289	40.55288851
16	4	2	1	-60.6232	0.624484	-37.85821526	37.85822	37.85821526
17	4	2	1	-54.8851	0.624484	-34.27482071	34.27482	34.27482071
18	5	2	1	-65.0568	0.624484	-40.6269189	40.62692	40.6269189
19	5	2	1	-55.0489	0.624484	-34.37711267	34.37711	34.37711267
20	5	2	1	-41.3559	0.624484	-25.82610326	25.8261	25.82610326
21	5	2	1	-61.8768	0.624484	-38.64107007	38.64107	38.64107007
22	5	2	1	-43.8596	0.624484	-27.38963352	27.38963	27.38963352
23	6	3	1	-50.4886	0.741168	-37.420525	37.42053	37.420525
24	6	3	1	-57.8462	0.741168	-42.87370762	42.87371	42.87370762
25	6	3	1	-55.0173	0.741168	-40.77705295	40.77705	40.77705295
26	6	3	1	-46.1017	0.741168	-34.16909262	34.16909	34.16909262
27	7	3	1	-51.5337	0.741168	-38.19515135	38.19515	38.19515135
28	7	3	1	-59.7315	0.741168	-44.27109784	44.2711	44.27109784
29	7	3	1	-59.434	0.741168	-44.05054012	44.05054	44.05054012
30	7	3	1	-54.8611	0.741168	-40.66129001	40.66129	40.66129001
31	8	3	1	-54.6032	0.741168	-40.47011577	40.47012	40.47011577
32	8	3	1	-57.9861	0.741168	-42.97743944	42.97744	42.97743944
33	8	3	1	-26.7857	0.741168	-19.85270941	19.85271	19.85270941
34	8	3	1	-21.673	0.741168	-16.06333293	16.06333	16.06333293
35	8	3	1	-41	0.741168	-30.38788053	30.38788	30.38788053
36	9	4	1	-47.3684	1.039638	-49.24603228	49.24603	49.24603228
37	9	4	1	-40.8946	1.039638	-42.51556639	42.51557	42.51556639
38	9	4	1	-35.8209	1.039638	-37.24078063	37.24078	37.24078063
39	9	4	1	-42.8571	1.039638	-44.55593397	44.55593	44.55593397
40	10	4	1	-34.715	1.039638	-36.09107605	36.09108	36.09107605
41	10	4	1	-45.5189	1.039638	-47.32316572	47.32317	47.32316572
42	10	4	1	-43.7681	1.039638	-45.50301662	45.50302	45.50301662
43	10	4	1	-40.7507	1.039638	-42.36596402	42.36596	42.36596402
44	10	4	1	-36.828	1.039638	-38.28776046	38.28776	38.28776046
45	11	4	1	-47.8142	1.039638	-49.70948917	49.70949	49.70948917
46	11	4	1	-48.4507	1.039638	-50.37121549	50.37122	50.37121549
47	11	4	1	-57.3604	1.039638	-59.63408421	59.63408	59.63408421
48	11	4	1	-53.3875	1.039638	-55.50373346	55.50373	55.50373346
49	12	1	2	-38.843	0.764901	-29.711035	29.71104	29.711035
50	12	1	2	-53.7815	0.764901	-41.1375389	41.13754	41.1375389
51	12	1	2	-47.8261	0.764901	-36.58222719	36.58223	36.58222719
52	12	1	2	-58.6207	0.764901	-44.83903081	44.83903	44.83903081
1	1	1	2	-57.6389	0.764901	-44.08805031	44.08805	44.08805031
2	1	1	2	-55.303	0.764901	-42.30134948	42.30135	42.30134948
3	1	1	2	-62.2951	0.764901	-47.64957759	47.64958	47.64957759
4	1	1	2	-54.4	0.764901	-41.6106206	41.61062	41.6106206
5	1	1	2	-53.9063	0.764901	-41.23295067	41.23295	41.23295067
6	2	1	2	-38.6139	0.764901	-29.53578559	29.53579	29.53578559

