Foraging on café sugar packets by the house sparrow (*Passer domesticus*): Learning mechanisms, distribution, and human perception

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Abstract

People in cities interact with house sparrows (*Passer domesticus*) on a daily basis. Sparrows have previously been observed foraging on sugar packets at a single café in Hamilton City, New Zealand. The aim of this thesis was to explore aspects of this novel foraging innovation by sparrows and to investigate people's perceptions of sparrows being present at cafés.

Sparrows' preferences for different grain sizes of raw sugar and artificial sweetener were assessed at a single café, which demonstrated that sparrows have a strong preference for raw sugar over artificial sweetener, but no clear preference between granulated raw sugar and powdered raw sugar. Sparrows' responses to novel sugar packet colours were also investigated at the same café. The sparrows did not start foraging on the novel-coloured sugar packets within 10 experimental sessions, but did interact with the novel sugar packets, which demonstrated neophilia in the sparrows and is an important step in the process of learning.

The distribution of sugar packet foraging by sparrows across 174 cafés in Hamilton City was determined, and staff from 15 cafés had observed sparrows taking sugar packets. A short survey was also used to assess the attitudes of café staff members towards the presence of sparrows at their cafés, which showed that café staff had mixed views on the local sparrows. A different survey was used to investigate the attitudes of 249 members of the general public towards sparrows being at cafés. These participants tended to like sparrows being present as part of their café experience.

This thesis demonstrates the value of sparrows being present in the urban environment, and is the first study to comprehensively describe sugar packet foraging in sparrows: a fascinating behavioural innovation.

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Chapter 1

General introduction

The urban landscape is a dynamic ecosystem like any other, rich with opportunities for its organisms to compete for resources required for survival. Over half of the world's human population now lives in urban areas, which are undergoing constant expansion (United Nations, 2014). As native habitats are reduced by urban development, increasingly more animals are living in cities alongside human residents (Schilthuizen, 2018). Although urbanization tends to reduce the local biodiversity (Concepción, et al., 2016), some species are able to thrive in these highly modified environments.

Successful urban inhabitants have evolved physical and behavioural traits that give them competitive advantages in the urban environment. For example, pigeons (*Columba livia*) that have darker coloured feathers are more successful in urban areas than pigeons with lighter-coloured feathers, which demonstrates an adaptive physical trait (Chatelain et al., 2014). Darker feathers contain more melanin, which binds to toxic heavy metals. Heavy metals are concentrated in urban environments and by keeping these toxic metals out of their tissues, pigeons with darker feathers are more likely to survive, reproduce, and pass this trait to their offspring. In contrast to the adaptive physical trait observed in urban pigeons, an adaptive behavioural trait can be seen in urban great tits (*Parus major*). Great tits are songbirds that rely on auditory signals for courtship. In an urban environment their normal signals are often masked by low pitch urban sounds, such as roadworks and traffic. Individuals that are able to increase their pitch above the urban sounds are far more likely to succeed in courting a mate (Slabbekoorn & Peet, 2003). Urban adaptations may have a strong

genetic basis like the darker pigment in pigeon's feathers, a strong learned basis like the higher pitched songs of great tits, or a combination of both genetic and learned factors. In any case, there is a growing number of examples that demonstrate how animals are responding to life in the city (Schilthuizen, 2018).

Natural selection and evolution are known for being lengthy processes that take thousands of years to produce adaptations. However, cities are growing and changing so rapidly that selection pressures are strong, and physical/behavioural changes can happen over much shorter timeframes (Schilthuizen, 2018). Rapid natural selection is demonstrated by the classic example of industrial melanism in peppered moths (*Biston betularia*). During the industrial revolution in the 19th century, light-coloured features of the urban environment became blackened by industrial smoke (Cook, 2018). It was proposed that black variants of the black and white peppered moths were selected for as they had enhanced camouflage from predators on black surroundings. In modern times, the output of industrial smoke has decreased, the buildings have become lighter, and lighter-coloured peppered moths have become more numerous again (Cook, 2018).

In contrast to evolutionary processes, learned behavioural changes do not require several generations and can result in novel behaviours within the lifespan of the individuals. Behaviour change is especially rapid if it is accelerated by social learning. For example, Lefebvre (1986) found that urban pigeons learned a novel foraging behaviour (piercing paper to access food) within 14 trials (30 minutes per trial). When a demonstrator pigeon that had already learned the novel foraging behaviour was present, other birds in the flock learned the behaviour at a rate of approximately one bird every two trials. Consequently, learning presents the most rapid form of adaptive trait change, contributing to the success of animals in urban areas.

1.1 Behavioural innovations

A behavioural innovation is a novel behaviour that has not been acquired by an individual through social learning or inheritance (Ramsey, Bastian, & van Schaik, 2007). Behavioural innovations usually become established in a population through individual learning, which involves an individual animal learning a novel behaviour without observing that behaviour from another individual (Tebbich et al., 2016). For example, Overington et al. (2011) found that 20 Carib grackles (*Quiscalus lugubris*) independently opened a novel foraging apparatus within eight trials (demonstrating individual learning), whereas 16 Carib crackles did not. In contrast to individual learning, social learning occurs when an individual modifies their behaviour to match the behaviour they observed from another individual (Heyes, 1994). Matching may be exact in form, i.e., imitation, or the matching may result in the same consequences of the behaviour regardless of form, i.e., goal emulation (Tomasello, 1998). A behavioural innovation may become established in a population through social learning if an individual with an innovation immigrates to another population where that innovation was not present.

Once a behavioural innovation has been established in a population, it may be restricted to a few individuals, or it may spread throughout the population/other populations. The latter describes the social diffusion of the behaviour, and is measured by the rate of new learners over time (Reader & Laland, 2000). The spread of a behaviour happens much faster through social diffusion than by individual learning (asocial diffusion). Reader (2004) demonstrated that social diffusion of a behaviour in Carib grackles tends to follow an exponential learning model over time, whereas asocial diffusion of the same behaviour tends to follow a linear or decelerating learning model over time. However, the process of behavioural diffusion is complex

and does not always occur as predicted. For example, blue tits (*Cyanistes caeruleus*) were first recorded foraging on flowers of the Crown Imperial (*Fritillaria imperialis*) by piercing the flowers' nectaries at two nearby sites in England in 1992 (Thompson, Ray, & Preston, 1996). However, this behaviour did not spread out of the either of the sites over five years of observations, and became extinguished at one site despite there being adequate opportunities for the behaviour to spread to nearby sites. The authors hypothesized that the behaviour failed to spread because the flowers bloomed only during the breeding season when blue tits are most territorial and not when fledglings were learning to forage. Consequently, it was concluded that the behaviour spread predominantly via asocial diffusion.

1.2 Behavioural innovation in sparrows

Birds' ability to innovate and disperse great distances contribute to their success in urban environments. Several other traits have been associated with birds that are successful urban dwellers, including being a habitat generalist, nesting above ground, having a predominantly granivorous diet, increased boldness, shorter reproductive cycles, and a greater propensity to develop foraging innovations (Lowry, Lill, & Wong, 2013). Furthermore, birds tend to be liked by humans, with whom they share the urban environment (Bjerke, Østdahl, & Kleiven, 2003). Other urban animals such as rats (*Rattus spp*.) and mice (*Mus spp.*) tend to be disliked by humans, and considerable human efforts are put into reducing or eradicating their populations (Bjerke & Østdahl, 2004). In some contexts, however, birds may be seen as pests too and are actively controlled. For example, pigeons were eradicated from the Galapagos Islands due to fears that the pigeons would

transmit disease to human inhabitants (Phillips, Cooke, Carrión, & Snell, 2012).

House sparrows (*Passer domesticus*, henceforth referred to as sparrows) are the ideal urban innovators. Firstly, they have evolved alongside human civilizations, probably since humans started agricultural practices (Summers-Smith, 1988). Once humans started to store products such as grain, sparrows had access to a reliable food source throughout the year, giving them an adaptive advantage over other birds and a strong selection pressure to live close to human settlements (Summers-Smith, 1988). Consequently, the urban environment has become the sparrows' natural environment. However, proximity to humans alone does not predict a good innovator. Though debated in the literature, behavioural flexibility is arguably the biggest determinant of a good innovator (Sol, Timmermans, & Lefebvre, 2002). Behavioural flexibility is the ability of an organism to behave variably when problem solving (Nicolakakis, Sol, & Lefebvre, 2003; Audet, & Lefebvre, 2017). Variable environments such as towns and cities provide a plethora of novel foraging opportunities, many of which cannot be utilised through typical foraging behaviours. An individual that is able to vary their behaviour is more likely figure out how to access these novel opportunities, and thus, variable environments tend to select for behavioural flexibility (Gross, Pasinelli, & Kunc, 2010; Tebbich & Teschke, 2014).

The behavioural flexibility of a species is measured by relative brain size (RBS) and the relative rate of foraging innovations (Overington et al., 2009). Evans et al. (2011) found no strong evidence that RBS affected the behavioural responses of a species to the urban environment, instead arguing that generalist species were most likely to be successful. However, the RBS of birds is positively correlated with innovation rate in several other

studies (Lefebvre, Reader, & Sol, 2004; Lefebvre et al., 1998; Nicolakakis, & Lefebvre, 2000). Sparrows have a RBS of 0.423 standard deviations above the average (Sol, Timmermans, & Lefebvre, 2002), which suggests that they are likely to innovate when provided novel foraging opportunities. Furthermore, at least 10 novel foraging innovations by sparrows have been recorded, demonstrating their behavioural flexibility in urban environments (Sol, & Lefebvre, 2000).

Sparrows are a social species and often forage in large groups (Anderson, 2006). Juveniles develop their foraging preferences by learning from adults that they have imprinted on (Truskanov & Lotem, 2015). Adult sparrows are therefore able to transfer foraging-related behaviours to their young in this way. A complex set of dynamics influences social learning in sparrows, including dominance, group size, sex, age, relatedness, and foraging strategy (Ensminger & Westneat, 2012; Katsnelson et al., 2008; Liker & Barta, 2001; Liker & Bókony, 2009; Tóth et al., 2009). Sparrows tend to use a predominant foraging strategy, either a producer strategy or a scrounger strategy (Katsnelson et al., 2010). A producer strategy relies on individual learning and independent foraging. The producer will locate their own food and access it without the help of conspecifics. Although a producer strategy may be used in the presence of conspecifics, conspecifics are not required for foraging. Conversely, a scrounger strategy relies on social learning and using social cues to determine where food has been located by conspecifics (producers) instead of searching for food independently. Scroungers often benefit directly from the foraging attempts of producers. For example, in 2003, Gajdon, Fijn, and Huber (2006) investigated the producer-scrounger dynamics of kea (*Nestor notabilis*) in New Zealand. The authors discovered that kea experienced with a bin-opening innovation were the producers in the flock, and gained more food from foraging around the bin than did the scroungers. They concluded that the innovation task was challenging (only

a 9% success rate), and it was unlikely to spread to inexperienced individuals that used the scrounging strategy. Consequently, foraging innovations in sparrows may be affected by the producer-scrounger dynamics of the population.

1.3 People's perceptions of the behaviour of urban birds

Behavioural innovations in urban areas are likely to be noticed by members of the public. In some cases, these innovations can provide entertainment for people, such as the fascinating behaviour of crows in Sendai, Japan. These birds drop walnuts in front of cars at traffic lights so that the tough shells are cracked when driven over and the edible interior of the walnut can be consumed (Nihei & Higuchi, 2001). On the other hand, behavioural innovations can become a nuisance for people, such as bears opening car doors in search of food in America (Boonman-Berson, Turnhout, & Carolan, 2016). Problematic behaviours often result in increased culling of animals in urban areas, especially if the behaviour has become pervasive (Thearle, 2013). As a consequence, it is important to assess the impact that behavioural innovations have on human societies so that the spread of undesirable or dangerous behaviours can be mitigated, ideally via behaviour modification.

Humans and animals interact occur all the time in cities. Interactions with birds are especially common because they are so conspicuous in the outdoor environment. Birds tend to be perceived positively by people in cities, especially for aesthetic reasons (Belaire et al., 2015). There are several conflicting findings in the existing literature about people's perceptions of sparrows. Sparrows are slightly disliked by the general public according to some studies (Belaire et al., 2015; Conover, 1997), whereas in other studies sparrows are liked by the general public for their visual aesthetics and

familiarity (Adams, 1988; Hedblom et al., 2014). Approximately 50,000 sparrows were culled in England in 1967, as they were considered to be a pest (Thearle, 2013). More recently in the United States, it has been common practice to actively destroy sparrow eggs or kill adults (Larson, Cooper, & Hauber, 2016). The intensity of the sparrow management strategies used by participants in this study was best predicted by the level of anger towards sparrows rather than a cognitive variable, i.e., people tended to use more lethal methods of sparrow control when they were angrier at the sparrows.

Some authors have concerns that a decrease in the diversity/abundance of wildlife in cities will lead to a weakened relationship between society and nature, termed the "extinction of experience" hypothesis (Skandrani et al., 2015). This hypothesis states that positive interactions with nature maintain healthy relationships between people and nature, and keep people invested in an ecologically rich future. Without these positive interactions, it is hypothesized that people will care less about nature, stop supporting policies that promote the conservation/restoration of nature, and end up with a decreased overall wellbeing. Positive interactions with nature in urban areas can be facilitated in many ways, such as planting trees alongside roads, having nearby parks/reserves, and including nature in shared spaces such as town squares, or even cafés (Savard, Clergeau, & Mennechez, 2000; Haemig et al., 2015).

1.4 Milk bottle opening innovation

Milk bottle opening by birds in Europe is a classic example of a behavioural innovation that spread through avian populations and became a nuisance for people in cities. This innovation was first recorded in 1921 when a tit was observed opening the wax stopper on top of a milk bottle, after which it drank milk from the bottle (Fisher & Hinde, 1949). By 1949, over 450

observations of milk bottle opening had been recorded from 11 countries in Europe (Hinde & Fisher, 1951). Great tits and blue tits were the most common species observed engaging in this behaviour, though 11 other species, including sparrows, had also been observed opening milk bottles. This behaviour became a considerable nuisance to members of the public once it was established (Fisher & Hinde, 1949; Hinde & Fisher, 1951). Homeowners would encourage the milkmen to put inverted glass jars (or other such means to stop the birds) over the milk bottles in order to prevent the birds from accessing them. On several occasions, birds were recorded finding solutions to these additional barriers, usually by physically removing the barriers using their beaks (Fisher & Hinde, 1949).

Milk bottle opening by tits was reported at locations over 15 miles apart on several occasions. Tits typically disperse within a few miles during their lives, and thus it was concluded that the behaviour arose independently in different locations (Hinde & Fisher, 1951). However, the rate of observations of milk bottle opening increased rapidly over time, and so it was hypothesized that social transmission was responsible for accelerating the spread of the behaviour. Lefebvre (1995) provided support for this idea by analysing several models predicting the social transmission rate of this behaviour, and concluded that milk bottle opening was learned independently in different locations and then spread throughout local populations at an accelerating rate by social learning. Asocial spread of the behaviour was likely accelerated by birds coming into contact with bottles that had already been opened by other birds. This would have facilitated learning in naïve birds by pairing the milk bottles (as a discriminative stimulus) with reinforcement, i.e., gaining access to milk (Sherry & Galef, 1984). Interestingly, it was noted that there was a delay in the establishment of the behaviour for several years after milk bottles were regularly left on people's doorsteps (Fisher & Hinde, 1949).

Milk bottle opening by tits became prevalent before World War II and then decreased during the war when it was less common to leave milk bottles on doorsteps (Fisher & Hinde, 1949). After the war, milk bottles were put on doorsteps again and the behaviour increased in frequency. In modern times, this innovation has decreased again as milk tends to be sold in stores. This example demonstrates the dynamic nature of behavioural innovations and how their prevalence is context-dependent.

1.5 Sugar packet foraging innovation

The first recorded instance of sugar-packet foraging was by Barbados bullfinches (*Loxigilla barbadensis*) in Barbados in the year 2000 (Reader, Nover, & Lefebvre, 2002). The behaviour was observed outside a hotel where sugar packets were available. The Barbados bullfinches opened the sugar packets using their beaks, pecking at the packet until a hole was made. Sugar packets were presented to Barbados bullfinches at over 40 sites nearby, but only birds from the initial observation site engaged in the packet-opening behaviour. A follow-up study was conducted over 10 years later to investigate the persistence and spread of the behaviour (Ducatez, Audet, & Lefebvre, 2013). The behaviour was still present in the hotel population of Barbados bullfinches, but had not spread further than 200 m from the initial observation site. However, observations of the same behaviour were made with birds 1 km away with sugar packets of a different colour. There were several opportunities for the birds to forage on sugar packets between these two sites where sugar packets were available, but no instances of sugar packet foraging were observed. Consequently, the authors suggested that the behaviour developed independently at both sites. However, the populations were close enough for it to be possible that a sugar-foraging bird immigrated from one population to another. In the

same study, the behavioural innovation was also observed in Lesser Antillean bullfinches (*Loxigilla noctis*), 145 km away on the island of St Lucia. This distance is too great for dispersal to or from populations on Barbados, so the authors concluded that the behaviour had developed independently in each population, rather than being spread across populations via social transmission.

The only other recorded instance of sugar packet foraging to date was by noisy miners (*Manorina melanocephala*) in 2013 at a café in Wollongong, Australia (Delgado-V & Correa-H, 2015). These birds were observed opening sugar packets using a combination of their beaks and feet, characteristic of their usual foraging behaviours. Furthermore, only raw sugar packets were seen being opened, despite the fact that the birds also had access to artificial sweetener packets and packets containing coffee.

1.6 Current research project

In addition to the two aforementioned studies documenting sugar packet foraging in birds, sugar packet foraging behaviour has also been observed in sparrows at the Momento Lakeside Café (henceforth referred to as Momento), at the University of Waikato campus in Hamilton, New Zealand (Davy, 2018). In New Zealand, cafés have become more prevalent since Espresso coffee machines were introduced in the 1950s (Ministry for Culture and Heritage, 2014), and the introduction of sugar packets to outdoor seating areas has been even more recent. This has provided a novel resource that sparrows at some cafés have learned to forage on through innovation. This behavioural innovation is of particular interest, as sparrows have not been recorded engaging in this behaviour in any current literature. For the sugar foraging behaviour to be possible across sparrow populations in New Zealand, sparrows require the physical capabilities to

open a sugar packet, the ability to learn the behaviour, and the tolerance of humans at cafés.

In the summer of 2017/18, an unpublished student research project was conducted on sparrows foraging on sugar packets at Momento (Davy, 2018). The main objective of this study was to quantify the rate of sugar packet foraging by sparrows at this café. The prior studies on Barbados bullfinches and noisy miners discussed only a few discrete instances of sugar packet foraging behaviour (Delgado-V & Correa-H, 2015; Ducatez, Audet, & Lefebvre, 2013; Reader, Nover, & Lefebvre, 2002), and it was unclear if the sparrows' behaviour was prevalent enough to be a nuisance at local cafés.

Thirty sparrows at Momento were leg-banded for the student research project so that each member of the population could be identified individually. However, post-banding observations showed that only a small proportion (<10%) of the banded birds were seen at the café within each three hour sampling period. Consequently, the sparrows were studied as a group rather than as individuals. Preliminary observations showed that the Momento sparrows forage on the sugar packets using a topography similar to the Barbados bullfinches (Reader, Nover, & Lefebvre, 2002), i.e., they remove the sugar packets from the tops of café tables and tear them open with their beaks, after which sugar granules are shaken out onto the ground and consumed.

Across 100 hours of behavioural observations over 10 weeks, sparrows removed an average of four sugar packets from the café tables every hour (Davy, 2018). Over 99% of the packets taken were orange-coloured raw sugar packets, despite blue-coloured artificial sweetener packets also being available. It was unclear why only the orange packets were taken, but it was hypothesized to be because of the greater calorific content of the raw sugar, or because the raw sugar was granulated and thus easier to manipulate than

the artificial sweetener which was in a powdered form. Furthermore, the orange colour of the packets was hypothesized to be a discriminative stimulus for the sugar packet foraging behaviour. The diffusion of this behaviour to nearby cafés was unknown, and there are no known published studies that have investigated the attitudes of New Zealanders towards the presence of sparrows at cafés.

This thesis expands on the preliminary work done on the innovative foraging behaviour observed in the sparrows at Momento (Davy, 2018). Three main research objectives were developed for this thesis, which is structured into four chapters:

- To investigate the mechanisms behind the sugar packet foraging behaviour by sparrows at Momento (Chapters 2 and 3).
    - To establish how the sweetening agent preferences of Momento sparrows are affected by sweetening agent type and sweetening agent grain size (Chapter 2).
    - To examine the behavioural flexibility of the Momento sparrows by assessing how they respond to the presentation of novel-coloured sugar packets (Chapter 3).
- To determine the possible mechanisms underlying the distribution of sugar packet foraging in sparrows by recording the distribution of the behaviour within Hamilton City and the wider regions of New Zealand (Chapter 4).
- To investigate whether or not the presence of sparrows at cafés is a problem for the general public in New Zealand by surveying their attitudes towards sparrows at cafés (Chapter 5).

Chapter 2

Preferences of sparrows for different sweetening agent attributes

2.1 Introduction

All animals have preferences related to foraging. These preferences influence the context in which the animal engages in foraging behaviour. For example, sparrows and tui (*Prosthemadera novaeseelandiae*) have overlapping habitat in New Zealand. However, sparrows have a preference for seeds and thus forage predominantly on the ground (Summers-Smith, 1988), whereas tui have a preference for nectar and predominantly forage on flowers above ground (Bergquist, 1985). Knowing the foraging preferences of animals can help us understand their foraging patterns, which may vary both across and within species. Some foraging preferences may be adaptive. For example, long-eared owls (*Asio otus*) have a strong preference for common voles and will eat them preferentially over other prey items such as mice, rats, and small birds (Korpimäki, 1992). When common voles are more abundant in the environment, long-eared owls tend to have a greater clutch size and a greater brood size. Other foraging preferences may be maladaptive. For example, blue tits learned to preferentially forage on opened milk bottles on people's doorsteps (Fisher & Hinde, 1949). Several reports were made of blue tits that had fallen into opened milk bottles and drowned.

Preference is used as a behavioural measure to describe what an animal chooses to do in a given context, rather than what an animal "likes" or "dislikes" (Sumpter, Foster & Temple, 2002). Although animals always have behavioural options (e.g., standing, sitting, grooming), preference

typically refers to an animal's choice from an array of presented options, such as food types or nesting material. There are many established methods to assess preference depending on the nature of the research. Common methods to assess preference include paired choice assessments, free access assessments, and concurrent schedules of reinforcement.

Paired stimulus preference assessments present different, paired combinations of options (e.g., food types) to subjects (Fernandez, Dorey, & Rosales-Ruiz, 2004). The option that was not chosen is removed from the trial, and the next pairing is presented. A preference hierarchy is then constructed by assessing the relative proportion of times each option is chosen. For example, five captive cotton-top tamarins (*Saguinus Oedipus*) were presented with seven different food items in a paired stimulus preference assessment (Fernandez, Dorey, & Rosales-Ruiz, 2004). As a group, the tamarins chose graham crackers more often than all the other options, followed by Fig Newtons, raisins, grapes, mealworms, Apple Jacks, and bananas. Thus when presented with a banana and a graham cracker, one would predict that the cotton-top tamarins would select the graham cracker over the banana on most occasions.

Free access preference assessments present the all of the options to the subjects within a set time period, and a preference hierarchy is constructed by assessing the relative amount of time spent with each option or the relative amount of each option consumed within the time period (Sumpter, Foster, & Temple, 2002). For example, when lambs (*Ovis aries*) were given free access to unflavoured solid food or thyme-flavoured solid food during a 15 minute access period, the lambs displayed a strong preference for the unflavoured solid food by eating significantly more of that option (Saint-Dizier, Levy, & Ferreira, 2007).

Concurrent schedules of reinforcement present two or more choices to an individual (Sumpter, Foster, & Temple, 2002). The individual can work on both schedules to gain access to reinforcement, but not simultaneously. The relative amount of work done on each available schedule is used to produce a preference hierarchy. For example, Flevill (2002) assessed the relative preferences of domestic hens (*Gallus gallus domesticus*) for wheat, puffed wheat, and honey-puffed wheat using concurrent schedules of reinforcement. Each food item was available on a different schedule, and hens could work on only one schedule at a time by pecking the appropriate discriminative stimulus. Using this method, the authors found that hens preferred wheat the most, followed by honey-puffed wheat and puffed wheat, respectively.

Preferences are typically under stimulus control. Controlling stimuli are attributes of an option that determine whether or not that option is selected over other options in a given context (Baum, 2005). For example, different attributes of food preferences were assessed in grey partridge chicks (*Perdix* perdix, Moreby, Aebischer, & Southway, 2006). Attributes such as food movement (alive vs. dead), food item size, and food item colour were all assessed. This experiment showed that food item colour and food item size were the most influential attributes, as chicks actively chose larger green/green-yellow-coloured food items preferentially over other colours that were smaller in size. Food movement had relatively less influence on the preferences of the chicks for different food items, demonstrating that different attributes can have disproportionate influence on foraging preferences.

It was established in the unpublished student research project that the local sparrows at Momento foraged frequently on packets of raw sugar (99% of the time) compared to artificial sweetener packets (Davy, 2018). The

controlling stimuli influencing this foraging behaviour could include the colour of the packets, the grain size of the sweetening agents, the type of sweetening agent (taste, caloric value), or a combination of several factors. The effect of grain size was of particular interest because sparrows at Momento normally have access to granulated raw sugar and powdered artificial sweetener.

The aim of this study was to investigate how the sweetening agent preferences of Momento café sparrows are affected by sweetening agent type and sweetening agent grain size, via preference assessment. It was hypothesized that sparrows have a preference for raw sugar over artificial sweetener, and have a preference for granulated sweetening agents over powdered sweetening agents.

2.2 Methods

2.2.1 Subjects

Wild sparrows were studied at Momento on the University of Waikato campus, Hamilton, New Zealand. The sparrows were free to enter and exit the experimental area at any time during the experimental sessions, and up to eight sparrows were present at any given time.

Animal ethics approval for this study was granted by the University of Waikato Animal Ethics Committee (protocol 1051). Direct contact with the sparrows was not made in this experiment. Sparrows had access to sugar on plates during three-hour sessions; the same sugar was already available to the sparrows at Momento in the form of sugar packets. Having only three-hour long sessions restricted the quantity of freely accessible sugar that could be consumed by the sparrows throughout the experiment. Furthermore, research on the metabolism of sugar by passerines suggests that these birds have evolved to process high-sugar diets effectively, without disease consequences such as the development of diabetes (Sweazea & Braun, 2006).

