Behaviour of Captive North Island Brown Kiwi (*Apteryx mantelli*)

A thesis submitted in partial fulfilment
of the requirements for the degree
of
**Degree (e.g. Masters of Science
in Biological Sciences)**
at
The University of Waikato
by

Katie Davison

The University of Waikato
2015

Abstract

The behaviour of captive North Island brown kiwi (*Apteryx mantelli*) in nocturnal displays and how different aspects of their enclosure and management might affect their behaviour has been studied. The most common behaviours expressed by all kiwi was feeding and sleeping/resting behaviour. Kiwi behaviour was compared from observational data collected at four kiwi facilities in New Zealand; identified as Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D. Kiwi husbandry (hutches and enrichment) and enclosure design (naturalistic and complex characteristics, size and lighting) varied between facilities. There is evidence to suggest that kiwi husbandry and enclosure design may have had an effect on the behaviour of the kiwi, as well as the kiwi viewing experience for the public. Disturbance sources (visitor-generated noise, visitor proximity, keeper disturbance and environmental disturbance) were observed to elicit abnormal behaviours (pacing, startle response) among the kiwi at Kiwi House A, Kiwi House B, and Kiwi House D. Results suggest abnormal behaviours can be minimised among the captive kiwi population by eliminating or reducing disturbance sources. The soundproofing qualities of the enclosure viewing windows at each facility were tested; the viewing window at Kiwi House C was the most effective in reducing sound. Kiwi House C also had the most soundproof enclosures due to the insulation material (Bondor Panel®) used throughout the structure of the building. This research has resulted in more detailed information of captive kiwi and enclosures, as little information was available on the behaviour of captive kiwi. Furthermore, this research can provide reasoning for normal and abnormal behaviours demonstrated by the kiwi as well as give recommendations on how management of captive kiwi, enclosure design and structure might be improved in the future.

Acknowledgements

Firstly, I would like to thank Carolyn King, my research supervisor, from the University of Waikato. I greatly appreciate the time she has dedicated toward guiding me through this thesis and her invaluable advice from her impressive career in scientific research. I would like to acknowledge Bruce Patty for his time and effort in acquiring equipment and teaching me how to use it, and Steven Miller for his help with the statistical analysis for this thesis research. This research was made possible by funding from Kiwi House B, and Suzy Barlow, who helped kick start this research, and provide the necessary permit to make it possible.

The staff at the kiwi facilities involved in this thesis research were kind enough to allow me to visit their facilities and observe their kiwi, as well as provide the information required for this thesis. In particular, I would like to thank Claire Travers, Jo Russell and Lizzy Perrett, Richard Gibson, Richard Jakob-Hoff and Debra Searchfield, also Paul Kavanagh and Nicole Kunzmann.

I am grateful to Bruce and Mary Simmons, Paul Kavanagh and his partner, and Geoff and Bev Davidson for welcoming me into their homes, and providing accommodation and food while I carried out observations at each facility.

My family and friends have been the main source of encouragement, throughout the development of this thesis, for which I am extremely thankful. A particular mention must go to Roberta Farrell, whose knowledge, expertise and friendship has been a highlight, and has resulted in my improvement as a scientist. I cannot thank my parents enough, who have always been encouraging and supportive, not only during this thesis research, but throughout my entire university journey as well as every other aspect of my life. Words cannot express how grateful I am, and how grateful I will always be.

I write this thesis for my Grandmother, Pat Cowan, and in memory of my Grandfather, Arthur Cowan. Their passion for conservation of New Zealand's native forests has resulted in the salvation of countless expanses of forest and native birds; and has developed a similar passion of mine that will last a lifetime.

Table of contents

Table of contents

Abstract i

Acknowledgements..ii

Table of contents iii

List of figures and tables vi

List of tables vii

1 Chapter 1 1

General introduction and review of current literature 1

1.1 Introduction.. 1

1.2 Literature Review 4

1.2.1 Behaviour of wild and captive kiwi, and other animals 4

1.2.2 Disturbance in captive animals.. 6

1.2.3 Enclosure design 9

1.2.3.1 Visual barriers 9

1.2.3.2 Size 11

1.2.3.3 1.2.6 Complexity... 12

1.2.3.4 Retreat space 14

1.2.4 Enrichment.. 15

1.2.5 Effects of artificial diet on behaviour 17

1.2.6 Lighting and behaviour 18

2 Chapter 2 21

Behaviour of Kiwi in captivity... 21

2.1 Introduction.. 21

2.2 Methods 23

2.2.1 Ethical Approval... 23

2.2.2 Information on Kiwi 23

2.2.3 Ethogram 23
2.2.4 Recording behaviour using Infrared cameras.................................. 24
2.2.5 Observation of kiwi 25
2.2.6 Statistical Analysis 26
2.3 Results 27
2.4 Discussion 33
2.4.1 Feeding behaviour 33
2.4.2 Sleeping/resting behaviour 40
2.4.3 Miscellaneous Behaviour 44
2.5 Conclusion 49
3 Chapter 3 50
Kiwi husbandry and enclosure design 50
3.1 Introduction 50
3.2 Methods 53
3.2.1 Husbandry and enclosure design... 53
3.2.2 Statistical analysis 53
3.3 Results 54
3.4 Discussion 57
3.4.1 Naturalistic enclosure (enclosure complexity) 57
3.4.2 Size of enclosure 60
3.4.3 Lighting.. 61
3.4.4 Hutches 63
3.4.5 Enrichment.. 66
3.5 Conclusion 68
4 Chapter 4 70
Sources of disturbance and enclosure design 70
4.1 Introduction 70

4.2 Methods 71

4.2.1 Statistical Analysis 72

4.3 Results 73

4.3.1 Sound data and behaviour 73

4.3.2 Sound data and window design 74

4.3.3 Roofing and wall materials 78

4.4 Discussion 78

4.4.1 Viewing window 78

4.4.2 Ceiling, roof, and wall materials 80

4.4.3 Pacing 82

4.4.4 Startle 83

4.4.5 Disturbance Sources 85

4.5 Conclusion 89

5 Chapter 5 91

General conclusions, implications for kiwi facilities and recommendations for further research. 91

5.1 Discussion of findings 91

5.2 Implications for kiwi facilities 97

5.3 Recommendations for further research 101

References 105

List of figures

Figure 1.1: North Island Brown Kiwi (Source: Lizzy Perrett) 4

Figure 2.1: Example of kiwi feeding behaviour (probing) at Kiwi House B.......... 24

Figure 2.2: Example of kiwi sleeping/resting behaviour (top right), at Kiwi House B 25

Figure 2.3: Example of miscellaneous behaviour (sniffing), at Kiwi House A...... 25

Figure 2.4: Cobalt (Source: Emma Bean) 29

Figure 2.5: Toi (Source: Emma Bean) 30

Figure 2.6: Te Kaha (Source: Emma Bean) 30

Figure 2.7: Frequency of behaviours seen in observations carried out on the display kiwi at Kiwi House A.. 33

Figure 2.8: Frequency of behaviours seen in observations carried out on the display kiwi at Kiwi House B.. 34

Figure 2.9: Frequency of behaviours seen in observations carried out on the display kiwi at Kiwi House C.. 35

Figure 2.10: Frequency of behaviours seen in observations carried out on the kiwi kiwi at Kiwi House D 36

Figure 3.1: Kiwi display enclosure at Kiwi House A.. 62

Figure 3.2: Kiwi display enclosure at Kiwi House A.. 63

Figure 3.3: Kiwi display enclosures at Kiwi House B 64

Figure 3.4: Kiwi display enclosures at Kiwi House B 65

Figure 3.5: Kiwi display enclosure at Kiwi House C (Source: Debra Searchfield) 66

Figure 3.6: Kiwi display enclosure at Kiwi House C (Source: Debra Searchfield) 67

Figure 4.1: Sound data (dB) and behavioural data (normal/abnormal) received and observed, respectively, every five minutes during seven one-hour observations for each display kiwi at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D 81

List of tables

Table 2.1: Ethogram used to observe kiwi behaviour 26

Table 2.2: Sex, age and experience of the display kiwi at Kiwi House A 31

Table 2.3: Sex, age and experience of the display kiwi at Kiwi House B 31

Table 2.4: Sex, age and experience of the display kiwi at Kiwi House C............. 32

Table 2.5: Sex, age and experience of the display kiwi at Kiwi House D 32

Table 2.6: P-values obtained on the difference in behaviour of the display kiwi at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D 37

Table 2.7: P-values obtained on the difference in behaviour of the display kiwi at Kiwi House A and Kiwi House B, and Kiwi House C and Kiwi House D 37

Table 3.1: Naturalistic aspects (complexity) of nocturnal display enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D 59

Table 3.2: Size of nocturnal display enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D 59

Table 3.3: Hutch management in nocturnal display enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D 60

Table 3.4: Nourishment provided for kiwi at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D 61

Table 4.1: Thickness and design of the viewing window used in the nocturnal display enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D 83

Table 4.2: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House A 83

Table 4.3: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House A, at Kiwi House B.. 84

Table 4.4: Sound data during different levels of heavy rain inside the nocturnal enclsoure at Kiwi House B 84

Table 4.5: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House C (enclosure 1) 85

Table 4.6: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House C (enclosure 2) 85

Table 4.7: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House D 85

Table 4.8: Design of nocturnal enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D.. 86

Chapter 1

General introduction and review of current literature

1.1 Introduction

The behaviour of captive North Island brown kiwi (*Apteryx mantelli*) and how different aspects of their enclosure and management might affect their behaviour has been studied in this thesis research, focusing on captive kiwi in nocturnal displays.

Kiwi (*Apteryx spp.*) are large, flightless, nocturnal birds endemic to New Zealand. Kiwi belong to the genus *ratite* along with the emu, ostrich, cassowary and rhea, as well as the extinct moa and elephant bird (Cooper et al. 1992). There are five recognised species of kiwi including the great spotted kiwi (*Apteryx haastii*), little spotted kiwi (*Apteryx owenii*), North Island brown kiwi (*Apteryx mantelli*), tokoeka (*Apteryx australis*) and rowi (*Apteryx rowi*) (Holzapfel 2008). The brown kiwi and tokoeka have been divided further into a total of four genetically distinct species (Holzapfel 2008).

Kiwi are the most distinctive bird species in New Zealand, widely recognised for their long beaks which are used to probe into soil and leaf litter in search for invertebrates (Fraser & Johnson 2009). Other characteristics of kiwi are more commonly found among mammals rather than birds, making them one of the most unique birds in the world (Baker et al. 1995). Kiwi have whiskers at the base of their beak, acute hearing and the lowest body temperature of any bird, which closely resembles the body temperature of a mammal (Sales 2005).

Kiwi mate for life, however, evidence suggests that some individuals deviate from this rule (Taborsky & Taborsky 1999). Even so, those who are of sexual maturity often have a breeding partner (Taborsky & Taborsky 1999). The majority of kiwi live in forested habitats throughout New Zealand (Taborsky & Taborsky 1995) and each kiwi pair defend a large territory which contains multiple burrows excavated from banks or cavities (McLennan 1988). Kiwi spend a considerable amount of time in these burrows which they use for roosting or nesting (McLennan 1988).

Kiwi have two functional ovaries which means the formation of a second egg can start while the first is at the end of development, a characteristic not seen in any other bird species (Fraser & Johnson 2009; Kinsky 1971). Remarkably, kiwi lay the largest eggs of any bird relative to body size, typically weighing between 330-519 grams (Sales 2005). Once the egg/s have been laid, the female kiwi leaves the nest, and the male kiwi incubates the egg for approximately three months (Taborsky & Taborsky 1999). After hatching, the chick remains in the burrow for up to one week to fully absorb the internal yolk sac, which has been nourishing the chick throughout the commencement of incubation (Colbourne et al. 2005; Sales 2005). After the yolk sac has been absorbed, the kiwi chick leaves the nest and is independent. This is termed as precocial, meaning the young kiwi are developed enough to be able to carry out all necessary behaviours for survival (Colbourne et al. 2005; Sales 2005).

Kiwi did not evolve with native mammalian predators, resulting in kiwi being equipped with very few defences against their predators that exist today (McLennan et al. 1996). When Māori and Europeans immigrants arrived on the shores of New Zealand, a variety of mammalian predators were introduced, of which the stoat, weasel, ferret, possum, rat, cat and dog are among the most destructive to the kiwi populations (Gibbs 2010; McLennan et al. 1996). As well as being relatively defenceless (particularly when they are juvenile), the kiwi are easily located by predators due to their strong, musky scent (McLennan et al. 1996). Juvenile kiwi are particularly vulnerable due to their early independence. They did not possess the long, strong claws of their adult conspecifics, which is their primary means of attack and defence. Furthermore, kiwi lack a sternum, exposing their ribs and resulting in crushing injuries from predators which are often fatal (Castro et al. 2010). During the 20th century, kiwi populations declined rapidly with all species of kiwi being classified as threatened (Robertson et al. 2011).

There are many facilities in New Zealand that focus on the captive breeding of kiwi. These facilities enable kiwi to breed and produce offspring in the safety of predator-proof enclosures (Colbourne et al. 2005). Once the eggs hatch, the chicks are kept within the safety of the facility until they're big enough to be able to defend themselves (approximately six months old), before being released into the wild (Colbourne et al. 2005). As well as private breeding enclosures, some facilities have a nocturnal kiwi display open to the public. These facilities are popular because kiwi are difficult to see in the wild, and attract visitors from all over the world. Revenue generated from these facilities help fund the continuation of captive kiwi breeding, kiwi nourishment and enclosure maintenance.

In New Zealand, there are approximately 95 captive brown kiwi (recorded in 2011) within 16 facilities, of which 40% of this captive population are housed in nocturnal displays (Barlow 2011). Captive birds provide an opportunity for research to be carried out on their biology, ecology and behaviour. However, very little research has been done on the behaviour of captive kiwi (Wesley & Brader 2014). Therefore, this research is important as it is widely recognised that the behaviour of some captive animals differ from their wild conspecifics due to various disturbance sources, or from being housed in an enclosed space (Mason 2010). If a captive animal is not comfortable within its environment, it may affect it's well-being (Mason 2010). Furthermore, this research highlighted areas regarding enclosure design and husbandry which appeared to have a detrimental effect on the behaviour of kiwi, suggesting a review in certain areas of kiwi management be considered.

For many people, the only impression they will have of kiwi are the birds they see in nocturnal displays. It is important, because of expectations, that the visitors do see the kiwi. Because these birds are nocturnal and spend a large majority of their day sleeping, it is difficult to guarantee a kiwi viewing in a facility. However, it is likely that some nocturnal houses have better kiwi displays than others due to enclosure design and/or management; promoting more natural behaviour. The visitors who get a good view of the kiwi displaying natural behaviours are more likely to spread public awareness of the plight of these birds and an aim of the facilities is to encourage volunteering or donations towards further understanding and protection of kiwi.

Figure 1.1: North Island Brown Kiwi (Source: Lizzy Perrett)

1.2 Literature Review

1.2.1 Behaviour of wild and captive kiwi, and other animals

The behaviour of a wild animal is influenced by environmental and evolutionary pressures with minimal or no human intervention (Veasey et al. 1996). Wild animals spend their time searching for food, finding mates or being vigilant for predators; in order to survive in their environment (Jamieson 2014). Captive animals are not exposed to these pressures as their environment is controlled so that all their daily requirements are provided, such as food, water and shelter. The behaviour of captive and wild conspecifics is, therefore, likely to be different (Mohapatra et al. 2014).

The behaviour of wild kiwi is not fully understood as kiwi are nocturnal and shy away from humans (Howland et al. 1992). Because of this limited research has been conducted on the behaviour of wild kiwi. However, the most extensive study to date on the behaviour of wild kiwi was done by Cunningham and Castro (2011), which was also the first study to collect behavioural data through direct observation. Thirty kiwi were observed directly, using infra-red cameras to compensate for the darkness, in two forested gullies at Ponui Island, New Zealand. The kiwi were observed, during 100% of the observations, doing foraging or foraging-related behaviour (Cunningham & Castro 2011). Jumping occurred 8% of the observational time, probably as a startle response to researcher disturbance (Cunningham & Castro 2011). Pacing was not observed at all among the wild kiwi. This was expected as pacing is typically only observed in animals in captivity (Mohapatra et al. 2014). Sleeping was not included as a behaviour category in the observations of wild kiwi, as the kiwi were only observed when active.

Less information is available on the behaviour of kiwi in captivity, even though there are many captive kiwi in New Zealand and a lesser number of facilities overseas. Only one study has been published on the behaviour of captive kiwi (Wesley & Brader 2014). This study involved two juvenile brown kiwi residing at the Smithsonian National Zoological Park, London. Behaviour data was collected through the use of video cameras and the observed behaviours were categorised as either an activity behaviour (instantaneous behaviours e.g. jumping, digging or stretching), or a motion behaviour (continuous behaviours e.g. probing, resting, or running). Results showed that the activity budget of the kiwi was dominated by feeding behaviours and occurred at approximately the same frequency by the two kiwi (Wesley & Brader 2014). Other frequent behaviours included resting, pacing, walking, interaction and bathing, which also occurred at approximately the same frequency by the two kiwi. Other comfort behaviours (e.g. stretching, smelling, sniffing, preening, shaking, and scratching) occurred at different frequencies between the two individuals.

Comparing these studies of wild versus captive kiwi clearly show that feeding is the most common behaviour for wild and captive kiwi, and likely the most important behaviour (Cunningham & Castro 2011; Wesley & Brader 2014). The only behaviour observed in captive kiwi was pacing, and is a behaviour that is commonly associated with poor animal welfare (Meagher et al. 2014). However, these conclusions are limited as the research by Wesley and Brader (2014) was restricted in several ways. Firstly, they had low replication with access to only two kiwi. In addition, both birds were juvenile which which may not be an accurate representation of the behaviour of captive kiwi. Among many species, the behaviour of juveniles differs greatly from their adult conspecifics (Held & Špinka 2011). However, young kiwi become independent soon after hatching, meaning they have to face the same perils as the adult birds (Lemons et al. 2012). This could mean that juvenile kiwi might have similar behaviours compared to their adult conspecifics. Unfortunately, one of the kiwi in Wesley and Brader’s (2014) research contracted a fatal disease and died. The remainder of the study continued with only one individual.

Few studies have compared the behaviour of captive animals to their wild conspecifics. Melfi and Feistner (2002) compared activity budgets of captive and wild Sulawesi crested black macaques. However, direct observation was only conducted on the individuals in captivity and the behavioural information on the wild macaques was obtained through published literature (O'Brien & Kinnaird 1997). The behavioural differences observed were a higher resting behaviour, and less movement and feeding behaviours within the captive macaque population (Melfi & Feistner 2002); however, results were not statistically significant. This was expected as one of the main motivations for an animal to move is to search for food, however, food is presented to captive animals which can be obtained with little effort (Melfi & Feistner 2002).

A common difference between the behaviour of captive and wild conspecifics are abnormal behaviours which are observed in captivity but which are absent in wild animals (Birkett & Newton-Fisher 2011). Birkett et al. (2011) studied the behaviour of captive chimpanzees, and compared their findings to previously published studies on the behaviour of wild chimpanzees (Birkett & Newton-Fisher 2011). Among displaying many behaviours typical of that of a wild chimpanzee, the captive population were also observed displaying abnormal behaviours, including self-harm and repetitive behaviours, which were absent in the wild population (Birkett & Newton-Fisher 2011).

The behaviour of captive and wild giraffe was also studied (Veasey et al. 1996). Behavioural differences were observed between giraffe housed in multiple zoos and a wild population inhabiting a national park (Veasey et al. 1996). Statistical significance was found between the frequency of the more common behaviours shown by giraffe (e.g. standing, feeding) and abnormal behaviours (Veasey et al. 1996). Wild giraffe generally spend more time standing and feeding, while captive giraffe spend more time on abnormal behaviours e.g. mane biting, pacing (Veasey et al. 1996).

1.2.2 Disturbance in captive animals

One of the most detrimental aspects in the life of a captive animal is exposure to multiple disturbance sources (Pomerantz et al. 2012). The most common tool used to measure the welfare of an animal is to identify any abnormal behaviour that might occur in the animal's activity budget. There is an ongoing debate over the validity of abnormal behaviours in assessing welfare, however, overall it is the most accepted method (Veasey et al. 1996).

A common source of disturbance among captive animals is visitor disturbance (Morgan & Tromborg 2007). When animals are held in captivity (i.e. zoos), they are often on display to the public. Extensive research has shown that noise from the public viewing the enclosure can be a major cause of distress among captive animals (Larsen et al. 2014; Quadros et al. 2014). The visitor generated sound that captive animals are exposed to is much louder and more frequent than what it would be in the animals natural habitat (Morgan & Tromborg 2007; Quadros et al. 2014), particularly during busy times of the year such as the summer or school holidays. Other factors related to disturbance in captive animals are visitor number and visitor proximity to the animal, which can also correlate with noise level (Choo et al. 2011; Larsen et al. 2014).

The ‘zoo visitor effect’ was investigated by Quadros et al. (2014) at Belo Horizonte Zoo, Brazil. Twelve different species of mammal were observed in their zoo enclosures and their response to different noise levels was recorded, where frequency of vigilance behaviour was used as a measure of disturbance. Collectively as a group, no difference in behaviour was observed (Quadros et al. 2014). However, at an individual level, there was a positive correlation between increase of noise and frequency of vigilance behaviour. Over half of the population sample increased their vigilance in response to an increase in visitor noise (Quadros et al. 2014). Also, over a third of the animals increased their movements when the noise increased, suggesting that there was a correlation and that the animals were unsettled (Quadros et al. 2014). The more popular animals attracted the most visitors, which resulted in higher disturbance among those individuals (Quadros et al. 2014). These results suggest that a high noise level results in a negative response among captive animals.

A similar study on captive koala conducted by Larson et al. (2014) produced the same conclusions concerning the relationship between the number, proximity and disturbance of the koala, with disturbance measured as the percentage of time the koala showed ‘visitor-related vigilance’ (Larsen et al. 2014). It was found that all three visitor-related variables increased disturbance among the koala population but a high noise level resulted in the highest disturbance (Larsen et al. 2014).

Choo et al. (2011) studied the behaviour of captive orangutans and showed that an increase in visitor proximity decreased the amount of play and socialising behaviour within the orangutan population, suggesting that close visitor proximity may be a source of disturbance (Choo et al. 2011). However, socialising may not be an accurate indicator when it comes to measuring disturbance, as orangutans are among the few large primates who do not live in social groups and are solitary (Hanazuka et al. 2013).

Not all research on disturbance obtained results where the animals responded negatively toward visitor disturbance. This was demonstrated by Azevedo et al. (2012) on captive rhea, a member of the ratite family. Direct observation determined whether the rhea showed signs of disturbance in the presence and absence of the viewing public. The rhea showed no response when visitors were present or absent, suggesting the birds were habituated to humans and considered them part of their environment (Azevedo et al. 2012). Habituation can be beneficial for captive animals as it often means they are less stressed in the presence of humans (Higham & Shelton 2011; Romero & Wikelski 2002). However, this is a disadvantage if the animal is to be released to the wild as their lack of danger perception may increase fatalities of released animals (Azevedo et al. 2012).

Keeper disturbance is also common among captive animals. Keepers are required to enter enclosures to feed the animals and to handle them for health checks, among other things. Most captive animals would have no contact with humans in their natural habitat and some respond negatively as a result, often expressing a startle response by running away from the approaching keeper or hiding in a 'safe' area (Hosey 2013). Wielebnowsk et al. (2002) studied how the husbandry of captive clouded leopards might cause them stress, determined by faecal corticoid levels. As the number of hours the keepers spent with the leopards decreased, so did the faecal corticoid levels of the leopards. Furthermore, as the number of keepers that interacted with the leopards increased, so did the faecal corticoid levels of the animals (Wielebnowski et al. 2002). This suggests that it might be beneficial to have only one or fewer keepers that enter the enclosure as the animal may familiarise itself with the keepers, resulting in less stress (Claxton 2011).

Chelluri et al (2013) investigated the relationship between chimpanzees and gorillas and their keepers. When keepers spent more time carrying out positive interactions with the animals (e.g. playing, feeding, grooming), the animals displayed a lower frequency of abnormal behaviours. This study suggests that negative interaction between the keeper and animal will result in a higher degree of abnormal behaviours; than when a keeper participates in positive interactions (Chelluri et al. 2013). It is possible that these results were obtained due to the intelligent nature of the primates. Other species may not react as well to positive interaction of a keeper, or may not respond at all, but this remains to be tested and reported in the literature.

1.2.3 Enclosure design

For a captive animal to have a high level of welfare, it is considered that they perform the same behaviours as their wild conspecifics (Veasey et al. 1996). If the animal is deprived of any behaviours, it will likely have a detrimental effect on the animal. The ideal design of an enclosure is to ensure there is enough space for the animals to carry out their daily activities, as well as replicating their natural habitat as close as possible (Fàbregas et al. 2012). The enclosure must also have an off-display area where the animals can retreat to if they are disturbed, need to rest, or feel the need to escape from any animals they might share their enclosure (Fàbregas et al. 2012). In many enclosures, when the animals are in these areas, they cannot be observed by the public. Therefore, one of the most difficult tasks in designing a display enclosure is to achieve a balance between an animal that is content and is subject to little stress, and the needs of the visitors who expect to be satisfied with the viewing experience they paid money for.

1.2.3.1 Visual barriers

In order to lower disturbance among captive animals, many enclosures have visual barriers. The purpose of a visual barrier is to block visual contact between animals and visitors, or other animals, particularly if there are different species housed in the same enclosure (Fàbregas et al. 2012). Visual barriers can be in the form of features of the environment such as rocks or vegetation (Quirke et al. 2012). The importance of visual barriers was demonstrated by De Rouck (2005) on the behaviour of captive tigers; some tigers had neighbouring conspecifics in separate enclosures, whereas some tigers were isolated. Pacing occurred at a much higher frequency among tigers who had a neighbouring conspecific than those who did not (De Rouck et al. 2005). This is expected as wild tigers are solitary animals (Morein 2014). Therefore, it would be predicted that a tiger housed close to others of its own species might become distressed. Visual barriers are an important addition to an enclosure and may be a useful tool to improve the welfare of captive animals.