7	2	1	2	-50	0.764901	-38.24505569	38.24506	38.24505569
8	2	1	2	-42.9825	0.764901	-32.87732858	32.87733	32.87732858
9	2	1	2	-47.8261	0.764901	-36.58222719	36.58223	36.58222719
10	3	2	2	-51.1628	0.624484	-31.95032599	31.95033	31.95032599
11	3	2	2	-43.1034	0.624484	-26.91739846	26.9174	26.91739846
12	3	2	2	-46.729	0.624484	-29.18147871	29.18148	29.18147871
13	3	2	2	-53.7037	0.624484	-33.5370846	33.53708	33.5370846
14	4	2	2	-42.1569	0.624484	-26.32627128	26.32627	26.32627128
15	4	2	2	-69.8529	0.624484	-43.62201927	43.62202	43.62201927
16	4	2	2	-57.2727	0.624484	-35.76588145	35.76588	35.76588145
17	4	2	2	-53.0612	0.624484	-33.13586684	33.13587	33.13586684
18	5	2	2	-78.0488	0.624484	-48.74018687	48.74019	48.74018687
19	5	2	2	-53.271	0.624484	-33.26688572	33.26689	33.26688572
20	5	2	2	-40.6593	0.624484	-25.39109323	25.39109	25.39109323
21	5	2	2	-62.6168	0.624484	-39.10318147	39.10318	39.10318147
22	5	2	2	-56.3107	0.624484	-35.16509842	35.1651	35.16509842
23	6	3	2	-65	0.741168	-48.17590816	48.17591	48.17590816
24	6	3	2	-67.4797	0.741168	-50.01376332	50.01376	50.01376332
25	6	3	2	-78.1818	0.741168	-57.94584757	57.94585	57.94584757
26	6	3	2	-64.3564	0.741168	-47.69891897	47.69892	47.69891897
27	7	3	2	-68.75	0.741168	-50.95528747	50.95529	50.95528747
28	7	3	2	-74.2574	0.741168	-55.03721419	55.03721	55.03721419
29	7	3	2	-75.2137	0.741168	-55.74595553	55.74596	55.74595553
30	7	3	2	-69.3069	0.741168	-51.36806658	51.36807	51.36806658
31	8	3	2	-61.9048	0.741168	-45.88181729	45.88182	45.88181729
32	8	3	2	-61.7978	0.741168	-45.8025056	45.80251	45.8025056
33	8	3	2	35.59322	0.741168	44.80589123	-44.8059	0
34	8	3	2	-16.6667	0.741168	-12.35279696	12.3528	12.35279696
35	8	3	2	-38.3838	0.741168	-28.44886573	28.44887	28.44886573
36	9	4	2	-59.1667	1.039638	-61.51194217	61.51194	61.51194217
37	9	4	2	-43.5294	1.039638	-45.25485058	45.25485	45.25485058
38	9	4	2	-19.0476	1.039638	-19.80263732	19.80264	19.80263732
39	9	4	2	-36.4964	1.039638	-37.94300946	37.94301	37.94300946
40	10	4	2	-35.8621	1.039638	-37.28358613	37.28359	37.28358613
41	10	4	2	-44.3609	1.039638	-46.11930007	46.1193	46.11930007
42	10	4	2	-25.8929	1.039638	-26.91921011	26.91921	26.91921011
43	10	4	2	-38.9706	1.039638	-40.51532231	40.51532	40.51532231
44	10	4	2	-36.6667	1.039638	-38.12007684	38.12008	38.12007684
45	11	4	2	-28.7129	1.039638	-29.85100527	29.85101	29.85100527
46	11	4	2	-61.7886	1.039638	-64.2378235	64.23782	64.2378235
47	11	4	2	-54.0146	1.039638	-56.155654	56.15565	56.155654
48	11	4	2	-46.6102	1.039638	-48.4577248	48.45772	48.4577248
49	12	1	3	-43.2099	0.764901	-33.0512827	33.05128	33.0512827
50	12	1	3	-53.4091	0.764901	-40.85267313	40.85267	40.85267313
51	12	1	3	-45.3333	0.764901	-34.67551716	34.67552	34.67551716
52	12	1	3	-33.9286	0.764901	-25.95200208	25.952	25.95200208

1	1	1	3	4.444444	0.764901	5.489328383	-5.48933	0
2	1	1	3	-39.2157	0.764901	-29.99612211	29.99612	29.99612211
3	1	1	3	-38.7755	0.764901	-29.65943095	29.65943	29.65943095
4	1	1	3	-41.8605	0.764901	-32.0191164	32.01912	32.0191164
5	1	1	3	-34.0426	0.764901	-26.03918686	26.03919	26.03918686
6	2	1	3	-41.0714	0.764901	-31.41558146	31.41558	31.41558146
7	2	1	3	-50.8772	0.764901	-38.91602158	38.91602	38.91602158
8	2	1	3	-49.1525	0.764901	-37.59683441	37.59683	37.59683441
9	2	1	3	-35	0.764901	-26.77153899	26.77154	26.77153899
10	3	2	3	-56.5217	0.624484	-35.29690163	35.2969	35.29690163
11	3	2	3	-42.2535	0.624484	-26.38663286	26.38663	26.38663286
12	3	2	3	-50	0.624484	-31.22418221	31.22418	31.22418221
13	3	2	3	-29.6296	0.624484	-18.50321909	18.50322	18.50321909
14	4	2	3	-31.1111	0.624484	-19.42838004	19.42838	19.42838004
15	4	2	3	-55.5556	0.624484	-34.69353579	34.69354	34.69353579
16	4	2	3	-57.4468	0.624484	-35.87459233	35.87459	35.87459233
17	4	2	3	-47.1698	0.624484	-29.45677567	29.45678	29.45677567
18	5	2	3	-58.4615	0.624484	-36.50827459	36.50827	36.50827459
19	5	2	3	-33.3333	0.624484	-20.81612148	20.81612	20.81612148
20	5	2	3	-38	0.624484	-23.73037848	23.73038	23.73037848
21	5	2	3	-43.1373	0.624484	-26.93851015	26.93851	26.93851015
22	5	2	3	14.28571	0.624484	19.65023365	-19.6502	0
23	6	3	3	-37.037	0.741168	-27.45065992	27.45066	27.45065992
24	6	3	3	-45.098	0.741168	-33.42521531	33.42522	33.42521531
25	6	3	3	-40	0.741168	-29.64671271	29.64671	29.64671271
26	6	3	3	-21.4286	0.741168	-15.88216752	15.88217	15.88216752
27	7	3	3	-10.2041	0.741168	-7.562936917	7.562937	7.562936917
28	7	3	3	-56.8627	0.741168	-42.1448367	42.14484	42.1448367
29	7	3	3	-52.2727	0.741168	-38.7428632	38.74286	38.7428632
30	7	3	3	-25	0.741168	-18.52919545	18.5292	18.52919545
31	8	3	3	-20	0.741168	-14.82335636	14.82336	14.82335636
32	8	3	3	-36.8421	0.741168	-27.30618276	27.30618	27.30618276
33	8	3	3	-54.717	0.741168	-40.5544655	40.55447	40.5544655
34	8	3	3	-24	0.741168	-17.78802763	17.78803	17.78802763
35	8	3	3	-40.678	0.741168	-30.14919937	30.1492	30.14919937
36	9	4	3	-50	1.039638	-51.98192296	51.98192	51.98192296
37	9	4	3	-48	1.039638	-49.90264605	49.90265	49.90264605
38	9	4	3	-24.4898	1.039638	-25.4605337	25.46053	25.4605337
39	9	4	3	-43.662	1.039638	-45.39266512	45.39267	45.39266512
40	10	4	3	-16.9492	1.039638	-17.62099084	17.62099	17.62099084
41	10	4	3	-55.2083	1.039638	-57.39670661	57.39671	57.39670661
42	10	4	3	-54.7619	1.039638	-56.93258229	56.93258	56.93258229
43	10	4	3	-43.4783	1.039638	-45.20167214	45.20167	45.20167214
44	10	4	3	-37.5	1.039638	-38.98644222	38.98644	38.98644222
45	11	4	3	-56.1644	1.039638	-58.39065319	58.39065	58.39065319
46	11	4	3	-60.2941	1.039638	-62.68408357	62.68408	62.68408357