No human participants were sought for inclusion in this study, however, members of the public were at risk of being recorded on camera when the sparrows were being filmed. Accordingly, human ethics approval for this research was granted by the University of Waikato Faculty of Science and Engineering Human Research Ethics Sub-committee (protocol FSEN_2018_7). Members of the public were informed of the experiment through signage at the café (Appendix A and B), and only a small proportion of the café outdoor area was used. The camera was angled away from the café to minimize the chances of accidentally filming members of the public.

2.2.2 Experimental area

The experimental area was confined to three Momento outdoor tables, and the space between these tables (Figure 2.1). Two of the tables were used to present sweetening agents to sparrows (sweetening agent tables), while the other table was used to set up the video camera and observe the birds (observation table). The layout of the tables changed slightly each day (depending on how the café staff placed them), but three tables in the same geographic area of the café were always used to conduct the preference assessment.

2.2.3 Sample preparation and equipment

Two different sweetening agents were presented to sparrows: raw sugar from Momento-branded sugar packets and Café Style-branded artificial sweetener packets. Sparrows at Momento already had access to both of these sweetening agents in the sugar packets on the outdoor tables. The raw sugar contained no additives. The artificial sweetener had an equal ratio of aspartame and acesulfame potassium as the primary ingredients. Each sweetening agent was also presented to sparrows in a granulated form and a powdered form in this experiment (Figure 2.2), resulting in four combinations of sweetener types and grain sizes, which were prepared in the following ways:

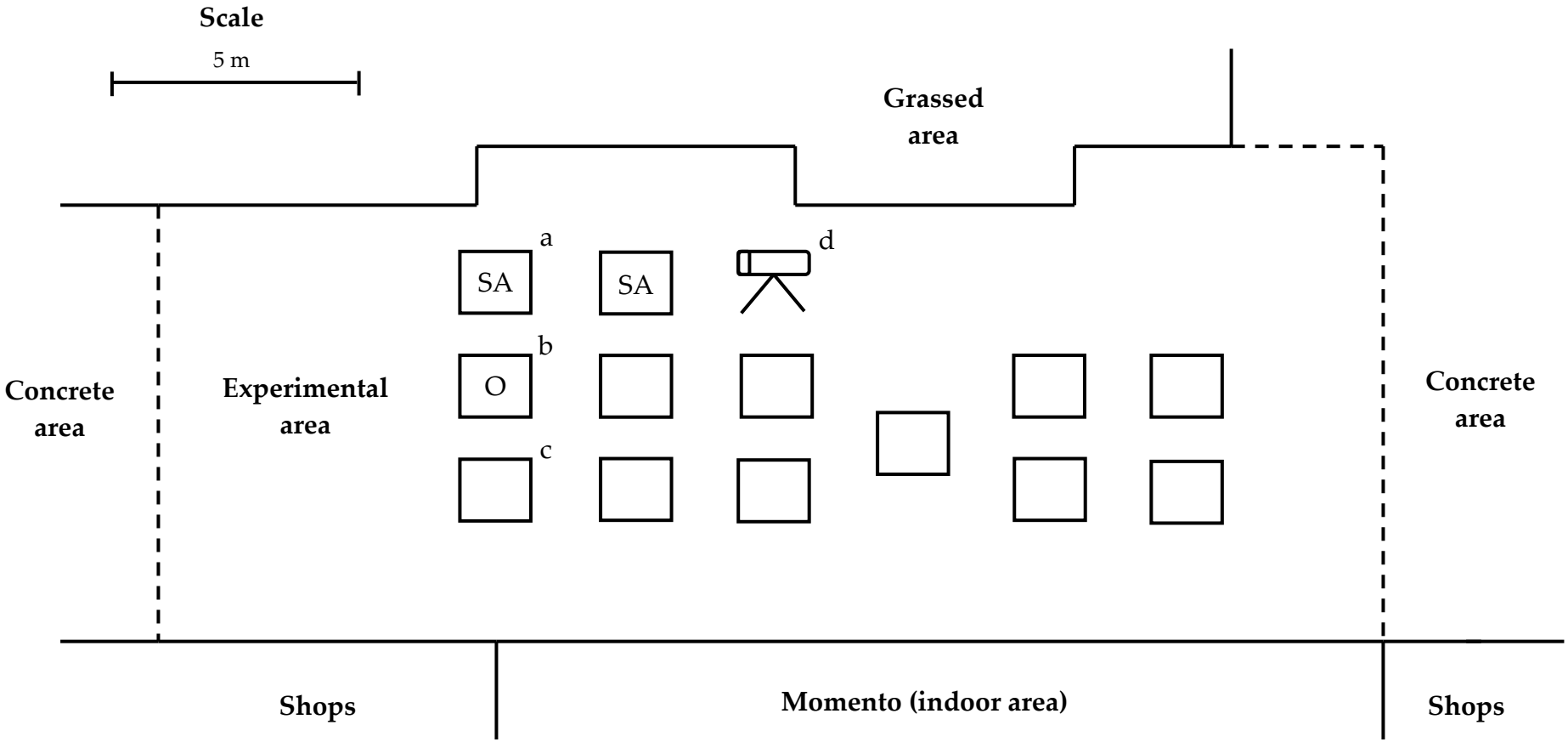

Figure 2.1. The typical layout of the experimental area outside Momento, and the experimental set-up used to study the sweetening agent (SA) preferences of Momento sparrows, including the sweetening agent tables (a), the observation (O) table (b), ordinary tables (c), and the positioning of the camera (d).

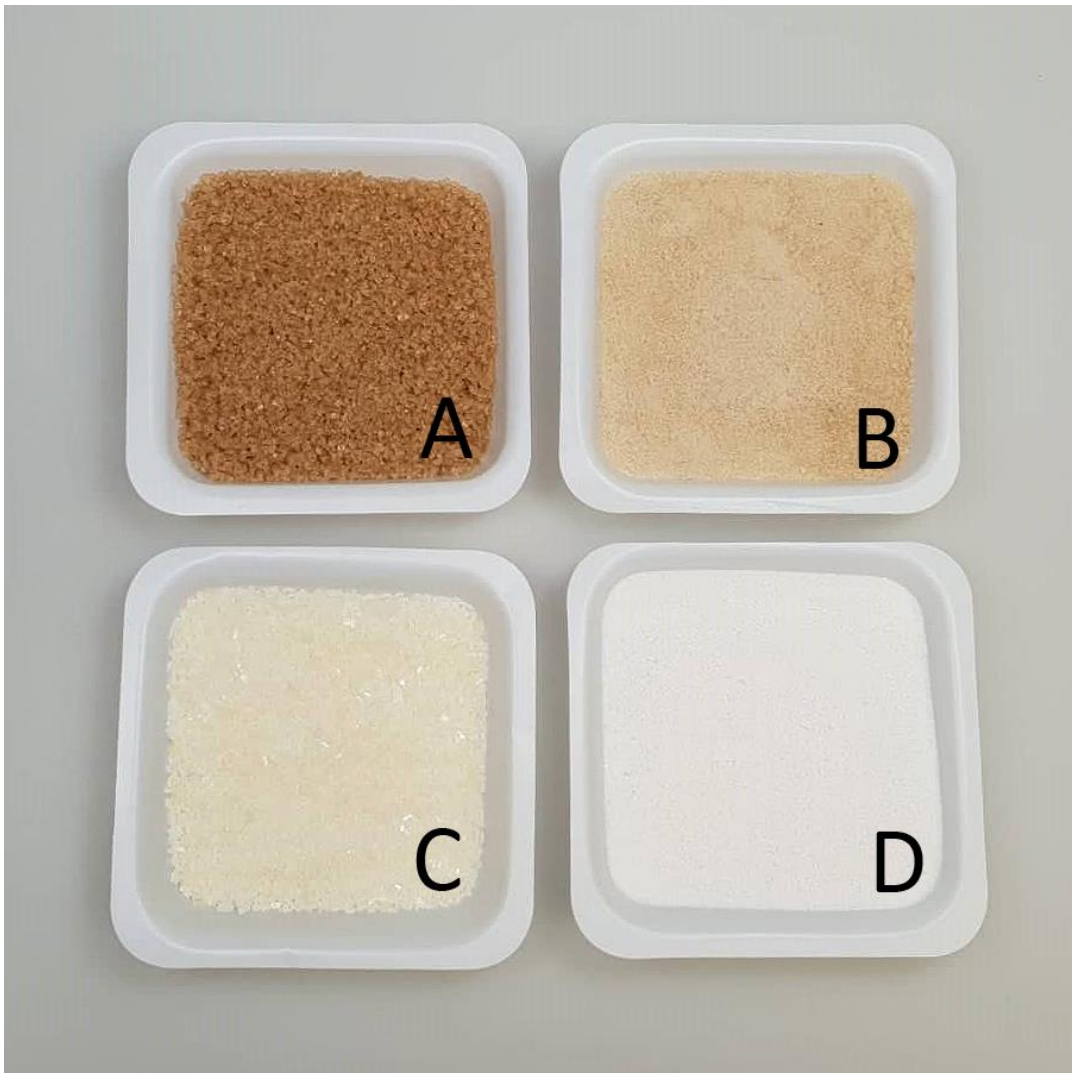

Figure 2.2. The four sweetening agents used in this experiment: granulated raw sugar (A), powdered raw sugar (B), granulated artificial sweetener (C), and powdered artificial sweetener (D).

Granulated raw sugar

This was purchased in bulk from Momento staff. The raw sugar grains were removed from their packets and passed through a 0.5 mm sieve, and then through a 2 mm sieve. All of the grains between 0.5 mm and 2 mm were stored in a labelled Living & Co 1.1 L glass jar prior to experimental use. Approximately 400 g of granulated raw sugar was prepared.

Powdered raw sugar

The same raw sugar from the café was turned into a powdered form by grinding it in a marble mortar and pestle. This was then passed through a 0.5 mm sieve. Everything less than 0.5 mm was stored in a labelled Living & Co 1.1 L glass jar prior to experimental use. Approximately 400 g of powdered raw sugar was prepared.

Powdered artificial sweetener

This was purchased in bulk from Momento staff. The powdered artificial sweetener was removed from packaging and passed through a 0.5 mm sieve. Everything less than 0.5 mm was stored in a labelled Living & Co 1.1 L glass jar prior to experimental use. Approximately 400 g of powdered artificial sweetener was prepared.

Granulated artificial sweetener

A supersaturated solution was made using 26 g of the powdered artificial sweetener from the café mixed with 100 ml of tap water, warmed using a NEC 800 W microwave oven. Each batch was then dehydrated in a Digital Series Contherm oven at 75^{o}C for 30 hours, or until large crystals had formed. The crystals were lightly crushed using a marble mortar and pestle. The crushed artificial sweetener crystals were then passed through a 0.5 mm sieve, and then through a 2 mm sieve. Crystals that were too big to fit through the 2 mm sieve were crushed again using the mortar and pestle. All of the grains between 0.5 mm and 2 mm were stored in a labelled Living & Co 1.1 L glass jar prior to experimental use. Approximately 400 g of granulated artificial sweetener was prepared.

Sartorius analytical scales were used to weigh 40 g samples of the required sweetening agent in small weighing dishes, before and after each experimental session. This quantity was chosen based on an experiment investigating avian nectarivore preferences for different concentrations of sugar solution, though their sweetening agent was presented in liquid form (Schondube & Martinez del Rio, 2003). Sistema Klip It containers (400 ml) were used to transport the 40 g samples from the laboratory to Momento. At Momento, each 40 g sample was presented on a white Living & Co Edge side plate (20 cm diameter), and these plates were placed on the appropriate café tables. A small paintbrush was used to spread the 40 g samples into an even layer on each plate. This was done to mimic the natural conditions when packets are opened onto the table or ground, i.e., the sugar/sweetener cannot be scooped up, it must be picked up grain by grain using the beak. The plates had raised edges to prevent loss of the sweetening agent from wind. Cling film was used to cover and seal the plates containing the samples at the end of each session. A Sony HDR-PJ410 digital video camera was set up on a Slik U8000 tripod at the observation table to record the experimental sessions.

For the duration of both experiments, signs were placed around the café informing café patrons of the nature of the research being conducted on sparrow behaviour (Appendix A). The three outdoor tables used in this experiment also had signs displayed for members of the public to be aware of the experiments that were in progress (Appendix B). Information sheets were also available from the researcher if members of the public wanted more information about the project (Appendix C).

2.2.4 Experimental design

A preference assessment was carried out using a modified paired choice design between two different sweetening agents (raw sugar and artificial sweetener), and two different grain sizes (powdered and granulated). Although the sweetening agents were presented in pairs (paired choice), both sweetening agents were presented for the duration of the experiment (free access) and interactions with each sweetening agent were recorded.Sparrows at the café were presented with different paired combinations of granulated raw sugar, powdered raw sugar, granulated artificial sweetener, and powdered artificial sweetener; making a total of six different presentations per set (Table 2.1). Each pairing was assigned a number from 1-6, and the order of the presentations was randomly determined using the equation "=RANDBETWEEN(1,6)" in Microsoft Excel. The side of each presentation (i.e., the plate containing the sweetener being placed on the left or right table relative to the researcher) was randomized using the same method. A second and third set of presentations were developed using a new random order. Although the birds were able to access the sweetening agents from all directions, the side on which a sweetening agent was presented was switched (left table-right table) in the third set to minimize potential side bias.

Table 2.1. Six possible pairings of granulated raw sugar, powdered raw sugar, granulated artificial sweetener, and powdered artificial sweetener, with each pairing to be used in a single set of the preference assessment.

Side A		Side B
Granulated Raw Sugar	+	Powdered Raw Sugar
Granulated Raw Sugar	+	Granulated Artificial Sweetener
Granulated Raw Sugar	+	Powdered Artificial Sweetener
Granulated Artificial Sweetener	+	Powdered Raw Sugar
Granulated Artificial Sweetener	+	Powdered Artificial Sweetener
Powdered Artificial Sweetener	+	Powdered Raw Sugar

2.2.5 Experimental procedure

The preference assessment was conducted over 18 days, between Wednesday the 17th of October 2018 and Monday the 12th of November 2018. The sessions were conducted only on weekdays (as the café was closed on weekends), and ran for a three hour period between 7.00 am and 10.30 am depending on when the outdoor area had been set up; i.e., if the café tables were set up at 7.15 am then the session ran between 7.15 am and 10.15 am. This time period was chosen as it was the most feasible time to observe the sparrows without interfering with the business of the café (Davy, 2018).

Approximately 10 minutes before each experimental session, a camera and tripod were set up at the observation table to record the sparrows' behaviour around the plates containing sweetening agents. The signs informing the public that there was an experiment on sparrows in progress were taped to the sweetening agent tables and to the observation table. The two plates, each containing a thin sweetening agent layer, were then placed in the centre of sweetening agent tables.

The camera was set to record at the start of each experimental session. The researcher supervised the entire duration of each session to ensure that there were no problems or obvious confounds, e.g., another species attempting to forage on the open-access sweetening agents. All categorical data were recorded on paper (Appendix D). Instances of sparrows approaching sweetening agents (without foraging) and instances of sparrows foraging on sweetening agents were recorded as different interactions with the relevant tables and plates (Table 2.2). The time of the interaction, the plumage of the sparrow, and the sweetening type that a bird interacted with were also recorded for each interaction. The plumage of the sparrow was used as a proxy for sex, as male plumage indicates a male sparrow, whereas female plumage indicates either a female sparrow or an

immature male sparrow (Anderson, 2006). Latency to first approach the table or plate of each sample was also recorded in every session; e.g., if the first sparrow to land on the left table did so at 8 am, then the latency for that sample was recorded as 60 minutes.

Table 2.2. An ethogram of sparrow behaviours that were recorded during the preference assessment.

Behaviour	**Description**
Approach without foraging	An approach interaction was initiated when a sparrow made physical contact with a table or plate, and was terminated when the physical contact ceased. No contact was made between a sparrow's beak and the sweetening agent.
Forage	A foraging interaction was initiated when the beak of a sparrow made physical contact with a sweetening agent, and was terminated when the physical contact ceased.

After three hours of the sparrows having free access to two plates of sweeteners, the plates were removed and sealed with cling film to prevent any further foraging. The samples were then taken back to the laboratory, carefully transferred into weighing dishes using the small paintbrush, and weighed again with the analytical scales. This procedure was repeated for all 18 sessions.

2.2.6 Data analysis

The sparrows' preferences for different sweetening agent types and grain sizes were assessed using several methods, based on the animal preference assessments conducted by Sumpter, Foster and Temple (2002). The sparrows' preferences were assessed as a group, as individual birds could not be identified. A preference hierarchy is usually constructed as the final result of a preference assessment. This was done by assessing the proportion of times each stimulus was chosen relative to the number of opportunities given to interact with that stimulus. The following dependent variables were also used to construct preference hierarchies: the total number of observations of sparrows approaching and foraging on each sweetening agent, the net amount (g) of each sweetening agent consumed (original weight – final weight), and the mean latency (s) to first approach each sweetening agent. Approach to each sweetening agent and consumption of each sweetening agent were assessed both independently and as a combined measure. The data were also analysed for potential left-right side bias, and potential sex bias.

Microsoft Excel 2013 was used to produce graphs. Statistica 13.0 was used to perform statistical analyses. Where the data were not normally distributed, a Kruskal-Wallis H test was performed to compare the means of several groups, whereas Mann-Whitney U tests were performed to compare the means of two groups. The significance level was set to $a = 0.05$. All p values were reported to three decimal places, and p values smaller than 0.001 were reported as $p < 0.001$. Where Mann-Whitney U tests were conducted post-hoc after a Kruskal-Wallis test, the Bonferroni correction was applied to the p values because increased pairwise comparisons in hypothesis testing tends to increase type I errors (Frane, 2015).

2.3 Results

2.3.1 Measures of preference

Number of foraging instances and approaches without foraging

The total number of instances of sparrows foraging on the sweetening agents (i.e., direct contact with a sweetening agent), and approaches to the sweetening agents without foraging by sparrows (i.e., direct contact with a table or plate), are displayed in Figure 2.3. A total of 69 foraging instances and 46 approaches (without foraging) were observed across all sessions. There were more foraging instances observed on both grain sizes of the raw sugar (n = 66, 96% of all foraging instances) than on both grain sizes of artificial sweetener (n = 3, 4% of all foraging instances).

Sparrows displayed the most behavioural responses (approaches and foraging instances, combined) towards granulated raw sugar (n = 47, 41% of all behavioural instances), whereas there were fewer combined responses directed towards powdered raw sugar (n = 40, 35% of all behavioural instances). However, the opposite was shown when foraging instances were examined without approaches; i.e., powdered raw sugar had the most foraging instances (n = 36, 52% of all foraging instances), whereas granulated raw sugar had less foraging responses (n = 30, 43% of all foraging instances).

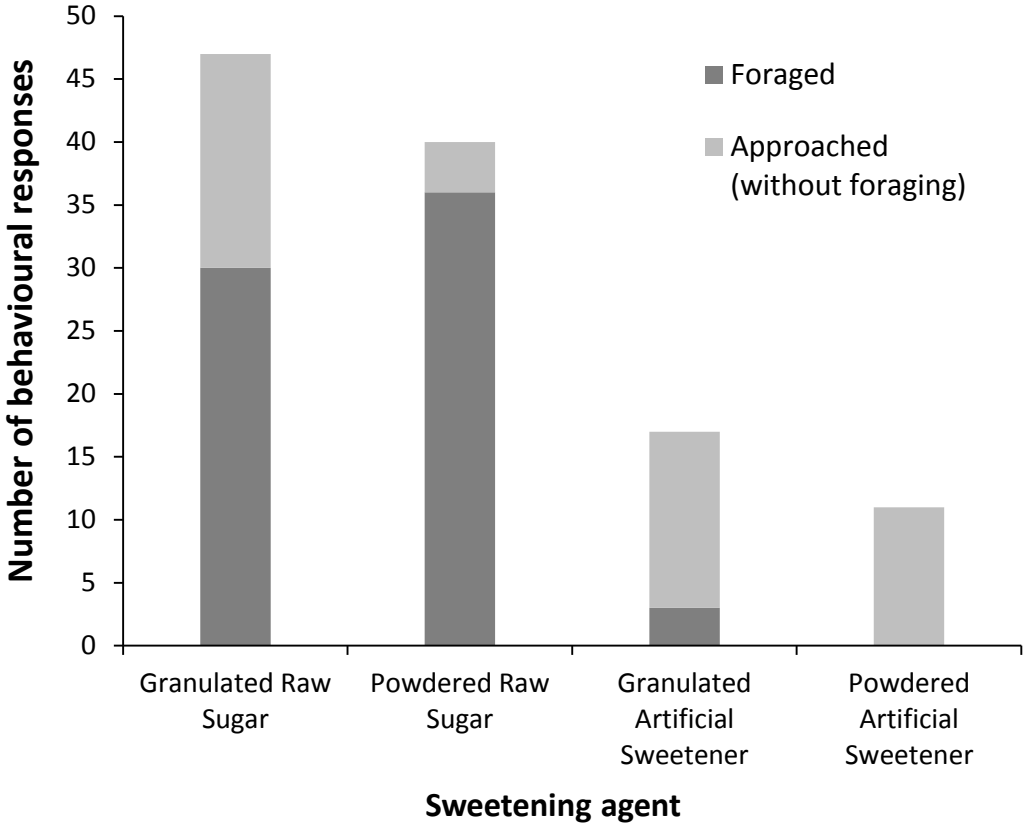

Figure 2.3. The number of instances each sweetening agent was foraged on, and approached (without foraging), by sparrows over a total of nine, three-hour sessions per sweetening agent.

The data on the number of instances of sparrows foraging and approaching the sweetening agents were not normally distributed. A Kruskal-Wallis H test showed that the number of approaches (without foraging) that sparrows made towards the sweetening agents did not differ significantly between the four sweetening agent groups ($H = 1.267$, $p = 0.737$). However, the number of foraging instances differed significantly between at least two of the four groups ($H = 21.252$, $p < 0.001$). Post-hoc pairwise Mann-Whitney U tests showed that three of the pairs had significant differences after the Bonferroni correction was applied (alpha level adjusted from 0.05 to 0.05/6 = 0.0083). Significant differences were found between the number of instances of sparrows foraging on granulated raw sugar and powdered artificial sweetener ($U = 4.5$, $p = 0.002$), the number of instances of sparrows

foraging on powdered raw sugar and granulated artificial sweetener ($U = 8$, $p = 0.005$), and the number of instances of sparrows foraging on powdered raw sugar and powdered artificial sweetener ($U = 4.5$, $p = 0.002$). The number of instances of sparrows foraging on granulated raw sugar and granulated artificial sweetener differed significantly only before the Bonferroni correction was applied ($U = 11$, $p = 0.01$). The number of instances of sparrows foraging on granulated raw sugar did not differ significantly from the powdered raw sugar ($U = 34.5$, $p = 0.627$), and instances of sparrows foraging on granulated artificial sweetener did not differ significantly from the powdered artificial sweetener ($U = 31.5$, $p = 0.453$).

When instances of sparrows foraging on sweetening agent types were assessed without grain size, the data were not normally distributed. A non-parametric Mann-Whitney U test showed that the number of instances of sparrows foraging on raw sugar differed significantly from the number of instances of sparrows foraging on artificial sweetener ($U = 28$, $p < 0.001$). The data were also not normally distributed when grain sizes were assessed without sweetener type. A Mann-Whitney U test showed that the number of instances of sparrows foraging on granulated sweetening agents did not differ significantly from the number of instances of sparrows foraging on powdered sweetening agents ($U = 155.5$, $p = 0.849$).

No foraging attempts were made by any sparrows in the first two sessions of this experiment, and there was a general trend that the number of foraging instances for each pairing increased upon each presentation across the 18 sessions (Figure 2.4). The highest number of foraging instances in each set was observed with the granulated raw sugar-powdered raw sugar pairing (GRS + PRS). Conversely, presentation of the granulated artificial sweetener-powdered artificial sweetener pairing (GAS + PAS) resulted in the lowest number of foraging instances (none) in the second two sets.

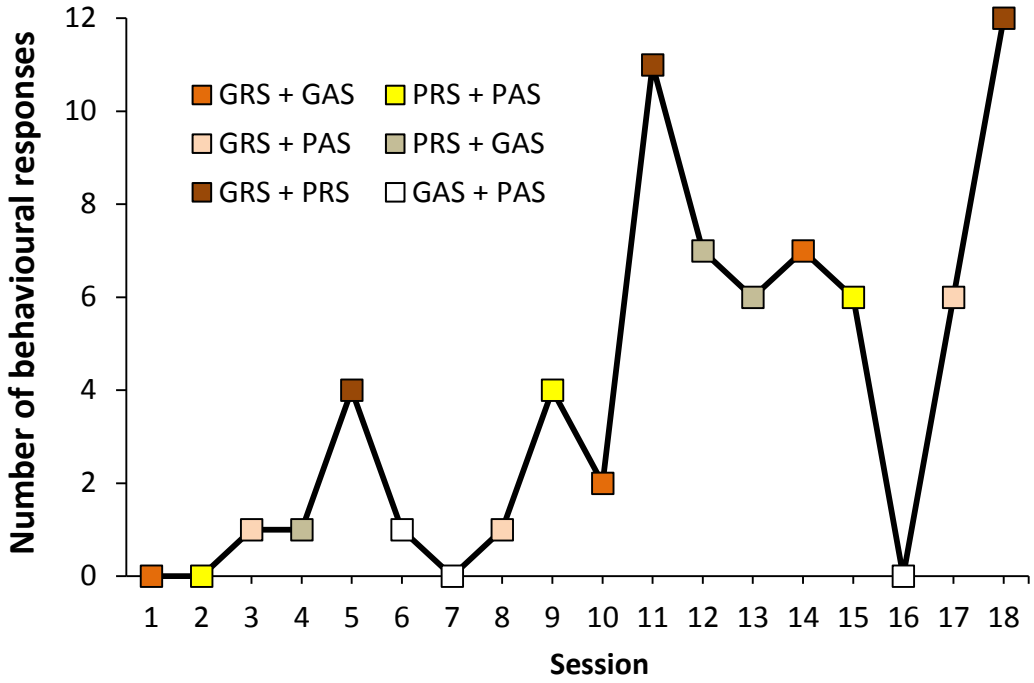

Figure 2.4. The number of instances of sparrows' behavioural responses (approach without foraging, and foraging, combined) on different pairings of sweetening agents for each three-hour session across three sets of presentations (sessions 1-6 for the first set, 7-12 for the second set, and 13-18 for the third set). The sweetening agent types in the legend are as follows: granulated raw sugar (GRS), granulated artificial sweetener (GAS), powdered raw sugar (PRS), and powdered artificial sweetener (PAS).