Visual barriers can also serve to increase the welfare of animals by keeping the visitors at a distance. As previously discussed, research has shown that an increase in visitor proximity may cause disturbance among the animal in question (Choo et al. 2011; Larsen et al. 2014). Many enclosures have a barrier that spans the perimeter of the enclosure and can be fences walls or windows (Benbow 2000). As well as keeping the viewing public at a distance, these barriers serve other functions including protecting the public from a potentially dangerous animal and confining the animal within its enclosure (Benbow 2000). In nocturnal enclosures, the barrier also reduces noise levels as nocturnal animals typically have acute hearing and are only familiar with nocturnal sounds (Schmidt & Balakrishnan 2014)

Visual barriers that also function as a means of keeping the animal within the enclosure have a trade-off; depending on the type of visual barrier used, as they can compromise the viewing experience. A visual barrier must be made of a material which the visitors can see through, for example, window or wire fence. A visual barrier that is solid will no doubt be comforting to the animals, however, they would not be visible to the public. Some enclosures have no visual barrier. This would provide an interactive experience for the visitors, however, they may invade the animals' space.

A viewing window is a popular method of barrier used in nocturnal enclosures, including all kiwi enclosures used in this study. A viewing window is beneficial for both the animal and the visitors. The public is prevented from getting too close to the animal, but the window does not compromise the view of the animal if it is kept clean.

1.2.3.2 Size

The size and complexity of an enclosure can have an effect on the occurrence of normal or abnormal behaviour of a captive animal (Bashaw et al. 2007). The size of an enclosure should be related to the size of the animal's territory in the wild. If an animal has a large territory, then their enclosure should also be large.

A study on tigers and lions housed in captivity in a zoo has shown that the animals housed in large, more naturalistic enclosures paced less and displayed a higher frequency of normal behaviours than those animals in smaller, simpler enclosures (Bashaw et al. 2007). Breton et al. (2014) conducted a similar study on the pacing of captive tigers in different sized enclosures. Wild tigers travel long distances searching for food, and their territories are very large (depending on the density of tigers in the region) (Breton & Barrot 2014). The tigers that inhabited larger enclosures showed a lower frequency of pacing (Breton & Barrot 2014). These studies clearly show that animals benefit if given more space to carry out their daily behaviours. However, a large enclosure could also compromise the visitors' experience as the animal may be more difficult to see.

The same result was obtained by Kitchen et al. (1996) in an earlier study on how cage size affects the behaviour of marmosets. Marmosets were observed in either small or large cages. Marmosets housed in large cages showed an increase in frequency of normal behaviour (locomotion and foraging) and a decrease in frequency of abnormal behaviours (pilo-tail, repetitive jumping, pacing) (Kitchen & Martin 1996). These results clearly show that cage-size likely have direct influences on the behaviour of a captive animal.

1.2.3.3 Complexity

Complexity of enclosures is a feature that has been identified as one of the most important aspects of enclosure design (Fàbregas et al. 2012). A complex enclosure is one that has structures and natural elements that replicate the natural habitat of the animal, and also enables the animals to carry out normal behaviours

(Fàbregas et al. 2012). Complex enclosures can stimulate the animal and decrease boredom (Goerke et al. 1987). A simple enclosure is relatively bare, with few naturalistic characteristics, in which the animals can carry out very few behaviours (Fàbregas et al. 2012). Naturalistic enclosures would also be beneficial to animals exposed to disturbances as they would be able to find areas which would conceal them away from the disturbance.

Choo et al. (2011) investigated the degree of disturbance of captive orangutans that had access to two, large, naturalistic free-ranging enclosures. Their behaviour did not significantly change with an increase of visitors and visitor activity, a positive result that is rare when studying potential disturbance of zoo animals. It is likely that they were not disturbed because their vast and high-complexity enclosures consisted of vegetation and tall trees that would be typical of their wild habitat. There was also extra apparatus such as artificial vines, platforms and hammocks to encourage naturalistic behaviours (Choo et al. 2011).

The benefits of a well-designed, complex enclosure were demonstrated in a study by Ross et al. (2011). Behaviour of chimpanzees and gorillas was compared between two enclosures, one significantly more complex and naturalistic than the other. Results indicated that the activity of the animals decreased when they were transferred to the naturalistic enclosure (Ross et al. 2011). Inactivity of captive animals can be thought of as a negative element for the viewing public, but has not been considered as a negative response for the primates, as these animals sleep and rest for approximately a third of the day in the wild (Ross et al. 2011). This may mean that the animals are content and happy with their environment as an increase in activity would suggest restlessness and distress among the gorilla and chimpanzee population (Ross et al. 2011). Abnormal behaviours were observed within the gorilla population in their original, simpler enclosure, including pacing. The frequency of pacing decreased when inhabiting their naturalistic enclosure.

Anderson (2014) studied the behaviour of captive gibbons before and after their basic enclosure was renovated to make it more complex, with focus on increasing the vertical space available to the animals. This was important as gibbons are primarily arboreal monkeys and spend most of their time in trees amongst the canopy (Anderson 2014). Before the renovation, the gibbons spent most of their time in the lower regions of the enclosure and did not display a high frequency of species-typical behaviour (Anderson 2014). After the enclosure renovation, the gibbons spent approximately two thirds of their time in the upper regions of the enclosure and showed a significantly higher frequency of species-typical behaviour (Anderson 2014). It was concluded that making their enclosure more naturalistic and complex improved the welfare of the gibbons.

Complex enclosures also provide major benefits for animals that are to be released into the wild, particularly those animals that were born into captivity (Guy et al. 2013). This will increase their chances of choosing natural food that can be eaten and learning which food to avoid, as well as learning the necessary behaviours to survive in their natural environment (Guy et al. 2013). If the animal is able to carry out species-specific behaviours in their captive environment then they will adapt quickly to their wild habitat after release, increasing their chance of survival (Guy et al. 2013).

Increasing the complexity of an enclosure can decrease the visibility of the animal to the viewing public, as there are more features which the animals can hide behind. Davey (2005) investigated whether increase in complexity of an enclosure affected the visitor's interest in viewing the animal, compared to a basic enclosure where the animals were easy to view. Davey (2005) found the animals did become less visible in the complex enclosure, however, the length of time the visitors spent looking at the display did not decrease compared to the length of time the visitors spent viewing the barren enclosure (Davey 2006). This suggests the visitors prefer observing a naturalistic enclosure, even though the animal might be harder to spot. A naturalistic enclosure encourages the visitors to look for the animal, therefore increasing interest of the enclosure (Davey 2006). These results imply that it is possible to achieve a balance in fulfilling both the animals and visitor's needs when designing an enclosure (Davey 2006).

1.2.3.4 Retreat space

A reason why animals can become distressed in captivity is that they have no control over their environment (Kagan 2013). The addition of retreat spaces in an enclosure is a way to help reverse this problem, as the animal can choose when to occupy this area. Retreat spaces are areas to which an animal may go if it wants to get away from a disturbance or other animals that might be co-inhabiting its enclosure, or just to rest (Fàbregas et al. 2012). A retreat space gives an animal control on its exposure as well as enabling it to feel safe from the commotion surrounding it (Fàbregas et al. 2012), however, this can also present a problem. If the animal spends too much time in retreat spaces, the visitors will not be able to see it. Therefore, it is essential that the design of the enclosure enables the animal to feel comfortable in its surroundings so that it doesn't need to spend a significant amount of time in off-display areas.

Anderson et al. (2002) researched how different retreat spaces (no retreat, semi-retreat, full-retreat) affected the behaviour of goats and sheep housed in petting zoos. They designed three spaces, as follows:

- A no-retreat space where the visitors had full access to all areas of the enclosure and were able to interact with the animals anywhere,

- A semi-retreat space that consisted of a shelter, where the visitors were still able to interact with them in this area,

- A full-retreat space that consisted of a shelter with extra barriers which prevented any interaction of visitors with the animals.

Animals that had access to the full retreat space showed a lower frequency of abnormal behaviours (e.g. pacing). This was to be expected as these animals were able to get a greater distance between the visitors, and also concealed themselves from their view. However, the frequency of abnormal behaviours in the semi-retreat enclosure was significantly higher than in the no-retreat enclosure, which Anderson et al. (2002) stated as unexpected. Even so, the animals were still in a position where visitors could interact with them. These results indicated that animals that had access to a retreat space within their enclosure were more likely to express normal behaviour and show less signs of distress.

Fanson and Wielebnowski (2013) studied captive lynx and the effects of different housing and husbandry practices on their stress levels, measured by levels of hormones. Results suggested that enclosures that had more retreat spaces housed lynx with a lower stress hormone level than lynx who were housed with few retreat spaces (Fanson & Wielebnowski 2013). As with the previous study on the behaviour of goats and sheep in a petting zoo, this research suggests that retreat spaces lowers the stress levels of captive animals, which would likely decrease the frequency of abnormal behaviour. Furthermore, the presence of more than one retreat space would be even more beneficial to the animal (Andrews & Ha 2014).

1.2.4 Enrichment

It is well documented that environmental enrichment can have an effect on the behaviour of a captive animal (Grazian 2012). Captive animals have the benefit of never experiencing food scarcity, a problem that some wild animals have to overcome daily. An effort has been made to provide food which the animal would normally eat in the wild, as well as present the food in a natural way. For example, a predator might get presented live food or have its food hidden within its enclosure so it is required to actively search, similar to the behaviour that would be required in the wild. Tree grazers might have branches and leaves presented to them at a height attached to a pillar to depict a tree, whereas ground foragers might have food scattered throughout the enclosure floor so they will have to search for it, as they would in the wild (Maple & Perdue 2013). Unpredictability is important for enrichment presentation. Spatial unpredictability, when the location of the food is often changed so the animals have to search for it, and temporal unpredictability, when the feeding time is random, have been known to increase the behavioural repertoire of an animal and decrease abnormal behaviours (Bassett & Buchanan-Smith 2007)

Environmental enrichment can reduce abnormal behaviours in captive animals. Azevedo et al. (2013) worked on the environmental enrichment of captive rheas. Abnormal behaviours shown by the rhea included pacing, escape attempts, and consuming their own faeces, behaviours which are typically not observed in wild rhea (de Azevedo et al. 2013). Previous to the research by Azevedo et al. (2012), rheas had food provided for them in two feeders and proceeded to eat the food before scanning their enclosure for faeces and eating that, too. However, when Azevedo et al. (2013) scattered food throughout the rhea's enclosure, as well as provided food in the feeders, the rhea spent a long time foraging around their enclosure for the scattered food and avoided the feeders (de Azevedo et al. 2013). As a result, all abnormal behaviours were almost eliminated, suggesting that animals prefer to search or 'work' for their food rather than have it presented in front of them in a feeder (de Azevedo et al. 2013).

A similar study on two captive grizzly bears tested the occurrence of repetitive behaviours (predominately pacing) in response to an enrichment method (Andrews & Ha 2014). The abnormal behaviours expressed by the bears were thought to stem from their feeding regime which was scheduled at set times during the day and required them to make almost no effort to obtain the food. During this research, Andrews and Ha (2014) used feeders that scattered food around the bear's' enclosure randomly, five times a day. The bears spent more time activity looking and feeding on the enrichment and significantly less time on repetitive behaviours. This suggests that if a captive animal has to be active in order to access food, it will spend more time on species-specific behaviours (Andrews & Ha 2014).

Veeraselvam et al. (2013) did a similar study on captive sloth bears. These bears spent a large percentage of their activity budget on abnormal behaviours, the most common being pacing (Veeraselvam et al. 2013). Various enrichment tools (honey-log, underground food pipes and a wobbling box) were used as part of an experiment to determine if the frequency of abnormal behaviours decreased if the bears were more challenged during feeding. These tools also encouraged the bears to carry out behaviours that would typically be observed among their wild conspecifics (Veeraselvam et al. 2013). During the experiment, the sloth bears spent less time on passive and abnormal behaviours and more time on active, normal behaviours (Veeraselvam et al. 2013). However, this change was not statistically significant, probably due to low replication (n=5).

These areas of research suggested that different enrichment strategies are a useful tool in captive animal husbandry to increase the activity levels of the animals and decrease the frequency of abnormal behaviours. However, recent publications have produced contradicting results. For example, tapirs are crepuscular animals, only being active at dawn and dusk and remain inactive for most of the day (Dutra & Young 2014). Understandably, tapirs are difficult to see in captivity. Dultra and Young (2014) tested whether environmental enrichment might increase the activity levels of the tapirs in an attempt to make them more visible to the viewing public (Dutra & Young 2014). In order to achieve this, the number of enrichment items were increased within their enclosure, to stimulate the animal and encourage natural feeding behaviours (Dutra & Young 2014). This proved to be unsuccessful as the activity levels of the tapir did not increase. This may not be a good representation, however, as it is difficult to alter the circadian rhythm of an animal (Dutra & Young 2014). Furthermore, the data may have been confounded as the tapirs were likely habituated to their environment.

1.2.5 Effects of artificial diet on behaviour

Artificial diets may be provided for animals whose diet is very specific and difficult to provide for (Potter et al. 2010). Artificial diets are often utilised so the animals ingest the same amount of nutrients as they would if they were eating their natural food (Potter et al. 2010). However, it is often impossible to replicate an animal's natural diet exactly and this may have an impact on their behaviour. In the earlier days of housing kiwi in captivity (predominantly between January 1995 to June 2000) a common reason for fatality among the captive kiwi was due to a lack of certain nutrients in their diet (Potter et al. 2010), but this is now rare. A large amount of research has been conducted on the dietary needs of animals, and artificial diets have been proven to be very successful.

Herrmann et al. (2013) carried out a study on how an artificial diet might affect the behaviour of captive feather-tailed gliders, a marsupial of Australia. Originally, the gliders were fed a diet predominately of artificial nectar, an important natural food source for this species (Herrmann et al. 2013). The gliders spent a large majority of time in the off-exhibit area sleeping. During an experiment, part of the artificial nectar diet was replaced with native browse, another food source utilised by wild feather-tailed gliders. (Herrmann et al. 2013). As a result, the gliders spent significantly less time sleeping and more time on active behaviours. In the wild, gliders require a significant amount of energy acquiring nectar. However, in captivity, they did not need to exert much effort to get to the nectar, suggesting that the high-sugar (high evergy) diet triggered sleeping behaviour (Herrmann et al. 2013). However, with less nectar and more browse, the urge to sleep was lessoned and the animals became more active and visible to the viewing public (Herrmann et al. 2013).

1.2.6 Lighting and behaviour

Lighting is important in the design of nocturnal enclosures. Many nocturnal enclosures use a 'reverse lighting method' (Fuller 2014). Low artificial lights are used during the day to produce an artificially lit nocturnal environment for the animals, so their night and day is switched, and visitors can see them when they are active at 'night' (Fraser & Johnson 2009). During the clock correct night time, a different set of much brighter artificial lights were used to replicate day time for the animals, so they slept when humans sleep (Fuller 2014). The aim was to achieve a balance between an enclosure that is dark enough to ensure the well-being of the animal, but light enough so the visitors can see the animals, a task that has proven to be difficult. Nocturnal animals are very sensitive to light and most have acute eyesight and large eyes to pick up any nocturnal light rays (Grant 2012).

Lewanzik & Voigt (2014) investigated the affect artificial light had on captive, nocturnal bats. Bats were captured from the wild and placed within in-flight cages (Lewanzik & Voigt 2014). Different compartments were made and connected to the flight cages with different levels of illumination; dimly lit and dark. The bats were enticed with fruits which were placed in all compartments (Lewanzik & Voigt 2014). The bats fed in the dark compartment significantly more often than in the dimly lit compartment (Lewanzik & Voigt 2014). Observations were also made on wild bats in their natural habitat. These bats focused their feeding on fruit trees that were not illuminated by artificial light (Lewanzik & Voigt 2014). Their study suggests that bats actively avoid artificial light during the night, which may have an impact on their ecological significance as the artificial light caused by cities and towns continues to spread further across the landscape (Lewanzik & Voigt 2014).

As previously stated, nocturnal animals typically have large eyes in proportion to their body size. However, kiwi are an exception as they are large birds with very small eyes (Martin et al. 2007). Even though kiwi have poor eyesight, it is thought they can perceive light intensity just as acutely as any nocturnal animal (Grant 2012). It is assumed that they will be affected if the intensity of the light in their enclosure is too high. Grant (2012) researched how the behaviour of captive kiwi may be affected by artificial lighting of nocturnal enclosures. It was discovered that the kiwi spent the majority of time in the darker areas of the enclosure, but they did not have any preference in relation to light intensity (Grant 2012). There was an obvious individual preference among the kiwi, making it difficult to examine how the kiwi, as a species, respond to artificial lighting at different intensities (Grant 2012). These results suggest that kiwi are not affected by light as much as other nocturnal animals (e.g. bats), however, their individual preference suggests the possibility of additional factors having an influence on preference. For example, the amount of experience the kiwi has had in the enclosure may be important as a kiwi that has inhabited the enclosure for longer may be more familiar with the lighting scheme, and therefore, not affected as much as kiwi that have only been in an enclosure for a short time

Chapter 2

Behaviour of Kiwi in captivity

2.1 Introduction

The aim of this chapter was to compare the behaviour of captive kiwi among facilities. Observational studies have shown that the two most important behaviours observed in wild kiwi are feeding and sleeping (Cunningham & Castro 2011). Kiwi spend most of their time feeding or searching for food when they are active during the night and sleep throughout the day. Therefore, feeding and sleeping were considered at the start of the thesis research to be the two most important behaviours to study in the activity budget of a captive kiwi.

The only published research on the behaviour of captive kiwi was conducted on two juvenile kiwi residing at the Smithsonian Zoo in London (Wesley & Brader 2014). However, Wesley and Brader (2014) conceited many more behaviours in their ethogram and their methodology differed, therefore direct comparisons could not be made between the results of this thesis research and that of Wesley and Brader (2014), in terms of frequency of observations. The behaviour of an animal in captivity is typically compared to the behaviour of their wild conspecifics, in order to determine if the behaviours of captive animals are normal or abnormal (Chosy et al. 2014; Crast et al. 2014). Abnormal behaviours include any behaviours seen in captive animals significantly more or less frequently, or repetitively, than in their wild conspecifics (Crast et al. 2014). These include stereotypic behaviours, defined as behaviours which occur repetitively with no obvious function, such as pacing (Tarou et al. 2005). In this thesis research, the nocturnal and secretive behaviour of wild kiwi was not included.

As with all wild animals, the behaviour of wild kiwi is primarily related to survival in their environment (White 1978). This involves finding enough food, water, shelter, and interacting with others of the same species (finding mates) as well as defending territories (White 1978). Captive kiwi do not experience these same survival related pressures. Food is provided for them, as well as various options for shelter. Kiwi are very aggressive, and have the potential to cause each other serious harm (Jamieson 2014), (Fàbregas et al. 2012). Captive kiwi are often housed singly to reduce this risk, or with another kiwi which they do not respond aggressively to, such as a breeding partner. Because captive kiwi do not have to spend all of their time on survival behaviours, they might show a higher frequency of miscellaneous or leisurely behaviours (Mathews et al. 2005).

It is well recognised that different species adapt differently to a captive environment (Mason 2010). This is because some species are less easily stressed than others and settle more quickly in a new environment (Mason 2010). No research has been carried out specifically on kiwi to determine whether this species can easily adapt to a new environment. However, most of the captive kiwi held in New Zealand were born in captivity, with only a small population being previously free-living birds. Cabezas et al. (2013) demonstrated that parrots born into captivity expressed a higher frequency of 'normal' behaviour in a captive environment, than those birds that were wild-caught (Cabezas et al. 2013). This was most likely because the captive parrots had physiologically acclimated to captivity and the presence of humans (Cabezas et al. 2013). Therefore, it might be expected that kiwi born into captivity would also exhibit a high frequency of 'normal' behaviour.

It is important to research the behaviour of captive kiwi in order to understand if, and by how much, their behaviour differs from that of their wild conspecifics. More importantly, to also identify whether captive kiwi display behaviours that are not expressed by wild kiwi, as this could mean there are other variables acting on their surroundings which are not present in the wild. Because there is so little information available to the managers of kiwi facilities on the behaviour of captive kiwi, this thesis research was designed to provide a foundation study to help improve the operation of kiwi facilities.

2.2 Methods

2.2.1 Ethical Approval

Prior to the beginning of this research a permit was obtained from the Zoological Aquarium Association (ZAA). A permit was also obtained from Kiwi House C to enable research to be carried out at their facility. No permits were required for the remaining facilities. A permit was not required from the Waikato University Ethics Committee as no contact with the animal was required in this thesis research, as the data collected was from researcher observation.

2.2.2 Information on individual Kiwi

The detailed information on the individual kiwi in captivity was gathered through the knowledge of park staff.

2.2.3 Ethogram

A pilot study was conducted at Kiwi House B in order to identify the most commonly observed behaviours displayed by the kiwi. The pilot study consisted of observing four individual kiwi housed in nocturnal display enclosures, for one-hour intervals, ultimately producing an ethogram of kiwi behaviours (a table which describes all behaviours observed in an animal). The ethogram, summarised in Table 2.1, defined the following behaviours:

(1) Feeding behaviour: kiwi probing its beak into the leaf litter, soil and other substrates or objects, or moving around the enclosure with its beak to the ground detecting prey, as given in Figure 2.1.

(2) Sleeping/resting: when the kiwi is occupying its hutch or if it is curled up in a sleeping position and motionless, as given in Figure 2.2. Sleeping/resting could not be differentiated as they appear very similar.

(3) Startle response: jumping or sprinting away from a disturbance source.

(4) Pacing: Moving back and forth in a set path at a fast pace.

(5) Miscellaneous: Behaviours not included in the ethogram, for example walking, running, stationary, preening, sniffing, calling or interaction with another kiwi., as given in Figure 2.3.

(6) No-view: When a kiwi could not be seen due to obstruction of objects or vegetation present in the enclosure, or the darkness of enclosure. This did not include when the kiwi were occupying a hutch.

Figure 2.1: Example of kiwi feeding behaviour (probing) at Kiwi House B

Figure 2.2: Example of kiwi sleeping/resting behaviour (top right), at Kiwi House B

Figure 2.3: Example of miscellaneous behaviour (sniffing), at Kiwi House A

Table 2.1: Ethogram used to observe kiwi behaviour

Behaviour	Description
Feeding	Behaviours related to feeding/foraging, involving the use of the beak
Sleeping/resting	Curled up sleeping position, motionless. Or occupying nest box or retreat space
Startle	Flight reaction to a sudden or novel event
Pacing	Continuously running up and down a set path
No-view	Cannot be seen
Miscellaneous	Any behaviour which is not described by the ethogram

2.2.4 Recording behaviour using Infrared cameras

The original research plan specified the use of infra-red cameras to capture the behaviour displayed by the kiwi. Five infra-red cameras (Hawkeye Colour weatherproof) were installed in a display enclosure at Kiwi House B which contained three female, Western Brown kiwi. Two of the younger kiwi were housed together, and the third older kiwi (2 years old) was solitary, separated from the other two by an open fence. The cameras were attached to a Digital Video Recorder (DVR, Hikvision 8 channel DVR Model # DS-8708 HI-S) equipped with four 2TB hard drives to store and save the footage. Recording was set to continuous in order to capture behaviour over 24 hours.

After 16 days, the hard drives were at full capacity of stored footage. After scanning through the footage, it was discovered that one of the cameras stopped working a few days into recording. After further investigations of the DVR, it was decided to limit recording to during the nocturnal house display hours (1.30pm-5.00pm) in order to be able to store footage over more days. The original footage was deleted and recording was reset using the new time frame. After 12 days of data was collected, the hard drives containing the footage were transferred to another hard drive at the University of Waikato. Once the footage was transferred, the equipment was established in the nocturnal enclosures at Kiwi House A.

At Kiwi House A, there was a nocturnal enclosure containing a female Eastern Brown kiwi, Te Kaha of 34+ years, and two female Western Brown kiwi; Cobalt of 8 months and Toi of 7 months. Five infrared cameras and the DVR were installed in Te Kaha's enclosure. It took approximately two weeks to set-up the equipment because only a short period was available each day for establishment. Multiple technical difficulties were encountered. When the equipment was successfully established, only one of the cameras worked. The cameras were eventually fixed but significant time was spent identifying the source of the problem, and subsequently the connecting cords needed to be replaced and the situation altered. When all cameras were working, recording was set to 8.30am – 5.00pm (display hours). Two days of footage were successfully stored, but soon after that, two cameras ceased to work. It was clear a new method had to be developed to capture the behaviour of the kiwi as too much time had been spent on remediating equipment problems.

2.2.5 Observation of kiwi

The new methods consisted purely of direct researcher observation, which was adopted as instantaneous sampling method such that the behaviour of the kiwi in focus was noted every five minutes for one hour, using the ethogram. Observations began at Kiwi House A on the three nocturnal display kiwi. One or two practice days were needed at each facility to ensure fast and accurate behaviour identification and recording, as well as getting accustomed to the behaviour pattern of the individual kiwi . Each kiwi was observed for one hour per day, for nine days. The times of observation, and the decisions on which kiwi was observed during this time, were randomised using the Excel function 'RAND'. This method was repeated at Kiwi House C with two pairs of kiwi, at Kiwi House D (Queenstown) with two pairs of kiwi, and at Kiwi House B with one pair of kiwi and two singular kiwi. In cases where two kiwi in the same enclosure could not be easily differentiated, a white band was put on the leg of one of the kiwi for easy identification.

Only eight days of data was from each facility for the data analysis, as there was often one day at each facility where the data logger stopped working or the park had to close early for a variety of reasons including a burst water pipe. The same amount of observations was not collected for each kiwi from each different facility even though this was the original aim. There were some observations where the data logger did not produce a value. In another case there were no people in the park so the park closed early and observations had to be stopped earlier than the desired time period. In another case, the hutches were opened earlier than expected which resulted in a shorter observation time. Some observations made outside the formal observations times given above were also recorded and are reported in the thesis.

2.2.6 Statistical Analysis

In order to determine whether there was a difference in behaviour of kiwi within each facility, each behaviour was categorised into normal or abnormal behaviour. A count was made on the number of observations in each category, observed at each facility. A Fisher's Exact Test (Edwards 2005) was performed on the resulting table of counts.

2.3 Results

Kiwi House A have three kiwi, described in Table 2.2. Cobalt is a female kiwi who is 7 months old, with 5 months experience on display, shown in Figure 2.4. Toi is a female kiwi who is 8 months old, with 7 months experience on display, shown in Figure 2.5. Te Kaha is a female kiwi who is 33 years old with 32 years of experience in captivity, on and off display, shown in Figure 2.6.

Figure 2.4: Cobalt (Source: Emma Bean)

Figure 2.5: Toi (Source: Emma Bean)

Figure 2.6: Te Kaha (Source: Emma Bean)

Table 2.2: Sex, age and experience of the display kiwi at Kiwi House A

Name	Sex	Age	Experience
Cobalt	Female	7 months	5 months
Toi	Female	8 months	7 months
Te Kaha	Female	33 years	32 years (on and off display)

Kiwi House B have four kiwi on display, as given in table 2.3. Kevin is a male kiwi who is three years and three months old, with 5 months experience on display. Kahurangi is a female kiwi who is one year and 3 months old, with one year experience on display. Koru is a female kiwi who is one year and four months old, with one year experience on display. Aroha is a female kiwi who is one year and seven months old, with one year experience on display.