47	11	4	3	-49.3506	1.039638	-51.30683306	51.30683	51.30683306
48	11	4	3	-51.4286	1.039638	-53.46712076	53.46712	53.46712076
49	12	1	4	-98.6842	0.764901	-75.48366255	75.48366	75.48366255
50	12	1	4	-88.1579	0.764901	-67.43207188	67.43207	67.43207188
51	12	1	4	-88.8889	0.764901	-67.99121012	67.99121	67.99121012
52	12	1	4	-92.0635	0.764901	-70.41946763	70.41947	70.41946763
1	1	1	4	-80	0.764901	-61.19208911	61.19209	61.19208911
2	1	1	4	-90.1408	0.764901	-68.9488328	68.94883	68.9488328
3	1	1	4	-87.2727	0.764901	-66.7550063	66.75501	66.7550063
4	1	1	4	-97.619	0.764901	-74.66891826	74.66892	74.66891826
5	1	1	4	-92.8571	0.764901	-71.026532	71.02653	71.026532
6	2	1	4	-96.2963	0.764901	-73.6571443	73.65714	73.6571443
7	2	1	4	-98.7654	0.764901	-75.54578903	75.54579	75.54578903
8	2	1	4	-96.5116	0.764901	-73.82185169	73.82185	73.82185169
9	2	1	4	-75.5556	0.764901	-57.7925286	57.79253	57.7925286
10	3	2	4	-87.1429	0.624484	-54.419289	54.41929	54.419289
11	3	2	4	-97.561	0.624484	-60.92523359	60.92523	60.92523359
12	3	2	4	-88.6364	0.624484	-55.35195938	55.35196	55.35195938
13	3	2	4	-80.4878	0.624484	-50.26331771	50.26332	50.26331771
14	4	2	4	-94.6429	0.624484	-59.10291634	59.10292	59.10291634
15	4	2	4	-92.8571	0.624484	-57.98776697	57.98777	57.98776697
16	4	2	4	-84.2105	0.624484	-52.58809636	52.5881	52.58809636
17	4	2	4	-83.7209	0.624484	-52.28235162	52.28235	52.28235162
18	5	2	4	-72.7273	0.624484	-45.41699231	45.41699	45.41699231
19	5	2	4	-76.087	0.624484	-47.51505989	47.51506	47.51505989
20	5	2	4	-73.5294	0.624484	-45.91791502	45.91792	45.91791502
21	5	2	4	-95.8333	0.624484	-59.84634925	59.84635	59.84634925
22	5	2	4	-89.2857	0.624484	-55.75746824	55.75747	55.75746824
23	6	3	4	-86.4865	0.741168	-64.10100046	64.101	64.10100046
24	6	3	4	-91.1765	0.741168	-67.57706574	67.57707	67.57706574
25	6	3	4	-87.5	0.741168	-64.85218406	64.85218	64.85218406
26	6	3	4	-77.7778	0.741168	-57.64638583	57.64639	57.64638583
27	7	3	4	-93.75	0.741168	-69.48448292	69.48448	69.48448292
28	7	3	4	-92.8571	0.741168	-68.82272594	68.82273	68.82272594
29	7	3	4	-92.5926	0.741168	-68.6266498	68.62665	68.6266498
30	7	3	4	-86.6667	0.741168	-64.23454421	64.23454	64.23454421
31	8	3	4	-84.8485	0.741168	-62.88696636	62.88697	62.88696636
32	8	3	4	-72.4138	0.741168	-53.67077301	53.67077	53.67077301
33	8	3	4	-85.7143	0.741168	-63.5286701	63.52867	63.5286701
34	8	3	4	-69.4444	0.741168	-51.46998735	51.46999	51.46998735
35	8	3	4	-77.5	0.741168	-57.44050588	57.44051	57.44050588
36	9	4	4	-74	1.039638	-76.93324599	76.93325	76.93324599
37	9	4	4	-74.359	1.039638	-77.30644954	77.30645	77.30644954
38	9	4	4	-86.2745	1.039638	-89.69429845	89.6943	89.69429845
39	9	4	4	-91.7808	1.039638	-95.41887229	95.41887	95.41887229
40	10	4	4	-86.5385	1.039638	-89.96871282	89.96871	89.96871282