Proportion of opportunities taken to approach and forage

Each sweetening agent was presented nine times, and the proportion of times each sweetening agent was approached and/or foraged on by sparrows is displayed in Figure 2.5. The preference hierarchy obtained from the current method to assess the sparrows' sweetening agent preferences varies depending on whether "approach without foraging" or "foraging" is used as the dependent measure. When approach without foraging is used to measure preference, the preference hierarchy is: both grain sizes of raw sugar > both grain sizes of artificial sweetener (0.89 > 0.44). However, when foraging is used to examine preference, the preference hierarchy is: both grain sizes of raw sugar > granulated artificial sweetener > powdered artificial sweetener (0.89 > 0.22 > 0).

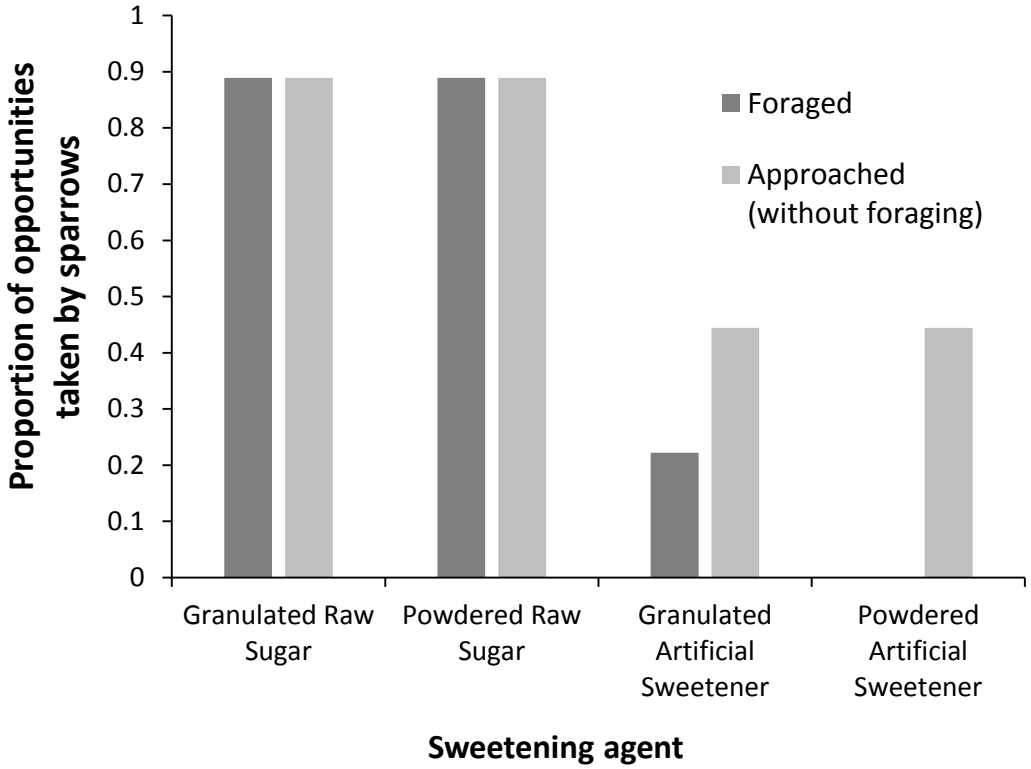

Figure 2.5. The proportion of opportunities taken by sparrows to approach (without foraging), and forage on four different sweetening agents over a total of nine, three-hour sessions per sweetening agent.

Weight change

The net amount of each sweetening agent consumed across sessions is reported in Figure 2.6. Many of the samples had a greater weight after the experiment than beforehand, and each type of sweetening agent gained weight in at least one session. When weight change was used as the measure of preference, the following preference hierarchy was produced: granulated raw sugar > powdered raw sugar > granulated artificial sweetener > powdered artificial sweetener (6.93 g > 3.87 g > -2.4 g > -3.66 g).

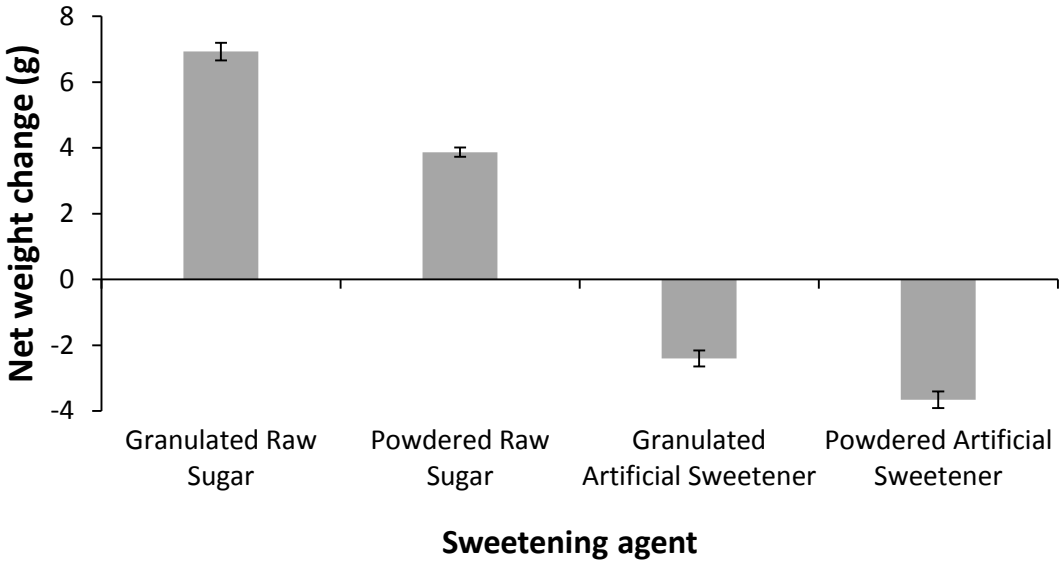

Figure 2.6. The net weight change of each sweetening agent type across all 18 sessions. Error bars represent the standard error.

The weight change data were not distributed normally. A Kruskal-Wallis H test showed that weight change differed significantly between at least two of the four groups ($H = 14.6$, $p = 0.002$). Post-hoc pairwise Mann-Whitney U tests showed that five of the pairs did not have significant differences after the Bonferroni correction was applied (alpha level adjusted from 0.05 to 0.05/6 = 0.0083). Weight change did not differ significantly within sweetening agent types (raw sugar $U = 30$, $p = 0.377$; artificial sweetener $U = 33$, $p = 0.537$). The only significant difference in the six post-hoc tests was between the granulated raw sugar weight change and the powdered artificial sweetener weight change ($U = 8$, $p = 0.004$). When analysed without grain size using the Mann-Whitney U test, there was a statistically significant difference between the weight change of the raw sugar and the weight change of the artificial sweetener ($U = 44$, $p < 0.001$).

Latency to first approach

The latency to first approach each sample was the final measure used to assess sparrows' preferences for different sweetening agents (Figure **2.7**). The sparrows tended to approach the granulated artificial sweetener the fastest, with an average latency of 32.5 minutes. Powdered artificial sweetener on the other hand, had the largest average latency (131.3 minutes). All latency data were normally distributed. A one way ANOVA supported null hypothesis that the latency means were the same ($F(3) = 2.56$, $p = 0.084$).

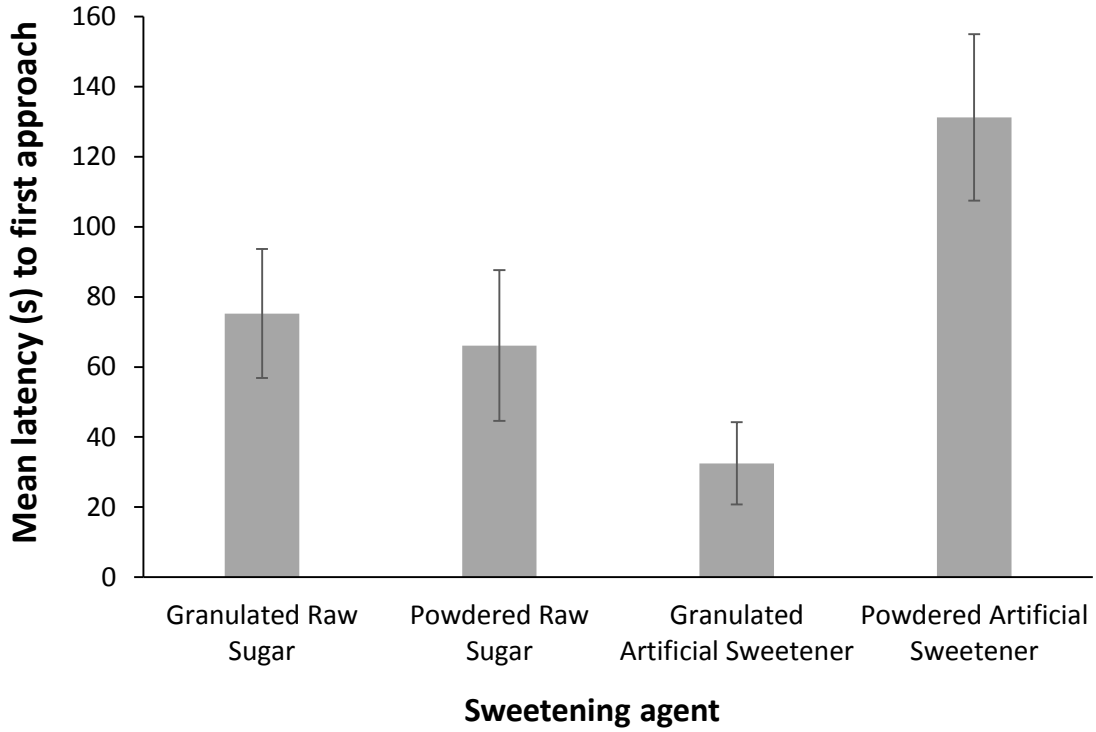

Figure 2.7. The average latency (s) for sparrows to first approach each sweetening agent across all sessions (nine sessions for each sweetening agent). Error bars represent the standard error.

2.3.2 Measures of bias

Left-right side bias

There were 75 approaches and foraging instances (65%) on the left-hand side table in contrast to 40 instances (35%) on the right-hand side table. These data were not normally distributed. A non-parametric Mann-Whitney U test showed that there was no significant difference between the number of responses on the left-hand side and the number of responses on the right-hand side ($U = 139.5$, $p = 0.486$).

Sex bias

Of the 115 observed approaches and foraging instances, sparrows with male plumage were responsible for 105 instances (91%), whereas sparrows with female plumage were only responsible for 10 instances (9%). These data were not normally distributed. A non-parametric Mann-Whitney U test revealed that there was a statistically significant difference between behavioural responses by sparrows with male plumage and sparrows with female plumage ($U = 31$, $p < 0.001$).

2.4 Discussion

The aim of this study was to assess how sweetening agent type and grain size affected the preference of wild sparrows for different sweetening agents. Overall, the evidence suggests that raw sugar was highly preferred by sparrows over artificial sweetener even if the raw sugar was powdered or the artificial sweetener was granulated. This preference for raw sugar in sparrows is consistent with the observations of sugar packet foraging in noisy miners, as those birds were only ever observed taking raw sugar packets and never artificial sweetener packets (Delgado-V & Correa-H, 2015). Several of the preference assessment measures (the number of instances of foraging behaviour, the proportion of foraging opportunities taken, and the net amount of each sweetening agent consumed) supported the conclusion that raw sugar was preferred to artificial sweetener, whereas latency to first approach each sweetening agent did not support this.

Latency to first approach was the least consistent measure of preference. The results using this measure suggested that granulated artificial sweetener was the most preferred sweetening agent. Foraging preferences of wild animals are typically measured using the number of times each food item is eaten, or the proportion of each food eaten relative to its availability (Moreby, Aebischer, & Southway, 2006). However, latency is commonly used to assess preferences in laboratory animal studies and studies on human preference (Aaker et al., 1980; Sumpter, Foster, & Temple, 2002). Latency to first approach may be more appropriate in human studies than in animal studies as the procedures often involve rule-governed behaviour, i.e., the human participant knows that they are required to make choices (Derby et al., 1995). Furthermore, when the number of instances was used as the measure of the sparrows' preference for different sweetening agents, the number of approaches did not differ significantly across treatments,

whereas instances of actual foraging did. In other studies, approach is commonly used to measure investigative behaviour in animals and is associated with neophilia experiments (Stöwe et al., 2006). Consumption on the other hand may be a better measure of food selection preferences (Kirkden & Pajor, 2006).

Although the sparrows at Momento have a clear preference for raw sugar over artificial sweetener, the underlying cause of this preference remains unknown. One hypothesis is that artificial sweeteners like acesulfame potassium have a bitter aftertaste. Multiple artificial sweeteners are commonly used in human food products so that the bitter aftertaste of one sweetener can be masked by the sweetness of another sweetener (Deis, 2006). However, it is not known currently whether sparrows have the perceptual capabilities to detect these taste differences, though sparrows have demonstrated taste aversions to bitter substances in previous studies (Clapperton et al., 2012; Greig-Smith & Rowney, 1987).

Another hypothesis that could explain sparrows' preference for raw sugar, is that artificial sweeteners have low calorific value. Artificial sweeteners were designed to be a low calorie alternative to sugar. From a survival perspective, raw sugar would give sparrows energy whereas artificial sweetener would not, and so sparrows foraging on artificial sweetener would potentially have lower survivorship/reproductive success. Martin (1987) demonstrated a positive relationship between caloric intake and breeding success in multiple bird species, including sparrows, which supports this hypothesis. Sometimes the attributes of food items can be used by animals to infer greater caloric content, e.g., Northwestern crows (*Corvus caurinus*) invest in opening larger littleneck clams (*Venerupis japonica*) but reject smaller littleneck clams. However, the hypothesis that raw sugar is preferred due to its caloric content assumes that sparrows are able to tell

the difference between the caloric content of different sweetening agents, which is unlikely without the presence of salient attributes directly relating to caloric content. Furthermore, if sugar foraging at cafés offered a large caloric advantage, it may be expected that this behaviour would increase in frequency over time within populations where sugar foraging had been established. However, the rate of raw sugar packet foraging by sparrows at Momento decreased from four packets every hour in the previous student research project (Davy, 2018) to only one packet every hour in the current study (one year later at the same time of year). Whilst there may be many variables influencing the rate of sparrows foraging on sugar packets, the decline in the rate of sugar packet foraging by sparrows at Momento suggests that the net energy gained from foraging sugar is not superior to alternative food sources.

Sparrows manipulate food items using their beaks and often forage on small seeds (Anderson, 2006). Small seeds are more similar in size to granulated sweetening agents than powdered sweetening agents, so it was hypothesized that sparrows would demonstrate a preference for the granulated forms over the powdered forms. Granulated sweetening agents were not significantly preferred over powdered sweetening agents when the number of instances, weight change, or latency to first approach the samples were used as the measure of preference. However, a slight grain size preference for granulated artificial sweetener over powdered artificial sweetener was shown using the proportion of foraging opportunities taken to assess preference. The interpretation of this result should be treated cautiously as the sparrows in this experiment never foraged on powdered artificial sweetener, and therefore this finding cannot be directly related to foraging preference.

Why did the sparrows never even attempt to forage on the powdered artificial sweetener? Knowing the past history of the sparrows would be useful for answering this question. For example, because sparrows always have access to powdered artificial sweetener in packets at Momento, they may have already foraged on them in the past and learned to avoid future foraging attempts on powdered artificial sweetener. This highlights how a lack of control can often be a major limitation in experiments on wild animal populations (Campbell et al., 2009).

In wild animal populations, a vast number of uncontrolled variables may influence behaviour latencies, such as the weather or the behaviour of conspecifics (Stöwe et al., 2006). Wild animals also have access to numerous schedules of reinforcement (e.g., dust bathing, courtship, etc.), so responding on the schedule of interest is less likely than in a laboratory environment in which many reinforcement schedules are removed (Campbell et al., 2009). On several occasions during the experiment, the latency to approach could not be measured because no birds approached the sweetening agent table during the entire three-hour session. Furthermore, the large error bars displayed on the latency graph demonstrate that the variability in the data was quite large compared to other measures of preference, such as the net amount of sweetening agent consumed.

The net weight change of sweetening agent during each experimental session was used as a measure of preference, and any decreases in weight were attributed to consumption by the sparrows. Interestingly, the net consumption of both granulated artificial sweetener and powdered artificial sweetener were negative values. This is likely the result of moisture adsorption from the atmosphere by the sweetening agent throughout the experiment, and thus it should not be interpreted that the

sparrows produced sweetening agents. All sweetening agent types gained weight during the experiments, as demonstrated in the first two sessions when no sweetening agents were foraged on, but it cannot be assumed that each sweetening agent gained moisture at the same rate. For example, Mathlouthi and Roge (2003) demonstrated that smaller grain sizes of sugar are associated with increased moisture adsorption rates, though the moisture adsorption properties of artificial sweetener were not assessed. Potential bias caused by the unintended weight gain of the samples in the current study was mitigated by weighing each sample immediately before and after every session, and having a variety of preference measures.

Although no bias was found on sparrows approaching or foraging on the left table or the right table, a significant sex bias was established in favour of males foraging on the sweetening agents. This is consistent with the findings from the previous student research project where males were responsible for approximately 69% of the 447 observed sugar packet removals (Davy, 2018). Because sparrows were not identified individually in this experiment, it is impossible to say whether this sex bias is the result of inherent sex differences (e.g., boldness), or whether a few male birds were responsible for the majority of the observations.

Chapter 3

Behavioural responses of sparrows to novel sugar packet colours

3.1 Introduction

For a behavioural innovation to develop, individuals require the physical capabilities to perform the behaviour. Like all diurnal birds, sparrows have the perceptual abilities to discriminate between different colours (Maier & Bowmaker, 1993), as demonstrated by the near exclusive preference of sparrows for orange-coloured sugar packets in the unpublished student research project (Davy, 2018). Sparrows also have sharp beaks that they use to forage on insects and grains (Anderson, 2006), which allow them to manipulate and open the sugar packets. Furthermore, sparrows have an above average relative brain size, which enhances their capacity to solve problems and innovate (Sol, Timmermans, & Lefebvre, 2002). However, little is known about the learning processes involved in the sugar packet foraging behaviour.

Novel behavioural innovations require learning. Common learning processes involved in the development of innovations include operant conditioning (Taylor et al., 2010), trial and error learning (Kuba, Byrne, & Burghardt, 2010), and insight learning (Epstein et al., 1984). Though it is not possible to determine exactly how sugar packet foraging in Momento sparrows first came about, aspects of the learning process involved can still be investigated. For example, the flexibility of this behavioural innovation is unclear, i.e., does the behaviour generalise to packets of novel colours and sugar types, or is it restricted to Momento-branded orange-coloured raw sugar packets? If sparrows generalized sugar packet foraging to different

coloured packets, the spread of the behaviour to nearby cafés would be facilitated, regardless of what colour sugar packets were available. On the other hand, sparrows may not generalize this behaviour to different coloured packets, and stick to opening packets they are familiar with. For example, tits have been documented opening different types of milk bottles, each type of milk bottle with a different coloured stopper. Households that received several types of milk reported that the birds had a strong preference for one type of coloured stopper (Hinde & Fisher, 1951). The authors argued that this was likely a product of their initial learning experiences, which may be also be an influential factor in the expression of sugar packet foraging behaviour in sparrows.

The aim of the current study was to investigate how the Momento café sparrows responded to sugar packets with novel colours replacing the familiar packets in the cups on the Momento café tables. When presented with a novel item, neophobic individuals avoid the novel item, whereas neophilic individuals interact with the item. Sparrows in previous studies typically had high initial neophobia scores, which decreased over time after a period of habituation (Ensminger, & Westneat, 2012). Consequently, when presented with novel packet colours, it is hypothesized that sparrows will avoid interacting with the novel sugar packets. However, changing the sugar packet colour would not be complete novelty as many attributes of the packets would remain consistent, including size, shape, location.

3.2 Methods

3.2.1 Subjects

Wild sparrows were studied at Momento on the University of Waikato campus, Hamilton, New Zealand. The sparrows were free to enter and exit the experimental area at any time during the experimental sessions, and up to eight sparrows were present at any given time.

Animal ethics approval for this study was granted by the University of Waikato Animal Ethics Committee (protocol 1051). Direct contact with the sparrows was not made in this experiment. No human participants were sought for inclusion in this study, however, members of the public were at risk of being recorded on camera when the sparrows were being filmed. Accordingly, human ethics approval for this research was granted by the University of Waikato Faculty of Science and Engineering Human Research Ethics Sub-committee (protocol FSEN_2018_7). Members of the public were informed of the experiment through signage at the café (Appendix A and B), and filming was only done opportunistically when the sparrows were interacting with tables or sugar packets.

3.2.2 Experimental area

The experimental area was defined as the concrete space outside Momento occupied by the outdoor café tables and chairs, and where sparrows were typically seen engaging in sugar packet foraging behaviour (Figure 3.1). The outdoor seating area at Momento has an overhanging roof as an extension of the café to shade the tables. Birds on top of the roof were obscured and thus were not considered within the experimental area, even when birdsong could be heard.

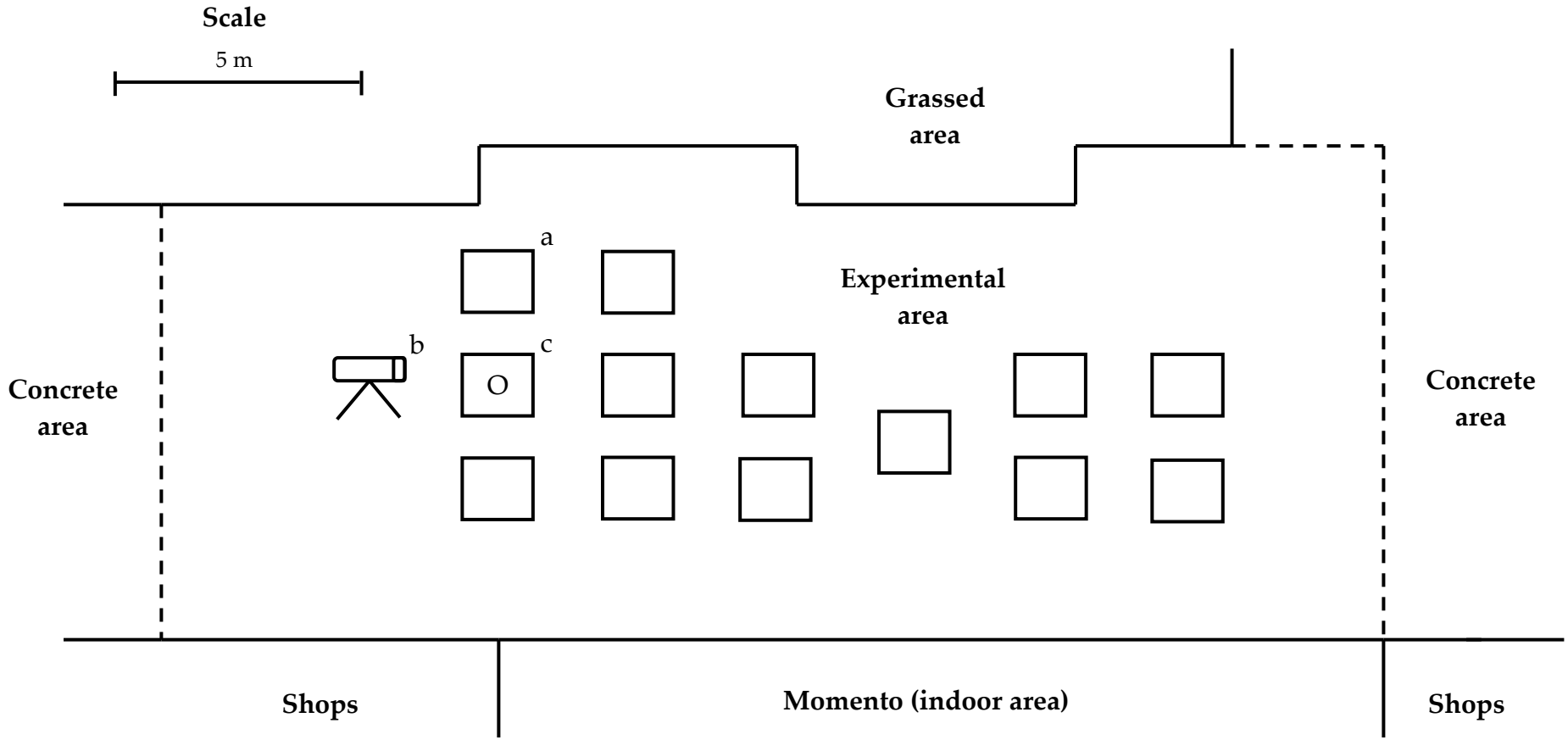

Figure 3.1. The typical layout of the experimental area outside Momento, and the experimental set-up used to study the behavioural responses of sparrows to sugar packets of novel colours, including the ordinary café tables (a), the positioning of the camera (b), and the observation (O) table (c).

3.2.3 Sample preparation and equipment

The following packets were used in this experiment (Figure 3.2):

Orange-coloured Momento-branded raw sugar packets

These packets were provided by Momento staff, and were always available to the sparrows during the café's opening hours. The packets weighed approximately 3.3 g +/- 0.26 g per packet.

Cream-coloured Chelsea-branded organic raw sugar packets

These packets were sourced online in bulk. They were the same packet material and shape as the Momento raw sugar packets. Like the Momento packets, they still contained granulated raw sugar, but of a lighter colour. This substitute was selected because the packet colour was different to the Momento packets whereas the sugar type was similar. The packets weighed approximately 3.27 g +/- 0.19 g per packet.

Pink-coloured Chelsea-branded white sugar packets

These packets were sourced online in bulk. They were the same packet material and shape as the Momento orange-coloured packets. Like the Momento packets, they still contained granulated sugar, but they contained white sugar instead of raw sugar. This substitute was selected because both the packet colour and sugar type were different to the Momento packets. The packets weighed approximately 3.29 g +/- 0.15 g per packet.

Light blue-coloured generic (non-branded) artificial sweetener (aspartame-acesulfame potassium) packets

These packets were provided by Momento staff, and were always available to the sparrows during the café's opening hours. The packets weighed approximately 1.09 g +/- 0.09 g per packet.

Figure 3.2. The array of sugar packet brands, colours, and types used in this experiment. The orange-coloured raw sugar packets (A) and light blue-coloured artificial sweetener packets (D) were always accessible to sparrows at Momento when the café is open. The cream-coloured raw sugar packets (B) and pink-coloured white sugar packets (C) were not normally accessible to sparrows at Momento but were added to the café tables during this experiment.

A Sony HDR-PJ410 digital video camera was used to film the behaviour of the sparrows. For the duration of this experiment, signs were placed around the café informing café patrons of the nature of the research being conducted on sparrow behaviour (Appendix A). The outdoor tables also had signs displayed for members of the public to be aware of the experiments that were in progress (Appendix B). Information sheets were available at the observation table for members of the public to read if they wanted more information about the project (Appendix C).