Table 2.3: Sex, age and experience of the display kiwi at Kiwi House B

Name	Sex	Age	Experience
Kevin	Male	3 years, 3 months	5 months
Kahurangi	Female	1 year, 3 months	1 year
Koru	Female	1 year, 4 months	1 year
Aroha	Female	I year, 7months	1 year

Kiwi House C have four kiwi on display, as described in table 2.4. Kahu is a male kiwi who is 27 years old, with four years’ experience on display. Omeka is a female kiwi who is 36 years old, with four years’ experience on display. Morehu is a male kiwi who is three years old, with two years’ experience on display. Maia is a female kiwi who is three years old with two years’ experience on display.

Table 2.4: Sex, age and experience of the display kiwi at Kiwi House C

Name	Sex	Age	Experience
Kahu	Male	27 years	4 years
Omeka	Female	36 years	4 years
Morehu	Male	3 years	2 years
Maia	Female	3 years	2 years

Kiwi House D have four kiwi on display, as described in table 2.5. Tamanui is a male kiwi who is eight years and eight months old, with six years and three months experience on display. Tawahi is a female kiwi who is six years and seven months old, with four years and one month experience on display. Kaitiaki is a male kiwi who I one year and six months old, with one year and seven months experience on display. Koha is a female kiwi who is seven months old, with one year and seven months experience on display.

Table 2.5: Sex, age and experience of the display kiwi at Kiwi House D

Name	Sex	Age	Experience
Tamanui	Male	8 years, 8 months	6 years, 3 months
Tawahi	Female	6 years, 7 months	4 years, 1 month
Kaitiaki	Male	1 year, 6 months	1 year, 7 months
Koha	Female	7 months	1 year, 7 months

2.3.1 Behaviour results

Figure 2.7 shows the frequency of behaviours observed of the kiwi of Kiwi House A. Toi displayed feeding behaviour in 88 out of a total 96 observations and miscellaneous behaviours occurred in six observations. Pacing was observed in two observations and sleeping/resting and startle response was not observed. Cobalt displayed sleeping resting behaviour in 96 out of a total 96 observations. No other behaviours were observed. Te Kaha displayed feeding in 41 out of a total 96 observations. Sleeping/resting behaviour and miscellaneous behaviours occurred in 21 observations each. A startle response occurred in one observations and pacing was displayed in 12 observations.

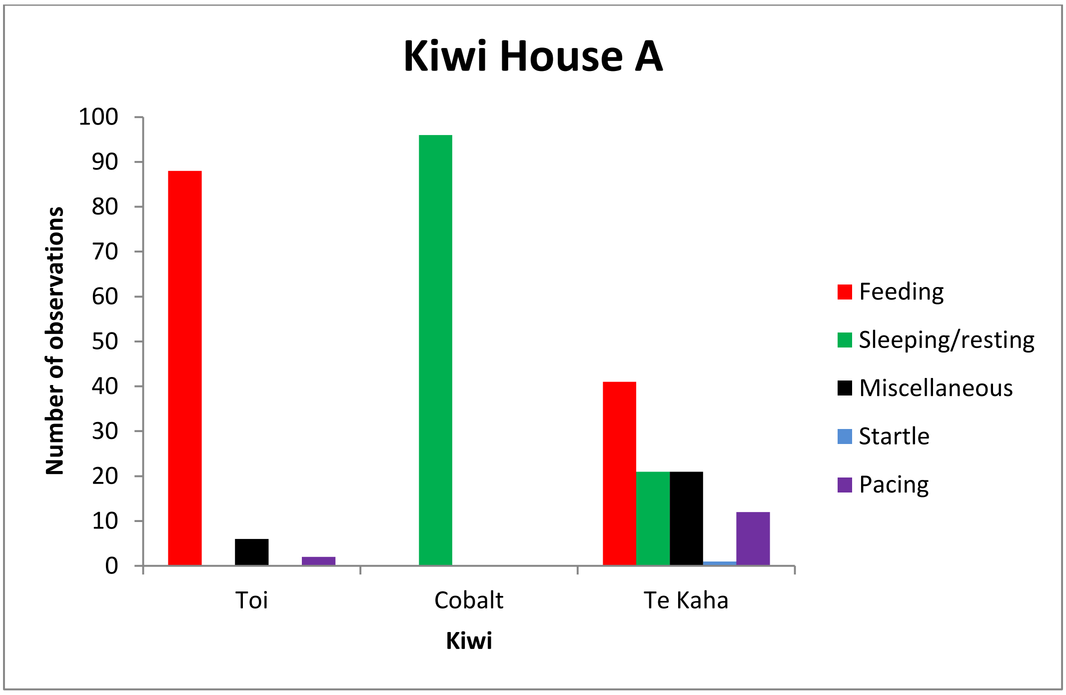


Figure 2.7: Frequency of behaviours seen in observations carried out on the display kiwi at Kiwi House A

Figure 2.8 shows the frequency of behaviours observed of the kiwi of Kiwi House B. Kevin displayed feeding behaviour in 99 out of a total 104 observations. Miscellaneous behaviours occurred in four observations and a startle response was only seen in one observation. Kahurangi was seen expressing feeding behaviours in 56 out of a total 102 observations. Sleeping/resting occurred in 15 observations. Miscellaneous behaviours occurred in 30 observations and pacing occurred in one observation. Koru was observed feeding in three out of a total 102 observations and sleeping/resting in 63 observations. Miscellaneous behaviour occurred in 36 observations. Aroha displayed feeding behaviours in 19 out of a total 104 observations. Sleeping/resting was seen in 40 observations and miscellaneous behaviours in 35 observations. Pacing occurred in 10 observations.

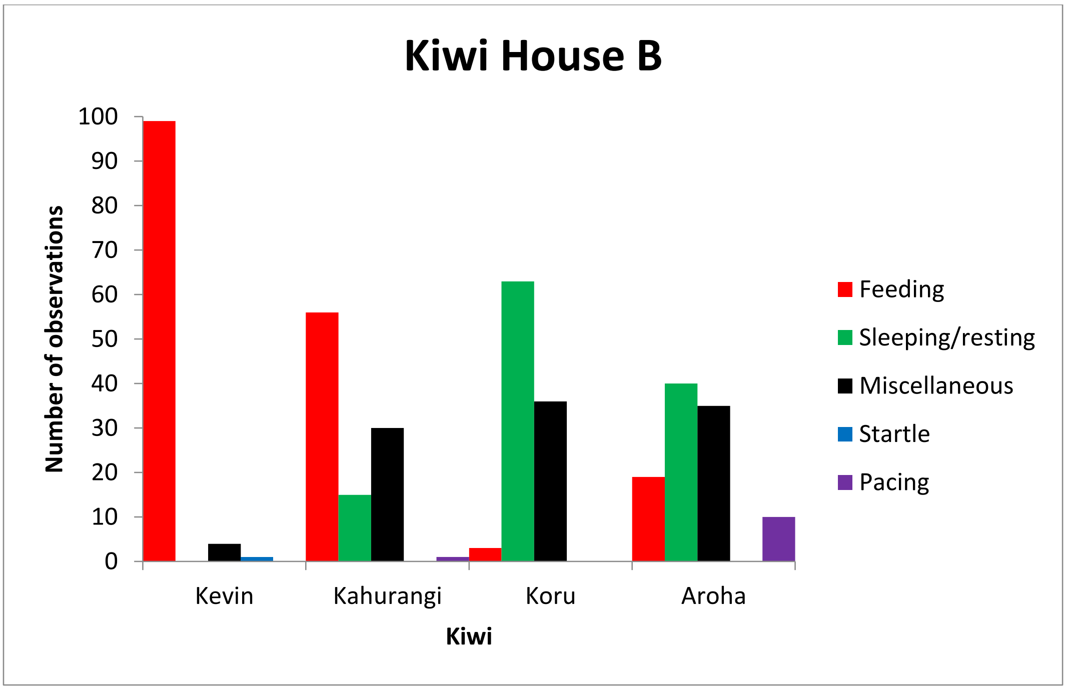


Figure 2.8: Frequency of behaviours seen in observations carried out on the display kiwi at Kiwi House B

Figure 2.9 shows the frequency of behaviours observed of the kiwi of Kiwi House C. Kahu exhibited feeding behaviour in 52 out of a total 104 observations. Sleeping/resting occurred in 32 observations and miscellaneous behaviour in 10 observations. The kiwi was not visible in 10 observations. Omeka was feeding in 24 out of a total 104 observations. Sleeping/resting occurred in 76 observations. Miscellaneous behaviour was seen in just three observations and during one observation the kiwi could not be seen. Morehu carried out feeding behaviour in 48 out of 104 observations. Miscellaneous behaviour was only seen in two observations and the kiwi could not be seen during 54 observations. Maia displayed feeding behaviour during 47 out of 104 observations. Sleeping/resting was seen in six observations and miscellaneous behaviour occurred in three observations. This kiwi could not be seen in 48 observations

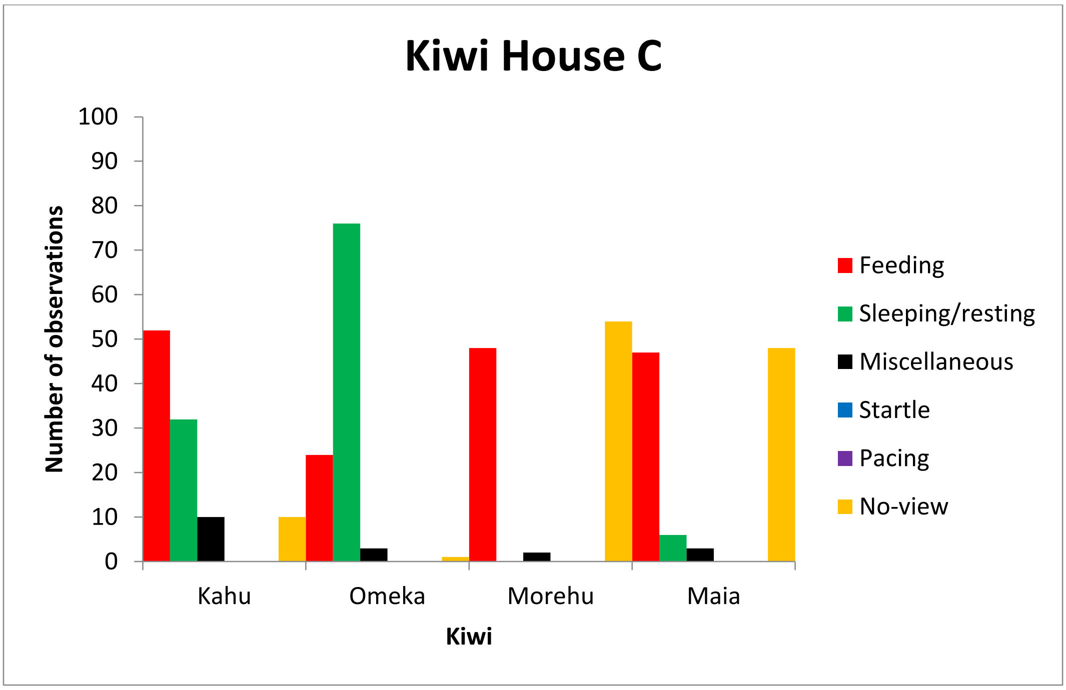


Figure 2.9: Frequency of behaviours seen in observations carried out on the display kiwi at Kiwi House C

Figure 2.10 shows the frequency of behaviours observed from the kiwi at Kiwi House D. Tamanui displayed feeding behaviours in 67 out of a total 101 observations. Sleeping/resting occurred in 14 observations and miscellaneous behaviour in 18 observations. A startle response occurred in one observation and the kiwi could not be seen in one observation. Tawahi was seen feeding in 91 out of a total 104 observations. Sleeping/resting occurred in nine observations and miscellaneous behaviour in four observations. Kaitiaki expressed feeding behaviours in 67 out of a total 104 observations. Sleeping/resting was occurred in 31 observations. Miscellaneous behaviour was seen in five observations and a startle response occurred in one observation. Koha expressed feeding behaviours in 94 out of a total 104 observations. Sleeping/resting occurred in 8 observations and miscellaneous behaviour in two observations.

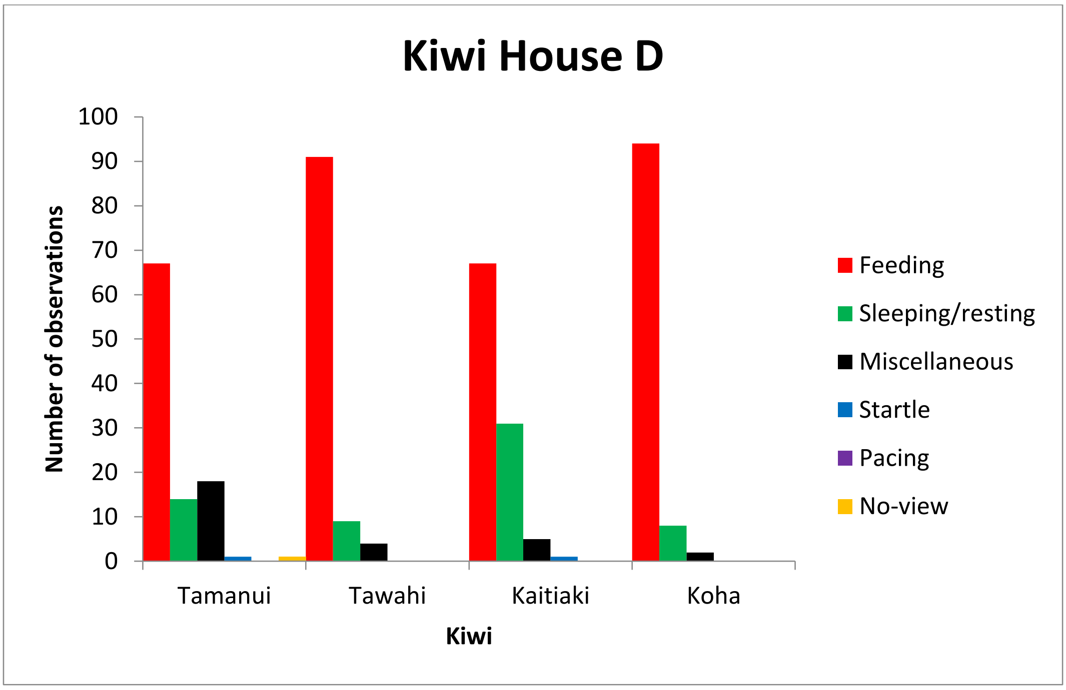


Figure 2.10: Frequency of behaviours seen in observations carried out on the kiwi kiwi at Kiwi House D

Results, given in Table 2.6, show that the behaviour of the display kiwi at Kiwi House A was significantly different to each other (p-value 0.00003); the behaviour of the display kiwi at Kiwi House B was also significantly different (p-value 0.00011). The behaviour of the display kiwi at Kiwi House C was not significantly different. A p-value of 0 was obtained as there was no evidence of bad behaviour, so it was impossible to distinguish between the birds. The behaviour of the display kiwi at Kiwi House D was not significantly different (p-value 0.6168).

Table 2.6: P-values obtained on the difference in behaviour of the display kiwi at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D

Facility	p-value
Kiwi House A	0.00003
Kiwi House B	0.00011
Kiwi House C	0
Kiwi House D	0.6168

Results, given in Table 2.7, show kiwi behaviour observed at Kiwi House A and Kiwi House B were not significantly different (p-value 0.1616). The kiwi behaviour observed at Kiwi House C and Kiwi House D were also not significantly different (p-value 0.1509).

Table 2.7: P-values obtained on the difference in behaviour of the display kiwi at Kiwi House A and Kiwi House B, and Kiwi House C and Kiwi House D

Facility		p-value
Kiwi House A	Kiwi House B	0.1616
Kiwi House C	Kiwi House D	0.1509

2.4 Discussion

2.4.1 Feeding behaviour

The kiwi housed at Kiwi House A had a significantly different frequency of feeding behaviour than the other facilities, as determined by the p-value of 0.00003, given in Table 2.6. Toi was observed feeding in 88 out of a total 96 observations, as given in Figure 2.7. It was evident that Toi's foraging behaviour was particularly energetic and vigorous. This observational research at Kiwi House A was carried out during the school holidays, where a large amount of visitors were present in the nocturnal house at any one time. Cunningham et al. (2009) showed that captive kiwi forage at a higher rate in the presence of white noise. It is possible that recurring visitor generated noise has the same effect as white noise, subsequently increasing the foraging rate of Toi. However, the noise data (as discussed in chapter 4) does not support this theory as the noise level was not constantly high.

Kiwi are precocial and independent from their parents soon after hatching, and are able to feed themselves (Colbourne et al. 2005). Young kiwi are not guided by their parents which suggest their foraging capabilities are less efficient than adult kiwi (McLennan 1988; Wilson 2014). Although no studies have yet been done on the feeding efficiency of young kiwi, there is speculation that young kiwi need to spend more time and effort searching for food because of their lower prey capture rate.

Cobalt, of Kiwi House A, did not show feeding behaviour during the observation periods for this research, as given in Figure 2.7. Cobalt is a sibling to Toi, and is of the same sex, similar age and has similar experience in the display enclosure, summarised in Table 2.2. It might be expected that Cobalt and Toi would behave similarly due to their common attributes, however, Cobalt expressed the lowest frequency of feeding behaviour that was seen relative to all kiwi included in this study.

It is possible that Cobalt was active during the 'day time' period, as wild young kiwi have been seen foraging during the day (Renwick et al. 2009). Although this behaviour has been reported, it is uncommon, thus making it unlikely that Cobalt would elicit this behaviour, but this is just a presumption. Precocial birds experience slow growth, the advantage of this being that less energy is required for this process (Ricklefs 1973; Ricklefs 1979). Furthermore, a small body requires less nourishment than a large one, suggesting that young kiwi require less food than their adult conspecifics, particularly as their diet is protein and nutrient rich (Wiebe & Slagsvold 2014). Because of this, it is speculated that young kiwi spend less time on feeding behaviour, explaining Cobalt's lack of foraging.

However, occasionally outside of observation times, Cobalt was seen creeping to the feeding bowl (which contained an artificial diet) to quickly consume a portion of food, before running back to her darkened roosting spot and out of view. This behaviour suggests that Cobalt has not settled in her enclosure, and possibly feels exposed when away from a darkened shelter. This is the most likely explanation and emphasises the fact that different conspecifics can react differently to a captive environment.

This result is consistent with other studies on how the individual personalities of animals can influence their decision making and foraging behaviour (Aplin et al. 2014). The foraging behaviour of great tits showed that the movement decisions of the birds were individually variable in that the birds took different risks to obtain different rewards, even when in flocks (Aplin et al. 2014). It is possible that the kiwi is analysing foraging in its enclosure as a risk, due to being exposed to noise and under scrutiny from the visitors on the other side of the viewing window.

Feeding was the most common behaviour expressed by Te Kaha, occurring in 41 out of a total 91 observations, as given in Figure 2.7. Te Kaha has had the most experience in captivity, and was the oldest kiwi, compared to the other individuals included in this study. It might be expected that Te Kaha would spend more time dedicated to foraging as it is likely that she was well settled in her enclosure, as previous studies on other captive animals have suggested. For example, observational studies on captive meadow voles found evidence that the longer the meadow voles were in captivity, the more time they spent on natural foraging behaviour, whereas the individuals that had only been in the enclosure for a short amount of time spent significantly less time on natural feeding behaviours (Kozuch & McPhee 2014). This suggests that experience in an enclosure is a strong variable effecting the expression of natural behaviour. However, it is possible that this correlation is species specific (Kozuch & McPhee 2014).

The frequency of feeding behaviour observed in the kiwi at Kiwi House B was also highly variable (p-value 0.00011), given in Table 2.6. Kevin expressed feeding behaviours in 99 out of a total 104 observations, as given in Figure 2.8. Feeding time for Kevin (where the bird is given its daily portion of artificial food), who occupies a different enclosure to the other three display kiwi included in this thesis research, is very late, occurring at the end of the display shift.

Evidence has shown that captive animals who are restricted by food increase their activity levels, as they are driven to search for food (Veasey et al. 1996). For example, a study on captive giraffes analysed how feeding restriction may affect locomotor activity (Veasey et al. 1996). The individuals who experienced feeding restriction had a significant increase in locomoter activity (Veasey et al. 1996). Because Kevin is restricted from artificial food, it is likely his high frequency of feeding behaviour is because of the need to satisfy his hunger. Alternatively, Kevin may have successfully settled into his enclosure and is at ease exploring his enclosure in search for food.

Kahurangi and Koru are female siblings who inhabit the same enclosure at Kiwi House B. Both kiwi are of similar age and have the same amount of experience in their enclosure, seen in Table 2.3. Kahurangi expressed feeding behaviours in 56 out of a total 102 observations, summarised in Figure 2.8. This is very similar to the feeding behaviour of both kiwi at Smithsonian Zoo. Koru demonstrated a low frequency of feeding behaviour, which only occurred in three out of a total 102 observations. Kahurangi and Koru are the most similar to the pair of kiwi at Smithsonian Zoo. Therefore, it would be expected that similar behavioural results would be obtained. The majority of feeding behaviour occurred before or during their daily feeding session, reinforcing the theory that restriction to food increases foraging activity (Veasey et al. 1996).

It was clear that Kahurangi was the dominant bird, as she was observed acting aggressively toward Koru on several instances, though this did not occur during the scheduled observation times, and therefore was not officially recorded in the results, nor included in the statistical analysis. Koru may have felt threatened by Kahurangi, which resulted in Koru expressing more submissive behaviours (stationary), and subsequently decreasing the frequency of foraging behaviour. Aggression was prominent among the female kiwi siblings observed at Smithsonian Zoo, and it was stated by Wesley and Brader (2014) that one, of the two kiwi included in the study, was dominant. However, the response of the non-dominant kiwi, when threatened, was to run away, resulting in an increase in activity levels (Wesley & Brader 2014). Although, it may be possible that different individuals of the same species react differently to a dominant conspecific. Other factors may contribute to the frequency of aggressive behaviour, for example, increasing the size of the enclosure could result in lower interaction between the birds, subsequently decreasing aggressive behaviour.

Because Koru was only seen feeding during the daily feeding session, it is possible that the feeding behaviour shown is an energy saving behaviour. The kiwi may consume as much artificial food as it can so it does not need to carry out natural foraging, in order to conserve energy. For example, baboons inhabiting a national park in Kenya have various food sources (Altmann et al. 1993). It was seen that a large majority of the baboons opted to forage in the garbage bins, where there was a concentration of digestible food that did not require considerable effort to obtain and consume, rather than forage for food in their natural habitat (Altmann et al. 1993).

Aroha spent little time feeding compared to other behaviours, of which this behaviour only occurred in three out of a total 104 observations, the data given in Figure 2.8. Foraging activity occurred in more observations at the beginning of the display shift period than at the end, supporting the theory that food restriction increases foraging activity (Veasey et al. 1996). The hutch in Aroha's enclosure was also closed during the time she was on display, and the kiwi may not have completely settled into her enclosure because of this. Even though all display kiwi at Kiwi House B have their hutch closed during the display period, they have not behaved similarly in terms of the number of observations spent feeding. By the observations, though, besides Kevin, all kiwi fed at a lower frequency than expected for a display that is only open for four hours, based on the typical sleeping hours of wild kiwi.

Feeding was clearly one of the most frequent behaviours shown by the kiwi at Kiwi House C, with the data presented in Figure 2.9. Kahu and Omeka are a breeding pair inhabiting the same enclosure, with the same amount of experience in their enclosure, given in Table 2.4. Omeka was observed feeding in 24 out of 104 observations. During the observational period, Omeka had laid an egg in a hutch. This occurrence could explain her low frequency of foraging behaviour as wild female kiwi are known to stay in the burrow for a few days after the egg has been laid (McLennan 1988). Kahu had a higher frequency of feeding behaviour, which occurred in 52 out of a total 104 observations. It might be expected that the feeding frequency of this male kiwi would be lessened as the male is typically the one who incubates the egg (McLennan 1988). However, not all males start incubating immediately (McLennan 1988). In the wild, some males will wait between 0-14 days after the egg has been laid to start incubating (McLennan 1988).

Morehu demonstrated feeding behaviour in 48 out of a total 104 observations, and Maia was observed feeding in 47 out of a total 104 observations, described in Figure 2.9. However, these kiwi could not be seen for more than half of the observations, due to the design and darkness of the enclosure. When the kiwi were visible, they were virtually always observed carrying out feeding behaviours. This gives rise to the assumption that when the kiwi were not visible, they continued to express feeding behaviours.

The enclosure that these kiwi inhabit have a high degree of naturalism and complexity. Observational studies by Anderson (2014) have shown that a naturalistic and complex enclosure results in a high frequency of feeding behaviour, further reinforcing the assumption that the frequency of feeding of these kiwi were much higher than what was observed in the results of this thesis research. A study on Langur monkeys, who were moved from a non-naturalistic enclosure to a naturalistic one, showed a large increase in feeding behaviour suggesting that this was a result of an increased complexity of the enclosure (Little & Sommer 2002).

The highest frequency of feeding behaviour was shown by the kiwi at Kiwi House D, as given in Figure 2.10. Tamanui and Tawahi are a breeding pair that inhabit the same enclosure. Tamanui expressed feeding behaviour in 67 out of a total 104 observations. Tawahi was observed feeding in 91 out of a total 104 observations. There is a notable difference between the feeding frequencies of this pair, which might be explained by the fact that Tamanui laid an egg during the observation period. It is possible that the feeding frequency of Tawahi decreased because of his need to tend to the egg.

Kaitiaki and Koha were also a potential breeding pair inhabiting the same enclosure. Both of these kiwi were observed to have a high frequency of feeding behaviour, as Kaitiaki was seen feeding in 67 out of a total 104 observations, and Koha in 94 out of a total 104 observations, as given in Figure 2.10. These feeding behaviour frequencies are similar to Tamanui and Tawahi, reinforced by the results as there was no statistical significant difference between the behaviour of the kiwi at this facility (p-value 0.6168), given in Table 2.6.