41	10	4	4	-94.5205	1.039638	-98.26719684	98.2672	98.26719684
42	10	4	4	-90.4762	1.039638	-94.06252727	94.06253	94.06252727
43	10	4	4	-81.0345	1.039638	-84.2465648	84.24656	84.2465648
44	10	4	4	-87.234	1.039638	-90.6918656	90.69187	90.6918656
45	11	4	4	-89.2857	1.039638	-92.82486244	92.82486	92.82486244
46	11	4	4	-88.5246	1.039638	-92.03356853	92.03357	92.03356853
47	11	4	4	-91.4286	1.039638	-95.05265913	95.05266	95.05265913
48	11	4	4	-88.8889	1.039638	-92.41230749	92.41231	92.41230749
49	12	1	5	-5	0.764901	-3.824505569	3.824506	3.824505569
50	12	1	5	-46	0.764901	-35.18545124	35.18545	35.18545124
51	12	1	5	-41.6667	0.764901	-31.87087975	31.87088	31.87087975
52	12	1	5	-80	0.764901	-61.19208911	61.19209	61.19208911
1	1	1	5	-56.8182	0.764901	-43.46029056	43.46029	43.46029056
2	1	1	5	-69.8113	0.764901	-53.39875701	53.39876	53.39875701
3	1	1	5	-70.8333	0.764901	-54.18049557	54.1805	54.18049557
4	1	1	5	-52.381	0.764901	-40.06624882	40.06625	40.06624882
5	1	1	5	-87.037	0.764901	-66.57472658	66.57473	66.57472658
6	2	1	5	-30.5556	0.764901	-23.37197848	23.37198	23.37197848
7	2	1	5	-56.7568	0.764901	-43.41330646	43.41331	43.41330646
8	2	1	5	-34.4828	0.764901	-26.37590048	26.3759	26.37590048
9	2	1	5	-72.7273	0.764901	-55.62917192	55.62917	55.62917192
10	3	2	5	-26.3158	0.624484	-16.43378011	16.43378	16.43378011
11	3	2	5	0	0.624484	0	0	0
12	3	2	5	-14.8148	0.624484	-9.251609545	9.25161	9.251609545
13	3	2	5	-57.8947	0.624484	-36.15431625	36.15432	36.15431625
14	4	2	5	-56.25	0.624484	-35.12720499	35.1272	35.12720499
15	4	2	5	-73.4694	0.624484	-45.88043101	45.88043	45.88043101
16	4	2	5	-60	0.624484	-37.46901866	37.46902	37.46901866
17	4	2	5	-28	0.624484	-17.48554204	17.48554	17.48554204
18	5	2	5	-67.8571	0.624484	-42.37567586	42.37568	42.37567586
19	5	2	5	-81.3559	0.624484	-50.80544903	50.80545	50.80544903
20	5	2	5	-50.8772	0.624484	-31.77197489	31.77197	31.77197489
21	5	2	5	-57.8947	0.624484	-36.15431625	36.15432	36.15431625
22	5	2	5	-50	0.624484	-31.22418221	31.22418	31.22418221
23	6	3	5	-40	0.741168	-29.64671271	29.64671	29.64671271
24	6	3	5	-52.2727	0.741168	-38.7428632	38.74286	38.7428632
25	6	3	5	-15	0.741168	-11.11751727	11.11752	11.11751727
26	6	3	5	-77.3585	0.741168	-57.33562364	57.33562	57.33562364
27	7	3	5	-36.3636	0.741168	-26.95155701	26.95156	26.95155701
28	7	3	5	-32.5	0.741168	-24.08795408	24.08795	24.08795408
29	7	3	5	-54.5455	0.741168	-40.42733552	40.42734	40.42733552
30	7	3	5	-45.7627	0.741168	-33.91784929	33.91785	33.91784929
31	8	3	5	-49.3151	0.741168	-36.5507417	36.55074	36.5507417
32	8	3	5	-55.5556	0.741168	-41.17598988	41.17599	41.17598988
33	8	3	5	-56	0.741168	-41.5053978	41.5054	41.5053978
34	8	3	5	-48.8372	0.741168	-36.19656785	36.19657	36.19656785