3.2.4 Experimental design

This experiment used one dependent measure (sugar packet removal), across four different phases:

1. **Baseline phase:** The normal foraging conditions available to the sparrows at the café; presentation of orange-coloured raw sugar packets and blue-coloured artificial sweetener packets. This was conducted over six consecutive weekdays.
2. **First treatment:** The substitution of normal-colour raw sugar packets for a novel-coloured raw sugar packet; presentation of cream-coloured raw sugar packets and blue-coloured artificial sweetener packets. This was conducted over 10 days (two weeks excluding weekends).
3. **Probe phase:** A short return to baseline conditions to re-establish sugar packet removal, which was required if the rate of sugar packet removal in the first treatment decreased from the baseline phase; presentation of orange-coloured raw sugar packets and blue-coloured artificial sweetener packets. The duration of the probe phase was dependent on the time taken to re-establish the sugar packet removal behaviour. This was conducted over consecutive weekdays.
4. **Second treatment:** The substitution of normal-colour raw sugar packets for a novel-coloured raw sugar packet, as well as the addition of another novel-coloured sugar packet of a different sugar type; presentation of cream-coloured raw sugar packets, pink-coloured white sugar packets, and blue-coloured artificial sweetener packets. This was conducted over 10 days (two weeks excluding weekends).

Momento staff required that both artificial sweetener and raw sugar options were available at the café at all times, so the cream-coloured raw sugar packets could not be substituted for the pink-coloured white sugar packets during the second treatment, as then there would have been no raw sugar option. However, the design still provided useful insight into the neophilic/neophobic tendencies of the café sparrows. The sugar packets in the cups on the café tables remained accessible to the sparrows for the duration of the café opening hours. Packet types were substituted before the café opened on the first days of treatment 1, the probe phase, and treatment 2.

3.2.5 Experimental procedure

Experimental sessions started on Monday the 5th of November 2018 and ended on Friday the 14th of December 2018. The sessions were conducted only on weekdays (as the café was closed on weekends), and ran for a three-hour period between 7.00 am and 10.30 am depending on when the outdoor area had been set up, i.e., if the cafe tables were set up at 7.15 am then the session ran between 7.15 am and 10.15 am. This time period was chosen as it was the most feasible time to observe the sparrows without interfering with the business of the café (Davy, 2018).

Approximately 10 minutes before each observation session, signs informing the public that there was an experiment on sparrows in progress were taped to the observation table. The video camera was kept at the observation table on standby until sparrows approached a table within the observation area, or until a sparrow interacted directly with a sugar packet. Direct interactions included complete removal of a sugar packet from a cup and partial sugar packet removal from a cup (Table 3.1). In each of these

instances, the video camera was used to film topographical aspects of the sparrows' behaviour.

Table 3.1. An ethogram of the Momento sparrows' behavioural responses to the presentation of novel-coloured sugar packets.

Behaviour	Description
Complete packet removal	A sparrow used its beak to lift a sugar packet out of a cup from on top of a Momento outdoor table so that the sugar packet was no longer inside the cup. Instances of sparrows knocking over the cup so that sugar packets spilled out were not included.
Partial packet removal	A sparrow used its beak to lift a sugar packet partway out of a cup from on top of a Momento outdoor table and the sugar packet remained in the cup. The extent of sugar packet removal was not recorded, i.e., the packet could have been lifted 5% out of the cup or lifted 95% out of the cup.

During each session, the outdoor tables were scanned continuously by the researcher for sparrow approaches and interactions with sugar packets. There were 12 tables to monitor (not including the observation table where the researcher was sitting), usually each with a cup full of all sugar packet types on top. Each table was assigned a table number by the researcher, which differed daily depending on how the tables were arranged by Momento staff on that particular day. The researcher sat at the same geographical location each day, even when the adjacent tables were positioned differently. Every observation of sugar packet removal was recorded onto a data sheet (Appendix E). When a sugar packet was removed, the time of day, plumage of the sparrow, and table number were all recorded. The plumage of the sparrow was used as a proxy for sex, as

male plumage indicates a male sparrow, whereas female plumage indicates either a female sparrow or an immature male sparrow (Anderson, 2006).

During the baseline phase, observations at Momento were made over six weekdays to establish a baseline rate of sugar packet removal. The first treatment was initiated on the next weekday following the baseline phase. All orange-coloured Momento-branded raw sugar packets were substituted for cream-coloured Chelsea-branded organic raw sugar packets before the café was opened in the morning. Packets from both the indoor area and the outdoor area of the café were substituted as birds also had access to sugar packets in the indoor area of the café. The first was conducted over 10 days (two weeks excluding weekends).

After the first treatment, the probe phase was carried out to re-establish sugar packet removal. On the first day of the probe phase, all of the cream-coloured raw sugar packets were replaced with orange-coloured raw sugar packets before the café was open in the morning. This phase was conducted over four consecutive weekdays.

The experiment progressed to treatment 2 after the probe phase. For treatment 2, all of the orange-coloured raw sugar packets were replaced with cream-coloured raw sugar packets again, before the café was open. Additionally, pink-coloured white sugar packets were added to the cups on top of the outdoor tables, resulting in a total of three types of packets (cream-coloured raw sugar packets, pink-coloured white sugar packets, and light blue-coloured artificial sweetener packets). Observations at the café were made over another 10 days (two weeks excluding weekends) following the same procedure as described above. All sampling was completed after six weeks of observations.

3.2.6 Data analysis

The rate of sugar packet removal was compared across treatments using Microsoft Excel 2013 to produce graphs and descriptive statistics. Statistica 13.0 was used to perform statistical analyses and assess potential weekday bias and potential sex bias. Where the data were not normally distributed, a Kruskal-Wallis H test was performed to compare the means of several groups, whereas Mann-Whitney U tests were performed to compare the means of two groups. The significance level was set to $a = 0.05$. All p values were reported to three decimal places, and p values smaller than 0.001 were reported as $p < 0.001$. Where Mann-Whitney U tests were conducted post-hoc after a Kruskal-Wallis test, the Bonferroni correction was applied to the p values because increased pairwise comparisons in hypothesis testing tends to increase type I errors (Frane, 2015).

3.3 Results

3.3.1 Treatment effects

Time-series

The results from this experiment are presented in Figure 3.3. A total of 41 sugar packets were removed or partially removed by sparrows at Momento throughout all of the experimental sessions. The baseline phase established an existing rate of responding of approximately three raw sugar packets removed per three-hour session. Six raw sugar packets were removed on the first day of treatment 1, which was higher than any of the days in the baseline phase. However, the rate of sugar packet removal was equal to or lower than the baseline rates of responding on all other days of treatment 1. The baseline rate of responding was re-established in the second and fourth days of the probe phase. Responses were made by sparrows on the fifth, sixth, and eighth days of treatment 2 but no more than two responses were observed on each of these days.

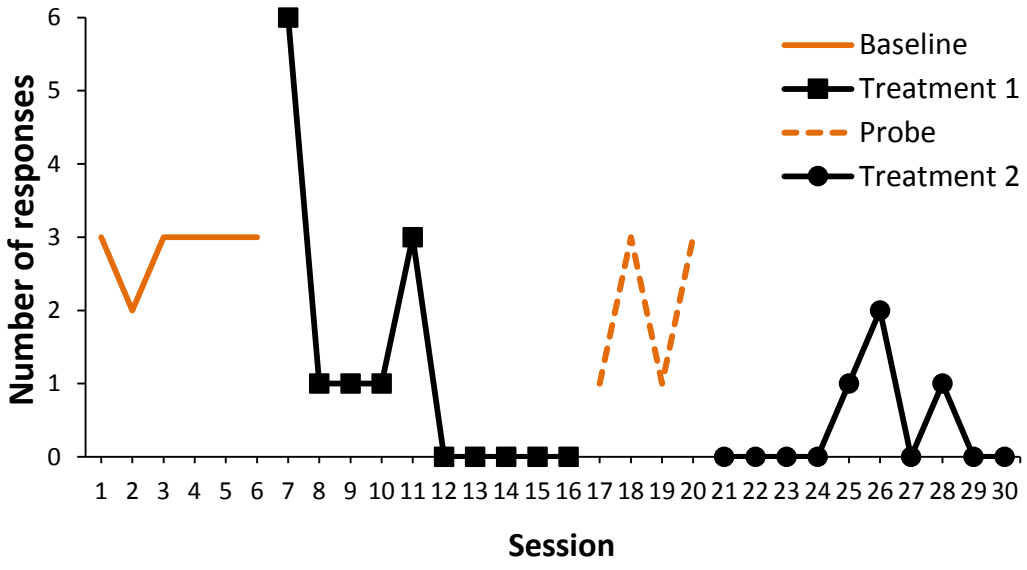

Figure 3.3. The total number of behavioural responses (complete sugar packet removals and partial packet removals, combined) displayed by sparrows during the baseline phase (orange and blue packets), treatment 1 (cream and blue packets), the probe phase (return to baseline conditions), and treatment 2 (pink, cream, and blue packets).

Mean number of responses

The phases of this experiment were conducted over different time frames; i.e., the baseline phase was conducted over six days, whereas treatment 1 was conducted over 10 days. Consequently, the mean rate of packet removal is a more appropriate measure to compare treatments than the total numbers of observed packet removals. The mean complete packet removal and partial packet removal rates are displayed below for each phase of the experiment (Figure 3.4). The baseline phase had the greatest average rate of complete removals (2.7 per day), followed by the probe phase (1.3 per day). Treatment 1 had higher average complete removal rates and partial removal rates than treatment 2. The baseline phase and the probe phase had more complete removals than partial removals on average, whereas treatment 2 had more partial removals than complete removals on average.

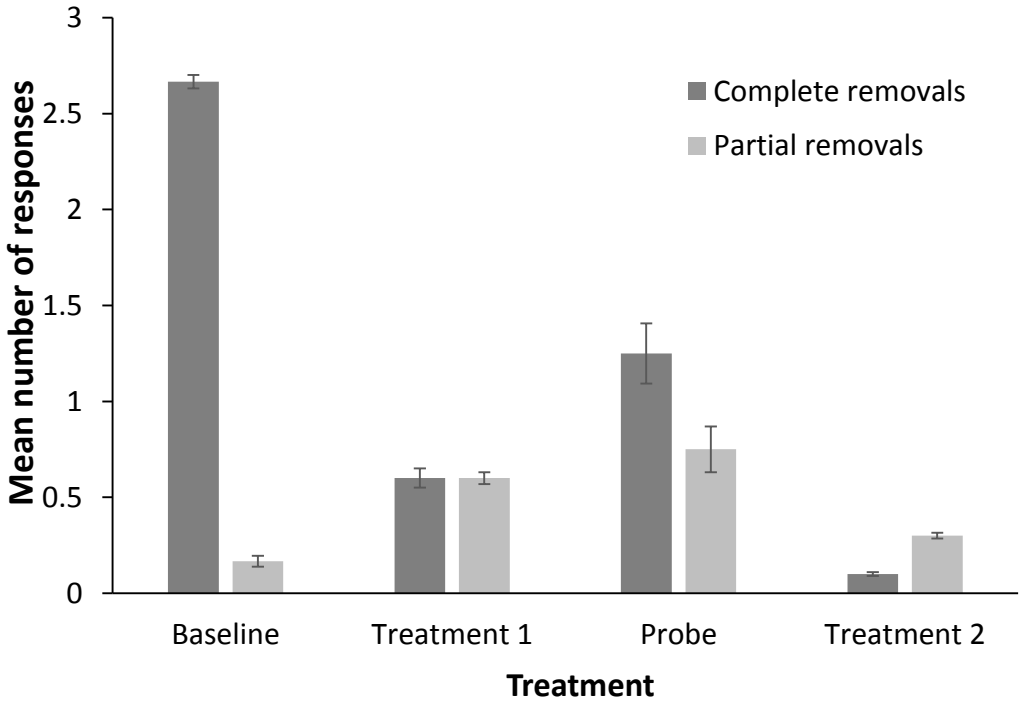

Figure 3.4. The mean number of complete and partial sugar packet removals by sparrows per session during the baseline phase (orange and blue packets), treatment 1 (cream and blue packets), the probe phase (return to baseline conditions), and treatment 2 (pink, cream, and blue packets). Error bars represent the standard error.

Complete and partial removals were combined for analysis and the data were not normally distributed. A Kruskal-Wallis H test indicated that at least two of the groups were significantly different from each other (H = 13.907, p = 0.003). Post-hoc pairwise Mann-Whitney U tests showed that only one of the pairs had a significant difference after the Bonferroni correction was applied (alpha level adjusted from 0.05 to 0.05/6 = 0.0083). The only significant difference was between the baseline phase and treatment 2, demonstrating that treatment 2 had significantly less responses than the baseline (U = 0.5, p = 0.002). When the analyses were repeated using complete removals only, a significant difference was still found between the baseline phase and treatment 2 (U = 0, p = 0.001).

3.3.2 Measures of bias

Weekday bias

The previous student research project showed that the Momento sparrows removed more sugar packets in the middle of the week than start or the end of the week, with the greatest response rates on Wednesdays and Thursdays. The data from the current study were also assessed to see if sparrows responded more on some days of the week than others across all phases of the experiment. The mean number of complete and partial packet removals by sparrows on each day of the week is displayed in Figure 3.5. On average, more complete packet removals were observed on Mondays and Tuesdays, whereas fewer packet removals were recorded on Wednesdays and Thursdays on average. These data were not normally distributed. A Kruskal-Wallis H test showed that the number of packet removals did not differ significantly across the days of the week (H = 1.52, p = 0.823).

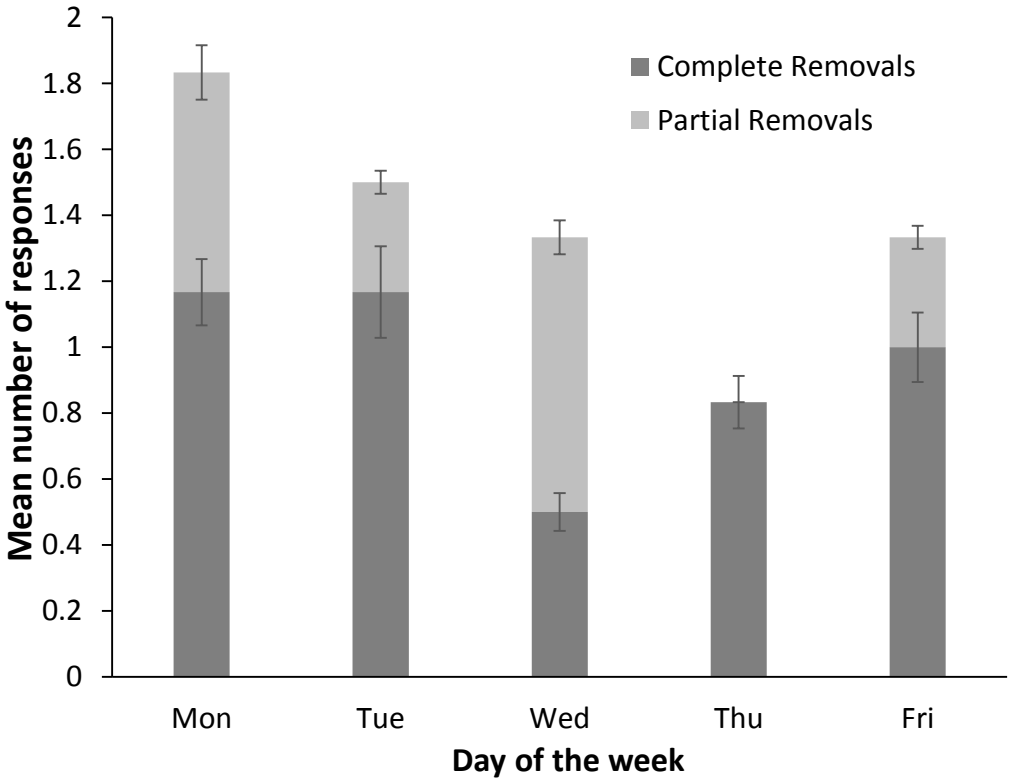

Figure 3.5. The mean number of complete and partial packet removals by sparrows across the days of the week when packets were available. Error bars represent the standard error.

Sex bias

Across all 41 observations of complete and partial packet removals in this experiment, sparrows with female plumage were responsible for 31 removals, whereas sparrows with male plumage were only responsible for 10 removals. These data were not normally distributed. A non-parametric Mann-Whitney U test showed no significant differences between packet removals by sparrows with female plumage and sparrows with male plumage ($U = 360$, $p = 0.186$).

3.4 Discussion

The aim of this study was to investigate how the Momento sparrows respond to the presentation novel sugar packet colours. The main finding was that the sparrows did not learn to forage on novel packet colours within a two week period. However, the birds did interact with the novel packets on several occasions. On the first day of treatment 1, the sparrows removed approximately 60% more novel packets than the established baseline rate of orange packet removal. On the next day the response rate dropped well below baseline levels. This temporary increase in responding is hypothesized to be an extinction burst. Extinction bursts are commonly seen in behavioural experiments following the removal of a reinforcement schedule (Cooper, Heron, & Heward, 1987). The reinforcement schedule in this case (gaining raw sugar from orange-coloured sugar packets) was removed at the start of treatment one, and the behaviour (sugar packet removal) temporarily increased in rate. Extinction bursts are commonly coupled with an increase in aggression (Lerman, Iwata, & Wallace, 1999), which was not measured as it was outside the scope of this experiment.

The probe sessions successfully recovered the sparrows' sugar packet foraging behaviour, as is the intention of a probe session (Railton, Foster, & Temple, 2010). This phase was a necessary step in the experiment as no responses were made at all during the last five sessions of treatment 1. Without a probe session it is difficult to establish whether a cessation in responding is due to the treatment or because of a confounding variable. A probe session is an alternative to a second baseline. Baselines require an established rate of responding over several sessions, whereas probe sessions are required only to re-establish a behaviour that has been extinguished, regardless of response rate. Because the probe in this

experiment quickly re-established the sugar packet removal behaviour, it is likely that the treatment was responsible for the cessation of responding.

A recovery of responding was also observed during both treatments after the behaviour had extinguished in previous sessions. This is characteristic of the phenomenon known as spontaneous recovery. Recovered responses typically increase in likelihood as the time since the previous reinforcement increases, and recovered response rates are usually lower than when the behaviour was recurring consistently (Bouton, 2004). Because each treatment only contained 10 sessions, it is difficult to confidently attribute increases in responding to spontaneous recovery and not to random variation. This could be clarified in future studies by increasing the number of sessions per treatment.

Treatment 1 and treatment 2 did not differ in rates of responding by the sparrows; however, the type of packets taken did differ. In treatment 1, cream-coloured packets were available, and some cream-coloured packets were removed. In treatment 2, both cream-coloured packets and pink-coloured packets were available, and the sparrows removed only pink-coloured packets. These results may demonstrate neophilia in the Momento sparrows, as the sparrows interacted with the most novel stimulus in each treatment. This interpretation is contradictory to the previous research done on neophilia in sparrows (Ensminger, & Westneat, 2012), which concluded that sparrows have a tendency to be neophobic. However, further research would be required to establish the whether or not the Momento sparrows display neophilic behaviours.

An alternative explanation for the lack of cream-coloured packets being taken by sparrows in treatment 2 is that sparrows have a preference for pink-coloured items over cream-coloured items. Colour is an important aspect of food preference in many avian species (Moreby, Aebischer, &

Southway, 2006; Hartley et al., 2000). Furthermore, the pink-coloured packets and the orange-coloured packets are brightly coloured, compared with the relatively drab cream-coloured packets, thus making generalization from orange- to pink-coloured packets more likely, but further research would still be required to support this supposition.

The current behavioural experiment may have had different results if it had been done during the previous summer when sugar packet foraging was more prevalent in the sparrow population (Davy, 2018). During the student research project one year prior to the current study, the sparrows removed an average of four raw sugar packets every hour. In contrast, the sparrows only removed an average of one packet every hour during the baseline phase of this experiment. Furthermore, the experiment may have had different results if each treatment was conducted over a longer time period, to account for neophobia and habituation (Ensminger & Westneat, 2012). The results showed no evidence of weekday bias or sex bias. However, other factors may have influenced the results, such as the rain that was present during many of the experimental sessions. The number of customers present at the café may also have influenced the results, as the presence of customers outdoors at cafés and restaurants draws in sparrows to feed on food scraps (Haemig et al., 2015).

Chapter 4

Distribution of sugar packet foraging behaviour by sparrows in New Zealand

4.1 Introduction

Behavioural innovations have the potential to spread rapidly across avian populations via social learning (Lefebvre, 1995). Understanding the social transmission of innovations can help to predict the spread of these behaviours throughout populations. Predicting the spread of nuisance innovations is of particular importance in urban-adapted species, as the density of these populations is on average 30% greater in cities than in rural areas (Møller et al., 2012). Greater population density increases the rate of intraspecific encounters, which increases the rate of social transmission, and thus nuisance innovations are likely to have greater impact on people in cities than in the countryside (Croney & Newberry, 2007).

The easiest way to study the social transmission of behavioural innovations is within a controlled environment, where the social dynamics of the study population have been established. For example, Boogert et al. (2014) looked at the social diffusion of two different foraging innovations in captive starlings. They discovered that the rate of innovation acquisition was 6.67 times faster when social learning was involved. Furthermore, learning one innovation facilitated the asocial learning of a second foraging innovation. They also discovered that the diffusion of these innovations could be predicted by analysing the starlings' social perch networks, rather than their social foraging networks. Analyses like these can help to explain why innovations may spread to some areas and not others.

The social transmission of innovations is much harder to predict in open populations, especially when social dynamics are unknown. However, maps showing the known distribution of the behavioural innovation can give insight into the probable diffusion mechanisms (Fisher & Hinde, 1949). If the observations are found in clusters, it has likely to have spread through social diffusion. If the observations are far apart and not clustered, the behaviour is likely to have developed independently (Ducatez, Audet, Lefebvre, 2013). If clusters are found but they are far apart from each other, it is likely that the behaviours initially developed through asocial learning (e.g., operant conditioning), and then spread out through social transmission.

Attempts have been made to develop sparrow deterrents at cafés (Cameron et al., 2018), indicating that some café staff members find sparrows to be a nuisance. These measures have only had short term success, and the sparrows return to the café after habituating to the deterrent. Haemig et al. (2015) suggested café staff may also benefit from having birds at cafés, as disease-carrying rodents are less likely to be present if the birds promptly eat any spilt food scraps at the café. However, future research is required to support this claim.

Sugar packet foraging by sparrows has been documented in New Zealand at only one café in Hamilton City (Davy, 2018). It is currently unknown how prevalent this behaviour is at other cafés in New Zealand, how the behaviour is distributed within cities, and how café staff feel about sparrows being present at their cafés. This study had three aims. The first aim was to assess the distribution of this behaviour in New Zealand to determine how widespread the behavioural innovation has become within the country. The second aim of this study was to determine the distribution of sugar packet foraging at cafés in Hamilton City, so that the possible

mechanisms underlying the spread of the innovation could be analysed. The third aim was to investigate the attitudes of café staff in Hamilton City towards sparrows at their cafés. It was hypothesized that sugar packet foraging would occur in several other regions of New Zealand and at cafés in Hamilton City that are in close to Momento. It was also hypothesized that café staff would find sparrows to be a nuisance at their cafés.

4.2 Methods

The data for this study were collected in two ways. The first method concerned the distribution of sugar packet foraging by sparrows in New Zealand as a whole, which involved low resolution data collection (few responses over a larger area). The second method concerned the distribution of sugar packet foraging by sparrows in Hamilton City, which involved high resolution data collection (many responses over a smaller area).

4.2.1 Participants

New Zealand

Dr. Bob Brockie is a renowned New Zealand biologist who regularly writes columns for Wellington's *Dominion Post* newspaper on the subject of biology, with a particular emphasis on animal behaviour. Dr. Brockie kindly assisted in the recruitment of participants and the collection of data for this study. A news article was written by Dr. Brockie and distributed through the *Dominion Post* newspaper in the Wellington Region and on the website stuff.co.nz (Brockie, 2018). Participants in this study were members of the public who responded to this new article. The greatest ethical consideration for this research was the confidentiality of the data. Accordingly, human ethics approval for this research was granted by the University of Waikato Faculty of Science and Engineering Human Research Ethics Sub-committee (protocol FSEN_2018_7). All personal information contained in participant responses was removed for analysis.

Hamilton City

All cafés that were identified within the Hamilton City boundary were visited. Staff members at cafés meeting the criteria for participation in the survey were recruited in person by approaching them at their cafés and requesting voluntary participation. Human ethics approval for this research was granted by the University of Waikato Faculty of Science and Engineering Human Research Ethics Sub-committee (protocol FSEN_2018_7). None of the data collected from Hamilton City café staff members contained personal information.

4.2.2 Survey content and procedure

New Zealand

The news article written by Dr Brockie gave some background information on the sugar-foraging phenomenon by sparrows, and requested that people from around New Zealand participate in the research by submitting personal observations of sparrows foraging on sugar packets and other such innovative behaviours by sparrows. Responses to the news article were collected via email over a three week period from Monday the 18th of June 2018 to Friday the 6th of July 2018.

Hamilton City

A survey was created for staff members at cafés around Hamilton City (Appendix F). The survey contained 29 questions, had a mix of open/closed question types, and took three minutes on average to complete. The survey questions were divided into three sections:

Café questions: Five questions related to attributes of the café where the staff member worked, such as sugar packet types used at the café, opening hours, and peak times for customers.

Sparrow questions: Eight questions related to observations of sparrows at the café where the staff member worked, such as roughly how many sparrows they saw on average at the café at peak times for their customers, if they had observed sparrows foraging on sugar packets at the café, and if the staff had modified their behaviour in response to the sparrows taking sugar packets.

Attitudes towards sparrows: Sixteen statements about the local sparrows were presented, where responses were required using a Likert scale from "strongly disagree" to "strongly agree", such as, did the sparrows entertain customers, are they unhygienic, and are they pests. This section was modified from a more extensive attitudes survey used in Chapter 5 (Appendix G).

Hamilton City was split into manageable sections using a map of Hamilton City suburbs (Figure 4.1). This map also included the Hamilton City boundary, and cafés outside of this boundary were not included in this study. The locations of cafés around Hamilton City were found by using the search terms "café" and "coffee" in Google Maps. There were 174 cafés located within the search area. A Garmin 60CSx GPS was used to collect GPS data at all 174 cafés. Café staff members were asked to complete the survey at cafés where the survey criteria were met (see below for survey criteria). Surveys were distributed in person, as this method has been shown to have the highest response rate among common distribution methods (Baruch & Holtom, 2008), and was feasible to use given the population size.