The unique feeding regime that is practiced by this facility may have an effect on the feeding behaviour of the kiwi. All four kiwi were fed four times a day, two small rations in the morning and two small rations in the afternoon. The kiwi were observed to eagerly await the feeding sessions as they were often waiting outside the door, which the keepers used to enter the enclosure, prior to feeding times. Because they were given smaller but more frequent rations of artificial food at any one time, they were not overfed. This encouraged the kiwi to forage throughout their enclosure to continue searching for food. This same behaviour response to multiple feedings have been documented in other captive animals (Andrews & Ha 2014). In a small population of captive grizzly bears, the nourishment regime was altered so the bears were fed randomly, six times a day; results showed that there was an increase in activity, including feeding behaviours, in response to this new feeding regime (Andrews & Ha 2014).

These results are not consistent with the feeding frequency of wild kiwi (Cunningham & Castro 2011). Foraging was the most common behaviour, which is consistent with 11 of the 15 kiwi included in this thesis research. However, Cunningham and Castro (2011) have stated that foraging, or foraging related behaviours, occurred 100% of the time. Only four kiwi (Toi, Kevin, Tawahi and Koha) included in this thesis research reached frequencies near this, however, no kiwi was foraging during all of the observations. It is possible that the difference in methodology could have an effect on the outcome of each study. For example, when observing wild kiwi, Cunningham and Castro (2011) recorded the frequency of all behaviours shown even if two behaviours were shown at once, which could explain the continuous occurrence of feeding behaviour. However, during observation of this thesis research, only one behaviour was recorded at a time. A difference in the frequency of behaviours between wild and captive populations has been seen among other species such as macaques and giraffes (Melfi & Feistner 2002; Veasey et al. 1996)

2.4.2 Sleeping/resting behaviour

The kiwi at Kiwi House A had a differing frequency of sleeping/resting behaviour, the data given in Figure 2.7. Cobalt was sleeping/resting throughout the entire observational period. It is possible that the kiwi had not yet adapted to the reversed lighting of the nocturnal house, as it had only seven months experience in the enclosure. This would suggest that the kiwi was active during the 'day time' in the nocturnal house, and subsequently would sleep during the 'night time', so as to not be sleep deprived. Kiwi have been seen active during the day, such as those on Stewart Island (Colbourne and Powlesland 1988). However, this behaviour appears to only occur within this population and has not been observed among kiwi living on the mainland or on other offshore islands. Furthermore, kiwi are very sensitive to light and tend to avoid bright lights (Grant 2012). Therefore, it is highly unlikely that the kiwi would be active during the nocturnal house 'day time'.

Cobalt may not have settled into the enclosure, which leads to speculation that it occupies the darkened roosting areas for seclusion and shelter. Some species adapt to a captive environment at a different rate than others, this can also be apparent on an individual level (Clubb & Mason 2007). Cobalt's lack of experience in her display enclosure may not have been enough time to settle. McDougall et al. (2006) emphasised the importance that every individual animal has a different temperament, which can subsequently have an effect on their behaviour in captivity (McDougall et al. 2006). This further reinforces Cobalt is an individual that has not adapted to her environment. The sleeping/resting behaviour of this kiwi had a substantial effect on the viewing experience as the visitors were not able to view the kiwi at all during the observational period.

Toi was not seen sleeping/resting in any of the observations, data given in Figure 2.7. This is unexpected as, through researcher observation as well as in other studies (Wesley & Brader 2014), captive kiwi are often seen taking resting periods throughout the time they are on display. Wild kiwi also sleep during part of the night (Taborsky & Taborsky 1995). It was previously discussed that the kiwi might need to stay active all 'night' in order to obtain enough food. However, this is unlikely as the kiwi is provided with a sufficient amount of artificial food. Because Toi has only had five months experience in her enclosure, it would be expected that this kiwi would behave similarly to Cobalt in that it would not yet have had enough time to completely settle in the enclosure. However, Toi's behaviour is likely due to the individuality of the kiwi and how it feels comfortable utilising the enclosure for its food sources.

Te Kaha demonstrated sleeping behaviour in 21 out of a total 96 observations, data given in Figure 2.7. Because wild kiwi spend a portion of the night roosting and/or sleeping, this result is expected (Taborsky & Taborsky 1995). As this kiwi has had 33 years' experience in a captive enclosure, it is possible that it has developed a routine that is not unlike that of a wild kiwi. The sleeping/resting behaviour of this kiwi did not affect the visitors viewing experience as the kiwi's hutch was closed during the time it was on display. Therefore, it would sleep or rest in full view to the visitors, in its favourite spots, according to comments from the staff at Kiwi House A.

The display kiwi at Kiwi House B showed a varying frequency of sleeping/resting behaviour. Because the nocturnal houses are only on display for four hours, it would be expected that these kiwi would not need to sleep or rest during the display time. Kevin did not demonstrate sleeping/resting behaviours in any observations. It is likely that this kiwi had sufficient sleep outside of the display hours and therefore did not require sleep or rest during the time he was on display. However, because these kiwi were not observed outside display hours, this is only an assumption. Other factors may have had an effect as this pattern does not appear to be consistent among the remaining kiwi at Kiwi House B.

Kahurangi appears to have a relatively high sleeping/resting frequency relative to the amount of time she was on display, as this behaviour occurred in 56 out of a total 102 observations, data given in Figure 2.8. Nevertheless, when observing this kiwi, it was noticeably more active than Koru and Aroha, most likely due to her dominance. Koru spent more time sleeping/resting than any other behaviour. Koru had the highest frequency of sleeping/resting behaviour, observed in 63 out of a total 102 observations. It is possible that this behaviour could partly be a submissive behaviour, elicited by the presence of a dominant bird in the same enclosure. However, because this was not a category included in the ethogram for this thesis research, this remains an assumption.

Aroha expressed sleeping/resting behaviour in 40 out of a total 104 observations. Aroha, and possibly Koru, may not have adapted to their display enclosure, and have shown a similar response as Cobalt. The hutches for these kiwi awere closed during their display shift. Technically, this should not deprive them of sleep due to the short display period. However, without observing the kiwi during their 'day time', this could not be determined. The sleeping/resting behaviour of these kiwi did not have a great effect on the visitors viewing experience as their hutches were closed. However, the small size of the young kiwi, and the darkened areas at the back of the enclosure did make them more difficult to spot as this is the area where they slept, when on display.

The kiwi at Kiwi House C also showed a varying frequency of sleeping/resting behaviour; however, among most of the kiwi, it did not take priority over feeding behaviours, data given in Figure 2.9. Omeka expressed sleeping/resting behaviour in 76 out of a total 104 observations. As previously described, at some point during the observations, she laid an egg. It is likely that the significant amount of time she spent in her hutch was correlated with this. Kahu was seen to pop in and out of his hutch throughout the day, which totalled up to a sleeping/resting frequency of 32 out of a total 104 observations. However, because Kahu was only in the hutch for short time periods, this did not affect the viewing standard of the bird. Kahu's behaviour suggests that a high percentage of total time spent in the hutch was connected to the egg that was laid by the female, and not spent sleeping or resting. Morehu was not observed sleeping/resting, and Maia only demonstrated this behaviour in six out of 104 observations, as given in Figure 2.9. The display kiwi at Kiwi House C live in a very complex enclosure, which may stimulate the kiwi, subsequently lowering the frequency of sleeping/resting behaviour.

The display kiwi at Kiwi House D spent little time sleeping/resting. An exception was Kaitiaki who demonstrated sleeping/resting behaviour in 31 out of a total 104 observations, described in Figure 2.10. Similar to Kiwi House C, the occurrence of Koha laying an egg in the hutch would have likely affected the behaviour of Kaitiaki. It is possible that Kaitiaki spent more time in the hutch as he was sitting on the egg to begin the process of incubation.

Koha had a low frequency of sleeping/resting behaviour, which only occurred in eight out of a total 104 observations. As the female kiwi leaves the nest after laying the egg to re-nourish her body, this low frequency of sleeping/resting behaviour could be because of the strong urge to remain active to forage for food. Tamanui and Tawahi both had relatively low frequencies of sleeping/resting behaviour, as Tamanui demonstrated this behaviour in 14 out of a total 101 observations, and Tawahi in nine out of a total 104 observations. The time that

Tawahi and Tamanui spent in their hutch was intended for sleeping. This was determined due to a camera in the hutch sending live video feed to a screen in the viewing area. These results suggest that kiwi do need to sleep for a period during their time on display. However, the time they spent on these behaviours were relatively significant and didn't affect the high standard of viewing the visitors got of the kiwi.

2.4.3 Miscellaneous Behaviour

The frequency of 'miscellaneous' behaviour at Kiwi House A, defined as behaviours not included in the ethogram, differed greatly between each kiwi. Te Kaha was seen carrying out miscellaneous behaviours relatively frequently; in 21 out of a total 96 observations, as given in Figure 2.7. These behaviours consisted of digging, listening, preening, shaking, walking and stationary. Listening was more frequent, undoubtedly due to noise from the visitors on the other side of the window. Most of these behaviours are all common animal behaviours and are expected to occur to some degree in captive kiwi, as they are seen among kiwi in the wild (Cunningham & Castro 2011). Digging was observed in multiple observations over two days, where the kiwi spent a significantly long time continuously digging what may have been a burrow. Captive kiwi have been known to dig holes or burrows, and this behaviour has previously been seen among captive kiwi (Wesley & Brader 2014). Digging is deemed a positive behaviour as it increases the range of natural behaviours shown by the captive kiwi (McLennan 1988). The extensive amount of time Te Kaha had spent in captivity could have had an effect on the frequency of miscellaneous behaviours, however, no research has been published on the effect of increasing experience on frequency of miscellaneous behaviours.

Toi only demonstrated miscellaneous behaviours in six out of a total 96 observations. The two behaviours that it did show were listening and preening, which are normal kiwi behaviours (Cunningham & Castro 2011). This further reinforces the kiwi's apparent urge to forage, and spend little time on comfort behaviours. Cobalt did not display any miscellaneous behaviours as he was sleeping/resting throughout all of the observations, and clearly had not settled into his enclosure.

The kiwi that expressed the highest frequency of miscellaneous behaviours were those at Kiwi House B, except for Kevin, who was observed carrying out miscellaneous behaviours in four out of a total 104 observations, as given in Figure 2.8. The behaviours that he did show were preening and investigating the back wall. The investigation of the back wall could have been an exploratory behaviour, which captive animals regularly carry out (Mainwaring & Hartley 2013).

Kahurangi expressed miscellaneous behaviours in 30 out of a total 102 observations, where digging was most prominent behaviour observed. Over a one-hour observation period, this kiwi was digging a hole to get into the hutch, which had been closed off. This suggests that the kiwi was eager to get access into the hutch, either to sleep or to seek shelter from a possible disturbance, although during this time there were no apparent disturbances. Another miscellaneous behaviour, which was seen in multiple observations, was stationary. This kiwi often remained stationary over long periods of time at the back of her enclosure, usually nearing the end of the display shift, suggesting the kiwi was ready to start the sleeping period of her day. As well as stationary, the other most common miscellaneous behaviour displayed by Kahurangi was investigating the back wall of her enclosure. There could be three possible reasons for this, as follows:

Firstly, the kiwi could be searching for food. The back wall of the enclosure consists of punga stumps. This wall is an area which spiders and other insects inhabit, and is a possible food source for the kiwi. However, over the observational period, the kiwi was not seen to actively grab and consume any food items from this wall.

Secondly, this behaviour could be a form of exploratory behaviour. It is well known that animals often explore their environment in order to familiarise themselves with novel objects or areas (Newberry 1999). However, this theory is compromised as these kiwi had been in their enclosure for a significant amount of time, enough time to completely familiarise themselves with their surroundings.

Thirdly, investigating the back wall could also come about because of the two kiwi on the other side of the wall. The morning and afternoon enclosures are side by side, and the punga fence separating them is only mid-height. Kiwi are very territorial and their acute sense of smell means they are well informed as to whether there are any other kiwi nearby (Wenzel 1971). The kiwi can sense the close proximity of the other kiwi, potentially encouraging the kiwi to search for a way through the dividing wall in order to get closer.

Koru demonstrated the highest frequency of miscellaneous behaviours in 36 out of a total 102 observations, as given in Figure 2.7. These behaviours were the same as Kahurangi; digging, stationary and investigating the back wall. As previously discussed, this kiwi was digging with Kahurangi in order to get into the closed off hutch. This was more than likely for the same reasons, to have access into the hutch in order to sleep. Koru also spent time investigating the back wall of the enclosure. However, the most common miscellaneous behaviour shown by Koru was stationary. Because this behaviour occurred throughout the display shift, it is unlikely that it is a pre-sleeping behaviour. Alternatively, this behaviour could be a defensive behaviour in response to the presence of Kahurangi, as kiwi are known to remain motionless in the presence of danger (Haeusler 1923).

Aroha showed a similar frequency of miscellaneous behaviours to Koru, expressed in 35 out of a total 104 observations. By far the more frequent behaviour was investigating the back wall. It is likely that the reason for this has already been discussed, that Aroha knows there are kiwi nearby and is eager to investigate further.

At Kiwi House C, Omeka was observed carrying out miscellaneous behaviours in three out of a total 104 observations, as given in Figure 2.9. Similarly, Kahu demonstrated expressed miscellaneous behaviours in 10 out of a total 104 observations. The miscellaneous behaviours observed from Omeka were solely interactive, where Omeka was fighting, or being chased by Kahu. Kahu showed miscellaneous behaviours such as preening, stationary and interaction with the female (chasing, following, fighting). These behaviours were all expected as these kiwi were housed together and are a mating pair. Interaction with the other bird was the most common miscellaneous behaviour seen. This is expected as observation showed the kiwi mating, which can involve pair bonding interaction (Potter & Cockrem 1992).

Morehu expressed miscellaneous behaviours in two out of a total 104 observations, and Maia was observed carrying out miscellaneous behaviours in six out of a total 104 observations. The only miscellaneous behaviour showed by both kiwi were interaction. This is similar to the kiwi in the other nocturnal enclosure at Kiwi House C, and expected as Morehu and Maia are going to be potentially a breeding pair, even though they were considered too young to breed.

Most of the kiwi at Kiwi House D showed a very low frequency of miscellaneous behaviours, however, Tamanui had a significantly higher frequency than the other kiwi at this facility, where miscellaneous behaviours occurred in 18 out of a total 101 observations, as given in Figure 2.10. The miscellaneous behaviours shown by Tamanui were drinking, exploring the exit door, interacting with male (chasing, following) and listening. Drinking and listening are behaviours captive kiwi are known to display (Wesley & Brader 2014). The frequency of interaction and investigating the exit door occurred at a higher frequency. As previously explained, interaction with the female was common. The reason that this kiwi was investigating the exit door was possibly because the keepers come through this door with food. The kiwi could anticipate when the feeding sessions were near and associate this door with the arrival of food. Tawahi expressed interaction with the female (fighting) and investigating exit door, which solely comprised the miscellaneous behaviours demonstrated in four out of 104 observations.

Kaitiaki, the mated pair to Koha from Kiwi House D, expressed interaction (fighting), running, stationary and preening, in five out of a total 104 observations. Koha showed interaction with the male and stationary in two out of a total 104 observations, as given in Figure 2.10. Again, as has been explained before, all of these behaviours are common behaviours in the activity budget of the kiwi (Wesley & Brader 2014). The remaining two abnormal behaviours, pacing and startle response, are discussed in chapter four.

There are a few limitations of this research which may have affected the results gained when observing the behaviour of the kiwi. Firstly, kiwi behaviour was not monitored during their 'day time'. The first original plan was to record kiwi behaviour 24 hours per day for an extended period, to include the time when the kiwi were asleep. The second plan developed, to account for problems with equipment, did not include this time period. It could be that the kiwi would not be active during their 'day time' as kiwi typically sleep all through the day (Wesley & Brader 2014). However, some kiwi are known to come out during the day, such as those living on Stewart Island (Colbourne & Powlesland 1988). Therefore, the possibility of these kiwi being active during the 'day' cannot be ruled out, even though this behaviour seems to be locally specialised. If the kiwi were to be active during the 'day', it is likely to affect the way they behave during their 'night', or when they are on display. For example, if the kiwi were active at some point during their 'day', then it is possible that they would spend more time sleeping and less time active during their 'night' to catch up on sleep. If they were active during their 'day' and feeding, it could mean that they would display a lower frequency of feeding behaviour during the 'night'.

These methods involved watching each kiwi for one hour over multiple days. These hours were randomised so the majority of a day was covered after all the observations were completed. However, there was a significant time during the day when the kiwi were not observed. It is possible that some behaviour was missed which may have had an influence on the results. Furthermore, all animals have an individual personality, and even though no research has been done specifically on kiwi, there is no reason to suggest that kiwi are any different (Herborn et al. 2014). It is possible that each kiwi displays a difference in behaviour because that is their own individual response to their environment, and there may not be a reason why the kiwi behaved as it did.

2.5 Conclusions

Feeding and sleeping/resting behaviours were the two most common behaviours observed in the majority of the kiwi included in this thesis research. This is expected as these are the most frequent behaviours seen among wild kiwi (Cunningham & Castro 2011). However, the frequency of feeding behaviour, among the majority of captive kiwi included in this thesis research, was considerably lower than that of wild kiwi.

The display kiwi at Kiwi House A and Kiwi House B had a variable frequency of behaviours. Cobalt showed an abnormal frequency of sleeping/resting behaviour, whereas Toi showed an abnormal frequency of foraging behaviours. Similarly, Kevin and Koru showed an abnormal frequency of foraging behaviour. Each pair of kiwi at Kiwi House C behaved relatively similarly, however, one pair behaved differently to the other. The female kiwi of the pair in enclosure 2 had laid an egg during observation which may have had an effect on the results. The kiwi at Kiwi House D all behaved similarly (regardless of the female of one pair having laid an egg), as feeding behaviour was clearly the most frequent behaviour.

Chapter 3

Kiwi husbandry and enclosure design

3.1 Introduction

Captive kiwi management relies on a number of aspects including nourishment provided for the kiwi, hutch arrangements and enclosure design, including naturalistic qualities (complexity) and lighting. These different aspects of a captive environment most strongly affect the two important behaviours expressed by the kiwi; feeding behaviour and sleeping.

One of the most important design practices for a kiwi enclosure is to introduce naturalistic qualities and make the enclosure more complex in order for the enclosure to depict the natural environment of the kiwi. This is so the kiwi are comfortable in their environment and to meet main biological requirements, as well as providing a stimulating environment for the kiwi (Fàbregas et al. 2012). Other research on the behaviour of captive kiwi have shown how an increase in the complexity of the kiwi enclosure encouraged different normal behaviours to be expressed (Wesley & Brader 2014).

The main habitat of the kiwi is the native forest of New Zealand. According to Taborsky and Taborsky (1995), native forest was one of the most common habitats adopted by brown kiwi to carry out their nocturnal activities, compared to other habitat types. All kiwi enclosures observed in this study, exclusively conducted in New Zealand, had nocturnal display enclosures which are defined as enclosures that use a reversed light cycle, so visitors are able to see the kiwi active during the day (Fraser & Johnson 2009). The nocturnal display also replicated a naturalistic effect of the New Zealand, North Island native forest, one of the most common habitats of the kiwi, introducing foliage into the enclosure as well as other features typical of a forest (Taborsky & Taborsky 1995).

A significant function of these nocturnal enclosures, besides providing for the kiwi, is to enable kiwi to be on public display. Therefore, it is essential that the enclosure is well received by visitors as they are the biggest critics. Nocturnal enclosures are also important as an income source for the enclosure and to provide an educational component for the public (Barlow 2011).

In the design of many enclosures, there is a trade-off where enclosures that have a high degree of complexity often have lower visibility, making the animal less observable (Davey 2006). Because of the vegetation present in the enclosures, the kiwi were often obstructed by them, particularly if they were foraging at the back of the enclosure, making it difficult for the visitors to view the birds.

Kiwi enclosures must depict a nocturnal environment, therefore lighting is an important part of enclosure design and has the potential to adversely affect the behaviour of the kiwi if the enclosure is too bright (Grant 2012). Kiwi require sufficient darkness to conduct their daily activities. However, on the other hand, the enclosure needs to be light enough to enable visitors to see the kiwi. Achieving this balance is difficult, however, kiwi facilities use reverse lighting to solve this problem (Grant 2012). Night lights are used during display hours which are standard lights that have been either dimmed or offset, or coloured lights which are known to have a lower disturbance factor among nocturnal animals (Grant 2012). There is no universal standard of brightness or darkness for nocturnal kiwi display enclosures and the lighting of nocturnal enclosures varies between different kiwi facilities. As lighting (or lack of it) is such an important part of the kiwi's habitat, an enclosure that is too bright might have an impact on the behaviour of the kiwi (Morgan & Tromborg 2007).

Nourishment is an important aspect of kiwi management, as, with all animals, enough food must be provided for the animal to carry out its daily functions (Smith et al. 2014). Kiwi are predatory birds feeding on worms and other invertebrates (Reid et al. 1982). If available, they also include fallen berries and some vegetation in their diet (Reid et al. 1982). Producing a completely natural diet for kiwi is very difficult due to the majority of their diet being live and it is relatively difficult to find the living animals in large numbers. The main source of nourishment for captive kiwi is an artificial diet with a range of fruits, vegetables, meat and oats which provide them with the nutrients they would normally get in a natural diet (Potter et al. 2010). Live food is also provided for them in the form of live insects as well as earthworms in the soil of their enclosure to encourage normal feeding behaviours (Fraser & Johnson 2009).

Different facilities have different ways of managing the feeding schedule of the kiwi. Some facilities feed their kiwi one large meal once a day, whereas others feed their kiwi multiple smaller portions. Even though research has not been done on how nourishment can affect the behaviour of the kiwi, studies have been done on many other captive species (Andrews & Ha 2014; de Azevedo et al. 2013; Dutra & Young 2014; Veeraselvam et al. 2013). The usual conclusion is that the activity levels of an animal increased if their feeding routine required the animal to actively search for the food and/or if food was offered multiple times a day in smaller portions (Grazian 2012). Therefore, it could be expected that one large meal might result in lower activity levels compared with smaller, multiple feedings (Kistler et al. 2009).

The burrow (hutch) regime of a kiwi enclosure has the potential to affect the behaviour of kiwi as it can have an impact on their sleeping pattern. Wild kiwi typically spend 17-20 hours a day asleep (McLennan 1988). Therefore, as expected, display kiwi spend a significant amount of time in off display areas such as shelters, man-made hutches or nest-boxes, where the kiwi are away from view (Potter 1989).

In the wild, kiwi sleep in burrows which are usually excavated in banks or developed from natural cavities (Jolly 1989). Kiwi often have more than one burrow in their territory and use them to roost and sleep in during the day and also as a nesting site (Renwick et al. 2009). Man-made hutches are provided for kiwi in their display enclosure. The management of kiwi hutches can be problematic for kiwi facilities in determining whether they should be kept open or closed when the kiwi are on display. Judging from observations of this thesis research, it appears some display kiwi sleep significantly more than others. Some facilities keep the hutches open 24 hours a day, whereas others close the hutch during display hours to ensure that the kiwi are visible to the visitors. Closing the hutches may cause the kiwi to express abnormal behaviours by decreasing their sleeping hours or depriving them of a 'safe-area' where they can escape disturbance. However, if the hutches are kept open throughout the day, there is a risk that the kiwi will spend a lot of its time in the hutch sleeping.

3.2 Methods

3.2.1 Husbandry and enclosure design

Information for this chapter was collected through researcher observation and from the facility staff at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D.

Aspects of kiwi husbandry and enclosure design at each facility were recorded between the months of April and July, 2014. The information obtained was the time of day the kiwi were fed, the frequency of kiwi feedings and the components of the diet provided to the kiwi, and how the hutches were managed. Also, observations were made on the day-night reversed lighting cycle and the naturalistic qualities of the enclosure such as presence of vegetation and other natural objects. Park staff measured the size of the enclosures and passed on the information.

3.2.2 Statistical analysis

Fisher's Exact Test was used to determine whether there was a statistically significant difference between the kiwi within each facility (Edwards 2005). The null hypothesis for this test assumed that all kiwi would behave normally or abnormally according to the proportions. The plausibility of this test was determined based on the behaviours that were observed.

The number of counts of normal and abnormal behaviours were tallied for each kiwi and divided by the sum to get a proportion of behaviour that was normal or abnormal. Firstly, a chi-square test was used to measure how different the observed behaviour was from what was expected, if all the kiwi behaved the same. The data was then randomly simulated according to the overall probabilities that were calculated to obtain p-values.

A Fisher's Exact Test was also done to determine whether there was a difference in behaviour of kiwi between Kiwi House A and Kiwi House B, and Kiwi House C and Kiwi House D (Edwards 2005).

3.3 Results

Table 3.1 summarises the naturalistic aspects of the kiwi display enclosures at each kiwi facility included in this thesis research. Kiwi House A had a moderately dense array of foliage within their enclosures with leaf litter and rotten logs on the enclosure floor. The walls of the enclosure are made of plywood and concrete blocks. There was a good lighting balance which met the needs of the kiwi and visitors. Kiwi House B had scattered foliage within the enclosures and leaf litter and logs on the enclosure floor. The external wall is made of punga stumps. A relatively good lighting balance had been achieved which met the needs of both the kiwi and the visitors. Kiwi House C had a dense array of foliage within their enclosures and leaf litter and logs on the enclosure floor. The walls are made of Bondor Panals and fake rocks in some areas. The lighting was beneficial for the kiwi but poor for the visitors, a suitable balance had not been achieved. Kiwi House D had foliage planted sparsely throughout the enclosures with leaf litter and logs. The enclosure walls are timber framed. An excellent lighting balance had been achieved where the needs of both the kiwi and the visitors were met.

Table 3.1: Naturalistic aspects (complexity) of nocturnal display enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D

Kiwi facility	Enclosure interior	Enclosure floor	Enclosure walls	Lighting (kiwi)	Lighting (visitors)
Kiwi House A	Foliage – moderately dense	Leaf litter, rotten logs	Plywood, concrete blocks	Good	Good
Kiwi House B	Foliage - scattered	Leaf litter, logs	Punga stumps	Good	Good
Kiwi House C	Foliage - dense	Leaf litter, logs	Bondor Panels®, fake rocks	Excellent	Poor
Kiwi House D	Foliage - sparse	Leaf litter, logs	Timber framed	Very good	Very good

Table 3.2 shows the sizes of each of the kiwi display enclosures for each Kiwi facility included in this thesis research. Kiwi House A had three enclosures, each with varying sizes at $35m^2$, $50m^2$ and $28m^2$. Kiwi House B had three enclosures of relatively similar sizes at $26.7m^2$, $20.8m^2$ and $29.4m^2$. At Kiwi House C the size of enclosure 1 and 2 were the same at $49.5m^2$. At Kiwi House D the size of enclosure 1 and 2 were the same at $56.55m^2$.