35	8	3	5	-76.4706	0.741168	-56.67753901	56.67754	56.67753901
36	9	4	5	-61.8182	1.039638	-64.2685593	64.26856	64.2685593
37	9	4	5	-73.0769	1.039638	-75.97357972	75.97358	75.97357972
38	9	4	5	-75.3086	1.039638	-78.29376051	78.29376	78.29376051
39	9	4	5	-60.7143	1.039638	-63.12090646	63.12091	63.12090646
40	10	4	5	-55.5556	1.039638	-57.75769218	57.75769	57.75769218
41	10	4	5	-44.6809	1.039638	-46.45193116	46.45193	46.45193116
42	10	4	5	-79.6296	1.039638	-82.78602546	82.78603	82.78602546
43	10	4	5	-61.4035	1.039638	-63.83744925	63.83745	63.83744925
44	10	4	5	-67.9245	1.039638	-70.61695195	70.61695	70.61695195
45	11	4	5	-79.1667	1.039638	-82.30471136	82.30471	82.30471136
46	11	4	5	-50	1.039638	-51.98192296	51.98192	51.98192296
47	11	4	5	-88.0597	1.039638	-91.55025238	91.55025	91.55025238
48	11	4	5	-79.3103	1.039638	-82.4540847	82.45408	82.4540847
49	12	1	6	-18.8406	0.764901	-18.84057971	18.84058	18.84057971
50	12	1	6	-28.9474	0.764901	-28.94736842	28.94737	28.94736842
51	12	1	6	-25	0.764901	-25	25	25
52	12	1	6	-20.9877	0.764901	-20.98765432	20.98765	20.98765432
1	1	1	6	-40	0.764901	-40	40	40
2	1	1	6	-4.61538	0.764901	-4.615384615	4.615385	4.615384615
3	1	1	6	0	0.764901	0	0	0
4	1	1	6	4.477612	0.764901	4.47761194	-4.47761	0
5	1	1	6	-40.9091	0.764901	-40.90909091	40.90909	40.90909091
6	2	1	6	-35.0649	0.764901	-35.06493506	35.06494	35.06493506
7	2	1	6	-24.3243	0.764901	-24.32432432	24.32432	24.32432432
8	2	1	6	-34.8315	0.764901	-34.83146067	34.83146	34.83146067
9	2	1	6	-36.5854	0.764901	-36.58536585	36.58537	36.58536585
10	3	2	6	-35.2941	0.624484	-35.29411765	35.29412	35.29411765
11	3	2	6	-54.6512	0.624484	-54.65116279	54.65116	54.65116279
12	3	2	6	-48.4536	0.624484	-48.45360825	48.45361	48.45360825
13	3	2	6	-25	0.624484	-25	25	25
14	4	2	6	-28.7671	0.624484	-28.76712329	28.76712	28.76712329
15	4	2	6	-44.5545	0.624484	-44.55445545	44.55446	44.55445545
16	4	2	6	-42.4658	0.624484	-42.46575342	42.46575	42.46575342
17	4	2	6	-57.4468	0.624484	-57.44680851	57.44681	57.44680851
18	5	2	6	-55.8824	0.624484	-55.88235294	55.88235	55.88235294
19	5	2	6	-14.8936	0.624484	-14.89361702	14.89362	14.89361702
20	5	2	6	6.25	0.624484	6.25	-6.25	0
21	5	2	6	-55.1282	0.624484	-55.12820513	55.12821	55.12820513
22	5	2	6	-31.8841	0.624484	-31.88405797	31.88406	31.88405797
23	6	3	6	-26.2295	0.741168	-26.2295082	26.22951	26.2295082
24	6	3	6	-38.3562	0.741168	-38.35616438	38.35616	38.35616438
25	6	3	6	-38.4615	0.741168	-38.46153846	38.46154	38.46153846
26	6	3	6	6.122449	0.741168	6.12244898	-6.12245	0
27	7	3	6	-40.3226	0.741168	-40.32258065	40.32258	40.32258065
28	7	3	6	-47.4359	0.741168	-47.43589744	47.4359	47.43589744

29	7	3	6	-26.5625	0.741168	-26.5625	26.5625	26.5625
30	7	3	6	-42.5926	0.741168	-42.59259259	42.59259	42.59259259
31	8	3	6	-9.87654	0.741168	-9.87654321	9.876543	9.87654321
32	8	3	6	-21.6867	0.741168	-21.68674699	21.68675	21.68674699
33	8	3	6	-32.7273	0.741168	-32.72727273	32.72727	32.72727273
34	8	3	6	-36	0.741168	-36	36	36
35	8	3	6	17.64706	0.741168	17.64705882	-17.6471	0
36	9	4	6	17.54386	1.039638	17.54385965	-17.5439	0
37	9	4	6	31.14754	1.039638	31.14754098	-31.1475	0
38	9	4	6	10	1.039638	10	-10	0
39	9	4	6	16.43836	1.039638	16.43835616	-16.4384	0
40	10	4	6	-2.35294	1.039638	-2.352941176	2.352941	2.352941176
41	10	4	6	12	1.039638	12	-12	0
42	10	4	6	-12.1212	1.039638	-12.12121212	12.12121	12.12121212
43	10	4	6	22.22222	1.039638	22.22222222	-22.2222	0
44	10	4	6	13.75	1.039638	13.75	-13.75	0
45	11	4	6	-19.3182	1.039638	-19.31818182	19.31818	19.31818182
46	11	4	6	15.49296	1.039638	15.49295775	-15.493	0
47	11	4	6	-27.6316	1.039638	-27.63157895	27.63158	27.63157895
48	11	4	6	-25.641	1.039638	-25.64102564	25.64103	25.64102564

APPENDIX H

Pigeon population index on the AJH van der Walt building during bird scarer (audio) and birds of prey (raptor) trials (September 2014 and April/May 2015)

Table 1: Method, pigeon and time coding for dawn and dusk scares

Method	
1	Control
2	Audio
3	Raptor

Pigeon	
1	Speckled pigeon
2	Feral pigeon
3	Combined speckled and feral pigeons

Time	
1	Count before scare at dawn
2	Scare count at dawn
3	10 minutes post-scare count at dawn
4	20 minutes post-scare count at dawn
5	30 minutes post-scare count at dawn
6	Count before scare at dusk
7	Scare count at dusk
8	10 minutes post-scare count at dusk
9	20 minutes post-scare count at dusk
10	30 minutes post-scare count at dusk

Table 2: Audio bird scarer and raptor trials at dawn

Audio and raptor trials (AM)				
Time	Method	Pigeon	Week	Count
1	1	3	5	100
1	2	3	5	165
1	3	3	5	72
1	1	1	5	92
1	2	1	5	156
1	3	1	5	67
1	1	2	5	8
1	2	2	5	9
1	3	2	5	5
1	1	3	1	29
1	2	3	1	31