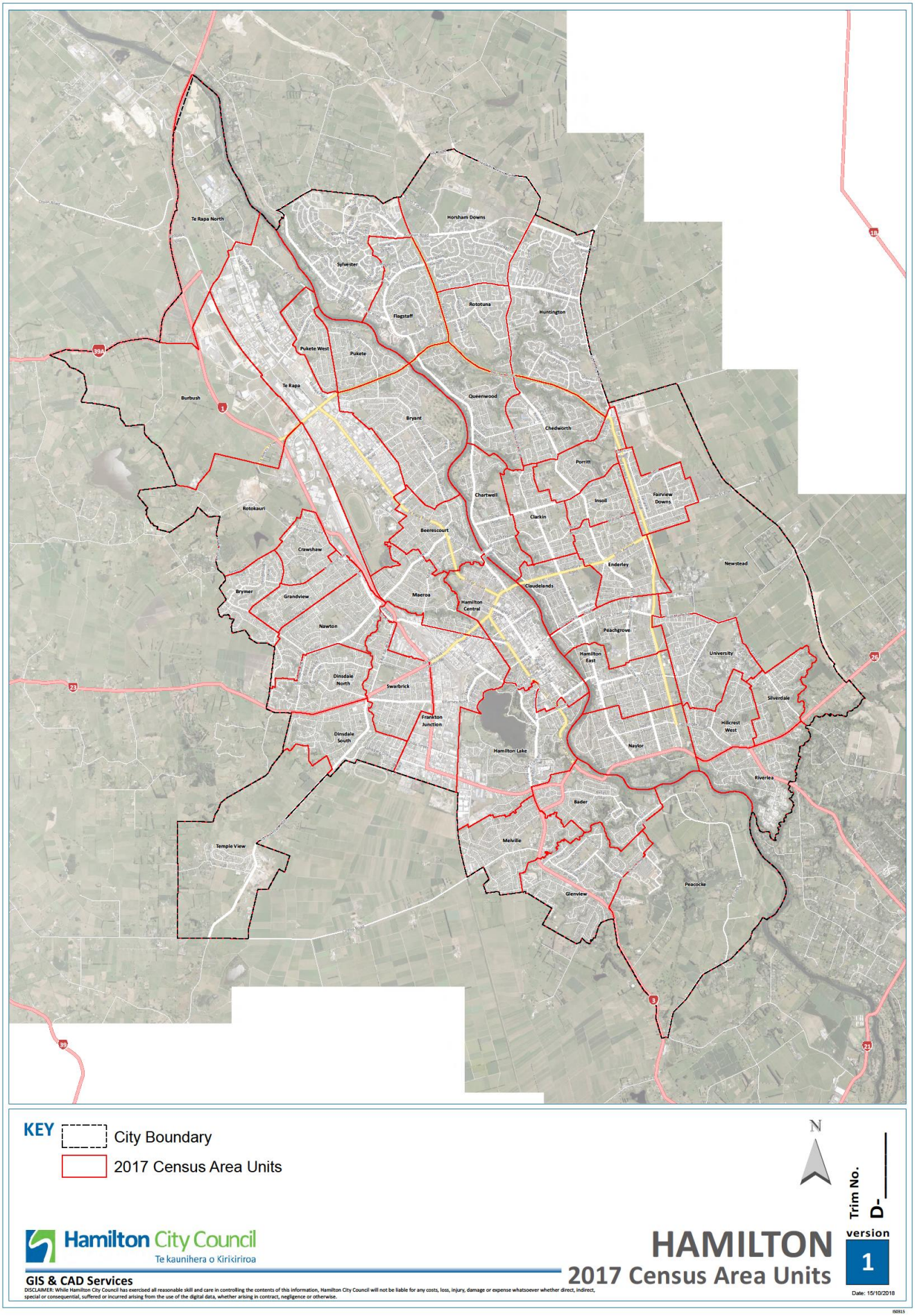

Figure 4.1. Map of Hamilton City boundary divided into 44 suburbs.

The Hamilton City café surveys were conducted between Thursday the 15th of November 2018 and Monday the 10th of December 2018. Surveys were usually completed orally so that staff members could continue working whilst participating. The two hours between 12 pm and 2 pm were often avoided as this period was peak time for customers. The first action that the researcher took at each café was to log the GPS co-ordinates using the Garmin GPS. The next action was to check the survey criteria. If the café had sugar packets that were accessible to sparrows, a staff member was approached and asked if any of their staff were available for three minutes to answer questions about sparrows at their cafe.

Café staff members were given the option to complete the survey independently in writing or through oral responses to the researcher. If the café did not have sugar packets accessible to sparrows, but did have outdoor tables, a staff member was asked for the main reason why their café did not put sugar packets on their outdoor tables. If their answer related to sparrows foraging on the sugar packets, an available staff member was asked to complete the survey. If their answer did not relate to sparrows foraging on sugar packets, their answer was recorded but the survey was not administered, and the next café was visited. A sample of each sugar packet type was collected from cafés where staff indicated the presence of sparrows foraging on sugar packets, so that similarities in sugar packet colour, shape, and type could be assessed.

4.2.3 Data analysis

New Zealand

The data collected from responses to the news article on sparrows foraging on sugar packets were entered into a Microsoft Excel spreadsheet. The responses contained anecdotal descriptions, which were standardised into "location", "species", "behaviour category", and "behaviour description" columns. Descriptive statistics on the distribution of observed sugar packet foraging by sparrows in New Zealand were produced in Microsoft Excel. The anecdotal descriptions relating to sugar foraging were compared across responses (including a comparison to the Momento sparrows). Furthermore, a map of New Zealand was created in Google Earth using polygons to show the regions where sugar foraging by sparrows had been observed.

Hamilton City

Several maps were created in Google Earth from the GPS data. The GPS co-ordinates were downloaded onto a computer using the Garmin MapSource software (version 6.16.3). Google Earth was then used to visualize aspects of the data in a map format. These maps displayed the distribution of cafés in Hamilton City, the cafés that met the survey eligibility criteria, and the cafés where sparrows had been observed foraging on sugar packets. A summary table was made of the reasons why some cafés did not put sugar packets on their outdoor tables.

The data from the surveys were analysed in Microsoft Excel and were summarized as graphs. Median averages were calculated from the Likert scale data obtained in the "attitudes towards sparrows" section of the survey. The median was used as a measure of central tendency instead of

the mean because whole numbers are more meaningful in the interpretation of Likert scale data (Sullivan & Artino Jr, 2013). The Likert scale responses for each question were summarized in the form of diverging stacked bar graphs as recommended by Robbins and Heiberger (2011). These graphs use the central Likert category ("neutral" in this case) to align the questions, so that responses greater than and less than the central Likert category can be compared easily across the responses to different questions. These graphs were used determine how participants perceived the impacts of sparrows at cafés. The distributions of the Likert scale data were compared to expected values using chi-squared tests. The significance level for the chi-squared tests was set to $a = 0.05$. All p values were reported to three decimal places, and p values smaller than 0.001 were reported as $p < 0.001$.

4.3 Results

4.3.1 New Zealand distribution

The news article distributed on stuff.co.nz garnered 40 email responses from members of the public. Thirteen (33%) of these responses included personal observations of sparrows foraging on sugar packets across the country (Table 4.1, Figure 4.2). The remaining responses (n = 27, 67%) contained personal observations of sparrow innovations not relating to sugar packets (e.g., flying in front of automatic doors sensors to open the doors), and observations of sugar foraging in Australia. Observations of sparrows foraging on sugar packets in New Zealand were most commonly from the Wellington Region (n = 88, 62%). Two observations were from the South Island (15%).

Table 4.1. Summary of locations around New Zealand where sparrows have been observed foraging on sugar packets at cafés.

Cities	Region	n
Auckland	Auckland	1
Nelson	Nelson-Tasman	2
Paraparaumu	Wellington	1
Pauatahanui	Wellington	3
Tauranga	Bay of Plenty	1
Unknown	n/a	1
Wellington	Wellington	4
Total observations		13

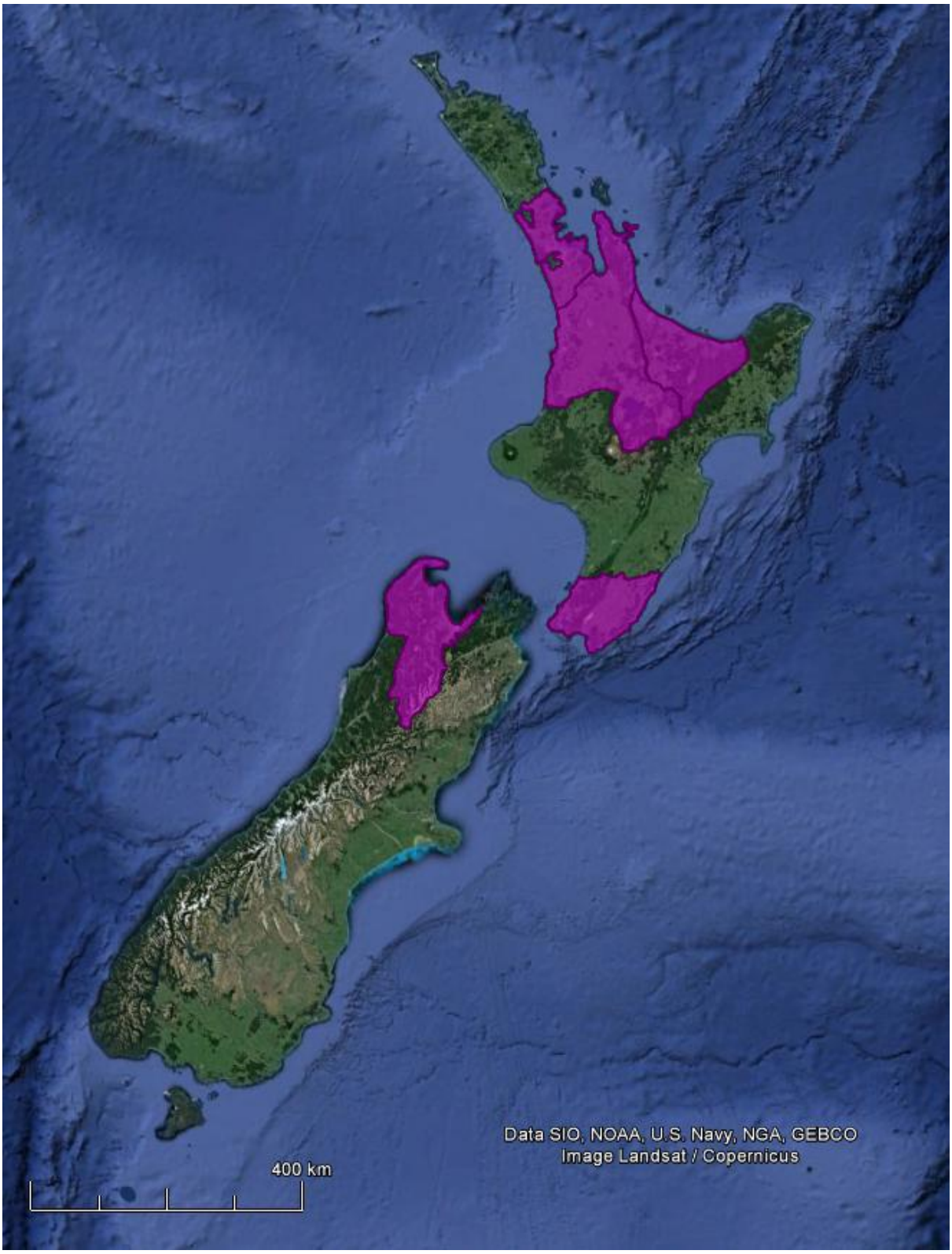

Figure 4.2. Regions of New Zealand where sparrows have been observed foraging on sugar packets at cafés by members of the public who responded to an article in the *Dominion Post* newspaper. The Waikato Region was included in this figure as this is where sugar packet foraging behaviour by sparrows is being investigated.

The personal observations from around New Zealand had three key themes aside from sparrows foraging on sugar packets. Firstly, observations in Auckland, Pauatahanui, and Wellington stated that only raw sugar was taken, never artificial sweetener. Secondly, reports from Nelson and Pauatahanui described the behaviour as being "confident" and present for many years. Lastly, observations from Wellington and Nelson described the sugar packet foraging behaviour as having a similar form to the personal observations made in Hamilton; i.e., packets were torn open with beaks and then sugar granules were shaken out onto the ground before being consumed.

4.3.2 Hamilton City distribution

Maps

Of the 174 Hamilton City cafés that were sampled in this study (Figure 4.3), 53 (30%) met the search criteria for the survey (Figure 4.4); i.e., they had sugar packets accessible to sparrows, and/or had a history of sparrows stealing sugar. The survey response rate of staff members at these 53 cafés was 100%. Seventeen of the cafés whose staff completed the survey (32%) were located in the central business district (CBD), 16 (30%) were located on the west side of the river, and 20 (38%) were located on the east side of the river. The red data points were used to indicate cafés that did not have sugar packets accessible to sparrows. The blue data points show cafés that did have sugar packets accessible to sparrows, but staff members had not observed sparrows foraging on the packets at their café. The green data points indicate cafés where sugar packet foraging has been observed.

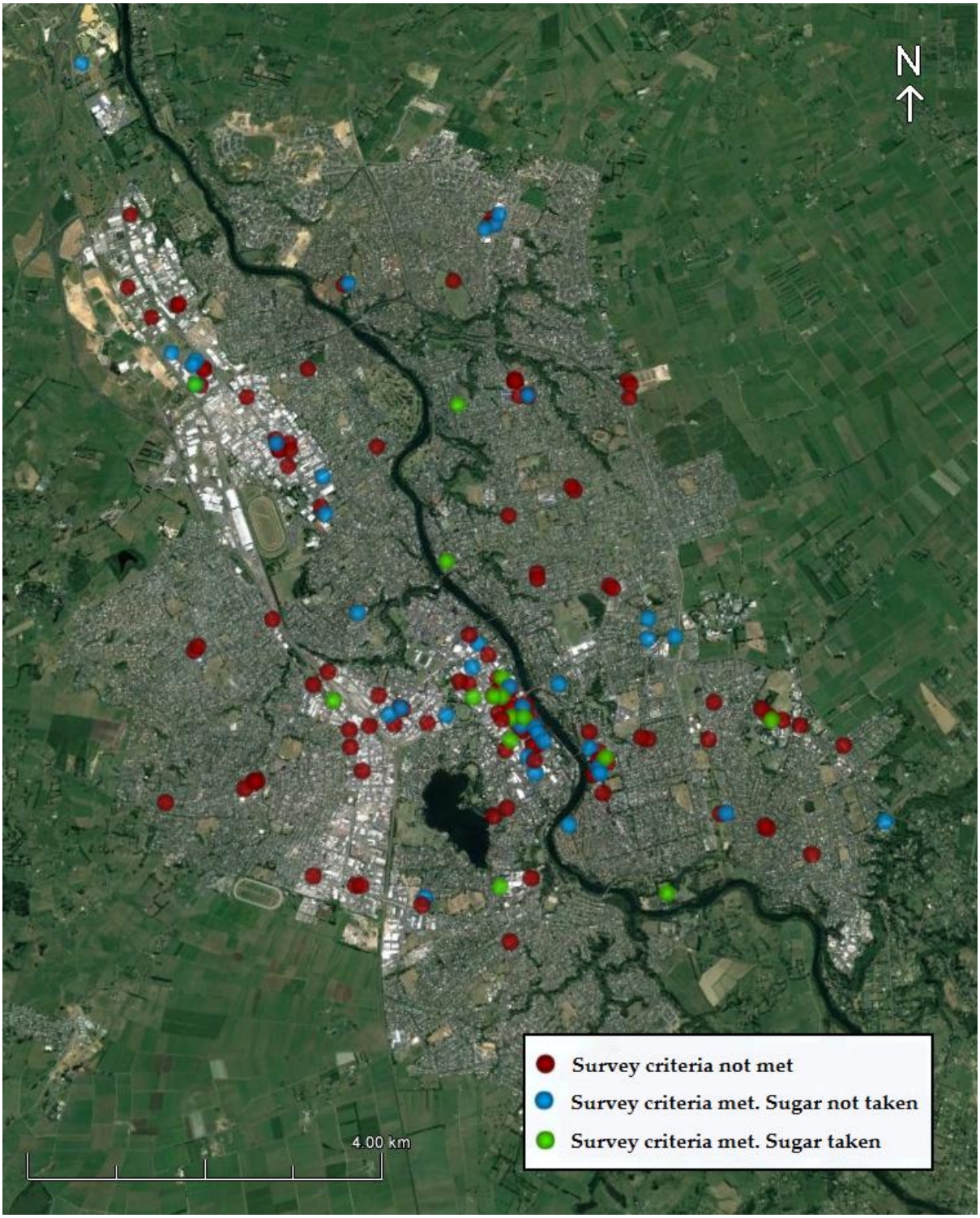

Figure 4.3. Locations of all 174 cafés in Hamilton City that were initially sampled to assess which cafés met the survey criteria (sugar packets were accessible to sparrows at the café and/or the café had a history of sparrows foraging on sugar packets there).

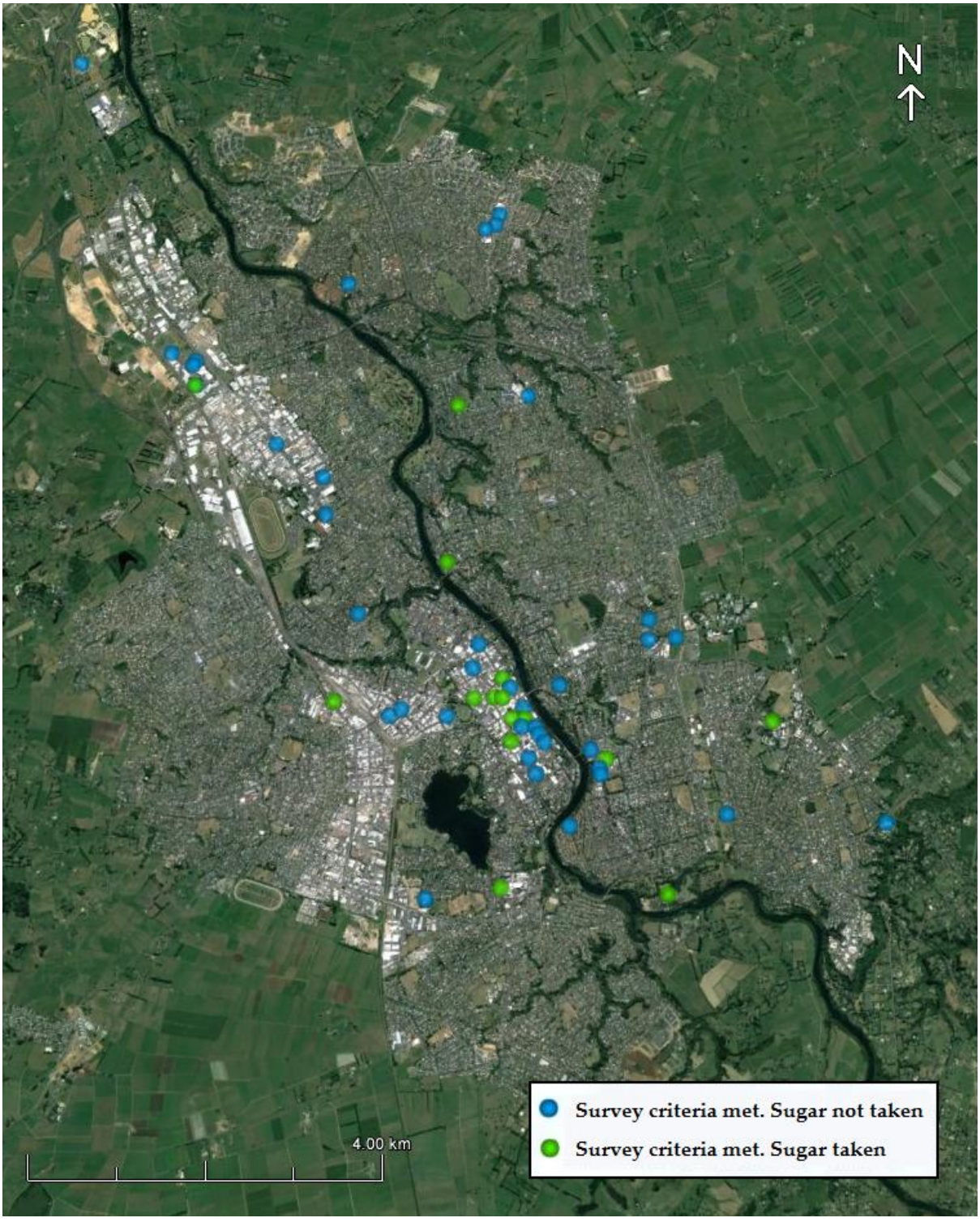

Figure 4.4. Locations of all 53 cafés in Hamilton City that met the search criteria for the survey (sugar packets accessible to sparrows and/or a history of sparrows foraging on sugar packets).

Sugar foraging had been observed at approximately 28% (15/53) of the cafés that completed the survey. Of these, 7/15 (47%) were located in the CBD, 3/15 (20%) on the west side of the river, and 5/15 (33%) on the east side. The farthest distance between adjacent cafés where sugar foraging had been observed was 3.3 km. Because many of the cafés were concentrated in the CBD, another map was constructed showing the distribution of cafés within this area where the survey was answered by café staff (Figure 4.5). Observations of sparrows foraging on sugar packets were clustered together in the centre of the CBD; all seven cafés were within 800 m of each other.

Figure 4.5. Locations of 19 cafés near the centre of Hamilton City that met the search criteria for the survey (sugar packets accessible to sparrows and/or a history of sparrows foraging on sugar packets).

Descriptive statistics

For the 44 cafés where staff did not put out sugar packets but outdoor seating was available, data were collected on the predominant reasons why they did not put out sugar packets. These responses are summarized in Figure 4.6. The most common reasons were because of human theft (n = 15, 34.1%) and because of the weather (n = 13, 29.5%). Five participants (11.4%) had stopped putting sugar on outdoor tables due to thievery by sparrows. Some cafés had switched to having sugar in jars instead of sugar packets for environmental reasons, or because they preferred the style (n = 6, 13.6%).

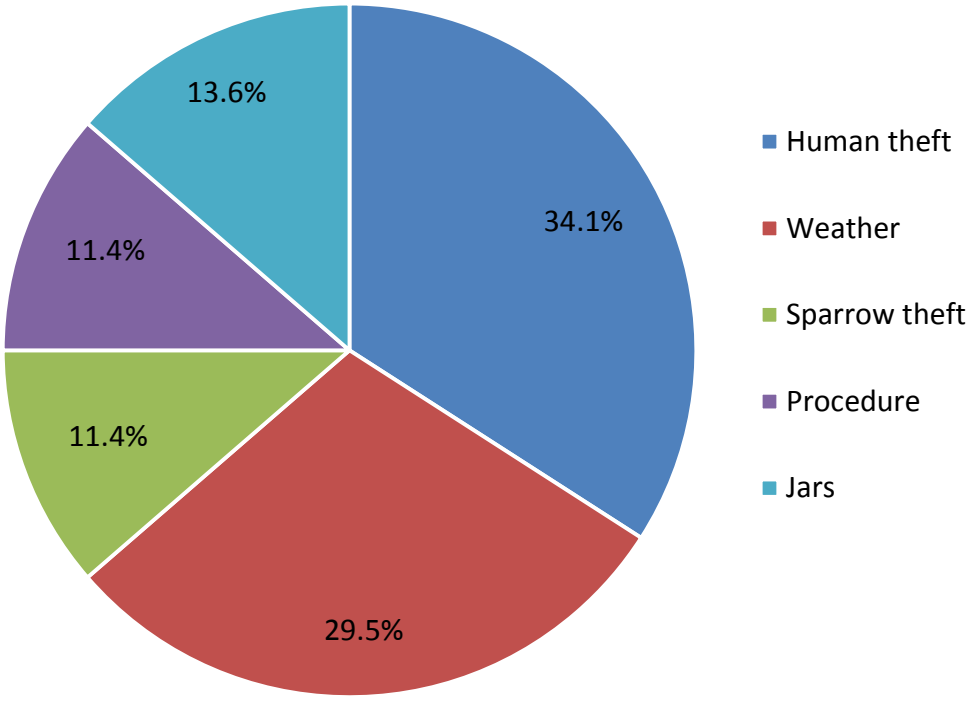

Figure 4.6. Reasons given by Hamilton City café staff members at 44 cafés for not putting sugar packets on outdoor tables.

As described above, staff from 15 cafés had observed sparrows foraging on sugar packets. One café staff member reported seeing a blackbird take a sugar packet from their café, but no other species were reported to have

taken sugar packets. Packet types at cafés included raw sugar, white sugar, and artificial sweeteners. All three options were not available at every café that was surveyed. Raw sugar was available at almost all cafés (n = 51, 96%), whereas white sugar was available at only about half of the surveyed cafés (n = 30, 56%). Artificial sweetener was available at most cafés (n = 47, 89%). The colours of the raw sugar packets and the artificial sweetener packets at these cafés tended to be similar across cafés (Figure 4.7). Raw sugar packets were predominantly brown whereas artificial sweetener packets were predominantly blue or green. White sugar packets were excluded from this analysis because they were present at only 40% of the cafés where sparrows had been observed foraging on sugar packets, whereas raw sugar packets and artificial sweetener packets were available at almost all of these cafés (100% and 93% respectively).

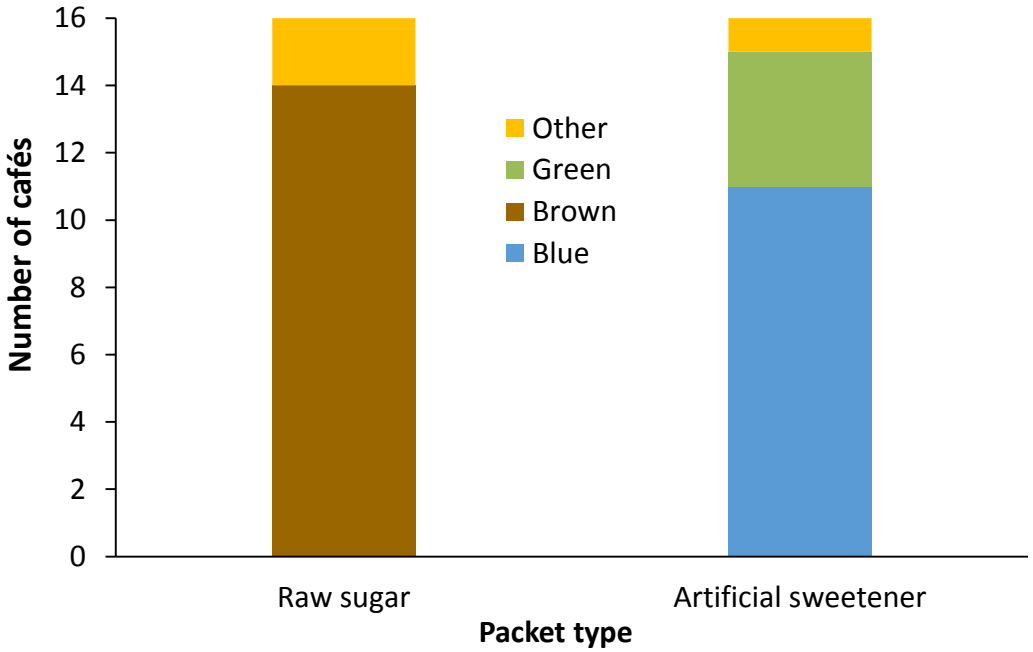

Figure 4.7. The colours of raw sugar packets and artificial sweetener packets from the 15 Hamilton City cafés where sparrows have been observed foraging on packets by café staff.