Table 3.2: Size of nocturnal display enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D

Kiwi facility	Size of enclosure 1	Size of enclosure 2	Size of enclosure 3
Kiwi House A	$35m^2$	50m	$28m^2$
Kiwi House B	$26.7m^2$	$20.8m^2$	$29.4m^2$
Kiwi House C	$49.5m^2$	$49.5m^2$	
Kiwi House D	$56.5m^2$	$56.5m^2$	

Table 3.3 describes the hutch management at each kiwi facility included in this thesis research. The hutches in the nocturnal display enclosures at Kiwi House A were open 24 hours a day, apart from the hutch in one enclosure which was closed during the display hours. The hutches in the nocturnal display enclosures at Kiwi House B were closed during the 4-hour display period, and remained open during the 20-hour off-display period. The hutches in the nocturnal display enclosures at Kiwi House C and Kiwi House D were open 24 hours a day.

Table 3.3: Hutch management in nocturnal display enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D

Kiwi facility	**Hutches**
Kiwi House A	Hutch in one enclosure closed during display, open 15 hours. Hutches in remaining enclosures not closed, open 24 hours a day
Kiwi House B	Closed during 4-hour display period, open 20 hours
Kiwi House C	Not closed, open 24 hours a day
Kiwi House D	Not closed, open 24 hours a day

Table 3.4 summarises the nourishment regime for the display kiwi at each kiwi facility included in this thesis research. The display kiwi at Kiwi House A were provided with an artificial diet which was given to them once a day. A natural diet of live insects was also provided once per day. Earthworms were in the soil of the enclosure which also made up part of the kiwi's diet. The display kiwi at Kiwi House B were provided with an artificial diet which was given to them once a day. Earthworms were in the soil of the enclosure which also made up part of the kiwi diet. The display kiwi at Kiwi House C were provided with an artificial diet which was given to them once a day. A natural diet of live insects and earthworms were also provided once per day. Earthworms were in the soil of the enclosure which also made up part of the kiwi's diet. The display kiwi at Kiwi House D were provided with an artificial diet which was given to them four times a day. A natural

diet of live insects were also provided once a day. Earthworms are in the soil of the enclosure which also made up part of the kiwi's diet.

Table 3.4: Nourishment provided for kiwi at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D

Kiwi facility	Artificial diet	Frequency	Natural diet	Frequency
Kiwi House A	Yes	Once per day (morning)	Live insects, earthworms	Once per day
Kiwi House B	Yes	Once per day (afternoon)	Earthworms	Once per day
Kiwi House C	Yes	Once per day (Afternoon)	Live insects, earthworms	Once per day
Kiwi House D	Yes	Four per day (Twice in morning, twice in afternoon)	Live insects, earthworms	Twice per day

3.4 Discussion

3.4.1 Naturalistic enclosure (enclosure complexity)

Kiwi House A had three nocturnal display enclosures of which they all had similar construction and aesthetics. The nocturnal display enclosures at Kiwi House A were a good example of a naturalistic, complex enclosure, data given in Table 3.1. There was a significant amount of living foliage in the enclosure which were able to grow due to the specialised growing lights, shown in Figure 3.1 and Figure 3.2. The plants were different heights, giving the effect of more dimensions which increased its likeness to a forest. This could also have been favourable to the kiwi when they were foraging, as they would have a cover which could make them feel more safe and comfortable in their environment (Fàbregas et al. 2012). Rotten pine logs were added to the enclosure four to six times per year. Rotten logs were used as they contained grubs, which the kiwi spent a long time searching for, based on comments by the facility staff. Leaf litter was spread throughout the enclosure floor which achieved a look of a natural forest floor. The walls of the enclosure consisted mainly of plywood, with concrete blocks at the bottom. This blended into the surroundings relatively well as the plywood was dark green, the colour of the forest. These naturalistic aspects made the enclosures aesthetically appealing to the visitors. All of the kiwi enclosures were relatively complex because of their likeness to a forest habitat.

Figure 3.1: Kiwi display enclosure at Kiwi House A

Figure 3.2: Kiwi display enclosure at Kiwi House A

Kiwi House B had two nocturnal houses with relatively the same enclosure specifics, described in Table 3.1 and shown in Figure 3.3 and 3.4. Kiwi House B utilised a variety of foliage in their display enclosures, planted more sparsely than Kiwi House A. The plants covered a range from short to medium height giving the appearance of different dimensions within the enclosure. The foliage was predominantly at the front and centre of the enclosure and was absent at the back. This was beneficial to the viewers because the kiwi were observed at the back of the enclosure often; however, they were not obscured by foliage. Logs (not rotten) were present in the enclosure and leaf litter was regularly provided which made a natural looking enclosure floor. The enclosure walls (excluding the viewing window) were made of punga stumps making an excellent natural backdrop as pungas are common sight in the North Island forests of New Zealand. The topography of the display enclosures at Kiwi House B was variable, such that the enclosures were flat and have some elevation. This increased the complexity of the enclosures and it is speculative that it made it a more stimulating enclosure for the kiwi to forage.

Figure 3.3: Kiwi display enclosures at Kiwi House B

Figure 3.4: Kiwi display enclosures at Kiwi House B

The two large nocturnal display enclosures at Kiwi House C were the most naturalistic and complex compared to the other enclosures that were included in this study, summarised in Table 3.1. Foliage was seen throughout the enclosure as well as at different vertical heights. These enclosures had the densest array of vegetation, similar to many New Zealand forests, shown in Figure 3.5 and Figure 3.6. This dense cover would undoubtedly be a comfort to the kiwi as they would feel safer roaming and foraging throughout their enclosure, as research has shown that kiwi prefer forest habitats for foraging (Taborsky & Taborsky 1995). Multiple logs were found in each enclosure with a floor of leaf litter, which added to the naturalistic appeal. Furthermore, Kiwi House C provided a natural concealment for the feeding tubes and mats that were placed in the enclosure's, as these feeding devices were made of foreign material and would otherwise have been obvious in the enclosure, affecting the viewers' experience. There was a waterfall and stream that ran along the back of each enclosure, an excellent way to increase aesthetic appeal and complexity. One of the enclosures contained rocks along the back wall, also increasing complexity and changing the topography. This can be an important aspect of enclosure design as the kiwi were often seen walking along the rocks.

A trade-off of having an enclosure of high complexity is that the animal can be hard to find. This is reflected in the results in chapter 4, as two kiwi (inhabiting the same enclosure) were not visible for at least half of the observations. Even so, the interest of the visitors may not have faded as research suggests visitors would rather observe an enclosure which is high in complexity and has naturalistic qualities (Davey 2006)

Figure 3.5: Kiwi display enclosure at Kiwi House C (Source: Debra Searchfield)

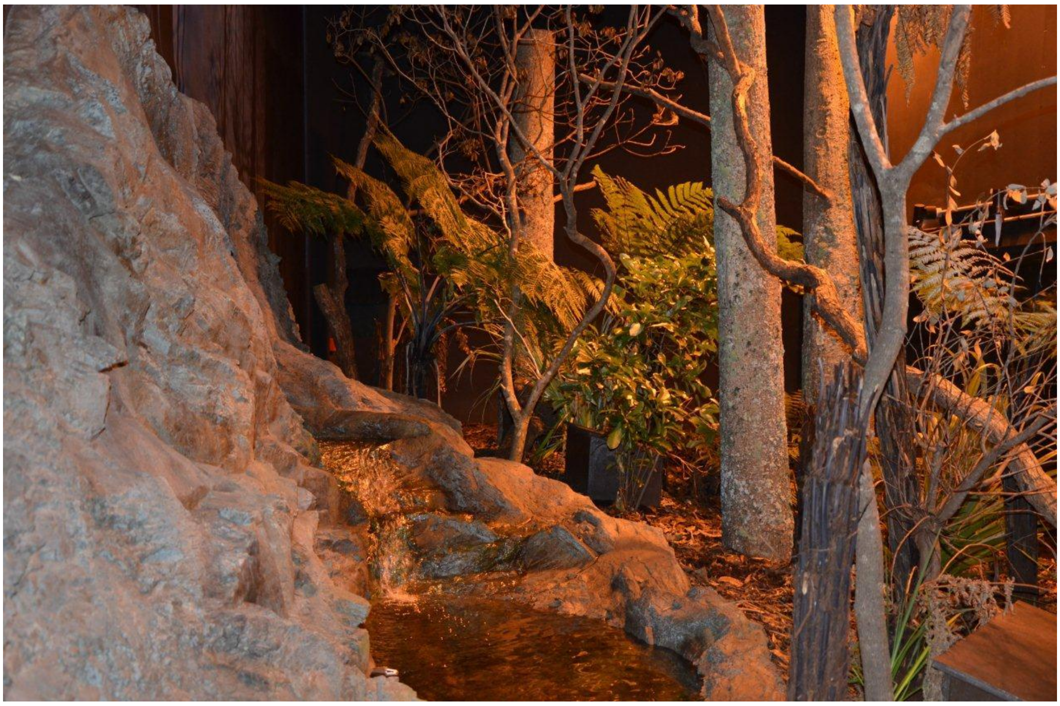


Figure 3.6: Kiwi display enclosure at Kiwi House C (Source: Debra Searchfield)

Kiwi House D had two nocturnal display enclosures which had the lowest degree of complexity compared to the other facilities, but still had a naturalistic appearance, data given in Table 3.1. The amount of foliage in the enclosure was fairly low with a scattering throughout of plants and bare patches. According to Taborsky and Taborsky (1995), this is not the preferred foraging environment for the brown kiwi. However, there were numerous logs present in the enclosure floor as well as leaf litter which increased the naturalistic appeal of the enclosure. Even so, aesthetic appeal was lost without the greenery typical of New Zealand forests. A study on visitor perception of captive animal enclosures provided evidence that visitors preferred enclosures with the most greenery (Melfi et al. 2004). They also associated these enclosures with inhabitants who would most likely have the best welfare (Melfi et al. 2004).

As previously mentioned, a simpler enclosure generally provides good viewing of the animal. The kiwi inhabiting these enclosures could be seen easily, regardless of where they were in the enclosure. When the kiwi were at the back of the enclosure, the lack of foliage meant the visitors still had an excellent view. From the observations of this thesis research, it was concluded that the nocturnal enclosures at Kiwi House D did not achieve a suitable balance between a naturalistic enclosure and good viewing from the visitors. Recent publications indicate how the complexity of an enclosure can have a positive effect on the behaviour of captive species such as in chimpanzees, gorillas and gibbons (Anderson 2014; Ross et al. 2011), and therefore is an important aspect of enclosure design.

3.4.2 Lighting

Artificial lighting is also important to enhance naturalistic enclosures. Artificial lighting can have an effect on the behaviour of a captive animal as nocturnal animals are typically not exposed to artificial illumination in the wild, as demonstrated with captive and wild bats (Lewanzik & Voigt 2014) and in a previous thesis on captive kiwi (Grant 2012).

Kiwi House A predominately used red and green lights. Research has shown that red lights disturb nocturnal animals significantly less than white lights as their perception of the red wavelength is poor (Grant 2012). Therefore, based on those results, it is beneficial to utilise red lights in a kiwi enclosure as it will be less invasive to the kiwi and also provide a light source to enable the visitors to view the bird. This achieved a good balance of lighting to meet both the needs of the visitors and the kiwi, summarised in Table 3.1. The light dispersion was patchy throughout the enclosures at Kiwi House A, as there was a lot of foliage which blocked out the light in places. However, this did provide ‘dark’ areas for the kiwi to access.

Kiwi House B used standard white lights which were placed around the walls of the enclosure. This achieved a balance between keeping the enclosure dark enough for the kiwi but light enough for visibility by the visitors, summarised in Table 3.1. The lights were not prominent at the back of the enclosure, making the kiwi more difficult to see by visitors if the kiwi were in this area. However, because the hutches were closed during their display time, it provided them with a darker area to reside. Soon afterwards, red lights were installed into one of the nocturnal enclosures. As previously explained, this should be beneficial as it would likely disturb the kiwi less and encourage them to come out into the 'light'.

The nocturnal display enclosures at Kiwi House C were the darkest compared to the other facilities that were included in this research. Standard lights were placed at the front of the enclosure resulting in the back of the enclosure to be very dark. This lighting scheme would be beneficial for the kiwi as this lighting is very similar to what would be experienced in their natural habitat (Martin et al. 2007). However, this level of darkness made kiwi viewing difficult. In one of the enclosures, there was a large area on the side where the viewing window did not reach. Light did not reach this area and it was almost pitch black. Both kiwi spent more than half of their time in this area meaning that the kiwi were not visible to the visitors for a large majority of the time. It was clear that the lighting in the nocturnal enclosures at Kiwi House C did not achieve a balance in fulfilling both the needs of the kiwi and the visitors, described in Table 3.1. It was already identified by staff that the lighting was not effective and the lights needed to be dispersed around the enclosure, instead of having all the lights at the front. Improving the lighting is a future project for the facility.

Kiwi House D used red lights as their sole source of artificial lighting in their kiwi display enclosures. Three red lights were situated relatively high on the ceiling, hanging down pointing directly to the enclosure floor, giving an even dispersion of light throughout the enclosure. Because of this, visitors were able to view the kiwi with ease, regardless of where the kiwi are in their enclosure, even if they were at the back. Because these lights were raised high above the enclosure, the enclosure was still dim enough for the kiwi. This was the best lighting that was observed among all facilities in this thesis research as they had achieved a great balance between the needs of the kiwi and visitors, described in Table 3.1.

One main variable measured in this thesis research, to determine if the enclosure achieved good lighting balance, was listening to the comments of the visitors, and determining how long it takes for them to spot the kiwi. However, it must be noted that, as a criteria for enclosure-light balance, this measurement has a major disadvantage. In all kiwi facilities, the enclosures were not bright enough for visitors to see the kiwi immediately. If the enclosures were so bright for immediate observation of kiwi, they would most probably be too bright and would disturb the kiwi (Grant 2012). Therefore, it is necessary for all visitors to allow time for their eyes to adjust to the darkness before they determine whether the kiwi is visible or not. A large majority of people did not do this or their ability to adjust their vision may be dependent on several factors (Owsley 2011). People expected to see the kiwi immediately, and if not, many of them left the nocturnal house. Therefore, some visitors did not appreciate the nocturnal house and had an opinion that the lighting needed to be brighter, even if the lighting balance was excellent in the opinion of this thesis research.

3.4.3 Size of enclosure

The size of an enclosure has been described to have an effect on the behaviour of captive animals in terms of the frequency of normal and abnormal behaviours, such as with lions, tigers and marmosets, where a larger enclosure increased the frequency of normal behaviours whereas a smaller enclosure decreased the frequency of abnormal behaviours (Bashaw et al. 2007; Breton & Barrot 2014; Kitchen & Martin 1996).

Kiwi House A had enclosures of 35m², 50m² and 28m². Kiwi House B had enclosure sizes of 26.7m², 20.8m² and 29.4m². Kiwi House C had enclosures of 49.5m², and Kiwi House D had enclosures of 56.55m², as given in Table 3.2. Therefore, Kiwi House C and Kiwi House D had large display enclosures compared to Kiwi House A and Kiwi House B. This was required as a pair of kiwi inhabited each display enclosure at Kiwi House C and Kiwi House D. However, evidence suggests that singular kiwi have territories twice the size as the territories of kiwi pairs (Taborsky & Taborsky 1991). The reason for this was assumed, based on Taborsky and

Taborsky (1991) to be that singular kiwi who have larger enclosures are more likely to obtain mates.

It is a requirement for all facilities holding captive animals to have enclosures large enough for the animals to be comfortable in their environment and to be able to conduct their daily activities. Table 3.2 states the sizes of the enclosures studied in this thesis. It is often thought the bigger the enclosure is, the more beneficial it is to the animal (Breton & Barrot 2014). However, this is difficult for nocturnal kiwi displays. Depending on the lighting of the enclosure, the bigger the enclosure, the harder it will be for the visitors to view the kiwi. However, the enclosure still needs to be big enough for the kiwi to have room to forage and roam. Furthermore, the territory of a wild kiwi is extensive (Taborsky & Taborsky 1992). Even though it is unrealistic to have an enclosure to scale, it further suggests that kiwi would not cope well in a small enclosure.

It must be understood that in an ideal world, all captive kiwi would be provided with generously sized enclosures. However, there are restrictions which deny this to many facilities. One of the major restrictions is the space that is available to the facilities for their enclosures. Some facilities, particularly the smaller ones, do not have the space available to them to create large kiwi enclosures, and have to make the best of what space is available. Furthermore, an issue which is also more prominent among the smaller and non-for-profit facilities is the cost of the enclosure and raising funds to support it. Building and maintaining large enclosures is expensive, so facilities need to keep their enclosures within their budget allowed e.g. regarding the public and tourist industry.

3.4.4 Hutches

Among the three kiwi display enclosures at Kiwi House A, two of the enclosures had hutches open 24/7 and one enclosure had the hutch closed during display hours, as given in Table 3.2. However, all enclosures had darkened roost spots which the kiwi were observed to utilise. Te Kaha hd her hutch closed during display hours. This kiwi was an excellent display bird and the most popular and easily spotted among the visitors. Nevertheless, Te Kaha did not seem to be deprived of sleep by having her hutch closed off. Often for a part of the day, Te Kaha would sleep in her 'favourite' darkened roost areas. The benefit of this is that she was still visible, meaning even if she was asleep the visitors could still see her. The hutches in the remaining two enclosures were open 24 hours a day. This facility did have a setup where a camera could be placed in Te Kaha's hutch which would produce live video, connected to a television screen in the enclosure viewing area. However, this setup had been out of action for some time due to technical problems. When the live video is again working, it might be beneficial to keep Te Kaha's hutch open during her display time, as even if she spent time sleeping in this area, the visitors would still be able to view her.

Cobalt was either sleeping or resting during the entire observation period. It was difficult to know how much of this time she was truly asleep without a closer view. It seemed that the kiwi spent her time both in the hutch and under the roosting areas. It might be expected that by closing the hutches, the kiwi would be more active, however, it is likely Cobalt would then spend all of her time in the roosting areas. Therefore, it would be more beneficial to keep the hutch open in order to avoid any disturbance.

The hutch in Toi's enclosure was also open 24 hours a day. However, unlike Cobalt, she was active during the whole observation period. It was obvious that having the hutch open did not encourage the bird to access this area. This observation emphasises the fact that all kiwi react differently to aspects of their environment.

At Kiwi House B, the kiwi were only on display for approximately four hours a day, of which their hutches were closed during this time, summarised in Table 3.3. This is the expected minimum amount of time the kiwi should be awake in order to obtain sufficient nourishment, as kiwi are naturally awake four to seven hours (McLennan 1988), though the estimated time awake is from a wild kiwi observation. However, the hours active were variable among the kiwi. Kevin was awake during almost all of the observations. This kiwi was feeding for the majority of the time which suggests that having his hutches closed did not cause the kiwi any disturbance.

Kahurangi often slept during the end of her display time, but was active for a large part of the four hours. Koru and Aroha also slept for a significant amount of their display time. It was apparent that the kiwi were aware that their hutches were closed as they were often observed investigating the hutch door with their beak, as if to check if it was open. If these kiwi happened to be awake when the hutches were opened at the end of the display time, they would run straight into the hutch without hesitation. These observations suggest that if their hutches were open during their display time they would spend a lot of their time in this area, which would have a negative effect on kiwi viewing. Alternatively, it is possible that keeping their hutches closed could have caused disturbance among the kiwi. Therefore, having them open might mean the kiwi are more comfortable in their environment and willing to be active for a larger part of their display time.

Kiwi House C had their hutches open 24 hours a day, described in Table 3.3. It was observed that the older pair of kiwi spent a lot of time in their hutch. However, they were only in the hutch for short periods at a time, suggesting that they were not using the hutch for sleeping during these times. As previously explained, the female had laid an egg, which potentially explained the large amount of time she spent in their hutch. Obviously, if an egg has been laid, the hutch must be kept open as it would surely disturb the kiwi if they were not able to get access to the egg. In the second enclosure, only the female kiwi spent time in the hutch and this occurred only in a few observations. These kiwi were awake for almost the entire observational period. This suggests that the kiwi were not encouraged to spend a portion of their display time sleeping because their hutches were open.

Kiwi House D also left the kiwi hutches open 24 hours a day, summarised in Table 3.3. These kiwi spent a portion of their time in the hutches but were generally active for most of the day. Cameras were placed in the hutch and live video was seen on a television screen in the viewing area, although the live feed connection was sometimes faulty. This lessened the impact of kiwi viewing when the kiwi happened to be asleep. In this case, it would be more beneficial to continue to leave the hutches open as they were usually visible either way, and to avoid any disturbance.

As well as a nesting or sleeping area during the day, a hutch in kiwi display enclosures can function as a retreat space. Kiwi at Kiwi House C, Kiwi House D, and one kiwi at Kiwi House A were seen regularly using this area, staying for short or long periods. It was known that some of these visits to their hutches were to sleep, as seen at Kiwi House D through live video. Retreat spaces have been documented to act as a safe area for display animals where they could get away from the viewing public, subsequently decreasing the abnormal behaviours shown by the animals, such an in the captive rhea (Anderson et al. 2002). This suggests that if a captive animal does not have access to a retreat space, it may become disturbed. Having multiple retreat spaces in an enclosure has also been recognised to lower the stress levels of captive animals, such as the captive lynx (Fanson & Wielebnowski 2013).

3.4.5 Enrichment

For most captive animals, the visitors are more likely to see the animal active when the keepers put food in their enclosure (Forthman et al. 1992). Observations from this thesis research showed that this was the same for kiwi and highlights the importance of kiwi feeding. One aspect of feeding that differed between facilities was how many times a day the kiwi was fed, described in Table 3.4. Kiwi House A fed their kiwi artificial food once in the morning, just before the enclosure was open for display. This was beneficial in that the kiwi got a sufficient amount of food to start off the day. Furthermore, this portion of food was divided up into separate smaller portions so multiple feeding stations could be placed around the enclosure to increase the spatial distribution of the feeding tubes. This encouraged the kiwi to roam around the enclosure to the different feeding stations, enabling visitors to get a good view of the kiwi no matter where they are in the viewing area. The disadvantage of this feeding routine was that because it was done at the start of the day, few visitors would see the kiwi feeding initially. It might be expected that because the daily portion of food was given to the kiwi in one sitting, the kiwi would eat a large portion of food and become inactive afterwards for a period of time. However, observations showed that Te Kaha and Toi took short trips to the feeding stations throughout their display period which suggested that they eat small portions, often. These kiwi also had access to worms in the soil of their enclosures, and were obviously utilising this food source as feeding behaviours (mainly probing) were seen in many of the observations. Live insects were also sometimes introduced into their enclosure during the day.

Kiwi House B fed their kiwi once a day. Their nocturnal display system of having one display open in the morning and another in the afternoon meant that there were a total of two kiwi feedings throughout the day. The first kiwi feeding occurred at the end of the morning kiwi display time (coinciding with the busiest time of day), and the second kiwi feeding occurred in the middle of the afternoon kiwi display time. The portion of kiwi food was divided between two feeding stations per kiwi, which were placed at different sides of their enclosure to ensure that all visitors were able to see the kiwi feeding. Because the morning enclosure feeding was at the end of the display shift, it might be expected that Kevin, who occupied this enclosure, would be relatively active until the feeding time in order to satisfy his appetite. This was seen as Kevin was active and foraging in a large majority of the observations. This enclosure had a plentiful stock of worms in the soil, which proved to be a good food source as the kiwi was seen to detect, and capture worms from the soil. In the afternoon display, Kahurangi, Koru and Aroha are provided with the same feeding conditions as Kevin. These kiwi were given their artificial diet in the middle of their display shift, meaning that they were on display for a further one and a half hours after feeding. Observations have shown that these kiwi were more active before feeding than after feeding as they would often go to sleep after feeding. Feeding the kiwi later on in their display shift may have encouraged the kiwi to be more active throughout the day. However, the facility was less busy at this time meaning that few people would be able to see the kiwi feeding.

Kiwi House C fed their kiwi artificial food in the middle of the day to early afternoon. This food was divided between two feeding stations in different areas of the enclosure. It would be expected that the kiwi would consume a vast amount of food in this sitting and then have an increase in inactivity afterwards. However, observations of this thesis research showed that the behaviour did not vary significantly before and after feeding. As previously mentioned, the older pair of kiwi spent a majority of their time in the hutches; however, this may have been for no other reason than the female having laid an egg, and not due to their nourishment regime. Having the feeding at this time of day was beneficial as it coincided with the busiest time of day, regarding visitors. Observations showed that the kiwi eagerly came right up to the window to feed once the keepers had placed it into the ground, making excellent kiwi viewing. These kiwi were also given live insects thrown near the window which was observed to be a very popular meal for the kiwi and great entertainment for the visitors.

Kiwi House D presented artificial food to their kiwi four times a day, twice in the morning and twice in the afternoon. Because they wre fed four times a day, their food was in smaller portions. This facility was the only facility that fed the kiwi multiple times a day, and it clearly had the most active kiwi. Therefore, it is possible that this feeding regime encourages kiwi to be more active. During feeding time, the portion of food the kiwi was given was relatively small. It is likely that the kiwi were not over-fed at any one time and still required to actively search for food. Insects were scattered throughout the enclosure twice per day and the worms naturally breed in the soil of the enclosure, providing a sufficient supply of food for the kiwi to forage between feedings.

3.5 Conclusions

Kiwi House C had the most naturalistic enclosures in terms of density of foliage and nocturnal lighting. Complexity of these enclosures were also very high with the presence of various elements which depicted a forest habitat. However the lighting was so dark that it did not satisfy the needs of the viewing public. Kiwi House D had the least naturalistic enclosures; however, their nocturnal lighting achieved an excellent balance between the needs of the kiwi and the viewing public. Kiwi House A and Kiwi House B both had naturalistic enclosures and the nocturnal lighting enabled the visitors to observe the kiwi relatively easily. One hutch at Kiwi House A, and all hutches at Kiwi House B were closed during the display period. Even though the kiwi at Kiwi House B were only on display for a short time, it may have had an effect on their behaviour. The hutches at Kiwi House C and Kiwi House D were open 24 hours a day. The kiwi were observed to utilise the hutches occasionally but did not spend significantly long periods of time in these areas. Kiwi House C and Kiwi House D had the largest enclosures. This was particularly necessary in these facilities as both of the enclosures at each facility held a pair of kiwi. Kiwi House A and Kiwi House B both had smaller enclosures, however, the size of the enclosures were often restricted by the funding and space available, regardless of the preference of the facility staff. All facilities fed their kiwi an artificial diet once per day, except Kiwi House D who fed their display kiwi four smaller meals per day. There was evidence to suggest the feeding regime utilised by Kiwi House D increased the activity levels of the kiwi. All facilities fed their kiwi live insects and provided live worms in the soil of their enclosure.