1	3	3	1	20
1	1	3	2	27
1	2	3	2	33
1	3	3	2	22
1	1	3	3	21
1	2	3	3	52
1	3	3	3	13
1	1	3	4	23
1	2	3	4	49
1	3	3	4	17
2	1	3	5	94
2	2	3	5	153
2	3	3	5	33
2	1	1	5	92
2	2	1	5	147
2	3	1	5	31
2	1	2	5	2
2	2	2	5	6
2	3	2	5	2
2	1	3	1	28
2	2	3	1	28
2	3	3	1	9
2	1	3	2	22
2	2	3	2	32
2	3	3	2	8
2	1	3	3	21
2	2	3	3	45
2	3	3	3	6
2	1	3	4	23
2	2	3	4	48
2	3	3	4	10
3	1	3	5	74
3	2	3	5	134
3	3	3	5	44
3	1	1	5	74
3	2	1	5	127
3	3	1	5	42
3	1	2	5	0
3	2	2	5	7
3	3	2	5	2
3	1	3	1	23
3	2	3	1	27
3	3	3	1	8
3	1	3	2	17
3	2	3	2	26
3	3	3	2	10

3	1	3	3	18
3	2	3	3	40
3	3	3	3	13
3	1	3	4	16
3	2	3	4	41
3	3	3	4	13
4	1	3	5	54
4	2	3	5	107
4	3	3	5	75
4	1	1	5	54
4	2	1	5	104
4	3	1	5	71
4	1	2	5	0
4	2	2	5	3
4	3	2	5	4
4	1	3	1	20
4	2	3	1	20
4	3	3	1	23
4	1	3	2	12
4	2	3	2	26
4	3	3	2	16
4	1	3	3	9
4	2	3	3	33
4	3	3	3	18
4	1	3	4	13
4	2	3	4	28
4	3	3	4	18
5	1	3	5	46
5	2	3	5	90
5	3	3	5	74
5	1	1	5	45
5	2	1	5	86
5	3	1	5	72
5	1	2	5	1
5	2	2	5	4
5	3	2	5	2
5	1	3	1	17
5	2	3	1	23
5	3	3	1	24
5	1	3	2	10
5	2	3	2	22
5	3	3	2	16
5	1	3	3	7
5	2	3	3	19
5	3	3	3	13
5	1	3	4	12

5	2	3	4	26
5	3	3	4	21

Table 3: Audio bird scarer and raptor trials at dusk

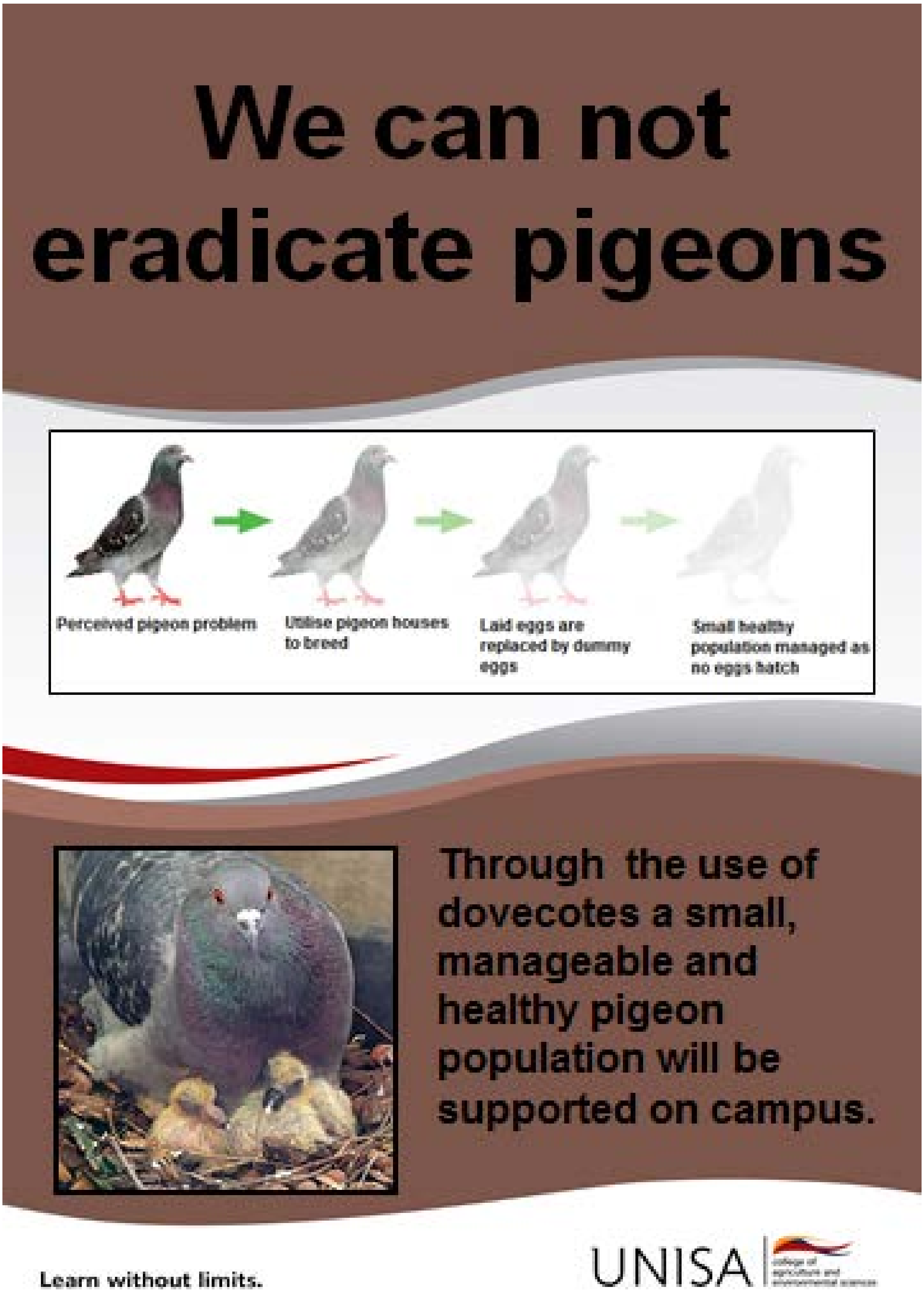
Audio and raptor trials (PM)				
Time	**Method**	**Pigeon**	**Week**	**Count**
6	1	3	5	84
6	2	3	5	119
6	3	3	5	80
6	1	1	5	82
6	2	1	5	102
6	3	1	5	70
6	1	2	5	2
6	2	2	5	17
6	3	2	5	10
6	1	3	1	23
6	2	3	1	29
6	3	3	1	22
6	1	3	2	13
6	2	3	2	34
6	3	3	2	18
6	1	3	3	26
6	2	3	3	28
6	3	3	3	17
6	1	3	4	22
6	2	3	4	28
6	3	3	4	23
7	1	3	5	84
7	2	3	5	132
7	3	3	5	56
7	1	1	5	82
7	2	1	5	116
7	3	1	5	47
7	1	2	5	2
7	2	2	5	16
7	3	2	5	9
7	1	3	1	23
7	2	3	1	35
7	3	3	1	18
7	1	3	2	13
7	2	3	2	40
7	3	3	2	15
7	1	3	3	26
7	2	3	3	33
7	3	3	3	11