According to the reports from café staff, raw sugar packets were taken more than the other sugar packet types; however, most respondents were unsure of what types were stolen (Figure 4.8). Each sugar packet type was reported to have been stolen by at least one café. Approximately half of the participants (n = 7, 47%) were unsure of what types of sugar packets were stolen. Although some participants (n = 2, 13%) were confident that raw sugar was not taken from their café, more participants (n = 5, 33%) were confident that artificial sweetener was not taken from their café.

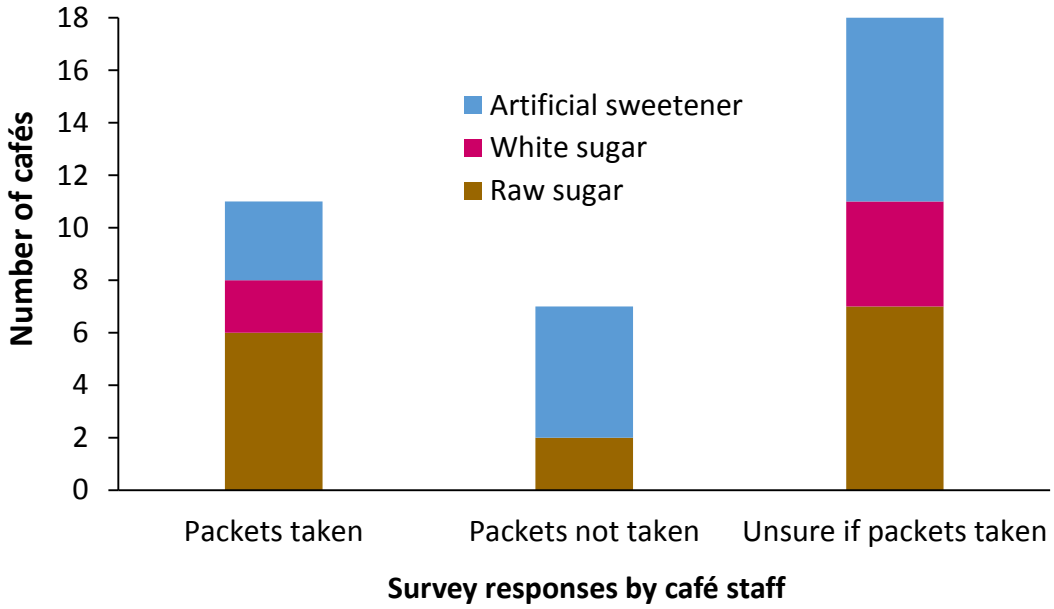

Figure 4.8. Survey responses by café staff on what type of sugar packets they have/have not observed being taken from their café (at the 15 Hamilton City cafés where sparrows have been observed foraging on packets by café staff)

Of the cafés where sparrows had been observed foraging on sugar packets, eight staff members (53%) reported that the staff had modified their own behaviour in response to the sparrows' behaviour. Four cafés (27%) removed sugar packets from all outdoor tables, four cafés encouraged their staff members to chase away the sparrows, one café started using sugar

shakers instead of sugar packets, and another café tried to satiate the birds by feeding them bread before their café opened.

Likert scales

The distribution of survey responses on the number of sparrows present at 53 Hamilton City cafés during peak customer times and off-peak customer times is displayed in Figure 4.9. Though the number of sparrows present appears similar at both times, sparrows were reported in greater numbers when there were fewer customers present. A chi-squared test showed that the distributions of responses about sparrows at peak and off-peak times did not differ significantly ($\chi^2 = 1.469$, $p = 0.566$).

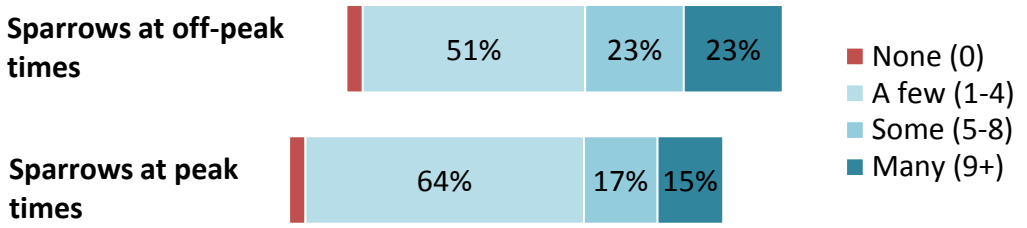

Figure 4.9. The distribution of answers given by respondents on how many sparrows they typically observed at peak and off-peak times for customers at their café. Values under 5% were not displayed with labels.

The degree to which the café staff members perceived the sparrows at their café to be a nuisance is displayed in Figure 4.10. The most common response was "not at all", though the frequency of responses was similar across all categories.

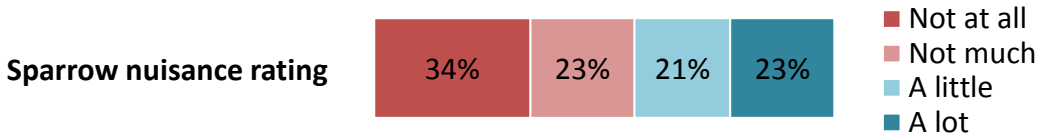

Figure 4.10. The distribution of answers given by respondents (café staff) on how much they perceive sparrows to be a nuisance at their café.

Several attitudes of staff members towards the negative impact of sparrows at their café were analysed collectively in Figure 4.11. Only 6 respondents (11%) had issues with sparrows building nests in their café. The majority of participants disagreed that sparrows invade their customers' personal space, are pests, steal customers' food, and are too noisy. Conversely, the participants tended to agree that sparrows are unhygienic and make a mess. A chi-squared test showed that the responses had significantly different distributions to expected values ($\chi^2 = 5.299$, $p < 0.001$). The seven distributions were then compared to expected values individually using chi-squared tests. Four of the seven distributions were significantly different to expected values. These included "They build nests in my café" ($\chi^2 = 0.839$, $p < 0.001$), "They are too noisy" ($\chi^2 = 0.839$, $p = 0.03$), "They are unhygienic" ($\chi^2 = 1.458$, $p < 0.001$), and "They make a mess" ($\chi^2 = 0.808$, $p < 0.001$).

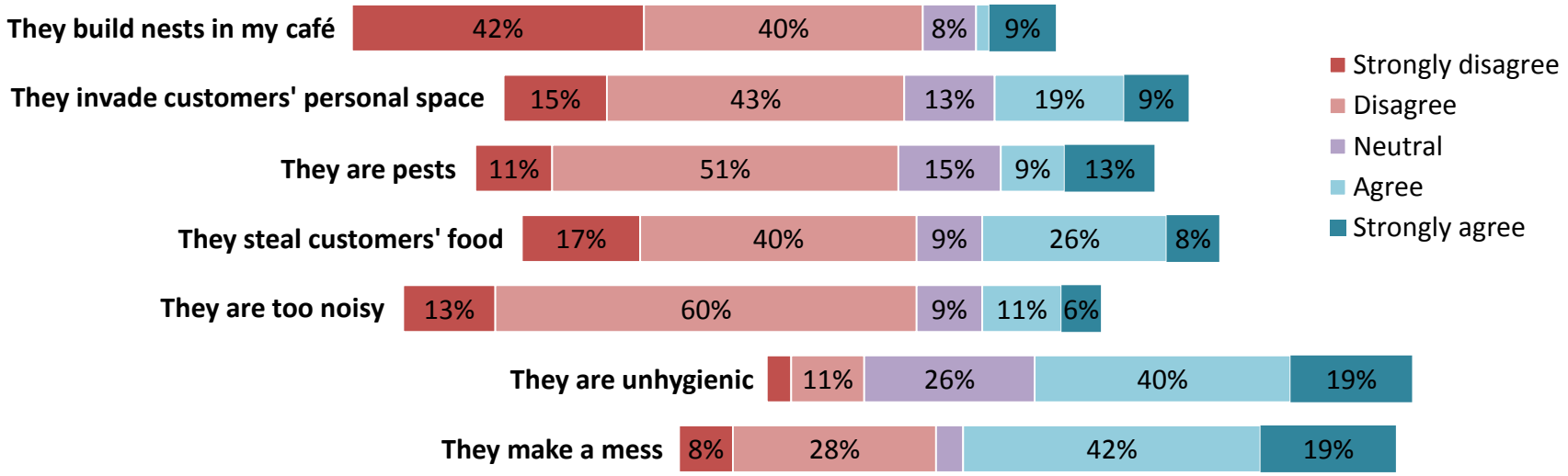

Figure 4.11. Participants' perceptions of the negative impacts of sparrows at cafés. Values under 5% were not displayed with labels.

The attitudes of café staff members towards potential benefits of sparrows at their café are displayed in Figure 4.12. Participants tended to agree that sparrows got rid of food scraps and insects at their cafés. Almost all participants (n = 49, 93%) agreed that sparrows were a part of nature. Participants had mixed attitudes towards the visual benefit, auditory benefit, and entertainment benefit of sparrows being present at their cafés. A chi-squared test showed that the distributions of these responses were significantly different to expected distributions ($\chi^2 = 4.436$, $p < 0.001$). The six distributions were then compared to expected values individually using chi-squared tests. "They are a part of nature" was the only distribution that significantly differed to expected values ($\chi^2 = 0.839$, $p < 0.001$).

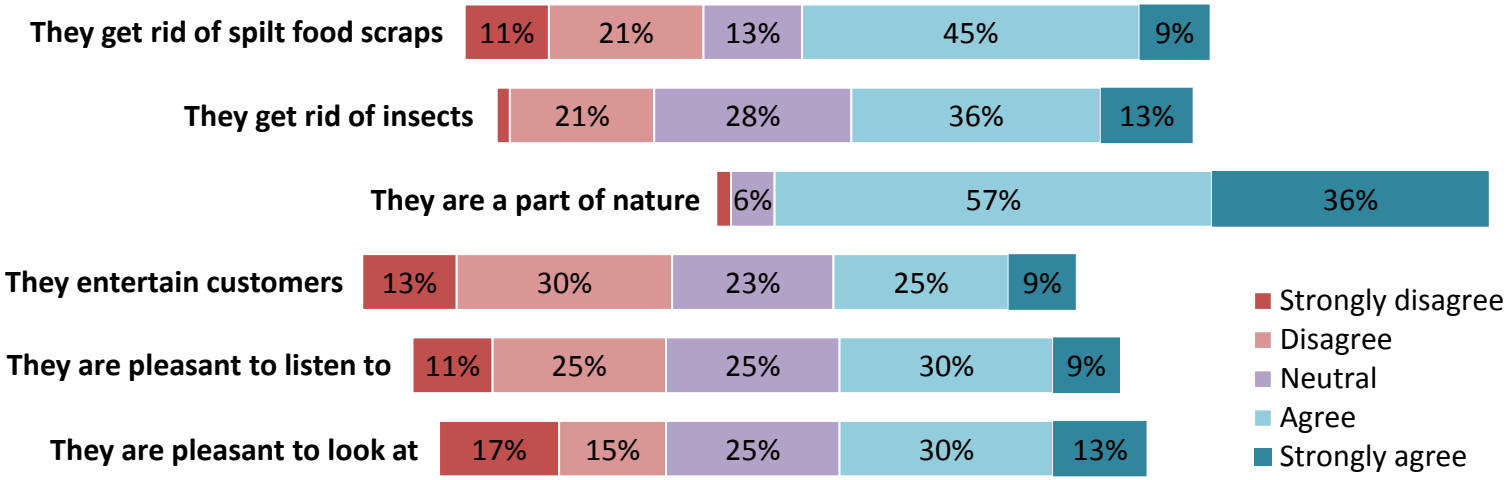

Figure 4.12. Participants' perceptions of the benefits of sparrows at cafés. Values under 5% were not displayed with labels.

4.4 Discussion

The first two aims of this study were to establish the current distribution of sugar packet foraging behaviour by sparrows in New Zealand and comprehensively within Hamilton City. Processes underlying these distributions were also proposed. Thirteen observations of sparrows foraging on sugar packets were recorded across five regions around New Zealand, and 15 observations of this novel behaviour were recorded within Hamilton City. This finding demonstrates that sugar packet foraging in New Zealand sparrows is not just an isolated instance at a single café.

Sparrows move up to 3.2 km daily from their nests and typically forage within a 0.5 km radius, though these ranges vary across populations (Anderson, 2006). Cafés around New Zealand are concentrated in the cities of these regions, and are often scarce in the vast extent of farmland/countryside that separate the cities (much greater than 3.2 km apart). Consequently, it is probable that the sugar packet foraging innovation developed independently in the five regions identified in this study (Ducatez, Audet, & Lefebvre, 2013). Furthermore, sugar packet foraging by sparrows has been observed in both the North and South islands of New Zealand, which are separated by Cook Strait. Cook Strait is 22 km wide at its narrowest point; far too wide for sparrows to cross and transfer the sugar packet foraging behaviour, thus supporting the idea that the behaviour has developed independently in different regions of New Zealand. Sparrows have not been documented using vehicles to disperse to new locations, so the accidental dispersal of sugar-packet foraging sparrows through human assistance is unlikely.

Self-report data were used to analyse the distribution of sugar packet foraging in New Zealand, which restricts the representativeness of the sample. Consequently, the absence of observations from many regions in

New Zealand does not necessarily mean the behaviour does not occur in these regions. The data on sparrows foraging on sugar packers from different regions around New Zealand were collected via responses to an article that was published in a Wellington-based newspaper, thus increasing the chance that a respondent was in close proximity to the Wellington Region.

The distribution of sugar packet foraging by sparrows in Hamilton City suggests that the behaviour may have spread both socially and asocially. The furthest distance between cafés in Hamilton City where sugar packet foraging had been observed was 3.3 km. It is not impossible that sparrows travelled between these cafés, but it is unlikely given their typical foraging radius of 0.5 km (Anderson, 2006), and therefore it is more probable that the behaviour was learned independently at these different locations. Furthermore, there are many cafés between sites of observed sugar foraging where the behaviour has not been observed, despite having sugar packets accessible to sparrows. If the behaviour spread socially from a single source, the behaviour would be expected at all intermediate cafés (Ducatez, Audet, & Lefebvre, 2013).

In the Hamilton City CBD, seven cafés were found all within 800 m of each other where sugar packet foraging behaviour by sparrows has been observed. This clustering suggests that the behaviour may have been spread socially across these cafés (Ducatez, Audet, & Lefebvre, 2013; Lefebvre, 1995). The cluster is located in the centre of the CBD where there is a high concentration of cafés. Furthermore, there is a grassed area containing trees near the centre of the cluster in an area called Garden Place, which may provide suitable nesting habitat for the sparrows. This greenspace habitat may also facilitate the sparrows' social network and maintain high rates of social transmission (Boogert et al., 2014).

Consequently, it is possible that that sugar-packet foraging sparrows in the CBD have clustered around dense resources. This analysis could be developed further in future research by examining the distance networks between cafés where sugar packet foraging was possible and where the behaviour has been observed.

Recently developed suburbs of Hamilton City such as Rototuna (North-east Hamilton) had cafés that had sugar packets accessible to sparrows but had no observed sugar packet foraging. This is consistent with the research on milk bottle opening by birds in Europe, which demonstrated that the milk bottle opening innovation took several years to establish in areas where milk bottles had recently been introduced (Fisher & Hinde, 1949). Future research would benefit from assessing the impact of different degrees of urbanization (urban vs. rural) on the distribution of sugar foraging behaviour by sparrows.

Of the 174 sampled cafés, 121 did not have sugar packets accessible to sparrows for a variety of reasons. Theft by homeless people was the most common reason for not putting out sugar packets, especially in the CBD. This may reflect some of the poverty within Hamilton City. Staff from 15 cafés had observed sparrows taking sugar packets from their café. Only about half of these 15 cafés found the sugar foraging behaviour enough of an issue to modify their behaviour, which was most commonly achieved by keeping the sugar packets indoors.

Almost all cafés that put out packets provided both raw sugar packets and artificial sweetener packets. Most of the raw sugar packets were brown coloured, and most of the artificial packets were blue or green coloured; blue for aspartame and green for stevia (Stein, 2011). Sparrows were observed taking brown packets more often than blue/green packets. This observation is consistent with known food colour preferences of sparrows.

Gionfriddo and Best (1996) found that sparrows foraged preferentially on brown, yellow, or white grit over red, green, blue, and black grit. However, approximately half of the participants in the current study were unsure what packet colours had been taken from their café. On average, staff members reported more sparrows being present when there were fewer customers around, though this difference was not statistically significant.

The third aim of this study was to determine how café staff felt about sparrows being present at their cafés. Overall, sparrows were not usually considered very problematic, except on issues of mess and hygiene, so management of sparrows at cafés should be targeted towards keeping the outdoor areas tidy and clean. Collectively, the results showed that the responses about the negatives of sparrows at cafés were not distributed equally, e.g., many participants agreed that sparrows made a mess at their café and many participants disagreed that the sparrows at their café were too noisy. There was a mixed distribution of nuisance ratings, and the most common response was "not at all", supporting the idea that the presence of sparrows at cafés is not a pressing issue for most café staff members.

The majority of responses on the benefits of sparrows at cafés were evenly distributed across the Likert scale, indicating mixed opinions from café staff on the benefits of sparrows at cafés. The only response that was different from expected values was "They are a part of nature", in which 93% of the responses were either "agree" or "disagree". This is may indicate that café staff members highly value the sparrows at their cafés for being a part of nature. However, it may also be a result of the interpretation of the survey question. The question was presented as "I like sparrows at my café because they are a part of nature". However, this was potentially interpreted as "sparrows at my café are a part of nature", which would consequently alter

the way the data should be interpreted. This feature applies to all of the Likert scale questions.

Like all surveys, the surveys completed by café staff members had inherent limitations (Price & Murnan, 2004). As previously stated, individual participants might interpret the same survey questions differently. Secondly, many of the participants answered these surveys whilst working, and had pressure to complete the surveys quickly rather than thoroughly. This was especially obvious at cafés around mall complexes where they were constantly busy with customers. Not all staff members were asked if they had observed sparrows taking sugar packets (usually the manager would delegate the least busy staff member to answer the survey). This increased the likelihood of receiving false negatives (i.e., the indication that no sparrows had not been seen taking sugar packets from the café when in fact, it had been noticed by a different staff member). However, it was not possible to assess this error rate. As a consequence, the true prevalence of sugar foraging by sparrows is likely to be higher than suggested by this study.

Chapter 5

Public attitudes towards sparrows at cafés

5.1 Introduction

Despite common perceptions, cities are rich with nature (Shilthuizen, 2018). Urban inhabitants interact with nature every day, whether it be feeling the grass between their toes on the lawn, listening to the starlings nesting in their roof, or watching the sparrows scrounge for food scraps at their favourite café. These daily interactions are unavoidable, and are often perceived as either 'pleasant' or 'unpleasant'. On the other hand, many human-nature interactions in the city go unnoticed, or are viewed with indifference (Clergeau et al., 2001). An ideal scenario would maximise the pleasant interactions with nature and minimize the unpleasant ones. However, human-nature conflicts are common in cities, ranging from minor nuisances to major problems (Soulsbury & White, 2016). Major issues are usually dealt with promptly, such as the infestation of a pest species. However, less pressing issues are often put aside.

Maintaining positive attitudes towards nature is important for human health, as has been demonstrated in many studies on relatedness to nature and mindfulness (Brown & Grant, 2005; Maller et al., 2006; Taylor & Hochuli, 2015), and may provide benefits for the birds as well, such as food gained from provisioning by humans and increased survival as a result of the control of rodent pests (Robb et al., 2008). Because most people spend much of their lives in cities, city greenspaces are optimal places to promote positive interactions with nature. A positive interaction with nature for one person may very well be perceived differently for another person. This variability in attitudes can make it difficult to promote appropriate

interactions with nature in cities (Bjerke, Østdahl, & Kleiven, 2003; Clucas & Marzluff, 2012). Consequently, a crucial step in this process is to assess people's attitudes towards their interactions with nature in a given context. For example, French citizens tend to have stronger negative attitudes towards pigeons in France than do tourists (Skandrani et al., 2015). This difference has been attributed to sociological factors, such as a strong cultural ideology that pigeons are unhygienic.

It is currently unknown how New Zealanders feel towards the presence of sparrows at cafés. If people tend to find them find them problematic, perhaps it is best to deter them from cafés, thus reducing people's negative interactions with nature. On the other hand, if people tend to have positive interactions with sparrows at cafés, these interactions could be facilitated or left as they are, thus strengthening or maintaining people's positive interactions with nature in cities. The aim of this study was to investigate the attitudes of New Zealanders towards the presence of sparrows at cafés. The main attitudes of interest were the perceived benefits of sparrows at cafés and the perceived problems of sparrows at cafés. It was hypothesized that the general public in New Zealand would like sparrows being present at cafés, as small birds tend to be liked more by people than other urban animals (Bjerke & Østdahl, 2004).

5.2 Methods

5.2.1 Pilot survey

Attitudes of the general public towards the presence of sparrows at cafés were assessed using a survey. A pilot survey was conducted to develop the survey content, and to ensure that the constructs that were measured in the survey had internal consistency. A brief description of the pilot study is provided below, detailing only where methodological improvements were made.

Participants

Participants for a pilot survey were recruited from staff members and students at the University of Waikato, Hamilton, New Zealand. These participants were approached in person and asked if they would anonymously participate in the pilot survey. The pilot survey used a total of 40 participants.

Procedure

Printed copies of a pilot survey were distributed to an initial group of 30 staff members/students at the University of Waikato. Participants were asked to complete the survey and provide constructive criticisms of the survey, including issues with length, clarity, and relevant content. Participants reported no difficulty in understanding the survey questions. The average survey completion time was 10 minutes. The pilot survey answers were also used to test the internal consistency of the survey using Cronbach's alpha (α):

$$\alpha = 1 - (MS_{Error}/MS_{ROWS})$$

Cronbach's alpha measures the degree to which all items in a value class measure the same construct. A Cronbach's alpha of 0.7 or higher is

generally considered an acceptable level of internal consistency, though this is debated in the literature (Taber, 2018). The pilot survey results showed that every value class except "tidiness" had acceptable internal consistency (Table 5.1). Slight alterations to the survey content were made based on the results from the pilot survey. Once the modifications had been made, a second pilot survey was conducted to check Cronbach's alpha for the "tidiness" value class, using 10 additional participants from the University of Waikato. The second pilot survey had an acceptable Cronbach's alpha (0.77). The modified version of the pilot survey was used to conduct the full survey.

Table 5.1. Cronbach's alpha score for each value class within the pilot surveys.

Value class	Cronbach's alpha
Visual Aesthetics	0.93
Auditory Aesthetics	0.93
Provisioning	0.76
Entertainment	0.93
Pest Control	0.81
Nature	0.79
Tidiness	0.48
Tidiness (modified)	0.77*
Personal Space	0.74
Anti-pest	0.81
Quiet	0.88
Hygiene	0.74
Food Security	0.79

* indicates a value that was obtained from the second pilot survey

5.2.2 Participants

Participants for the full, online survey were recruited through social media and word of mouth. A link to the survey was shared by several organizations and personal accounts to maximise the social media outreach. The survey garnered 306 participants, 249 of which completed the entire

survey. The greatest ethical consideration for this research was the confidentiality of the data, as personal information such as age and ethnicity were collected. Participants also had the option to provide their email addresses if they wanted a chance to win a $50 Pak'nSave voucher or if they wanted to receive a copy of the research results. Accordingly, human ethics approval for this research was granted by the University of Waikato Faculty of Science and Engineering Human Research Ethics Sub-committee (protocol FSEN_2018_7). All personal information was kept separate from any email addresses that were collected to maintain the confidentiality of the participants.

5.2.3 People, Cities and Nature collaboration

People, Cities and Nature (PCaN) is a New Zealand urban ecological research programme, and one of its research projects has been looking at the public perception of birds in urban greenspaces. Researchers on the PCaN project assisted in developing and refining aspects of the current survey. Certain questions from their survey were copied directly into the survey for the current study, to collect additional data for their research. Because the project topics are interrelated, the mix of questions did not disrupt the survey flow.

5.2.4 Survey content and procedure

Qualtrics (survey-building software) was used to construct and distribute the survey online. The survey contained 75 questions, had a mix of open/closed question types, and took approximately 10 minutes on average to complete (see Appendix G for the full survey). The beginning of the survey contained a short informative section about the nature of the survey.

A chance to win one of four $50 Pak'nSave supermarket vouchers was used as incentive for participation in the survey (Deutskens, Ruyter, Wetzels, & Oosterveld, 2004). The survey content was made up of three sections:

Demographics and familiarity with urban birds

The first section asked for demographic information on the participant's age, gender, country of birth, and ethnicity. This section was an important component for the PCaN project. Furthermore, a question was added about the number of household pets owned by the participant. The questions on "Encounters with animals" were taken directly from the PCaN survey, and required participants to rank their top five birds from 16 images of local birds and explain the reasons for their ranking order. The data were transformed so that top ranks were given a score of five and bottom ranks were given a score of one so that the degree of familiarity could be incorporated into the analysis. These familiarity scores were summed and compared across species both before and after the transformation of the data. Discerning the positioning of sparrows in this ranking was the primary objective of this analysis. A set of five statements about sparrows were presented to the participants (henceforth referred to as "sparrow statements". Participants were required to select the statements they considered to be true, and could select up to five of the answers. Likert scales were used to assess the frequency of café visitation by participants and the general feelings towards sparrows being present at cafés. Participants were also given an opportunity to share personal observations about sparrows at cafés in an open-ended format.

Specific attitudes towards sparrows at cafés

The second section contained the 35 core questions of the survey, which used value-based Likert scales to assess the attitudes of participants towards sparrows at cafés; these were adapted from Belaire et al. (2015).

The core questions of the survey were grouped into different "value classes", such as the degree to which people value hygiene at cafés, or the degree to which they value the ability to feed the birds at cafés. Value classes were separated into reasons for liking birds at cafés (Table 5.2) and reasons for disliking birds at cafés (Table 5.3).