Chapter 4

Sources of disturbance and enclosure design

4.1 Introduction

Disturbance of animals in captivity is one of the major concerns for managers of all facilities holding animals. An animal is defined as disturbed if it shows abnormal behaviours, as these behaviours are not seen among their wild conspecifics (Crast et al. 2014). Disturbance sources have been widely studied in enclosures holding diurnal species, however, very little research has been carried out on the disturbance of the kiwi in display enclosures. Even so, it is likely that some sources of disturbance affecting diurnal displays are the same as for nocturnal enclosures.

One of the main sources of disturbance that is investigated is the noise level in the viewing area of the nocturnal house. This is particularly important for nocturnal enclosures, as nocturnal animals are used to nocturnal sounds which are generally quiet compared to during the day (Schulze & Streicher). Emphasis is put on sounds that may be foreign to the kiwi, such as noise made by the visitors when they are in the viewing area observing the kiwi. If their enclosure is not well equipped to sound-insulate the viewing area, excessive noise from there could have an effect on the behaviour of the kiwi (Fitch-Snyder et al. 2008) . Furthermore, as with most nocturnal animals, kiwi have acute hearing, meaning they can easily pick up on low decibel sounds, making them especially susceptible to noise disturbance (Craigie 1930).

One important aspect of enclosure design is the viewing window, which most kiwi facilities adopt as a means to separate the visitors from the kiwi, and to reduce the sound that reaches through to the enclosure from the visitor area (Fraser & Johnson 2009). No studies have been carried out on how well these various window designs reduce noise level. It might be expected that viewing windows that do not significantly reduce noise level would result in abnormal behaviours being expressed by the kiwi.

Display enclosures have the potential to be affected by urban and environmental noise disturbances. This noise can travel through the walls and roof of the enclosures, and potentially disturb the kiwi within the enclosure. Sound proofing and insulation would be beneficial in the nocturnal houses to reduce these other potential sources of noise disturbance, and is recommended in the kiwi husbandry manual (Fraser & Johnson 2009).

4.2 Methods

The hypothesis of this part of the thesis research was that noise is a source of disturbance that might be associated with abnormal behaviours. To document this potential link, a datalogger was acquired (Digital Sound level Meter, SZBDJK Technology Industry Co.) which measured and stored sound data (dB). When observation began, the datalogger was set to neck-height and recorded and stored noise data every second for one hour. At each 5-minute interval, the behaviour that the kiwi were displaying was noted. After the observation was over, data was immediately downloaded onto a university laptop on SoundLab, a programme which analysed the sound data. It was necessary that this was done instantly in order for the datalogger to be subsequently cleared to create enough memory space for the next observation. After all necessary data was collected; the dB reading for each five-minute interval was noted. This was then linked to the behaviour the kiwi was showing at that time.

The datalogger was also used to measure how effective the enclosure viewing windows were in reducing sound from within the viewing area. Sound measurements could not be made within the enclosures as this was not allowed in some facilities, since facility staff required that the least possible impact was to be made on the kiwi, thus eliminating the original plan having a foreign object (datalogger) in the enclosure for a long period of time. An experiment was planned to determine the effectiveness of the viewing window in reducing sound that reaches to the enclosure from the viewing area. This was achieved by measuring a noise in the visitor area (control), then measuring the same noise in the kiwi enclosure in order to get the difference between the two locations.

The noise was produced from a cellular device, in order to get the same level of noise each time with no variation. Three tones were used, quiet, medium and loud. As a control, the tone was first played in the viewing area, approximately one metre away from the data logger. Each tone was repeated, and recorded, three times in order to get an average. The tones were played when the enclosure was silent and there was no background noise that would alter the results (eg. traffic, people). The cellular device was then taken inside the kiwi enclosure (during times when the kiwi were off display), and the datalogger remained in the viewing area, the same distance away from each other as in the control. The tones were repeated and recorded. The difference between the sound recorded from the inside and outside of the enclosure was calculated at each tone level.

At Kiwi House B, only one side of the nocturnal house was measured as the conditions, and window design, were the same on both sides. Both kiwi enclosures at Kiwi House C were measured as the external noise level in the viewing area of enclosure 1 was much louder than enclosure 2, because it was nearer a waterfall in the viewing area. At Kiwi House D, only one nocturnal house was measured as the conditions, and window design, were exactly the same for both houses.

4.2.1 Statistical Analysis

A generalised linear mixed effects model (McCullagh 1984) was used to determine whether the level of noise had a significant effect on the behaviour of the kiwi. It was expected there would be a variation in the behaviour of the kiwi due to individual differences. However, this variation is of no interest in the analysis of this thesis research, therefore, the variation was incorporated as a random effect.

Due to the nature of the data collection, it is possible that the behaviour at any given time is related to the behaviour of the previous recording. In order to compensate for this, a Boolean covariate recording was included on whether abnormal behaviour was observed in the immediately prior time point.

Two-sample paired t-tests were used to determine whether the viewing windows at each facility reduced a significant amount of noise.

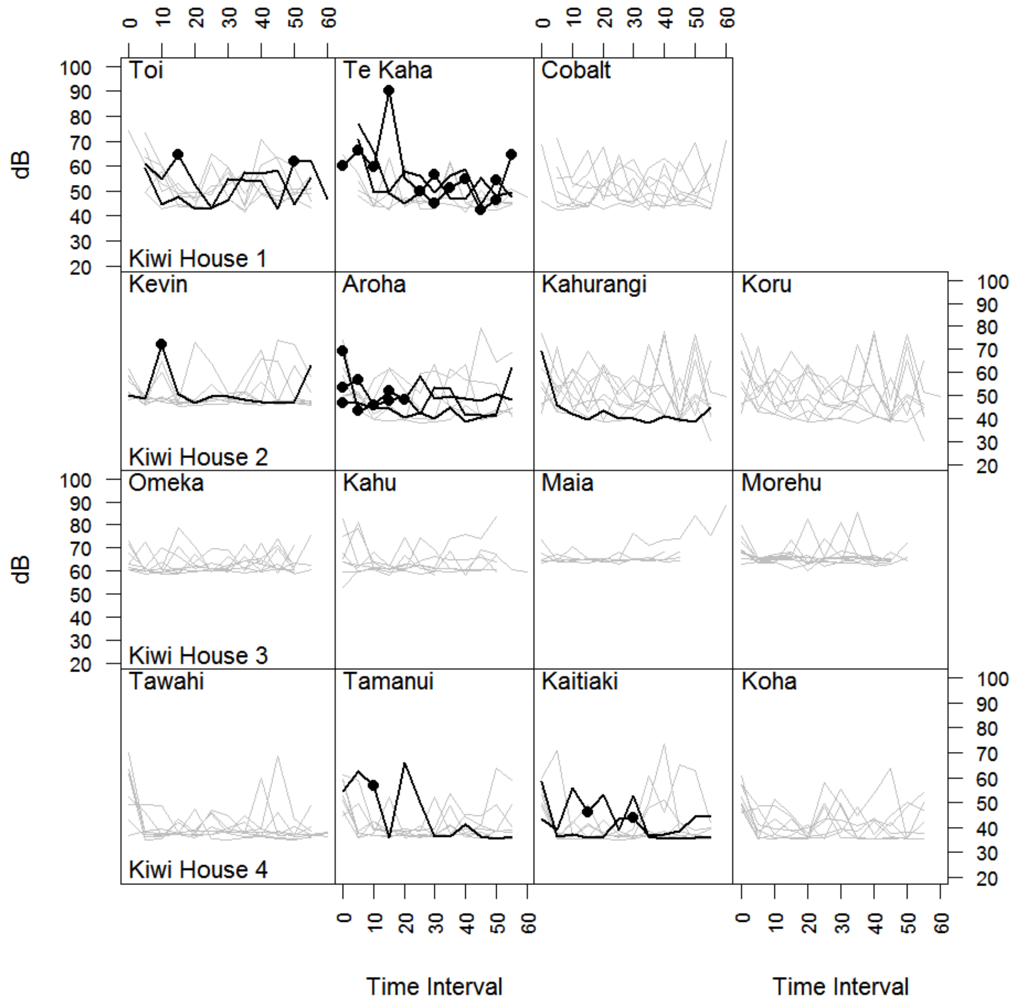
4.3 Results

4.3.1 Sound data and behaviour

Figure 4.1 shows normal and abnormal behaviours demonstrated by each kiwi at each facility during the observation periods, and the sound data collected during the observations. Each peak represents a defined behaviour. Normal behaviours are illustrated by light grey peaks and abnormal behaviours are illustrated as black peaks with dots. The higher the peak rises up the y-axis, the louder the noise level was at that point. The lines between the peaks function as joining lines, indicating the hour-long, continuous (5 minute intervals) observation. Some lines fall short as occasionally the data logger would stop recording before the observation had finished for an unknown reason.

The objective for this part of the experimentation was to determine whether noise level generated by visitors affected the behaviour of the kiwi, in terms of normal and abnormal behaviour (p-value 0.0569). Figure 4.1 shows Toi and Te Kaha from Kiwi House A expressed abnormal behaviour, as well as Kevin and Aroha from Kiwi House B. Kahurangi has a black line without a dot because an abnormal behaviour was observed, however, due to technological reasons, no sound data was received by the data logger; therefore, the abnormal behaviour of Kahurangi could not be analysed. Tamanui and Kaitiaki from Kiwi House D demonstrated abnormal behaviours. The kiwi at Kiwi House C did not show abnormal behaviours.

Figure 4.1: Sound data (dB) and behavioural data (normal/abnormal) received and observed, respectively, every five minutes during seven one-hour observations for each display kiwi at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D



4.3.2 Sound data and window design

Viewing windows varied among the facilities, as given in Table 4.1. Kiwi House D had a single-glazed plate glass viewing window, 5mm thick; the thickest window used compared to the other facilities. Kiwi House B used toughed safety glass for their design window which was 4mm thick. Kiwi House A used standard glass which was 10mm thick for their viewing window. Kiwi House C had the most advanced gas-filled and double glazed window. The thickness of this window could not be determined.

Table 4.1: Thickness and design of the viewing window used in the nocturnal display enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D

Kiwi Facility	**Thickness of viewing window (mm)**	**Description**
Kiwi House A	10	Standard glass
Kiwi House	4	Toughened safety glass
Kiwi House C	Unknown	Gas-filled, double glazed
Kiwi House D	5	Single-glazed plate glass

Table 4.2 gives the reduction of noise produced at different tones at Kiwi House A. The viewing window reduced a quiet tone by 14.13%, a medium tone by 15.75% and a loud tone by 20.74%.

Table 4.2: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House A

Tone	**Viewing area (dB)**	**Kiwi enclosure (dB)**	**% of sound**	**p-value**
Quiet	54.5	46.8	14.13	0.29
Medium	60.3	50.8	15.75	0.01
Loud	69.9	55.4	20.74	0.009

Table 4.3 gives the reduction of noise produced at different tones at Kiwi House B. The viewing window did not reduce the noise of a quiet tone, but it increased in

noise by 8.55%. This may have been because the sound was too quiet to be picked up accurately by the datalogger. A medium sound was reduced by 26.55% and a loud sound was reduced by 36.14%.

Table 4.3: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House A, at Kiwi House B

Tone	Viewing area (dB)	Kiwi enclosure (dB)	% of sound	p-value
Quiet	38.6	41.9	-8.55	0.26
Medium	53.1	39	26.55	0.007
Loud	64.2	41	36.14	0.01

Table 4.4 gives the noise of a rainstorm which was measured inside a kiwi display enclosure at Kiwi House B, during different stages of heavy rain. Steady rain produced a noise level of 66dB inside the enclosure, heavy rain produced a noise level of 70dB and torrential rain produced a noise level of 74dB.

Table 4.4: Sound data during different levels of heavy rain inside the nocturnal enclsoure at Kiwi House B

Rain	dB
Steady	66
Heavy	70
Torrential	74

Table 4.5 gives the reduction of noise produced at different tones at Kiwi House C, enclosure 1. The viewing window in enclosure 1 reduced a quiet tone by 5.26%. A medium tone did not reduce sound, but it gained by 1.13%. This is due to the loud

base level sound in the viewing area, discussed later in the chapter. A loud tone was reduced by 6.28%.

Table 4.5: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House C (enclosure 1)

Tone	Viewing area (dB)	Kiwi enclosure (dB)	% of sound	p-value
Quiet	64.7	61.3	5.26	0.19
Medium	61.7	62.4	-1.13	0.50
Loud	65.3	61.2	6.28	0.002

Table 4.6 gives the reduction of noise produced at different tones at Kiwi House C, enclosure 2. The viewing window in enclosure 2 reduced a quiet tone by 3.87%, a medium tone by 14.6% and a loud tone by 15.8%.

Table 4.6: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House C (enclosure 2)

Tone	Viewing area (dB)	Kiwi enclosure (dB)	% of sound	p-value
Quiet	62	59.6	3.87	0.25
Medium	69.2	59.1	14.60	0.01
Loud	70.9	59.7	15.80	0.004

Table 4.7 gives the reduction of noise produced at different tones at Kiwi House D. The viewing window did not reduce the noise of the quiet tone , but it increased by 2.42%. This may have been because the sound was too quiet to be picked up accurately by the datalogger. A medium sound was reduced by 10.42% and a loud sound was reduced by 25.99%.

Table 4.7: Noise reduction of the viewing window, over three different levels of electronically generated tones, at Kiwi House D

Tone	Viewing area (dB)	Kiwi enclosure (dB)	% of sound	p-value
Quiet	37.2	38.1	-2.42	0.36
Medium	48	43	10.42	0.04
Loud	58.1	43	25.99	0.02

4.3.3 Roofing and wall materials

The facilities employed a variety of different enclosure materials, as given in Table 4.8.

Table 4.8: Design of nocturnal enclosures at Kiwi House A, Kiwi House B, Kiwi House C and Kiwi House D

	Enclosure			
Facility	**Walls**	**Ceiling**	**Roof**	**Insulation**
Kiwi House A	Exterior walls: Concrete blocks. Interior walls: Half concrete blocks from the ground up, plywood sheet to the ceiling	Lowered plywood ceiling	Metal sheeting	Pink Batts® have been applied to the exterior walls for insulation
Kiwi House B	A mix of 1970's cement board and composite hardboard	1970's cement board	Trimform longrun roofing iron	No +insulation
Kiwi House C	Bondor-Panel and artificial rocks	Bondor-Panel	Bondor-Panel	Whole building is soundproofed from external sound
Kiwi House D	Timber framed	A-frame, trusses with plywood	corrugated iron	Walls and ceiling are insulated with Pink-Batts®

4.4 Discussion

4.4.1 Viewing window

All kiwi facilities of this study have a viewing window separating the kiwi from visitors. As well as separation, these windows are also expected to minimise the sound entering the enclosure from the viewing area. It was clear that some viewing windows were significantly more effective in reducing sound than others, as given in Tables 4.2, 4.3, 4.5, 4.6 and 4.7. The description of the windows is given in Table 1. Focus of the research was on the sound of the loudest tone produced by the cellular device as this was the noise level that would potentially elicit a response from the kiwi in the form of abnormal behaviour.

The viewing window at Kiwi House A blocked out approximately 20.74% of the sound produced in the viewing area, with a significant p-value of 0.009, as given in Table 4.2. This was apparently a good amount, as only one abnormal behavioural response was measured in response to noise disturbance in the viewing area. However, the viewing window was made of standard glass which had the capacity to reduce only a portion of the sound from the viewing area, despite the increased thickness of the window compared to the other facilities. Staff comments have described how double glazed glass would have been preferred, but was not permitted.

The viewing window at Kiwi House B reduced the sound from the viewing area by 34%, higher than that of Kiwi House A. This calculated a significant p-value of 0.01, as given in Table 4.3. There was only one instance in which the kiwi showed abnormal behaviour in response to noisy disturbance in the viewing area. The viewing windows at Kiwi House B were 4mm thick toughened safety glass. Due to the old age of the building, these viewing windows do not compare with the more modern designs, such as that at Kiwi House C. However, improvement of the viewing window has been included in the redevelopment plans at the park in 2015.

The results obtained for Kiwi House C, on how effective the viewing window reduced sound in the viewing area, was misleading. The results suggest that the viewing window in Enclosure 1 at Kiwi House C blocked virtually no sound, however still producing a significant p-value of 0.002 at the highest generated sound, as given in Table 4.5. The window is soundproof, gas-filled and double glazed. In the viewing area and within the enclosure, there was a nearby waterfall, and the noise level of these waterfalls were greater than the loudest tone used to measure the difference in sound, explaining why there was essentially no difference in the sound between the inside and outside of the enclosure. Further studies should include this variable and alter the methodology in order to incorporate the external variables affecting this unique viewing area.

In enclosure 2 at Kiwi House C, the situation was slightly different. This enclosure was further away from the waterfall in the viewing area, meaning the datalogger could detect the sounds produced in the viewing area without being overwhelmed by the sound of the waterfall. This can be seen in the results as the window blocked out 15.8% of the experimental sound, with a significant p-value of 0.004, as given in Table 4.6. Also, Kiwi House C had a soundproof window, so it was assumed no noise reached the inside of the enclosure, even though this could not be effectively measured. The kiwi was not expected to experience any noise disturbance from the viewing area, and this was confirmed by the results as no abnormal behaviours were expressed by these kiwi.

The viewing window at Kiwi House D reduced 26% of the noise produced in the viewing area, similar to Kiwi House A, and with a significant p-value of 0.02, as given in Table 4.7. This window is of a 5mm, single glazed plate glass design. The sound-proofing quality of this window could be improved. However, only one occurrence of abnormal behaviour was observed as a result of noise disturbance in the viewing area.

4.4.2 Ceiling, roof, and wall materials

The construction and the materials used in the roofing and walls of an enclosure can have a significant impact on how much external sound reaches into the enclosure, as some are better insulated than others. Details of the enclosure design are given in Table 4.8. The nocturnal enclosures at Kiwi House A had a roof of lowered plywood ceiling and metal sheeting. The walls were made of concrete blocks and plywood sheet. These materials alone would not be effective in blocking external sound, however, insulation in the form of Pink Batts® was applied to the exterior walls of the enclosure, though not the roof. This insulation would be very effective in minimising the amount of sound that reaches the enclosure from outside sources. The effectiveness of this is demonstrated by the fact that there were no external disturbance sources detected that affected the behaviour of the kiwi.

The floor of the nocturnal house was concrete, which created a loud noise when visitors walked along the path inside the nocturnal house, particularly if they had heavy or high-heeled shoes. Even though this noise was not seen to cause any abnormal behaviours among the kiwi, it is a potential disturbance that could easily be removed by applying carpet or soft padding to the floor.

At Kiwi House B, the ceiling was designed of 1970's cement board and the roofing was trimform longrun roofing iron. Kiwi House B was the first facility to be built in New Zealand, in 1971. Sound-proofing would likely not have been a priority 40 years ago, and the materials are now out-dated. These materials proved ineffective to minimise external noise. This was especially evident during heavy rain, which produced a high level of noise in the enclosure and subsequent abnormal behaviour in the kiwi. The walls were a mix of 1970's cement board and composite hardboard, without insulation, and, were relatively ineffective in minimising external sound. Redevelopments are planned to be done in 2015, with a main priority of updating the roofing and wall materials of the nocturnal houses with a main focus on reducing external noise.

The roof, ceiling and walls of the nocturnal house at Kiwi House C were made of Bondor-Panel. Bondor-Panels are excellent insulators and are very effective in reducing external noise. This enclosure structure should make the nocturnal house virtually soundproof from all external sound. This is reflected the in the results, as no abnormal behaviours were seen from the kiwi.

The roof of the nocturnal house at Kiwi House D was made of corrugated iron and the ceiling of A-frame trusses with ply with insulation. The walls were timber framed and insulated with Pink Batts. The insulation in the walls and ceiling of the enclosure would provide an effective means of reducing external noise. The roof may not be effective in reducing external noise; however, that possibility could not be measured as no heavy rain occurred during observation times.

4.4.3 Pacing

Pacing is the most common abnormal behaviour observed among many species of captive animals, such as the chimpanzee (Birkett & Newton-Fisher 2011). Pacing was seen only at two facilities in this research, Kiwi House A and Kiwi House B. Te Kaha had a high frequency of pacing which was observed in 12 out of a total 96 observations, given in Figure 2.7 (chapter 2). This behaviour occurred when multiple people were observing the kiwi, where both the visitors and the kiwi were in close proximity to the window. From the observations, it appeared that the kiwi was aware of activity or movement on the other side of the window as it was often seen to investigate the edge of the enclosure with its beak, and turn its attention in the direction of the visitors. Visitor proximity was thought to be the disturbance source because the noise level was relatively quiet during most of the time Te Kaha was pacing ruling out noise disturbance as the cause.

The conclusion that the behaviour was caused by visitor proximity was confirmed by the data given in Figure 4.1. Interestingly, Te Kaha showed pacing behaviour only during the school holidays. At this time, the number of people in the nocturnal house was relatively high, but Te Kaha's pacing behaviour was recurring, even when the number of visitors in the viewing area reduced. This suggests that Te Kaha was responding to a deeper level of disturbance, or that it was the higher overall number of visitors per day versus at any one time that was causing the abnormal behaviour. It could be that, since this kiwi has been in a display enclosure for over three decades, the ongoing disturbances may have had a permanent detrimental effect.

However, previous studies on the stress of captive animals are not consistent with this assumption. For example, the assessment of stress in captive numbats showed that the oldest individual (seven years) experienced the least amount of stress, according to faecal corticoid levels (Hogan et al. 2012). However, Te Kaha is significantly older than the oldest numbat included in the study which may explain the difference in results of these studies.

Toi also showed pacing behaviour in two out of a total 96 observations, as given in Figure 2.7 (Chapter 2), but at a much lower frequency than Te Kaha. This behaviour was due to both visitor proximity and visitor generated noise in the viewing area. When the disturbance source disappeared, so did the pacing behaviour of the kiwi, and did not recur, further prompting the question as to whether the length of time an animal has been exposed to disturbances has an effect how much they are influenced by the disturbances.

Pacing behaviour was observed in two kiwi at Kiwi House B. Kahurangi showed pacing behaviour in one out of a total 102 observations, as given in Figure 2.8 (Chapter 2). This behaviour began when it started raining outside. The noise level in the enclosure was very high as the rain hit the enclosure roof, as given in Table 4.4. Kahurangi started pacing in sync with the start of rain. Therefore, external noise disturbance is clearly the reason for the pacing behaviour of this kiwi.

Aroha also showed pacing behaviour at a higher frequency; in ten out of a total 104 observations, as given in Figure 2.8 (Chapter 2). This was also due to the noise produced by the rain outside. Both kiwi started pacing at the same time the rain started, and stopped pacing when the rain ceased. The rain continued over a long period of time, which is why the time Aroha spent pacing was recorded over many observations

4.4.4 Startle

A Startle response was only observed by Te Kaha at Kiwi House A, in one out of a total 96 observations, as given in Figure 2.7. This occurred when a keeper entered the enclosure and threw live insects nearby, which surprised her. Because this startle response was not caused by a recurring disturbance, it was not regarded as a concern in this thesis research. One startle response was also observed in Kevin at Kiwi House B, during one out of a total 104 observations. At the same time the noise in the viewing area of the nocturnal house suddenly went very loud, seen in Figure 4.1.

Startle responses were observed in two kiwi at Kiwi House D, as given in Figure 2.10. Tamanui expressed one startle response out of a total 101 observations. This occurred when a group of visitors entered the enclosure talking loudly, suggesting that noise disturbance was the cause of this abnormal behaviour. Kaitiaki showed startle responses in two, out of a total 104 observations. These were both recorded when the keeper entered the enclosure to begin a feeding session. One response appeared to be a reaction to the opening of the exit door where the keepers enter the enclosure, and the second when a keeper walked near the kiwi.

The results clearly show that frequency of abnormal behaviours were variable among the kiwi included in this thesis research. The differences in behaviour could be because the kiwi differed in sex, age and experience in their enclosure. However, due to the nature of the data, this relationship was not analysed.

It might be expected that increased experience in the enclosure, and an increase in age, would decrease the frequency of abnormal behaviours as kiwi would adapt to their environment, and subsequently, to the disturbance sources. Recent research has produced opposing results in terms of how the age of an animal might affect normal behaviour. For example, a study on the behaviour of captive chimpanzees showed every individual in the population expressed abnormal behaviour, occurring at different frequencies. However, this could not be explained by age or sex (Birkett & Newton-Fisher 2011).

There is also evidence to support the fact that for some species, age does affect the frequency of abnormal behaviours. A study on the abnormal behaviour of captive baboons showed that young baboons, when first introduced into their enclosure, spent significantly more time on abnormal behaviours (Lutz et al. 2014). However, this conclusion is not relevant to this research as none of the kiwi had been newly introduced into their enclosure.

One interesting observation concerning abnormal behaviour involved two kiwi (Kahurangi and Koru), of similar age and experience, housed in the same enclosure and exposed to the same disturbances, but only Kahurangi showed abnormal behaviours. This has been observed among other animals in captivity, suggesting that each animal has a different susceptibility to disturbance sources regardless of their background (Garner 2005).

Abnormal behaviours were seen among seven of the 15 kiwi included in this thesis research. (Birkett & Newton-Fisher 2011). However, Cunningham and Castro (2011) recorded no abnormal behaviours among the wild kiwi, besides startle response. These startle behaviours occurred as a response to the presence of the researchers movements in the kiwi's habitat. This indicates that it is not uncommon for wild kiwi to become startled when they are exposed to a sudden sound or movement, which was also demonstrated in this thesis research.

4.4.5 Disturbance Sources

Visitor generated noise disturbance and visitor proximity were among the main disturbance sources seen in this thesis research. Visitor generated sound is one of the most common forms of disturbance seen among captive display animals (Morgan & Tromborg 2007). Multiple studies on various species have shown that an increase in visitor disturbance increases the frequency of abnormal behaviours (Larsen et al. 2014; Morgan & Tromborg 2007; Quadros et al. 2014).

This same result was observed in this thesis research; however, it was not consistent, as given in Figure 4.1. A test of whether an increase in noise is directly correlated with abnormal behaviours among the kiwi was almost significant (p-value of 0.0569). When taking into account lagged behaviour (when the abnormal behaviour continued over time) the p-value increased to 0.0001. This was a highly significant value indicating that prior abnormal behaviour by kiwi increased the probability of bad behaviour at a given point in time. Furthermore, the estimated coefficient obtained from the generalised linear regression was positive, suggesting higher noise levels might increase the probability of observing bad behaviour.