7	1	3	4	22
7	2	3	4	24
7	3	3	4	12
8	1	3	5	107
8	2	3	5	117
8	3	3	5	79
8	1	1	5	104
8	2	1	5	102
8	3	1	5	69
8	1	2	5	3
8	2	2	5	15
8	3	2	5	10
8	1	3	1	26
8	2	3	1	29
8	3	3	1	26
8	1	3	2	23
8	2	3	2	40
8	3	3	2	20
8	1	3	3	33
8	2	3	3	24
8	3	3	3	19
8	1	3	4	25
8	2	3	4	24
8	3	3	4	14
9	1	3	5	125
9	2	3	5	127
9	3	3	5	109
9	1	1	5	121
9	2	1	5	114
9	3	1	5	98
9	1	2	5	4
9	2	2	5	13
9	3	2	5	11
9	1	3	1	29
9	2	3	1	31
9	3	3	1	34
9	1	3	2	26
9	2	3	2	37
9	3	3	2	27
9	1	3	3	36
9	2	3	3	29
9	3	3	3	23
9	1	3	4	34
9	2	3	4	30
9	3	3	4	25
10	1	3	5	139

10	2	3	5	138
10	3	3	5	115
10	1	1	5	132
10	2	1	5	123
10	3	1	5	104
10	1	2	5	7
10	2	2	5	15
10	3	2	5	11
10	1	3	1	33
10	2	3	1	32
10	3	3	1	31
10	1	3	2	30
10	2	3	2	34
10	3	3	2	30
10	1	3	3	39
10	2	3	3	40
10	3	3	3	27
10	1	3	4	37
10	2	3	4	32
10	3	3	4	27

APPENDIX I

Educational campaign posters


We can not eradicate pigeons
Perceived pigeon problem
Utilise pigeon houses to breed
Laid eggs are replaced by dummy eggs
Small healthy population managed as no eggs hatch
Through the use of dovecotes a small, manageable and healthy pigeon population will be supported on campus.
Learn without limits.
UNISA


Healthy vs. sick pigeons
• Clean
• Sleek appearance
• Perky and alert
• Actively feeding, preening or interacting
• Shows an active interest in food source
• Able to fly and walk in a deliberate manner
• Dirty / matted feathers
• Fluffed up appearance
• Hunched over
• Signs of bullying around head
• Encrusted / inflamed beak and eyes
• Stays on ground when flock flies off
Learn without limits.
UNISA

PLEASE DON'T feed the pigeons

Intentional feeding or thoughtless disposal of litter foodstuffs encourages breeding.

In turn this results in overcrowding which fosters diseases and parasites, both of which are harmful to the birds and to people in close proximity.

Learn without limits.

UNISA college of agriculture and environmental sciences

PLEASE DON'T feed the pigeons

Learn without limits.

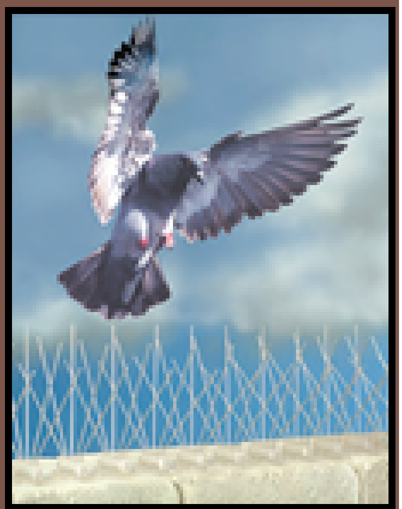
UNISA college of agriculture and environmental sciences

Reducing breeding space

Physical space reduction on buildings prevent perching and subsequent damage to buildings due to faeces build up and general wear and tear caused by pigeons.

Physical barriers such as spikes and netting will be used to prevent the pigeons from gaining access to problem areas.

PLEASE report open trunking, ceiling boards and open spaces in netting or access points.