Table 5.2. Survey questions regarding how people value the presence of sparrows at cafés. Note: in the actual survey the 'Value' column was not visible to participants and the order of the questions was randomized.

1	**2**	**3**	**4**	**5**
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
I like sparrows at cafés because…			**Value**	
They are pleasant to look at			Visual Aesthetics	
Watching them makes me happy			Visual Aesthetics	
They are beautiful birds			Visual Aesthetics	
They have a familiar call			Auditory Aesthetics	
They sound nice			Auditory Aesthetics	
They are pleasant to listen to			Auditory Aesthetics	
They come close to me for food			Provisioning	
It is fun to feed them scraps			Provisioning	
I can feed them food I don't want			Provisioning	
They are entertaining			Entertainment	
They interest me			Entertainment	
They are fun to observe			Entertainment	
They control pests			Pest Control	
They get rid of insects			Pest Control	
They keep rodents away by eating leftover food			Pest Control	
They are a part of nature			Nature	
They are important for the ecosystem			Nature	
They have the right to be there			Nature	

Table 5.3. Survey questions regarding how people do not value sparrows at cafés. Note: in the actual survey the 'Value' column was not visible to participants and the order of the questions was randomized.

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
I find sparrows problematic at cafés because…			**Value**	
They make a mess			Tidiness	
They increase litter in the area			Tidiness	
They make the area untidy			Tidiness	
They violate my personal space			Personal Space	
They land on my table			Personal Space	
They come too close to me			Personal Space	
They are pests			Anti-pest	
They are bad for the environment			Anti-pest	
They are not native			Anti-pest	
Their calls make it difficult to relax			Quiet	
They are too noisy			Quiet	
They are unpleasant to listen to			Quiet	
They are unhygienic			Hygiene	
They are dirty creatures			Hygiene	
They contaminate the tables and chairs			Hygiene	
They annoy me for my food			Food Security	
They steal my food			Food Security	
They prevent me from leaving my food alone			Food Security	

Nature-relatedness

The final section of the survey used a standard survey (Nisbet, Zelenski, & Murphy, 2009) to assess participants' connection to nature. The nature relatedness (NR) survey uses Likert scales to assess the degree to which each participant perceives and interacts with nature. The NR scores were

calculated for each participant and were grouped into one of five categories, including “strongly not related to nature”, “related to nature”, “neutral”, “related to nature” and “strongly related to nature”. All categories were of equal weight (1 Likert unit) except for the neutral category which only covered 0.1 Likert units.

At the end of the survey, participants had the option to input their email address to receive a copy of the research results and/or to participate in a prize draw for $50 Pak’nSave supermarket vouchers. A separate survey was created to collect the email address information so that the email addresses were not linked to the personal data. Furthermore, the prize draw was supervised by a Justice of the Peace to ensure there was no bias in the selection of the prize winners.

A link to the survey was made available to the public on Sunday the 11th November 2018. The survey could be completed online via Qualtrics through a computer or a smartphone. The survey was distributed through social media outlets, predominantly Facebook. Several organizations and personal accounts shared the survey link on their social media profiles. The survey remained accessible for approximately four weeks and was closed on Friday the 15th of December 2018.

5.2.5 Data analysis

The data were downloaded directly from the Qualtrics website in the form of a Microsoft Excel worksheet. Microsoft Excel was used to conduct all of the statistical analyses and produce all of the graphs. The data on ethnicity and country of birth were not used in the analyses. Descriptive statistics were produced for the demographic data and graphs were produced where appropriate. Likert scale responses were summarized in the form of

diverging stacked bar graphs, which were used to determine how participants perceived the impacts of sparrows at cafés (Robbins & Heiberger, 2011). The median was used instead of the mean as the measure of central tendency as whole numbers are more meaningful in the interpretation of Likert scale data (Sullivan & Artino Jr, 2013). The distributions of the Likert scale data were compared to expected values using chi-squared tests. The significance level for the chi-squared tests was set to $a = 0.05$. All p values were reported to three decimal places, and p values smaller than 0.001 were reported as $p < 0.001$. The scores from the NR scale were calculated for each of the participants and graphed.

5.3 Results

5.3.1 Descriptive statistics

The public attitudes survey had 306 responses online, of which 249 (81%) participants completed all of the survey. Participant ages ranged from 17 to 70 years of age, with a median age of 27. The majority of the participants were female (80%), and 71% of participants owned at least one pet (Figure **5.1**).

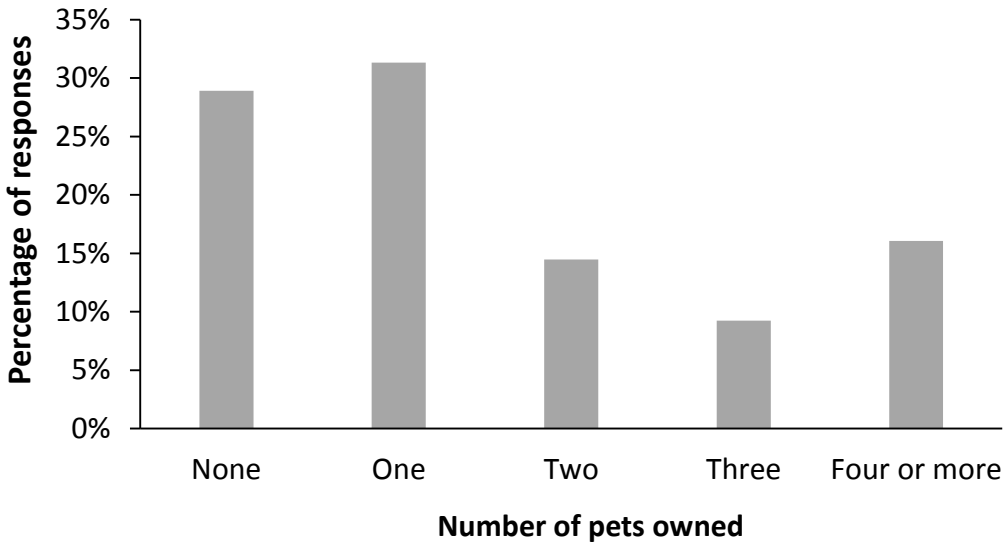

Figure 5.1. The number of pets owned by survey participants.

The ranking of birds in order of decreasing familiarity to participants is displayed in Table 5.4. Sparrows had the highest weighted familiarity score of 904, followed by a score of 497 for blackbirds (*Turdus merula*), 441 for fantails (*Rhipidura fuliginosa*), and 416 for tui. Only three birds changed their position in the ranking order after the transformation of the data (fantails moved down one ranking, tui moved down one ranking, and blackbirds moved up two rankings). Sparrows and blackbirds therefore had the highest number of top rankings across individual responses.

Table 5.4. Survey participants' combined familiarity ranking of birds found in Hamilton City in order of decreasing familiarity.

Ranking	Bird (common name)	Weighted familiarity score
1st	Sparrow	904
2nd	Blackbird	497
3rd	Fantail	441
4th	Tui	416
5th	Myna	388
6th	Kereru	230
7th	Starling	176
8th	Song thrush	142
9th	Kingfisher	124
10th	Silvereye	90
11th	Grey warbler	84
12th	Spotted dove	70
13th	Eastern rosella	68
14th	Chaffinch	38
15th	Swallow	34
16th	Plover	33

Participants' responses to each of the sparrow statements are displayed in Figure 5.2. Because it was possible to have multiple answers to this question, responses are displayed as frequencies rather than percentages. The most popular answer was that sparrows are a part of nature (n = 157, 63%). Sixty-three participants (25%) correctly reported that sparrows are exotic/non-native, whereas only 19 participants (8%) responded that sparrows are native.

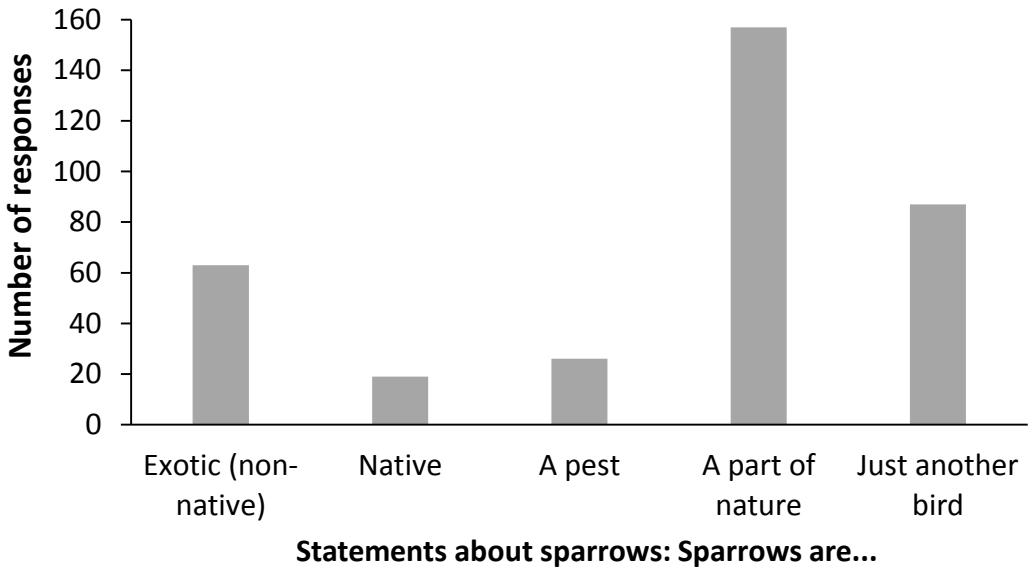

Figure 5.2. The number of participants that agreed with five descriptive statements about sparrows from an online survey that was distributed to the general public of New Zealand.

Approximately half of the participants (n = 111, 45%) reported that they visited cafés at least once a week (Figure 5.3). However, 21% of participants (n = 52) reported that they visited cafés less than once a month. When at cafés, most participants (n = 168, 68%) usually notice if sparrows are present (Figure 5.4). It was also notable that 69 participants (28%) had observed sparrows foraging on sugar packets at cafés.

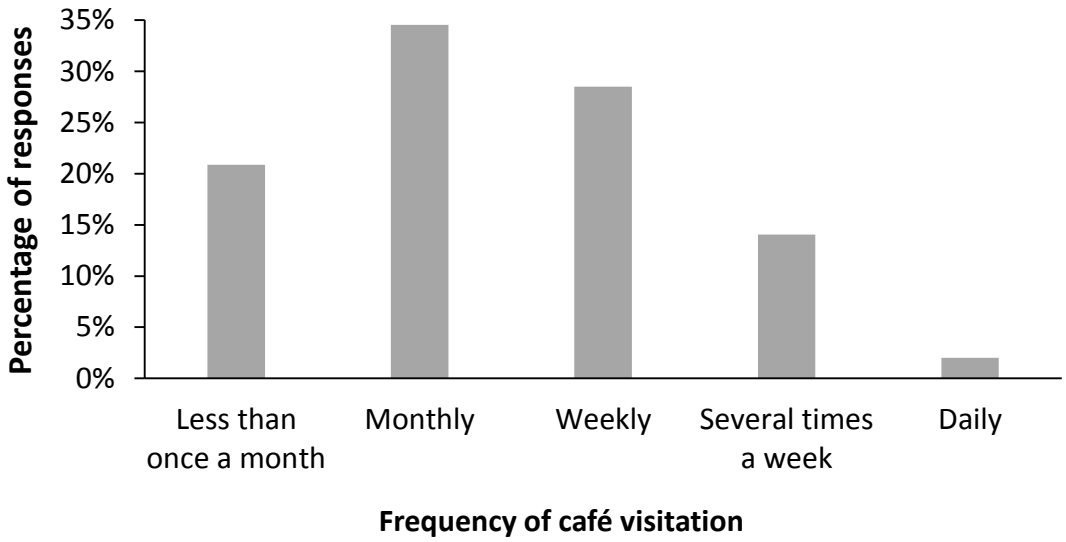

Figure 5.3. Frequency of café visitation by 249 survey participants.

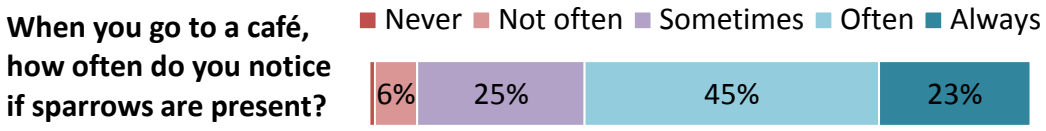

Figure 5.4. Proportion of survey participants that notice the presence of sparrows when they go to cafés. Values below 5% are not displayed with labels.

Common themes from participants' personal observations about sparrows at cafés are summarized in Table 5.5. Many observations were of sparrows taking different types of food from café tables, such as pasta, muffins, crumbs, and even marshmallows. Sparrows were often described as being entertaining to both adults and children. The greatest criticisms of sparrows in these comments were instances of sparrows defecating in close proximity to eating areas.

Table 5.5. Summary of participant observations about sparrows at cafés.

Observation	n
Sparrows being bold	12
Sparrows being entertaining	15
Sparrows being fat	4
Sparrows fighting over food	2
Sparrows stealing sugar	4
Sparrows taking/attempting to take food	21
Sparrows being unhygienic	8

When participants were asked if they felt that sparrows should be present at cafés, the most common response was neutral (n = 97, 39%; Figure 5.5). However, there was a greater distribution of participants in favour of sparrows being present at cafés (n = 96, 39%) than those against (n = 56, 22%). Furthermore, when participants were asked how they would feel if sparrows were no longer around, the vast majority of participants (n = 183, 74%) answered that they would feel sad if sparrows were no longer around (Figure 5.6). In contrast, only a few participants (n = 14, 6%) answered that they would feel happier if sparrows were no longer around.

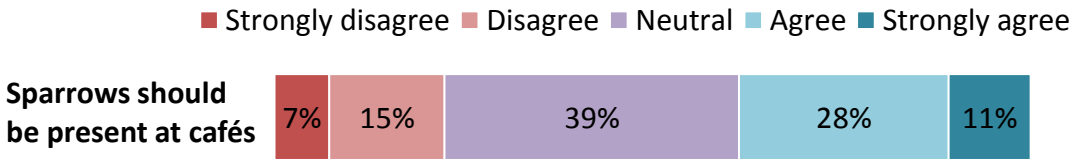

Figure 5.5. Attitudes of survey participants towards sparrows being present at cafés.

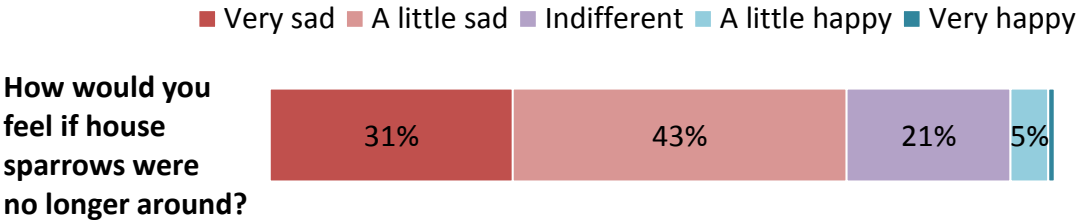

Figure 5.6. Attitudes of survey participants towards the presence of sparrows in their lives. Values under 5% are not displayed with labels.

5.3.2 Specific attitudes towards sparrows at cafés.

The responses of participants to all 35 Likert scale items can be found in Appendix H. The perceived benefits of sparrows being at cafés by survey participants are summarized in Figure 5.7. The majority of participants (>50%) agreed that sparrows added visual aesthetic value, entertainment value, and nature value to cafés. Many participants (~40%) were undecided or had neutral feelings about sparrow vocalisations being heard at the café, and about the sparrows' role in controlling pests at cafés. As a group, participants were divided on whether there was value in being able to feed sparrows at cafés (42% agreed, 38% disagreed). A chi-squared test showed that the responses in this set had significantly different distributions (χ^2 = 1.14, $p < 0.001$). Five out of the six distributions differed to expected values ($p < 0.001$ for all significant differences). Visual aesthetics value was the only distribution that was not different to expected values ($\chi^2 = 0.119$, $p < 0.097$).

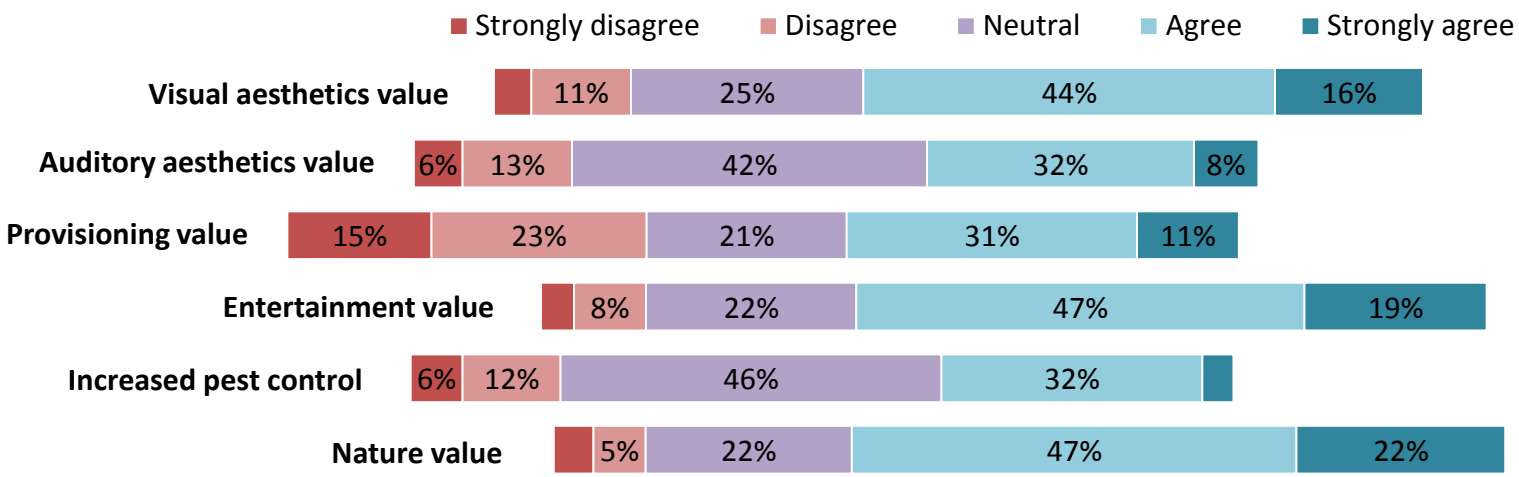

Figure 5.7. Summary of participants' perceptions of the benefits of sparrows being present at cafés. Values under 5% are not displayed with labels.

The perceived negative impacts of sparrows being at cafés by survey participants are summarized in Figure 5.8. In general, participants tended to disagree with statements about sparrows having a negative impact on their café experience, with disagreement over 50% in five out of six value classes. In contrast, 50% of participants agreed that sparrows worsened their café experience by being unhygienic, while only 24% disagreed with this. Collectively, the responses in this set indicated that people don't tend to find sparrows problematic at cafés, except for on matters of hygiene and cleanliness. A chi-squared showed that the responses in this set had significantly different distributions ($\chi^2 = 1.27$, $p < 0.001$). Two of these distributions differed to expected values, which were decreased quiet ($\chi^2 = 0.08$, $p < 0.001$) and decreased hygiene ($\chi^2 = 0.654$, $p < 0.001$).

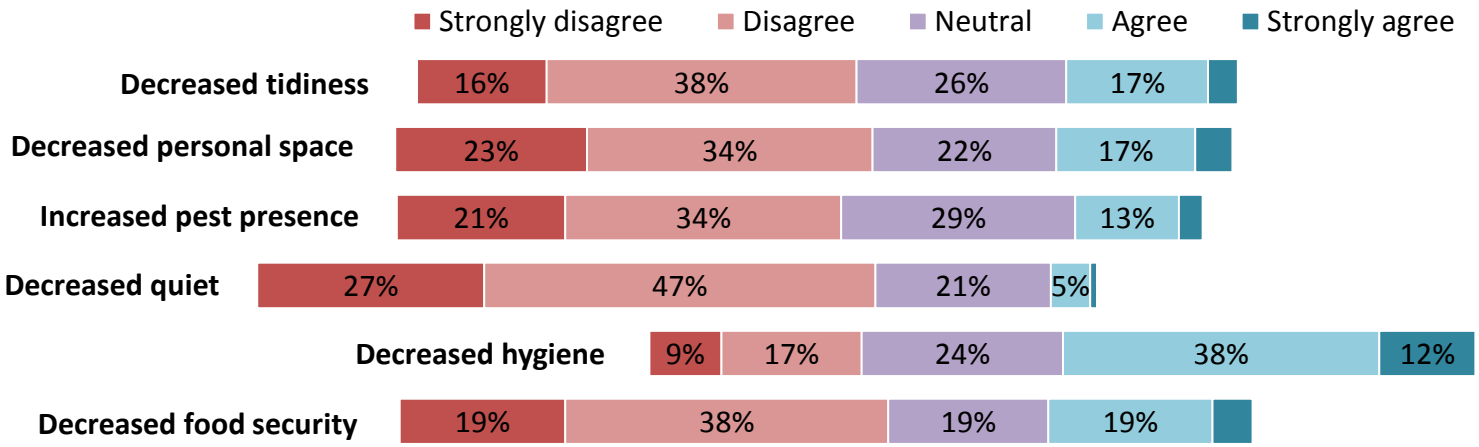

Figure 5.8. Summary of participants' perceptions of the negative impacts of sparrows at cafés. Values under 5% were not displayed with labels.

5.3.3 Nature relatedness

The categorized nature relatedness scores of participants are displayed in Figure 5.9. The vast majority of participants (235, 97%) either "related to nature" or "strongly related to nature". Only two participants "did not relate to nature", and none of the participants "strongly did not relate to nature".

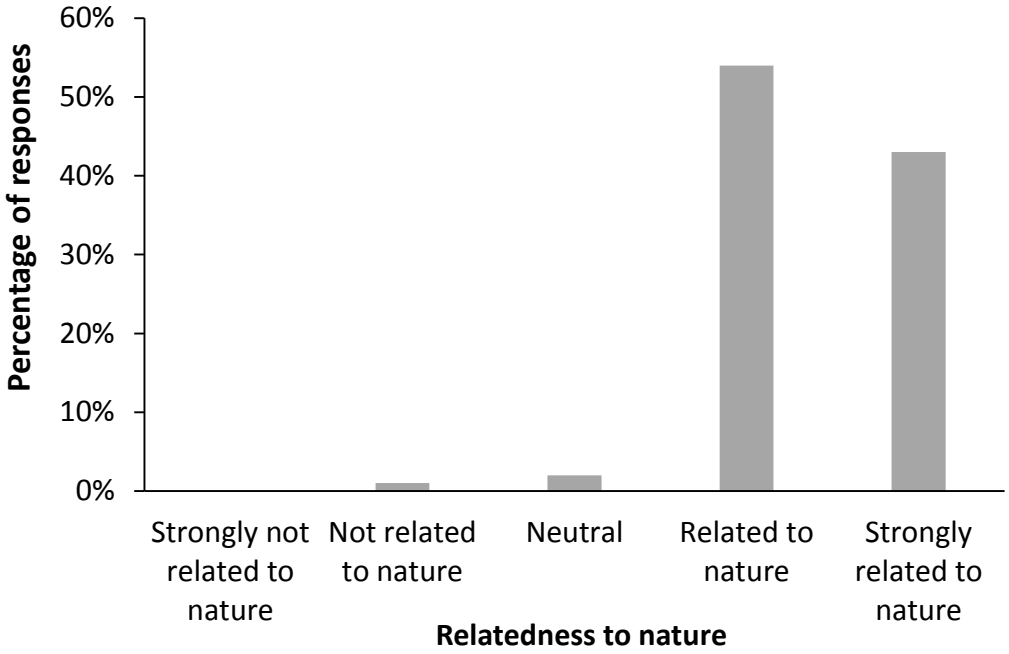

Figure 5.9. Distribution of the nature relatedness scores of 249 participants from an online survey that was distributed to the general public of New Zealand.

5.4 Discussion

The aim of this study was to investigate the attitudes of the general public towards sparrows being present at cafés. Overall, the results suggested that people tend to like sparrows being present at cafés. Sparrows were also by far the most familiar bird to participants. The high familiarity of sparrows may have been biased by the recruitment methodology, as people who choose to take a survey on sparrows are likely to be more familiar with them. However, the result is also not surprising as sparrows are ubiquitous in urban environments around the world (Anderson, 2006). The high familiarity that the survey participants had with sparrows indicates that people are likely come into contact with sparrows on a regular basis. Consequently, sparrows have a disproportionately greater potential of reducing urbanites' "extinction of experience" through positive interactions than do other birds found in the urban environment (Skandrani et al., 2015).

In the sparrow statements section of the survey, 87 participants (35%) answered that sparrows were "just another bird", which was interpreted as the participant having an indifferent attitude towards sparrows in general. Approximately 37% of participants did not answer that sparrows were a part of nature, which may indicate that these participants have a low relatedness to nature. However, only seven participants had low nature relatedness scores, and so it may be more pragmatic to assume that some participants did not select all of the statements that they agreed with. Although the question on sparrow statements requested participants to "select at least one", it may have been more appropriate to request participants to "select all that you agree with" to avoid confusion in the interpretation of the results. Nineteen participants considered sparrows to be native, despite the fact that they are exotic and classified as "introduced and naturalised" (Robertson et al., 2016); and only 10% of participants indicated that they thought sparrows were pests. These results may reflect

the general societal attitudes towards sparrows in contrast to strongly negative attitudes towards other exotic species such as the brushtail possum (Russell, 2014). For example, a survey of 1,002 New Zealanders found that 96% of the participants viewed possums as a problem in New Zealand (Wilkinson & Fitzgerald, 2006).

Participants had varying attitudes towards the benefits of sparrows at cafés. Some benefits were largely viewed with indifference, such as the enjoyment gained from hearing sparrows' calls, and their ability to control pests, whereas other benefits tended to have strong agreement, such as the entertainment value of sparrows and their value as a part of nature. Very small proportions of the participants disagreed with the potential benefits of sparrows at cafés, supporting the idea that members of the public in New Zealand tend to like sparrows at cafés.

Very small proportions of the participants agreed with the potential negatives of sparrows at cafés, thus further supporting the idea that sparrows are generally liked and well tolerated. However, most participants agreed that sparrows decreased the level of hygiene at cafés. Consequently, the public perception of sparrows at cafés could be improved by maintaining high hygiene standards, e.g., regularly cleaning sparrow droppings off tables and chairs. Deterring sparrows from cafés would also solve the hygiene issue, but successful deterrents have not been established (Cameron et al., 2018), and members of the public would then lose the perceived benefits of sparrows being present at cafés. Most participants (74%) also answered that they would be sad if sparrows were no longer around. However, many participants were ambivalent about whether or not sparrows *should* be present at cafés. From a pragmatic perspective, it is probably easiest for café staff to tolerate the sparrows at their cafés, and modify their own behaviours to minimise negative effects of sparrows being present. This could be achieved by clearing plates

immediately after the customers have left, discouraging customers from feeding the birds, and potentially by keeping raw sugar packets indoors.