However, there are many limitations when working with animals. Sensitivity to noise is species specific (Quadros et al. 2014). Kiwi have a high sensitivity to noise, as they have acute hearing. Therefore, the importance of sound minimisation in enclosures is greater for kiwi than other species.

Visitor generated noise has been documented to cause disturbance among many captive species, more recently in large mammals and koala, where an increase in visitor generated noise increased the vigilance behaviour of the animals (Larsen et al. 2014; Quadros et al. 2014). Vigilance behaviour is not considered an abnormal behaviour, however, it is still classified as a disturbance behaviour as the animal is scanning its environments and focussing its attention on its surroundings (Quadros et al. 2014).

A disturbance source in the form of visitor proximity was prominent at Kiwi House A, eliciting a pacing response in Te Kaha. From the observations of this thesis research, it was clear that her pacing started when visitors were lined up along her viewing window with their faces almost touching the glass, even though they were relatively quiet. What makes this pacing behaviour more significant was that it continued for the whole hour-long observation, even when the visitors left her window. This level of disturbance was unexpected due to Te Kaha's lengthy experience in a display enclosure. This exact behaviour was observed in the same kiwi in many other instances, but outside of the observation times assigned for this kiwi so were not included in the data. This behaviour was unique to this kiwi.

Speculation might be made that the abnormal behaviour demonstrated by Te Kaha is a result of the kiwi's extensive captive display history, as this was for a significantly longer period than for any other kiwi included in this thesis research. Previous research has shown that as a captive animal matures, the frequency of abnormal behaviours increase (Mason 1991; Veasey et al. 1996). Alternatively, Te Kaha is a wild caught bird which may have an effect on the results. However, research has shown animals that are introduced into captivity as an adult show less stereotypical behaviours than captive bred animals, which would contradict that assumption concerning Te Kaha (Cooper & Nicol 1996).

Toi showed pacing and startle behaviour in response to noise disturbance from visitors and their close proximity. A group of children were being loud next to her viewing window. The pacing behaviour was not recurring and ceased when the children quietened down and walked away.

Visitor proximity has been documented as a disturbance source among other captive, species such as orangutans and koala (Choo et al. 2011; Larsen et al. 2014). An increase of visitor proximity to an orangutan enclosure decreased frequency of socialising and play behaviour. Socialising behaviour is thought of as an important and necessary behaviour displayed by many of the primate species (Van Schaik & Hooff 1983). Therefore, a decrease in this behaviour suggests that visitor proximity caused disturbance among the orangutan population. Visitor proximity was also documented to be a disturbance source among captive koala where the frequency of vigilance increased as visitor proximity increased (Larsen et al. 2014).

Kevin, from Kiwi House B, showed a startle response in the presence of loud visitors; elicited from a sudden noise burst. The remainder of the observational period was relatively quiet. Interestingly, this noise level occurred throughout other observational periods for this kiwi, however, no abnormal response was observed. This result suggests that if the noise is random and isolated it will have a greater negative impact, rather than if the noise recurs throughout the observational period.

At Kiwi House D, Tamanui also showed a startle response from visitor-generated noise. It was clear that this response was from a sudden loud noise produced by visitors in the viewing area. Visitor number, proximity, and noise disturbance to an animal have been known to disturb captive animals, on which the most recent publication is that by Larson et al. (2014). Disturbance of the koala was measured in vigilance behaviour. Koala are not active animals, so an active response could not be used as a measure. Observational results showed that both the number of visitors and their proximity to the koala increased the amount of time they spent on vigilance behaviours (Larsen et al. 2014).

Another form of disturbance which, observed especially strongly at Kiwi House B, was external environmental noise caused from rain hitting the roof of the enclosure. This sound was accentuated due to the structure of the roof (discussed later in the chapter); the noise that was echoed within the kiwi enclosure on a rainy day was very high, as given in Table 4.4. The highest sound measurement taken during torrential rain was the same as that of the highest measurement taken during visitor generated noise disturbance. When the rain started, the behaviour of the kiwi changed from a normal behaviour to abnormal behaviour, in sync with the rain. The opposite affect happened when the rain stopped. This changes affected two kiwi, Kahurangi and Aroha, although, the data recorded from the datalogger for Kahurangi was not complete and therefore no firm conclusions can be made for this kiwi. However, the noise of the rain was observed to affect up to three different kiwi, seen in general observations made outside the randomised observation times set for each kiwi, and so were not included in the data set.

Environmental noise pollution is thought to cause a greater degree of disturbance among captive animals than sound from a natural cause (Kight & Swaddle 2011). The sound of rain is a natural noise, however, the sound that it makes when hitting the roof of the enclosure at Kiwi House B is not. Therefore, this noise has been classified as a foreign environmental noise. A literary search suggests that this particular disturbance source has not yet been documented. However, other foreign environmental noises, such as those from a construction site, have been known to cause disturbance among captive animals. Chosy et al. (2014) studied if the noise from a construction site caused stress among four captive felid species who inhabited nearby enclosures. Stress was measured from fecal glucocorticoid metabolite concentrations. An increase in glucocorticoid metabolite concentration was seen during the construction period, suggesting that the noise produced from the construction site was causing stress among the cats (Chosy et al. 2014).

The final disturbance source that was recorded was made by keepers. At Kiwi House A the keeper threw live insects into the enclosure with Te Kaha. One landed near the kiwi, startling the bird. At Kiwi House D, Kaitiaki got startled when the keeper opened the exit door of the enclosure to begin a feeding session, and in another instance when the keeper was walking through the enclosure to disperse feeding tubes.

Kiwi are shy birds and are clearly not comfortable in the presence of humans. The observed keeper disturbance demonstrated in this thesis research is not a criticism as some form of disturbance cannot be helped and they try to mitigate disturbance. Keeper disturbance is a common occurrence in animal holding facilities as demonstrated by many studies (Chelluri et al. 2013; Wielebnowski et al. 2002). Keeper disturbance is also an identified disturbance source among other captive species such as leopards, gorillas and chimpanzees (Chelluri et al. 2013; Wielebnowski et al. 2002).

4.5 Conclusions

Six kiwi included in this study showed abnormal behaviours (pacing and startle response). The relationship between noise data and the expression of abnormal behaviours among the kiwi was insignificant. Despite this, noise was a disturbance source which resulted in some kiwi to express abnormal behaviours. In some instances, the dB level reached to 70db or above, higher than the recommended sound level for human well-being (Quadros et al. 2014). Therefore, it was assumed that a noise level reaching this high was also detrimental for animals. There was evidence to suggest that the effectiveness of the viewing window may have had a direct effect on the frequency of abnormal behaviour. The viewing windows at all facilities reduced noise from the viewing area significantly. Kiwi House C had the only soundproof window and were the only facility housing display kiwi who did not show any abnormal behaviours. Alternatively, it is possible that the kiwi involved in this study may have become used to the sound produced in the viewing area, and subsequently showed a lower frequency of abnormal behaviour. Visitor generated noise disturbance was recorded at Kiwi House B, Kiwi House A and Kiwi House D. Visitor proximity disturbance was observed at Kiwi House A and environmental noise disturbance was observed at Kiwi House B. The design of the ceiling, roof, and wall proved to be most ineffective at Kiwi House B as it accentuated environmental noise, causing disturbance among the kiwi. This was the oldest facility included in this study and is due to be renovated in 2015 to improve enclosure designs. Kiwi House C had the most advanced enclosure design which was soundproof from all external noise.

Chapter 5

General conclusions, implications for kiwi facilities and recommendations for further research.

5.1 Discussion of findings

The behaviour of captive kiwi was observed with the main aspects of observation being behaviours including feeding, sleeping/resting, miscellaneous, pacing and startle response. Observations were conducted at four different facilities in New Zealand (Kiwi House A, Kiwi House B, Kiwi House C, Kiwi House D). An ethogram was used to identify each behaviour and the results were compared within, and between, facilities. Observations were made directly at differing periods of time during the day. The timing of observations were randomised so each kiwi was observed once during the day.

Feeding behaviour is a priority in the activity budget of the kiwi as wild kiwi have been observed feeding during the whole time they were active at night (Cunningham & Castro 2011). Feeding behaviour was the most common behaviour shown by 11 of the 15 captive kiwi involved in this thesis research, although at inconsistent frequencies. The kiwi at Kiwi House D, collectively, had the highest frequency of feeding behaviour. Cobalt, at Kiwi House A, showed no feeding behaviours, and Koru, at Kiwi House B, had a very low frequency of feeding behaviour. In contrast, Toi, at Kiwi House A was observed feeding at a very high frequency, as well as Kevin, from Kiwi House B.

Sleeping/resting behaviour is also an important behaviour in the kiwi's activity budget as kiwi typically sleep for a large majority of the 24 hour day (McLennan 1988). Sleeping/resting behaviour was observed in 12 of 15 kiwi. Ideally, the sleeping pattern of captive kiwi during display hours should occur as short resting periods throughout the day, instead of over long periods of time. This is to ensure the kiwi obtain enough nourishment, and to increase the chances the viewing public will see an active kiwi. The frequency of sleeping/resting behaviour occurred at different frequencies among the kiwi. A pattern was seen where a kiwi that had a high frequency of sleeping/resting behaviour, had a low frequency of feeding behaviour. Cobalt was observed sleeping/resting throughout all observations. Toi, Kevin and Morehu showed no sleeping/resting behaviours.

Miscellaneous behaviours, behaviours which are not defined by the ethogram, were observed in 14 of the 15 captive kiwi included in this thesis research. Among most kiwi, miscellaneous behaviours occurred at very low frequencies. The kiwi at Kiwi House B had the highest frequency of miscellaneous behaviours. This behavioural category was predominantly made up of kiwi in a stationary position and investigating the back wall of their enclosure.

Pacing behaviour was observed by four captive kiwi, at Kiwi House A and Kiwi House B, involved in this thesis research. Even though this behaviour was seen among a small number of kiwi, the occurrence of any pacing behaviour by a captive animal is of concern. Captive animals are known to carry out this behaviour when they are disturbed or stressed (Mason 1991). A vast array of literature has identified pacing as a widespread behaviour that occurs in many species (Anderson et al. 2002; Andrews & Ha 2014; Azevedo et al. 2012; Breton & Barrot 2014; De Rouck et al. 2005; Ross et al. 2011; Veasey et al. 1996; Veeraselvam et al. 2013) . Te Kaha showed the highest frequency of pacing behaviour, suggesting that particular attention might be paid to this kiwi as it was clearly affected at a higher degree from disturbance. Toi, Kahurangi and Aroha also showed pacing behaviour. Even though studies have identified a disturbance as a cause of pacing behaviour among some species, often the occurrence of pacing is because the animal is in an enclosed space (Mason et al. 2013). This suggests the possibility of captivity in general having a detrimental effect on captive animals.

Startle response was an abnormal behaviour observed in four out of 15 captive kiwi, at a very low frequency. This behaviour was not considered as detrimental as pacing as typically it was elicited from a sudden noise or movement, causing a temporary reaction (Geyer & Swerdlow 1998), also observed in this thesis research. Furthermore, this behaviour occurs among wild animals, including kiwi.

The behaviour of captive kiwi is important, not only to understand how kiwi respond to a captive environment, but how it also affects the kiwi viewing experience for the public. As visitors paid money to see the kiwi, it can be presumed that the visitors were not satisfied when the kiwi spent the majority of their time sleeping, based on visitor comments that were heard during observations. Furthermore, people's perception of the animal, and the facility, were often based on the behaviour of the animal they were viewing. If the kiwi was showing abnormal behaviours, some visitors were seen to have an ill-opinion of keeping kiwi in captivity. However, if the kiwi was showing natural behaviours and seemed, they would have a positive reaction to the facility, and the bird, potentially increasing the numbers of volunteers and donations.

The facility that housed kiwi who behaved most similarly to eachother was Kiwi House D. The frequency of each behaviour was relatively regular among all four display kiwi, reinforced by the results as there was no significant difference in behaviour among the kiwi. Kiwi House C also had no significant difference in behaviour among the four display kiwi. The behaviour of the display kiwi between Kiwi House D and Kiwi House C were not statistically significant. The behaviour of the display kiwi at Kiwi House A and Kiwi House B were similar, as they were both significantly variable. Results showed that the behaviour of kiwi between the two facilities were not statistically different.

Naturalistic, complex enclosures are an important part of a captive environment. For a nocturnal kiwi enclosure, one of the most essential design aspects are those of the enclosure interior, and lighting. A naturalistic enclosure depicts a kiwi's natural habitat, and the complexity makes the enclosure more interesting and stimulates the kiwi, as boredom is a known problem among some captive species (Goerke et al. 1987). A naturalistic enclosure not only has been correlated with a positive behaviour response from captive species, it also increases the aesthetic appeal of the enclosure (Davey 2006). This improves the visitors viewing experience as they like to see animals in a naturalistic enclosure.

Kiwi House C had the most naturalistic and complex interior enclosure design. The nocturnal enclosures were dense with foliage and a stream ran through each enclosure. The enclosure floor contained leaf litter and logs, as what would be found on the forest floor. As well as a dark panelled wall, the interior of the enclosure walls comprised partly of artificial rocks, which added another dimension to the enclosure. This enclosure design may have had a positive effect on the behaviour of the kiwi as no abnormal behaviours were seen among the display kiwi at Kiwi House C.

Kiwi House C had the darkest lighting scheme compared to the other facilities included in this thesis research. There is no doubt that this lighting was beneficial for the kiwi. However, the layout of the lights in the front of the enclosure accentuated the darkness of the remainder of the enclosure. An enclosure that is too dark is unfavourable to the viewing public as it makes the kiwi difficult to observe, or even spot, which was clearly observed as a frustration among the visitors at Kiwi House C.

Kiwi House D had a naturalistic enclosure; however, it had the lowest degree of complexity. The numerous logs and the presence of leaf litter on the enclosure floor achieved a realistic replication of a forest floor. However, the lack of foliage made the enclosure look bare. The negative affect of this appeared only to affect the aesthetic appeal of the enclosure. The lower complexity did not cause the occurrence of abnormal behaviours, and therefore was assumed to not have a detrimental effect on the kiwi.

Kiwi House D had the most consistent lighting throughout their enclosures. All areas of the enclosure were dimly lit, meaning the kiwi were easily observed regardless of where they were located in the enclosure. This proved to be very beneficial for the viewing public. Red lights were utilised in the enclosures, which are known to be less disruptive for kiwi (Grant 2012). There were few dark areas which the kiwi could have occupied; however, their burrows awere open at all times. The walls of the enclosure were of a light shade, which stood out significantly against the darker, brown enclosure. This lowered the naturalistic appeal of the enclosure.

The enclosures at Kiwi House C and Kiwi House D were significnalty larger than those at Kiwi House A and Kiwi House B. This was necessary as a pair of kiwi inhabited each enclosure in both facilities; however, there was still ample space for the kiwi to carry out their nightly behaviours. There was evidence to suggest a large enclosure had a positive effect on the behaviour of a captive animal (Breton & Barrot 2014; Kitchen & Martin 1996).

Kiwi House A had a naturalistic and complex enclosure which accurately portrayed the natural habitat of the kiwi. Foliage was present throughout the enclosure and leaf litter and rotten logs covered the enclosure floor. The enclosure had a variable topography which is thought to be a beneficial area of complexity in a kiwi enclosure (Wesley & Brader 2014). Kiwi House A utilised red and green lights for minimal disruption to the kiwi, which also achieved a balance between the needs of the kiwi and the visitors.

Kiwi House B had sufficient naturalistic and complex enclosures compared to other facilities included in this thesis research. The foliage was relatively scattered, however, the impact of this was minimalized due to the smaller enclosure sizes. The enclosures had variable topography which was beneficial to the kiwi. The lighting met the needs of both the kiwi and the visitor and the layout of the lights provided dark areas within the enclosure which the kiwi were observed utilising.

The enclosures at Kiwi House A and Kiwi House B were significantly smaller than that of Kiwi House C and Kiwi House D, however, there was only one kiwi inhabiting each enclosure, except for one pair at Kiwi House B.

Husbandry practices are a significant part of a captive kiwi's captive life and can impact the behaviour of kiwi. At least one manmade hutch was provided for each kiwi involved in this thesis research, which they utilised for sleeping/resting or nesting. Kiwi House B was the only facility, in this thesis research, that closed the hutches during the kiwi display hours. Theoretically, this should not affect the behaviour of these particular kiwi as they are only on display for four hours, the minimal amount of time a wild kiwi would be active during the night (McLennan 1988). However, these kiwi were observed trying to get access into a hutch when they were closed. Kiwi House A closed Te Kaha's burrow while she was on display. Te Kaha tried, and achieved to get access to the burrow during one observation.

All facilities provided their display kiwi with live insects and allowed access to live worms in the soil of the enclosure. They also provided their kiwi with an artificial diet, however, Kiwi House D was the only facility which fed their kiwi an artificial diet multiple times a day. The display kiwi at Kiwi House D were fed four small meals throughout the day, rather than one big meal, as practiced by the other facilities. It was clear that the kiwi in this facility were collectively the most active with very little abnormal behaviours shown. Therefore, it is likely the behaviour of these kiwi stem from the feeding regime practiced from this facility.

The viewing window of an enclosure is an important part of enclosure design as it acts as a separation between the kiwi and the visitors, and reduces the level of sound that reaches the enclosure from the viewing area. The viewing windows at all facilities reduced a significant amount of noise; however, Kiwi House C had the most effective window as it was soundproof.

The walls, ceiling and roof of the enclosure can also help reduce the amount of sound that reaches the enclosure from external sources. Kiwi House C had the most effective design as all aspects were made of Bondor Panel® which insulated the building. Kiwi House A and Kiwi House D both had insulation in their wall structure, and Kiwi House D also had additional insulation in the roof**.** Kiwi House B did not have insulation in the structure of the nocturnal houses. This was reflected in the high level of environmental sound that reached the inside of the enclosure during a rainstorm.

Four different disturbance sources were observed to cause abnormal behaviour among the captive kiwi in this thesis research. Close visitor proximity elicited a pacing behaviour from Te Kaha at Kiwi House A. This was the only kiwi which was affected by the disturbance source. Visitor generated noise provoked a startle response from kiwi at Kiwi House A, Kiwi House B and Kiwi House D. Keeper disturbance caused a startle response to occur among one kiwi at Kiwi House A and also at Kiwi House D. The final disturbance source seen was environmental disturbance at Kiwi House B, where the impact of heavy rain on the roof of the enclosure created a loud drumming sound, which reached the inside of the enclosure and caused a pacing response in two kiwi.

5.2 Implications for kiwi facilities

In terms of the naturalistic qualities and complexity of the enclosures, it is suggested from the results of this thesis research that improvements could be made to most facilities. From an aesthetic point of view, Kiwi House D would benefit with an increase in the number of plants in the enclosure. The design of enclosure 1 at Kiwi House C could be improved by taking out the space on the side of the enclosure where the viewing window does not reach. The kiwi spent a large majority of their time in this area where they could not be viewed by the public. The kiwi viewing experience would improve at Kiwi House C if the lighting of the enclosure was more uniform, which would also result in the enclosure being less dark. This would increase the number of visitors who see the kiwi and improve visitor satisfaction. However, comments from the facility staff say plans are being made to improve the lighting. Since the completion of observations for this thesis research, the lighting at Kiwi House B has been altered so the enclosures are darker for the benefit of the kiwi.

Areas in the husbandry of the kiwi can also be improved. It might be beneficial to the activity budget of the kiwi if they were fed more than once a day. The results obtained at Kiwi House D suggest that this could increase the activity levels of the kiwi in the other facilities. However, this may not be possible for all facilities as it would require more of the keepers time, when they otherwise might be busy with other commitments. After all observations were completed for this thesis research, facility staff at Kiwi House B said the display kiwi were now being fed three times per day. Designing feeding stations which challenge the kiwi when obtaining food may increase activity levels and decrease abnormal behaviours, as demonstrated in other studies (Veeraselvam et al. 2013).

Kiwi House B may benefit in keeping the kiwi hutches open. There is a risk that the kiwi may spend a large majority of their time in the hutch sleeping, decreasing the viewing experience for the visitor. A subsequent visit to Kiwi House B, after all observations for this thesis research were completed, showed that all kiwi hutches remained open 24 hours a day, apart from one. Live video from inside the hutches could be shown in the visitor area, similar to that observed at Kiwi House D. This would mean the visitors would still be able to view the kiwi even if it was not directly visible at the time. It is understood that this concept is to be considered for the renovations which are to happen at this facility in 2015.

The behaviour of some kiwi occurred at abnormal frequencies, such as Cobalt (Kiwi House A) and Koru (Kiwi House B) where very little activity is seen. It is likely that this behaviour was not a result of a disturbance source, but that the kiwi had not settled in their enclosure. Therefore, facilities might consider to transfer these kiwi to an outdoor pen and replace the kiwi with another that better adapts to a captive environment. After the completion of this thesis research, it was learned that both of these kiwi had been transferred out of their respective enclosures. Te Kaha (Kiwi House A) showed recurring abnormal behaviour, even after the disturbance was gone. It might be considered for this kiwi to be taken off display for a time to see if the frequency of abnormal behaviour decreases.

All viewing windows of the facilities which were observed in this thesis research reduced a significant amount of sound that reached inside the enclosure from the viewing area. Ideally, soundproof windows would be preferable to utilise in all kiwi facilities as this would eliminate visitor generated noise disturbance. However, soundproof glass can be financially not acceptable to many facilities. One-way glass would also be beneficial to the kiwi as this would eliminate visitor proximity disturbance. However, one-way glass is also expensive and may be out of the price range for kiwi facilities. Another scheme that could decrease visitor proximity disturbance is a hand bar that ran along the perimeter of an enclosure, in the viewing area. This would restrict how close people could get to the window. A hand bar would also have other benefits, as it may act as a guide for people in the dark enclosure, particularly for the elderly.

The enclosure design for most facilities was sufficient; however, insulation could be added to the roof of three facilities as this would increase the amount of external sound that could be reduced. The enclosure design at Kiwi House B could be improved. The roof should get particular attention in order to reduce the amount of noise reaching the enclosure during heavy rain. Insulation added to the walls and roof would also be beneficial in reducing noise levels, and subsequently noise disturbance among the kiwi. Kiwi House B was informed of these recommendations and the necessary improvements were incorporated in their upcoming renovation.

In order to improve the kiwi experience for the viewing public, it is suggested there be some form of notification that informs the visitors they require time for their eyes to adjust to the nocturnal lighting of the nocturnal house. Numerous visitors were observed to assume the kiwi was not visible when they had only been in the nocturnal house for a short time, as their eyes had not adjusted to the darker lighting. They would then leave the nocturnal house unsatisfied.

The level of noise that was produced in the viewing area, observed both during and outside of the specified observation times was, on many occasions, unacceptable by the startle responses observed in this thesis research. Even in facilities that had soundproof kiwi enclosures (e.g. Kiwi House C), visitor generated noise disrupt the experience of the nocturnal environment, and also disrupt other visitors.

All facilities had a sign at the entrance of the nocturnal house informing visitors that they must be quiet while in the nocturnal house. However, this effectiveness of these signs appearred to be limited. All kiwi facilities would benefit from utilising other methods to reduce visitor noise, as well as the use of signs. Nocturnal tours could be established, where tourists are taken in groups through the nocturnal house by a member of the facility staff, who could control the noise level if it gets too high (this is carried out at Kiwi House A). Alternatively, facility staff could take shifts to stay in the nocturnal house for a period of time to monitor the noise and control it, accordingly, even if this was only at the busiest time of the day, the busiest season of the year, or during school holidays. However, it is likely that some facilities cannot afford to assign a staff member to this job as there are too many other requirements to be met from the other animals in the park. The simplest method could be to mention to visitors that they must be quiet when in the nocturnal house, perhaps most efficaciously when they purchase tickets for the park.

Another aspect that may improve the kiwi experience for the visitors may be to provide a display which informs the visitors about the specific kiwi they are viewing. There is information provided for the visitors on kiwi pertaining to the Genus. However, in this thesis research, visitors often wanted to know the name, species, age, gender of the kiwi they were viewing and/or whether they had a mating partner, based on comments from the visitors during observation. Kiwi House B was the only facility which provided information on their display kiwi in the form of an information board present on each individual kiwi in the kiwi enclosures.

It is suggested that information be provided on the nocturnal kiwi display enclosures, so visitors can have a good understanding of not only the bird, but the enclosure they live in and why kiwi behave the way they do. For example, noting that the enclosure is dark because kiwi are nocturnal, and the kiwi may not always be visible as they typically sleep 17-20 hours per day in the wild. Also, the kiwi can be seen probing their beak into the soil as it contains worms, which makes up a large part of their diet. Kiwi House D have adopted an effective method to inform the visitors about the kiwi (and all other birds in the park), by giving each visitor an audio tour system. This was a recorded commentary of all the animals in the park, and acted as a personal tour as they walked around the park. This informed the visitor about the kiwi and was also observed to lower the noise level as the visitors were listening to their audio tour instead of talking. The visitors also tended to remain in the nocturnal house longer, leaving enough time for their eyes to fully adjust to the dark.

5.3 Recommendations for further research

Due to funding limitations, the datalogger used in this thesis research was not of high quality. This was reflected in the results as the datalogger unknowingly stopped recording nearing the end of multiple observations. A datalogger of better quality would likely not have malfunctioned. It is evident that the quiet tones produced from the researcher generated sound were too quiet for the datalogger to accurately detect. Therefore, a more sensitive datalogger, or alternatively, a louder 'quiet' tone would be needed in further research to increase the accuracy of the data.

In the methodology of this thesis research, it was noted that if two enclosures at the facility appeared the same, the effectiveness of the viewing window was not tested in both enclosures. However, further research should incorporate data from all display enclosures at facilities to prove that, in fact, they are the same. If the data between the two enclosures contrast, then they are not the same and should be treated separately.

In further research, it would be beneficial to carry out all experimentation in the same season. Due to unforeseen difficulties, observation at Kiwi House D occurred during winter, whereas observation at the other facilities occurred before the onset of winter. As there was a significant difference in the number of people visiting Kiwi House D, compared to the other facilities of this thesis research, it is likely that this had a differential effect on the behaviour of the kiwi, and subsequently the results. Collecting data during both summer and winter would be advantageous as comparisons could be made on visitor number and visitor generated noise. The behaviour of the kiwi might also be affected by differing temperature and season variation.

As a result of constraints, the number of facilities that were to be included in this thesis research was limited to four, however there are 12 facilities throughout New Zealand who hold captive display kiwi. Including more facilities in further research would increase quantity of data as well as increase the population sample, which would produce a greater depth of understanding.