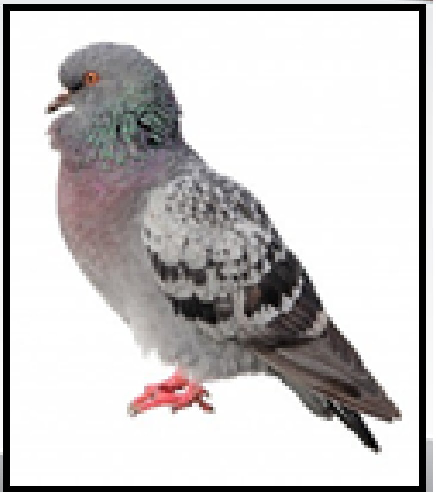
unisapigeons@gmail.com

Learn without limits.

UNISA college of agriculture and environmental sciences

Can you identify the pigeons on campus?

English: Feral pigeon
Afrikaans: Tuinduif
seSotho: Leeba
Descendent of the Speckled pigeon.
Varying plumage from blue-grey, reds, chequered to black with double bars on the wing and white rumps.



English: Speckled / African rock pigeon
Afrikaans: Bosduif / Kransduif
isiZulu: iJuba
seSotho: le-Eba, le-Evarope
Xhosa: Ivukutu
Various shades of grey and rufous plumage, with obvious white speckles on wings.
Bare red skin around eyes and legs.

Learn without limits.

UNISA college of agriculture and environmental sciences

Falcon fliers to deter pigeons

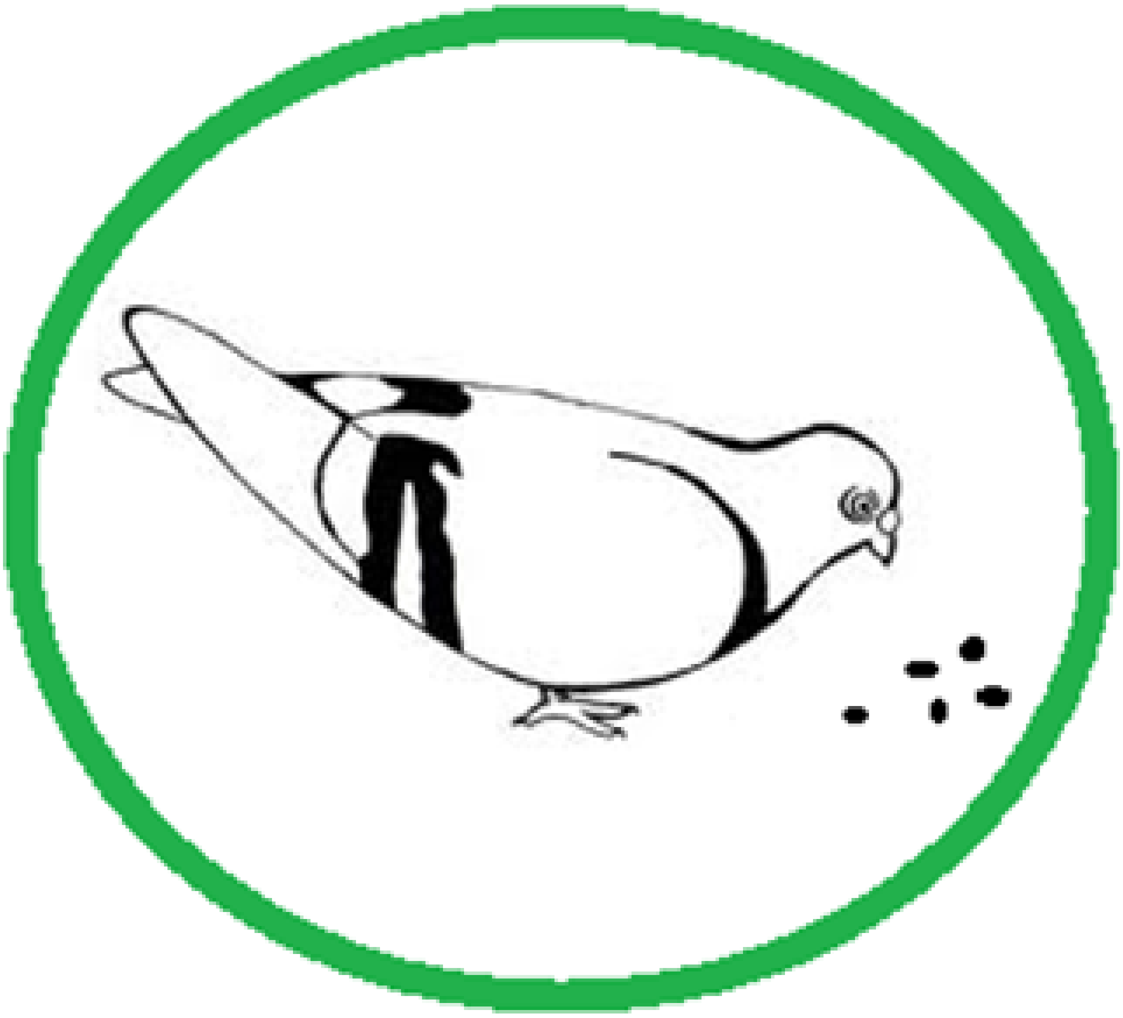
Falcons will be used as a visual deterrent, which will lead to behavioural changes through area avoidance by the pigeons.

Minimal deterrent impact is expected on other indigenous bird species inhabiting the campus; as Pied crows, Lanner falcons and Spotted eagle owls have been reported on a regular basis on campus.

Learn without limits.

UNISA college of agriculture and environmental sciences

Pigeon friendly feeding zone



Learn without limits.

UNISA college of agriculture and environmental sciences