Future methodology for observation of the behaviour of kiwi should include recording on video, which was originally planned for this thesis research. This would minimise any researcher error as the video footage would be able to be controlled so no behaviour is missed, and the behaviour is identified correctly, and viewed repeatedly. Furthermore, this would allow the behaviour to be recorded continuously which would permit the researcher to determine exactly how much time was spent on each behaviour. It would also be known whether the kiwi was active at any time during their ‘day time’, which could subsequently affect their behaviour the following day.

In further studies, more detail could be considered regarding the naturalistic qualities and the complexity of the enclosures, to quantify these variables. For example, how much area of the enclosure is bare, and how much is covered with foliage? Also, it would be beneficial to get quantitative data on the intensity of the light and the use of coloured lights in the enclosures, and comparing between facilities.

It would be interesting to do further observations specifically on Te Kaha (Kiwi House A). This kiwi was unique in many ways compared to the other kiwi in this thesis research, and it displayed the highest frequency of abnormal behaviour. Research on whether a display kiwi, which was showing abnormal behaviour, were to be taken off display for a long period of time, would include significant follow-through such as whether it's behaviour was the same when it was put back on display , or if it had changed. Similarly, at Kiwi House B, it would be interesting to investigate whether the behaviour of Koru could be improved by removing Kahurangi from the enclosure. The results would be valuable in future endeavours to house kiwi together in the same enclosure who were not a breeding pair.

It would be beneficial to conduct a second observational study at Kiwi House B on the behaviour of their display kiwi. As this facility had altered various aspects of husbandry (increasing the number of artificial feeds, leaving the hutches open 24 hours per day) and enclosure design (darkening the lighting of the enclosure), another observational study may highlight areas where kiwi behaviour may have improved as a result of these changes. This would have implications for other facilities, and may lead to similar changes with the goal to improve the behaviour of their display kiwi.

Evidence suggests that juvenile captive animals, who are first introduced to their enclosure, display a high frequency of abnormal behaviour (Lutz et al. 2014). This would be a worthy to pursue for future research as it could have implications on the management of captive kiwi. Captive kiwi are not transferred to their respective enclosures immediately after hatching (Bassett 2012). However, experiments could be designed to determine if younger birds show an increase in abnormal behaviours when they are first introduced into their enclosure, compared to older kiwi.

An interesting experiment would be to determine if having the hutches in the kiwi enclosures open or closed would have an effect on the kiwi. This could be achieved simply by closing the hutch for an extended period of time and recording the behaviour of the kiwi, and comparing this behaviour to the behaviour of the same kiwi when the hutch is open, with constant variables.

Further experimentation on different feeding regimes for kiwi would also be useful. This thesis research showed evidence that increasing the number of times the kiwi are fed in a day could also increase the foraging frequency of the kiwi, and increase general activity levels. Therefore, designing an experiment which involves feeding the kiwi one large meal a day, then increasing their feeds over time may produce significant results. Furthermore, unpredictable feeding should also be tested as evidence has shown that unpredictable feeding can increase the activity levels of captive animals (Andrews & Ha 2014).

In order to increase the reliability of data when testing how much sound the viewing window reduces, it would be recommended to have a data logger remain in the kiwi enclosure and a separate one in the viewing area, for further research. After a set period of time, the occurrence of sound could be compared between the two dataloggers in order to determine the difference in sound between the two areas.

Overall, captive kiwi behave differently between and within facilities in terms of frequency of foraging, sleeping/resting and miscellaneous behaviours. Some kiwi showed an abnormal frequency of foraging and sleeping/resting behaviour, which may be improved by alterations of husbandry and enclosure design. Kiwi House A, Kiwi House B and Kiwi House D all housed kiwi who were observed showing a startle response at least once in response to keeper disturbance or visitor generated noise. Visitor proximity and environmental noise also elicited pacing behaviour, seen from kiwi at Kiwi House A and Kiwi House B. This behaviour could be eliminated by introducing one-way glass, so the kiwi are not able to detect the visitors through movement, or a hand bar in the viewing area of the nocturnal house, outlining the perimeter of the enclosure. Environmental noise could be reduced by adding insulation and using materials in the structure of the enclosure to increase the amount of environmental noise that reaches the inside of the kiwi enclosure. The results of this thesis research may have implications for kiwi facilities to improve the behaviour of captive kiwi and the enclosure they are housed in. These results may also be applied to other nocturnal species that inhabit a nocturnal house.

References

Altmann J, Schoeller D, Altmann SA, Muruthi P, Sapolsky RM 1993. Body size and fatness of free - living baboons reflect food availability and activity levels. American Journal of Primatology 30(2): 149-161.

Anderson MR 2014. Reaching New Heights: The Effect of an Environmentally Enhanced Outdoor Enclosure on Gibbons in a Zoo Setting. Journal of Applied Animal Welfare Science 17(3): 216-227.

Anderson US, Benne M, Bloomsmith MA, Maple TL 2002. Retreat Space and Human Visitor Density Moderate Undesirable Behavior in Petting Zoo Animals. Journal of Applied Animal Welfare Science 5(2): 125-137.

Andrews NLP, Ha JC 2014. The Effects of Automated Scatter Feeders on Captive Grizzly Bear Activity Budgets. Journal of Applied Animal Welfare Science 17(2): 148-156.

Aplin LM, Farine DR, Mann RP, Sheldon BC 2014. Individual-level personality influences social foraging and collective behaviour in wild birds. Proceedings of the Royal Society B: Biological Sciences 281(1789): 20141016.

Azevedo CSd, Lima MFF, Silva VCAd, Young RJ, Rodrigues M 2012. Visitor Influence on the Behavior of Captive Greater Rheas (Rhea americana, Rheidae Aves). Journal of Applied Animal Welfare Science 15(2): 113-125.

Baker AJ, Daugherty CH, Colbourne R, McLennan J 1995. Flightless brown kiwis of New Zealand possess extremely subdivided population structure and cryptic species like small mammals. Proceedings of the National Academy of Sciences 92(18): 8254-8258.

Barlow 2011. Captive Management Plan for Kiwi. Zoo and Aquarium Association:

Bashaw MJ, Kelling AS, Bloomsmith MA, Maple TL 2007. Environmental Effects on the Behavior of Zoo-housed Lions and Tigers, with a Case Study o the Effects of a Visual Barrier on Pacing. Journal of Applied Animal Welfare Science 10(2): 95-109.

Bassett L, Buchanan-Smith HM 2007. Effects of predictability on the welfare of captive animals. Applied Animal Behaviour Science 102(3): 223-245.

Bassett S 2012. Operation Nest Egg incubation and chick rearing best practice protocols. Wellington, New Zealand, Department of Conservation:

Benbow SMP 2000. Zoos: Public Places to View Private Lives. The Journal of Popular Culture 33(4): 13-23.

Birkett LP, Newton-Fisher NE 2011. How abnormal is the behaviour of captive, zoo-living chimpanzees? PloS one 6(6): e20101.

Breton G, Barrot S 2014. Influence of enclosure size on the distances covered and paced by captive tigers (Panthera tigris). Applied Animal Behaviour Science 154(0): 66-75.

Cabezas S, Carrete M, Tella JL, Marchant TA, Bortolotti GR 2013. Differences in acute stress responses between wild-caught and captive-bred birds: a physiological mechanism contributing to current avian invasions? Biological invasions 15(3): 521-527.

Castro I, Cunningham SJ, Gsell AC, Jaffe K, Cabrera A, Liendo C 2010. Olfaction in birds: a closer look at the kiwi (Apterygidae). Journal of Avian Biology 41(3): 213-218.

Chelluri GI, Ross SR, Wagner KE 2013. Behavioral correlates and welfare implications of informal interactions between caretakers and zoo-housed chimpanzees and gorillas. Applied Animal Behaviour Science 147(3–4): 306-315.

Choo Y, Todd PA, Li D 2011. Visitor effects on zoo orangutans in two novel, naturalistic enclosures. Applied Animal Behaviour Science 133(1–2): 78-86.

Chosy J, Wilson M, Santymire R 2014. Behavioral and physiological responses in felids to exhibit construction. Zoo biology 33(4): 267-274.

Claxton AM 2011. The potential of the human–animal relationship as an environmental enrichment for the welfare of zoo-housed animals. Applied Animal Behaviour Science 133(1–2): 1-10.

Clubb R, Mason GJ 2007. Natural behavioural biology as a risk factor in carnivore welfare: How analysing species differences could help zoos improve enclosures. Applied Animal Behaviour Science 102(3–4): 303-328.

Colbourne R, Bassett S, Billing T, McCormick H, McLennan J, Nelson A, Robertson H 2005. The development of Operation Nest Egg as a tool in the conservation management of kiwi. Science & Technical Pub., Department of Conservation.

Colbourne R, Powlesland R 1988. Diet of the Stewart Island brown kiwi (Apteryx australis lawryi) at Scollay's Flat, southern Stewart Island. New Zealand Journal of Ecology 11: 99-104.

Cooper A, Mourer-Chauviré C, Chambers GK, von Haeseler A, Wilson AC, Pääbo S 1992. Independent origins of New Zealand moas and kiwis. Proceedings of the National Academy of Sciences 89(18): 8741-8744.

Cooper J, Nicol C 1996. Stereotypic behaviour in wild caught and laboratory bred bank voles (Clethrionymus glareolus). Animal Welfare 5(3): 245-257.

Craigie EH 1930. Studies on the brain of the kiwi (Apteryx australis). Journal of Comparative Neurology 49(2): 223-357.

Crast J, Bloomsmith M, Perlman J, Meeker T, Remillard C 2014. Abnormal behaviour in captive sooty mangabeys. Animal Welfare 23(2): 167-177.

Cunningham SJ, Castro I 2011. The secret life of wild brown kiwi: studying behaviour of a cryptic species by direct observation. New Zealand Journal of Ecology 35(3): 209.

Davey G 2006. Relationships between exhibit naturalism, animal visibility and visitor interest in a Chinese zoo. Applied Animal Behaviour Science 96(1): 93-102.

de Azevedo CS, Lima MFF, Cipreste CF, Young RJ, Rodrigues M 2013. Using environmental enrichment to reduce the expression of abnormal behaviours in Greater rhea Rhea americana at Belo Horizonte Zoo. International Zoo Yearbook 47(1): 163-170.

De Rouck M, Kitchener AC, Law G, Nelissen M 2005. A comparative study of the influence of social housing conditions on the behaviour of captive tigers (<i>Panthera tigris</i>). Animal Welfare 14(3): 229-238.

Dutra LML, Young RJ 2014. Can enrichment make brazilian tapir spend more time on view to the public? Journal of Applied Animal Welfare Science (ahead-of-print): 1-8.

Edwards A 2005. RA Fisher, statistical methods for research workers, (1925). Landmark Writings in Western Mathematics 1640–1940: 856.

Fàbregas MC, Guillén-Salazar F, Garcés-Narro C 2012. Do naturalistic enclosures provide suitable environments for zoo animals? Zoo Biology 31(3): 362-373.

Fanson KV, Wielebnowski NC 2013. Effect of housing and husbandry practices on adrenocortical activity in captive Canada lynx (<i>Lynx canadensis</i>). Animal Welfare 22(2): 159-165.

Fitch-Snyder H, Schulze H, Streicher U 2008. Enclosure design for captive slow and pygmy lorises. Primates of the oriental night. LIPI, Jakarta: 123-135.

Forthman DL, Elder SD, Bakeman R, Kurkowski TW, Noble CC, Winslow SW 1992. Effects of feeding enrichment on behavior of three species of captive bears. Zoo Biology 11(3): 187-195.

Fraser I, Johnson T 2009. Brown kiwi (Apteryx mantelli) husbandry manual. Department of Conservation:

Fuller GA 2014. The Night Shift: Lighting and Nocturnal Strepsirrhine Care in Zoos. Unpublished thesis, Case Western Reserve University,

Garner JP 2005. Stereotypies and other abnormal repetitive behaviors: potential impact on validity, reliability, and replicability of scientific outcomes. ILAR journal 46(2): 106-117.

Geyer MA, Swerdlow NR 1998. Measurement of startle response, prepulse inhibition, and habituation. Current protocols in neuroscience: 8.7. 1-8.7. 15.

Gibbs G 2010. Feathers to Fur. New Zealand Journal of Ecology 34(1): 152-157.

Goerke B, Fleming L, Creel M 1987. Behavioral changes of a juvenile gorilla after a transfer to a more naturalistic environment. Zoo Biology 6(4): 283-295.

Grant RK 2012. The effect of light on the behaviour of captive brown kiwi Apteryx mantelli: implications for captive management: a thesis presented in partial fulfilment of the requirements for the degree of Masters of Science in Conservation Biology at Massey University, Manawatu, New Zealand. Unpublished thesis,

Grazian D 2012. Where the Wild Things Aren't. The Sociological Quarterly 53(4): 546-565.

Guy A, Curnoe D, Banks P 2013. A survey of current mammal rehabilitation and release practices. Biodiversity and Conservation 22(4): 825-837.

Haeusler H 1923. Notes on the habits of the North Island Kiwi (Apteryx mantelli). Emu 22: 175-179.

Hanazuka Y, Shimahara N, Tokuda Y, Midorikawa A 2013. Orangutans (<italic>Pongo pygmaeus</italic>) Remember Old Acquaintances. PLoS ONE 8(12): e82073.

Held SDE, Špinka M 2011. Animal play and animal welfare. Animal Behaviour 81(5): 891-899.

Herborn KA, Heidinger BJ, Alexander L, Arnold KE 2014. Personality predicts behavioral flexibility in a fluctuating, natural environment. Behavioral Ecology: aru131.

Herrmann EA, Herrin KV, Gleen W, Davies P, Stapley R, Stebbings V, Wiszniewski J, Spindler R, Faichney GJ, Chaves AV 2013. Partial replacement of an artificial nectar diet with native browse for feather-tail gliders (Acrobates pygmaeus) in captivity. Zoo Biology 32(4): 394-399.

Higham J, Shelton E 2011. Tourism and wildlife habituation: Reduced population fitness or cessation of impact? Tourism Management 32(6): 1290-1298.

Hogan LA, Lisle AT, Johnston SD, Robertson H 2012. Non-invasive assessment of stress in captive numbats,< i> Myrmecobius fasciatus</i>(Mammalia: Marsupialia), using faecal cortisol measurement. General and comparative endocrinology 179(3): 376-383.

Holzapfel A 2008. Kiwi (Apteryx spp.) recovery plan: 2008-2018. Pub. Team, Department of Conservation.

Hosey G 2013. Hediger Revisited: How Do Zoo Animals See Us? Journal of Applied Animal Welfare Science 16(4): 338-359.

Howland HC, Howland M, Schmid KL 1992. Focusing and accommodation in the Brown Kiwi (Apteryx australis). Journal of Comparative Physiology A 170(6): 687-689.

Jamieson D 2014. Against zoos. Revista Brasileira de Direito Animal 3(4):

Jolly J 1989. A field study of the breeding biology of the little spotted kiwi (Apteryx owenii) with emphasis on the causes of nest failures. Journal of the Royal Society of New Zealand 19(4): 433-448.

Kagan RL 2013. Challenges of Zoo Animal Welfare—The Path From Good Care to Great Welfare: Keynote. Journal of Applied Animal Welfare Science 16(4): 381-381.

Kight CR, Swaddle JP 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. Ecology letters 14(10): 1052-1061.

Kinsky F 1971. The consistent presence of paired ovaries in the Kiwi (Apteryx) with some discussion of this condition in other birds. Journal für Ornithologie 112(3): 334-357.

Kistler C, Hegglin D, Würbel H, König B 2009. Feeding enrichment in an opportunistic carnivore: the red fox. Applied Animal Behaviour Science 116(2): 260-265.

Kitchen AM, Martin AA 1996. The effects of cage size and complexity on the behaviour of captive common marmosets, Callithrix jacchus jacchus. Laboratory Animals 30(4): 317-326.

Kozuch AE, McPhee ME 2014. Effects of Environmental Complexity and Temporary Captivity on Foraging Behavior of Wild-Caught Meadow Voles. Journal of Applied Animal Welfare Science 17(2): 157-171.

Larsen MJ, Sherwen SL, Rault J-L 2014. Number of nearby visitors and noise level affect vigilance in captive koalas. Applied Animal Behaviour Science 154(0): 76-82.

Lemons PR, Sedinger JS, Nicolai CA, Oring LW 2012. Sexual dimorphism, survival, and parental investment in relation to offspring sex in a precocial bird. Journal of Avian Biology 43(5): 445-453.

Lewanzik D, Voigt CC 2014. Artificial light puts ecosystem services of frugivorous bats at risk. Journal of Applied Ecology 51(2): 388-394.

Little KA, Sommer V 2002. Change of enclosure in langur monkeys: implications for the evaluation of environmental enrichment. Zoo Biology 21(6): 549-559.

Lutz CK, Williams PC, Sharp RM 2014. Abnormal behavior and associated risk factors in captive baboons (Papio hamadryas spp.). American journal of primatology 76(4): 355-361.

Mainwaring MC, Hartley IR 2013. Hatching asynchrony and offspring sex influence the subsequent exploratory behaviour of zebra finches. Animal Behaviour 85(1): 77-81.

Maple TL, Perdue BM 2013. Environmental Enrichment. In: Zoo Animal Welfare. Springer. Pp. 95-117.

Martin GR, Wilson K-J, Wild JM, Parsons S, Kubke MF, Corfield J 2007. Kiwi Forego Vision in the Guidance of Their Nocturnal Activities. PLoS ONE 2(2): e198.

Mason G, Burn CC, Dallaire JA, Kroshko J, McDonald Kinkaid H, Jeschke JM 2013. Plastic animals in cages: behavioural flexibility and responses to captivity. Animal Behaviour 85(5): 1113-1126.

Mason GJ 1991. Stereotypies: a critical review. Animal behaviour 41(6): 1015-1037.

Mason GJ 2010. Species differences in responses to captivity: stress, welfare and the comparative method. Trends in Ecology & Evolution 25(12): 713-721.

Mathews F, Orros M, McLaren G, Gelling M, Foster R 2005. Keeping fit on the ark: assessing the suitability of captive-bred animals for release. Biological Conservation 121(4): 569-577.

McCullagh P 1984. Generalized linear models. European Journal of Operational Research 16(3): 285-292.

McDougall P, Réale D, Sol D, Reader S 2006. Wildlife conservation and animal temperament: causes and consequences of evolutionary change for captive, reintroduced, and wild populations. Animal Conservation 9(1): 39-48.

McLennan J 1988. Breeding of North Island brown kiwi, Apteryx australis mantelli, in Hawke's Bay, New Zealand. New Zealand Journal of Ecology 11: 89-97.

McLennan J, Potter M, Robertson H, Wake G, Colbourne R, Dew L, Joyce L, McCann A, Miles J, Miller P 1996. Role of predation in the decline of kiwi, Apteryx spp., in New Zealand. New Zealand Journal of Ecology 20(1): 27-35.

Meagher RK, Dallaire JA, Campbell DL, Ross M, Møller SH, Hansen SW, Díez-León M, Palme R, Mason GJ 2014. Benefits of a Ball and Chain: Simple Environmental Enrichments Improve Welfare and Reproductive Success in Farmed American Mink (Neovison vison). PloS one 9(11): e110589.

Melfi V, Feistner A 2002. A comparison of the activity budgets of wild and captive Sulawesi crested black macaques (Macaca nigra). ANIMAL WELFARE-POTTERS BAR- 11(2): 213-222.

Melfi VA, McCormick W, Gibbs A 2004. A preliminary assessment of how zoo visitors evaluate animal welfare according to enclosure style and the expression of behavior. Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals 17(2): 98-108.

Mohapatra RK, Panda S, Acharya UR 2014. Study on activity pattern and incidence of stereotypic behavior in captive tigers. Journal of Veterinary Behavior: Clinical Applications and Research 9(4): 172-176.

Morein L 2014. Success of large felines breeding in captivity, a studbook review.

Morgan KN, Tromborg CT 2007. Sources of stress in captivity. Applied Animal Behaviour Science 102(3–4): 262-302.

Newberry RC 1999. Exploratory behaviour of young domestic fowl. Applied animal behaviour science 63(4): 311-321.

O'Brien TG, Kinnaird MF 1997. Behavior, diet, and movements of the Sulawesi crested black macaque (Macaca nigra). International Journal of Primatology 18(3): 321-351.

Owsley C 2011. Aging and vision. Vision research 51(13): 1610-1622.

Pomerantz O, Paukner A, Terkel J 2012. Some stereotypic behaviors in rhesus macaques (< i> Macaca mulatta</i>) are correlated with both perseveration and the ability to cope with acute stressors. Behavioural brain research 230(1): 274-280.

Potter M, Cockrem J 1992. Plasma levels of sex steroids in the North Island brown kiwi (< i> Apteryx australis mantelli</i>) in relation to time of year and stages of breeding. General and comparative endocrinology 87(3): 416-424.

Potter MA 1989. Ecology and reproductive biology of the North Island brown kiwi (Apteryx australis mantelli): a thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Zoology at Massey University, Palmerston North. Unpublished thesis,

Potter MA, Hendriks WH, Lentle RG, Thomas DV, Minson CJ, Pindur NB 2010. An exploratory analysis of the suitability of diets fed to a flightless insectivore, the North Island brown kiwi (Apteryx mantelli), in New Zealand. Zoo Biology 29(5): 537-550.

Quadros S, Goulart VDL, Passos L, Vecci MAM, Young RJ 2014. Zoo visitor effect on mammal behaviour: Does noise matter? Applied Animal Behaviour Science 156(0): 78-84.

Quirke T, O'Riordan RM, Zuur A 2012. Factors influencing the prevalence of stereotypical behaviour in captive cheetahs (Acinonyx jubatus). Applied Animal Behaviour Science 142(3–4): 189-197.

Reid B, Ordish R, Harrison M 1982. An analysis of the gizzard contents of 50 North Island brown kiwis, Apteryx australis mantelli, and notes on feeding observations. New Zealand Journal of Ecology 5: 76-85.

Renwick N, Craig E, Sporle W, Conservancy N 2009. Taxon Plan for Northland brown kiwi. Draft report (version 1) 12:

Ricklefs R 1973. Patterns of growth in birds. II. Growth rate and mode of development. Ibis 115(2): 177-201.

Ricklefs RE 1979. ADAPTATION, CONSTRAINT, AND COMPROMISE IN AVIAN POSTNATAL DEVELOPMENT. Biological Reviews 54(3): 269-290.

Robertson HA, Colbourne RM, Graham PJ, Miller PJ, Pierce RJ 2011. Experimental management of brown kiwi Apteryx mantelli in central Northland, New Zealand. Bird Conservation International 21(02): 207-220.

Romero LM, Wikelski M 2002. Exposure to tourism reduces stress-induced corticosterone levels in Galapagos marine iguanas. Biological conservation 108(3): 371-374.

Ross S, Wagner K, Schapiro S, Hau J, Lukas K 2011. Transfer and Acclimatization Effects on the Behavior of Two Species of African Great Ape (Pan troglodytes and Gorilla gorilla gorilla) Moved to a Novel and Naturalistic Zoo Environment. International Journal of Primatology 32(1): 99-117.

Sales J 2005. The endangered kiwi: a review. FOLIA ZOOLOGICA-PRAHA- 54(1/2): 1.

Schmidt AK, Balakrishnan R 2014. Ecology of acoustic signalling and the problem of masking interference in insects. Journal of Comparative Physiology A: 1-10.

Schulze HF-SH, Streicher U ENCLOSURE DESIGN FOR CAPTIVE SLOW AND PYGMY LORISES.

Smith BK, Remis MJ, Dierenfeld ES 2014. Nutrition of the captive western lowland gorilla (Gorilla gorilla gorilla): A dietary survey. Zoo Biology 33(5): 419-425.

Taborsky B, Taborsky M 1991. Social Organization of North Island Brown Kiwi: Long ‐ term Pairs and Three Types of Male Spacing Behaviour. Ethology 89(1): 47-62.

Taborsky B, Taborsky M 1992. Spatial organization of the North Island Brown Kiwi Apteryx australis mantelli: sex, pairing status and territoriality. Ibis 134(1): 1-10.

Taborsky B, Taborsky M 1995. Habitat Use and Selectivity by the Brown Kiwi (Apteryx australis mantelli) in a Patchy Environment. The Auk 112(3): 680-689.

Taborsky B, Taborsky M 1999. The mating system and stability of pairs in kiwi Apteryx spp. Journal of Avian Biology: 143-151.

Tarou LR, Bloomsmith MA, Maple TL 2005. Survey of stereotypic behavior in prosimians. American Journal of Primatology 65(2): 181-196.

Van Schaik CP, Hooff JV 1983. On the ultimate causes of primate social systems. Behaviour: 91-117.

Veasey J, Waran N, Young R 1996. On comparing the behaviour of zoo housed animals with wild conspecifics as a welfare indicator. Animal Welfare 5(1): 13-24.

Veasey J, Waran N, Young R 1996. On Comparing the Behaviour of Zoo Housed Animals with Wild Conspecifics as a Welfare Indicator, Using the Giraffe (Glraffa Camelopardalis) as a Model. Animal Welfare 5(2): 139-153.

Veeraselvam M, Sridhar R, Jayathangaraj MG, Perumal P 2013. Behavioural Study of Captive Sloth Bears Using Environmental Enrichment Tools. International Journal of Zoology 2013: 6.

Wenzel BM 1971. Olfactory sensation in the kiwi and other birds*. Annals of the New York Academy of Sciences 188(1): 183-192.

Wesley K, Brader K 2014. Video - graphic study of the behaviour of juvenile Brown kiwi Apteryx mantelli females at Smithsonian National Zoological Park, Washington, DC. International Zoo Yearbook 48(1): 128-138.

White TCR 1978. The Importance of a Relative Shortage of Food in Animal Ecology. Oecologia 33(1): 71-86.

Wiebe KL, Slagsvold T 2014. Prey size increases with nestling age: are provisioning parents programmed or responding to cues from offspring? Behavioral Ecology and Sociobiology 68(5): 711-719.

Wielebnowski NC, Fletchall N, Carlstead K, Busso JM, Brown JL 2002. Noninvasive assessment of adrenal activity associated with husbandry and behavioral factors in the North American clouded leopard population. Zoo Biology 21(1): 77-98.

Wilson AL 2014. The triumphs, challenges and failures of young North Island brown kiwi (Apteryx mantelli): a study of behaviour, growth, dispersal and mortality: a thesis in partial fulfilment of the requirements for the degree of Master of Science in Zoology at Massey University, Palmerston North, New Zealand. Unpublished thesis, The author,

Appendices

The appendices are on a CD in the back cover of this thesis. The CD contains a word document of tables displaying behavioural and noise data collected during researcher observation.