Approximately half of the participants usually visited a café at least once a week. These participants may have had stronger opinions about sparrows than the other half of the participants, as they are exposed to sparrows at cafés more often. Conversely, these participants may be habituated to the presence of sparrows at cafés and therefore notice them less. However, most participants (68%) reported that they usually notice if sparrows are present at cafés, so the habituation hypothesis is less likely.

Sugar packet foraging by sparrows at cafés was observed by more participants than expected (n = 69, 28%). This is likely due to the survey distribution method, i.e., the survey was spread out through social networks from a few initial sources. Participants who were closer to the initial distribution sources were more likely to have already been aware of this research project and the Momento sparrows that forage on sugar packets. Consequently, more participants than expected may have paid greater attention to sugar packet foraging by sparrows at cafés and reported seeing the behaviour. In hindsight, it would have been beneficial to request the name of the café where the behaviour had been observed, so that observations from Momento could assessed separately.

The most common observations made by participants were related to successful and unsuccessful foraging attempts on food scraps at cafés by sparrows. This is consistent with the work by Haemig et al. (2015) on the presence of birds (including sparrows) foraging on the food scraps at cafés and restaurants. Many participants also reflected on the boldness of the birds in their comments, i.e., the birds came close to people while they were sitting at café tables, sometimes even taking food directly from their plate in front of them. This may support either the local adaptation hypothesis,

that the boldness has been genetically selected for (Møller, 2008), or the habituation hypothesis, which only requires behavioural plasticity in the sparrows (Vincze et al., 2016). However, both of these hypothesis are heavily debated and without further investigation it is unknown which hypothesis best explains the origin of the observed boldness in sparrows at cafés.

The survey in this study had several limitations. Firstly, 80% of the respondents were female. Survey response rates by females are usually higher than by males, which makes it difficult to extrapolate the survey conclusions to all genders (Smith, 2008). Furthermore, almost all participants (97%) had nature relatedness scores above neutral. It is unclear whether this result is representative of the broader population, or whether the survey respondents represent a group that is highly connected to nature. In the latter case, people who are closely connected to nature may be biased towards survey responses that indicate positive attitudes towards sparrows. Finally, the sample of participants was self-selecting and thus was not random. As a consequence, many variables may bias the sample population, such as education level, economic class, age, place of residence, etc. To avoid making the survey too long (potentially decreasing the number of responses), data on many demographic variables were not collected and so representativeness shall remain a limitation of this study.

Chapter 6

General discussion

The four studies that comprise this thesis present the first documented evidence of sugar packet foraging in sparrows. Furthermore, it is also the first study to document sugar packet foraging in birds on a fine scale within a relatively large urban area, and is the first known investigation of the learning processes involved in the establishment of this behaviour. Sugar packet foraging in sparrows is a behavioural innovation that has arisen in at least 28 locations across New Zealand, and was likely spread through multiple distribution mechanisms. Sparrows are able to discriminate between different coloured packets, demonstrated by their preferences for brown/orange-coloured packets that contain raw sugar. Café staff members and the general public have mixed feelings towards sparrows being present at cafés, but overall, the presence of sparrows is not perceived as a serious issue.

Sweetening agent preference

Sparrows demonstrated a strong preference for raw sugar over artificial sweetener (Chapter 2). Consequently, if café staff have an issue with sparrows taking sugar packets, it may only be necessary to modify the presentation of their raw sugar packets. This could be achieved by keeping the raw sugar packets indoors, or keeping the raw sugar packets on the outdoor tables in sealed containers. Sparrows may also have a predisposition to forage on items of orange/brown colouration, as these colours reflect the carbohydrate component of their natural granivorous diet (Anderson, 2006). Not only are the sugar packets brown/orange

coloured, but the sugar itself is also brown-coloured, which is consistent with the colour of the food that these birds forage on naturally (Gionfriddo & Best, 1996). In contrast, artificial sweeteners are a bright white colour, which makes up a smaller proportion of their natural diet. Future research may benefit from swapping the colours of the raw sugar and artificial sweetener packets to assess the impact it would have on the sparrows' preferences and learning, i.e., if brown raw sugar was placed into blue or green packets, and white artificial sweetener was placed into orange or brown packets.

Packet colour associations

Sparrows foraged most frequently on orange packets at Momento (Chapter 3), and brown packets around Hamilton City cafés (Chapter 4). Brown is closer in wavelength to orange than it is to blue or green. Sparrows therefore may have learned to associate orange/brown colours with more preferred food (raw sugar), and learned to associated blues and greens with less preferred food (artificial sweetener); sparrows' preferences for different sweetening agents were established previously in Chapter 2. It is currently unclear whether associative learning would generalize across different brands of sweetening agents at different cafés, or whether each association must be learned independently at each café. Alternatively, sparrows may have an intrinsic aversion to blue-coloured packets. Sparrows in other studies have displayed aversions to blue-coloured food (Pawlina & Proulx, 1996), even when sparrows were trained that blue-coloured food was palatable (Greig-Smith & Rowney, 1987).

Learning

Sparrows at Momento did not learn to forage on novel sugar packet colours within the two week periods when they were presented with cream coloured packets or cream-coloured and pink coloured packets (Chapter 3). However, several of these novel packets were removed from the cups on top of the Momento tables, which is an important step in the foraging process and demonstrates neophilia. Both sexes of sparrow were present at Momento during the preference assessment (Chapter 2) and the learning experiment (Chapter 3), and there were no more than eight sparrows present at any given time. Although more males were observed consuming sugar than females during the preference assessment (Chapter 2), females were observed removing more packets than males in the learning experiment (Chapter 3). This may suggest that one or two females were responsible for the majority of sugar packet thefts, which would be consistent with the established producer-scrounger dynamics within sparrow populations. However, this cannot be said with certainty as individual sparrows were not identified.

If sugar packet foraging is only performed by a few individuals within a population, it may be a complex behavioural innovation. Complex innovations in other social species such as the kea are learned and performed by a few individuals in the population (Gajdon, Fijn, & Huber, 2006), demonstrating a producer strategy. In such cases, other individuals in the population do not learn the complex innovation, but scrounge food from the ones that do. Sparrows have a documented producer-scrounger dynamic in their populations (Katsnelson et al., 2008; Katsnelson et al., 2010), which may well be applied to sugar packet foraging. A potential consequence of this dynamic is a decreased rate in the social transmission of foraging innovations, especially in a species like sparrows that only travel short distances (Gajdon, Fijn, & Huber, 2006). Restricted social diffusion of

sugar packet foraging in sparrows could also explain why staff had observed sugar packet foraging at some cafés, whilst staff at nearby cafés had not observed the behaviour (Chapter 4). Furthermore, if only a few individuals from each population engage in this behaviour, it ought to be less problematic for café staff.

Human attitudes

In general, both café staff and café customers tended to like sparrows (Chapter 4 and Chapter 5). There was strong agreement from participants in both surveys that sparrows were a part of nature, and agreement that their calls were not an issue. However, there was also strong agreement that the sparrows decrease the hygiene standards at cafés, which was the most common reason for sparrows to be disliked in this context. In some cases, there was a perception of sparrows being unhygienic in general, but more often than not it was because of sparrow defecation on café tables and chairs. This finding is consistent with other research on the human perceptions of urban birds, where birds have been perceived as unhygienic and a human health risk (Skandrani et al., 2015). Responses by staff members tended to be more evenly distributed, indicating mixed opinions, whereas responses by members of the public were more consistently positive towards sparrows.

Collectively, the attitudes from both surveys indicate that sparrows present at cafés is at most a minor issue. Positives of sparrows at cafés appear to outweigh negatives, and staff behaviours can be modified to minimise the negative impacts of the sparrows if required. Additionally, the theft of sugar packets is not viewed as a serious issue by most staff members, and where it is seen as an issue, solutions are successfully implemented, e.g., keeping the packets indoors or keeping the raw sugar in jars. The sugar

foraging behaviour may also be entertaining for customers at cafés, which may benefit the café by increasing the number/loyalty of customers. On the other hand, sugar packet foraging by sparrows may confer financial cost to cafés. For example, in the previous student research project it was found that Momento sparrows were taking approximately four sugar packets per hour, and the financial cost to Momento was estimated to be approximately $400 per year (Davy, 2018).

6.1 Limitations

Sparrows did not learn to forage on novel sugar packets within two weeks (Chapter 3). Although two weeks was not long enough for the birds to learn to open the novel packets, they may have done so if more time had been allocated to each of the treatments, and thus it cannot be concluded that sparrows do not learn to forage on sugar packets with novel packet colours. Furthermore, the natural variability in the rate of sugar packet foraging was unknown. Much higher rates of sugar packet foraging were recorded in the previous year (Davy, 2018), but it is unknown if this represents natural variability in the rate of sugar stealing, or if the reduced rate is due to another factor, like the death of key foraging individuals. This problem could have been avoided by banding the sparrows so that individuals could be identified. However, banding was attempted in the student research project (Davy, 2018). Even after banding 30 birds caught near Momento, unbanded birds still outnumbered the banded ones in the café outdoor area, and it was concluded that banding was not feasible in such an open population.

The sparrow population studied in Chapter 2 and Chapter 3 was studied as a group. Individual preferences within this group could vary greatly, potentially skewing the results, especially if a few individuals were

responsible for a disproportionate amount of the observations. Additionally, these studies only assessed the preferences and learning latencies of the sparrows at one café, thus it is possible that the preferences and learning latencies of sparrows at other cafés may be different.

The recruitment of participants from different regions around New Zealand depended on members of the public reading and responding via email to the news article on sparrows foraging on sugar packets (Chapter 4), and thus there was no way to guarantee representativeness across the regions of New Zealand. In addition, staff from most cafés that had sugar packets accessible to sparrows reported that they had not observed sparrows foraging on the sugar packets. However, the lack of observation does not necessarily mean that the behaviour does not occur at these cafés. Furthermore, only one staff member at each café was asked if they had observed the behaviour, so even if the respondent had not seen the behaviour, other staff members may have. Consequently, the total number of observations of sugar packet foraging by sparrows in Hamilton City provides a conservative estimate of the prevalence of the behaviour. The public attitudes survey was potentially limited in its representativeness of people that visit cafés as it was not distributed to randomly-selected New Zealanders. Furthermore, self-report measures are not completely reliable, as they have an increased likelihood of expectancy bias and other such confounds (Cook, 2010).

6.2 Future research

The research reported in this thesis has provided a preliminary framework for future studies. Allowing a longer period of time for sparrows to learn to forage on sugar packets of novel colours may give insight into how long it takes for new individuals to develop this behaviour, and whether or not a

few key individuals are responsible for most of the packet foraging. Providing sparrows at cafés with partially opened sugar packets may also give insight into the learning mechanisms involved in the initial development of the sugar packet foraging innovation.

Future experiments could be done to assess why sparrows prefer raw sugar over artificial sweetener (e.g., do sparrows not like the taste of artificial sweeteners?), and to quantify whether this preference has adaptive advantages. Assessing the adaptive advantage of sugar packet foraging could be achieved, for example, by looking at the reproductive success of sparrows that forage on sugar packets at cafés relative to the reproductive success of sparrows that are present at cafés but do not forage on sugar packets. It would also be beneficial to assess what cues attract sparrows to cafés, such as the presence of customers or unattended plates, and what factors encourage/discourage the birds to stay, such as the behaviour of the staff or the availability of sugar packets. The information from assessing these variables would be helpful for the development of practical methods to minimise the nuisance of sparrows at cafés where their presence has become problematic.

The present study investigated sugar packet foraging only at urban and suburban cafés. It would be interesting to establish if this behaviour has developed at cafés in the countryside, and whether the same preferences for sugar packets are seen in these populations. Lastly, it would be useful to investigate how the hygiene practices of café staff affect the public perception of sparrows' impact on hygiene, e.g., if the café staff clear plates and clean tables more regularly, do customers view sparrows as less of a hygiene problem? If so, negative perceptions of sparrows could be minimised by improving hygiene practices.

6.3 Conclusions

This thesis produced several novel findings about sparrows foraging on sugar packets at cafés in New Zealand, and the human perception of sparrows present at cafés. Firstly, Momento sparrows preferred foraging on raw sugar over artificial sweetener, which they almost never consumed, even when it was openly accessible to them. Secondly, sparrows demonstrated some neophilia towards novel-coloured sugar packets at Momento, though they did not learn to open these packets within a two week period. Sugar packet foraging has been observed within several regions around New Zealand, and has been documented comprehensively in Hamilton City, where is has been observed at multiple locations. These distributions suggested that the sugar packet foraging behaviour probably established independently at different locations, spread outwards to some nearby cafés through social learning after the initial establishment of the behaviour. Sparrows at cafés are generally well-liked by the public and well-tolerated by café staff, so active control of sparrows at cafés is of low importance. Consequently, the presence of sparrows at cafés may facilitate positive interactions between people and nature in urban areas where these positive interactions are often lacking. However, measures may be taken by café staff to minimize issues of hygiene that are associated with sparrows being present at cafés by regularly cleaning the café tables and floors.

The findings in this thesis demonstrate how sparrows, birds that have lived alongside humans since the dawn of agriculture, have taken advantage of one of the many foraging opportunities available to them within the modern urban landscape: sugar packets on café tables. This has been done while assimilating into the café environments of human societies with little objection from human inhabitants, making the sparrow a truly successful urban bird.

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Appendix A: Signage (café access points)

Signage for Momento lakeside café access points at the University of Waikato for experiments conducted in Chapter 2 and Chapter 3:

Sparrow Filming in Progress

- Continue as you normally would.
- Footage will be used for data analysis (we are only interested in the sparrows' behaviour).

Appendix B: Signage (café tables)

Signage for Momento lakeside café tables at the University of Waikato for experiments conducted in Chapter 2 and Chapter 3:

Hi. I'm currently filming the café sparrows for a research project. Feel free to ask me any questions/provide comments. If you end up in any of the footage, I won't publish it without your consent first. Thanks!

Appendix C: Experiments information sheet

Project Information Sheet

School of Science

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Sparrow Behaviour Observations

These sparrow observation sessions are part of a behavioural research project being carried out by Mike Davy (Masters Student) in the School of Science at the University of Waikato.

Project background

Foraging on sugar packets from cafés is a novel behaviour of sparrows that has been observed anecdotally. Over the 2017/2018 summer, we discovered that the sparrows at the Momento café lakeside café at the University of Waikato steal approximately 4 packets of raw sugar every hour. The current research project aims to extend this research by looking at learning process involved with this behaviour, its distribution in the region, and the impact sparrows have on people who share urban greenspaces with them. The project may help to reduce losses to cafés and to further human understanding on the behavioural and intellectual capabilities of the sparrow, which has an extremely close relationship with humans worldwide.

Research procedure

We would like to film the sparrows stealing sugar packets. Video-recording is an invaluable way to collect data, particularly with fast-moving animals like sparrows. Customers of the café are NOT the focus of this research, but may be incidentally captured in the footage when we are filming the birds. These videos will primarily be used for data analysis. However, some recording will provide an excellent demonstration of the sparrows' behaviour for lectures, presentations and other media outputs. If you are captured in one of these videos, we will not use the video footage in any presentation without your consent (done via a separate consent form). If you have consented to the footage being used in presentations you may withdraw consent at any time prior to its presentation. No identifiable data concerning you or any other members of the public will be transcribed from the video recordings and facial features will be distorted.

Feel free to ask any questions about this research or to share your personal observations of the sparrows' sugar-stealing behaviour. If you would like to know the findings of this project, please let know and I will inform you of what we discover from this research. This study has approval from the University of Waikato Animal Ethics Committee and the Faculty of Science and Engineering Human Research Ethics Sub-committee (Faculty of Science and Engineering Human Research Ethics Sub-committee chair's contact details: Dr Karsten Zegwaard, 07 838 4892, k.zegwaard@waikato.ac.nz).Please use the contact details below if you have any further questions about any aspect of this project:

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Appendix D: Experiment 1 data collection sheet

Experiment 1: Trial # **Day:** **Date:**

Start time: __________

Finish time: _________

Left: Sweetening Agent	
Initial weight:	
Final weight:	
Weight change:	

Right: Sweetening Agent	
Initial weight:	
Final weight:	
Weight change:	

	Time	Latency	Sex
First approach:			

	Time	Latency	Sex
First approach:			

Time	# ♂	# ♀	T/P	A/E

Time	# ♂	# ♀	T/P	A/E

Appendix E: Experiment 2 data collection sheet

Behaviour sampling: Sugar packet thefts **Date: ______________**

Time:	Table code:	Plumage:	Band Colour:	Notes:

Appendix F: Café staff survey

Sparrows Stealing Sugar Survey

School of Science

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Thank you for taking around 3 minutes of your time to participate in this survey. I am interested in studying the attitudes of people towards house sparrows at cafés. The aim of my research is make comparisons between how café staff and café patrons feel about house sparrows at cafés. I also aim to determine what cafés house sparrows are stealing sugar packets from. Your answers will be useful even if you have not observed house sparrows taking sugar packets from your café.

This survey is anonymous and your responses are confidential. No personal information will be passed on. You can opt to not complete the survey and withdraw at any stage during the survey. However, because the surveys are fully anonymous, once you have submitted the survey you cannot withdraw your responses as we will not know which survey belongs to you. You must be 16 years or older to participate in this survey. By participating in this survey, you provide consent to have the data used for this research project.

This research has ethics approval from the University of Waikato (ref#: FSEN_2018_7). If you have any questions or concerns, please contact me (Mike Davy) at ambrose.davy@gmail.com or my supervisor, Dr Clare Browne at clare.browne@waikato.ac.nz. All photographs were sourced from http://nzbirdsonline.org.nz/.

Female house sparrow (left)
Male house sparrow (right)

Name of café: _____

Café questions:

1. Does your café have an **outdoor** seating area?

   Yes ☐

   No ☐

2. What types of **sugar packets** are put out on your café tables?

   Raw sugar ☐

   White sugar ☐

   Stevia ☐

   Artificial sweetener ☐

   None ☐

3. Approximately what time does your café typically **open**?

   6 am ☐

   7 am ☐

   8 am ☐

   9 am ☐

   10 am ☐

   11 am ☐

4. Approximately what time does your café typically **close**?

   1 pm ☐

   2 pm ☐

   3 pm ☐

   4 pm ☐

   5 pm ☐

   6 pm ☐

5. When is the **peak** time(s) of day for your customers sitting outside?

   Morning (7 am-11 am) ☐

   Lunch (11 am- 2 pm) ☐

   Afternoon (2 pm- 6 pm) ☐

   Not applicable ☐

House sparrow questions:

1. Have you observed the **house sparrows** stealing sugar packets from your café?

   Yes ☐

   No ☐

   a. What **types** of sugar packets do they steal?

      Raw sugar ☐

      White sugar ☐

      Stevia ☐

      Artificial sweetener ☐

      None ☐

      Not applicable ☐

   b. What **time(s)** have you **most frequently** observed sugar-stealing by house sparrows?

      Morning (7 am- 11 am) ☐

      Lunch (11 am- 2 pm) ☐

      Afternoon (2 pm- 6 pm) ☐

   c. Has the **behaviour** of café staff been modified in response to house sparrows stealing sugar packets from your café? For example, **keeping the sugar packets indoors**, or **keeping the sugar packets in closed containers**.

      Yes ☐

      No ☐

      Please describe what you/the café has done in response to the house sparrows stealing sugar (**optional**):

      _____

      _____

      _____

2. How many house sparrows (**on average**) do you see around the café during **peak** times?

   None (0) ☐

   A few (1-4) ☐

   Some (5-8) ☐

   Many (9+) ☐

   Unsure ☐

3. How many house sparrows (**on average**) do you see around the café during **off-peak** times?

None (0)	☐
A few (1-4)	☐
Some (5-8)	☐
Many (9+)	☐
Unsure	☐

4. How much do you consider the house sparrows a **nuisance** at your café?

Not at all	☐
Not Much	☐
A little	☐
A lot	☐

Attitudes towards house sparrows:

The following questions are about your attitudes towards house sparrows at cafés. Potential reasons for liking and disliking sparrows at cafés will be presented. Please rate how strongly you agree or disagree with each statement.

1. I **like** house sparrows at my café because…

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

They are pleasant to look at _____
They are pleasant to listen to _____
They entertain customers _____
They are a part of nature _____
They get rid of insects _____
They get rid of spilt food scraps _____

2. I find house sparrows **problematic** at my café because…

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

They make a mess _____
They are unhygienic _____
They are too noisy _____
They steal customers' food _____
They are pests _____
They invade customers' personal space _____
They build nests in my café _____

3. Have you observed any **other** birds stealing sugar packets?

   Yes ☐

   No ☐

   If so, what birds besides house sparrows have you observed? _____

4. Please describe any other interesting observations you have made about the behaviour of the **house sparrows** at your café (**optional**):

   _____
   _____
   _____
   _____
   _____

Thank you for participating in this survey.

I would like a copy of the research results (**optional**)

Yes ☐

No ☐

If you answered yes to the statement above, please enter your email address below:

_____

Appendix G: General public survey

Sparrow Perception Survey

School of Science

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Thank you for taking about 10 minutes of your time to participate in this survey. I am interested in studying the attitudes of people towards sparrows at cafés. The aim of my research is to make comparisons between how café staff and café patrons feel about sparrows at cafés.

This survey is anonymous and your responses are confidential. No personal information will be passed on. You can opt to not complete the survey and withdraw at any stage during the survey. However, because the surveys are fully anonymous, once you have submitted the survey you cannot withdraw your responses as we will not know which survey belongs to you. You must be 16 years or older to participate in this survey. By participating in this survey, you provide consent to have the data used for this research project.

This research has ethics approval from the University of Waikato (ref#: FSEN_2018_7). If you have any questions or concerns, please contact me (Mike Davy) at ambrose.davy@gmail.com or my supervisor, Dr Clare Browne at clare.browne@waikato.ac.nz.

There are four **$50 Pak'nSave vouchers** to be won by completing this survey!

Female house sparrow (left)

Male house sparrow (right)

Demographics:

Age: _____

Gender: _____

Country of birth: _____

Ethnicity(s): _____

How many pets do you own? (circle **one**)

None One Two Three Four or more

Encounters with animals:

Please select 5 birds that are the **most familiar to you** from the photographs. Then rank these top 5 birds from most familiar (1) to least familiar (5) and explain the reasons for your ranking order below.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Bird Letter	**Ranking (1-5)**
• _____	_____
• _____	_____
• _____	_____
• _____	_____
• _____	_____

Reasons for your ranking order:

_____

_____

Are there any other birds you would **prefer** to have more of in the places you visit? And why?

_____

_____

Attitudes towards sparrows at cafés:

1. I see **sparrows** as… (circle **at least one**)

    - Exotic (non-native)
    - Native
    - A pest
    - A part of nature
    - Just another bird

2. How would you feel if **sparrows** were no longer around? (circle **one**)

    Very sad A little sad Indifferent A little happy Very happy

3. How **often** do you go to a café? (circle **one**)

    Less than once a month Monthly Weekly Several times a week Daily

4. When you go to a café, how often do you notice if **sparrows** are present? (circle **one**)

    Never Not often Sometimes Often Always

The following questions are about your **attitudes** towards sparrows at cafés. Potential reasons for liking and disliking sparrows at cafés will be presented. Please rate how strongly you **agree or disagree** with each statement.

5. I **like** sparrows at cafés because…

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

a) They are pleasant to look at _____
b) They have a familiar call _____
c) They come close to me for food _____
d) Watching them makes me happy _____
e) They sound nice _____
f) They control pests _____
g) They are a part of nature _____
h) They are pleasant to listen to _____
i) It is fun to give them scraps _____
j) They are important for the ecosystem _____
k) They get rid of insects _____
l) They interest me _____
m) They are beautiful birds _____
n) I can feed them food I don't want _____
o) They are fun to observe _____

p) They have the right to be there _____
q) They keep rodents away by eating leftover food _____
r) Other (please specify below) _____

_____

_____

6. I find sparrows **problematic** at cafés because…

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

a) They make a mess _____
b) They violate my personal space _____
c) They are pests _____
d) Their calls make it difficult to relax _____
e) They are unhygienic _____
f) They annoy me for my food _____
g) They are too noisy _____
h) They increase litter in the area _____
i) They steal my food _____
j) They are bad for the environment _____
k) They land on my table _____
l) They are not native _____
m) They poo on things _____
n) They come too close to me _____
o) They make the area untidy
p) They are unpleasant to listen to _____
q) They prevent me from leaving my food alone _____
r) They contaminate the tables and chairs _____
s) Other (please specify below) _____

_____

_____

7. How strongly do you **disagree/agree** with the following statement: Sparrows **should** be present at cafés.

Strongly disagree Disagree Neutral Agree Strongly Agree

8. Have you observed **sparrows** taking sugar packets from café tables? **Yes / No** (circle **one**)

9. Please describe any other interesting observations you have made of **sparrows** at cafés. (**optional**)

_____

_____

_____

Nature relatedness:

1. For each of the following, please rate the extent to which you **agree with each statement**, using the scale of 1 to 5 as shown below:

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

1. I enjoy being outdoors, even in unpleasant weather ____
2. Some species are just meant to die out or become extinct ____
3. Humans have the right to use natural resources any way we want ____
4. My ideal vacation spot would be a remote, wilderness area ____
5. I always think about how my actions affect the environment ____
6. I enjoy digging in the earth and getting dirt on my hands ____
7. My connection to nature is a part of my spirituality ____
8. I am very aware of environmental issues ____
9. I take notice of wildlife wherever I am ____
10. I don't often go out in nature ____

2. For each of the following, please rate the extent to which you **agree with each statement**, using the scale of 1 to 5 as shown below:

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

1. Nothing I do will change problems in other places on the planet ____
2. I am not separate from nature, but a part of nature ____
3. The thought of being deep in the woods, away from civilization, is frightening ____
4. My feelings about nature do not affect how I live my life ____
5. Animals, birds and plants should have fewer rights than humans ____
6. Even in the middle of the city, I notice nature around me ____
7. My relationship to nature is an important part of who I am ____
8. Conservation is unnecessary because nature is strong enough to recover from any human impact ____
9. The state of non-human species is an indicator of the future for humans ____
10. I think a lot about the suffering of animals ____
11. I feel very connected to all living things and the earth ____

_ _

Thank you for participating in this survey.

I would like to enter a draw to win a **$50 prize** (optional) **Yes** / **No** (circle **one**)

I would like a copy of the **research results** (optional) **Yes** / **No** (circle **one**)

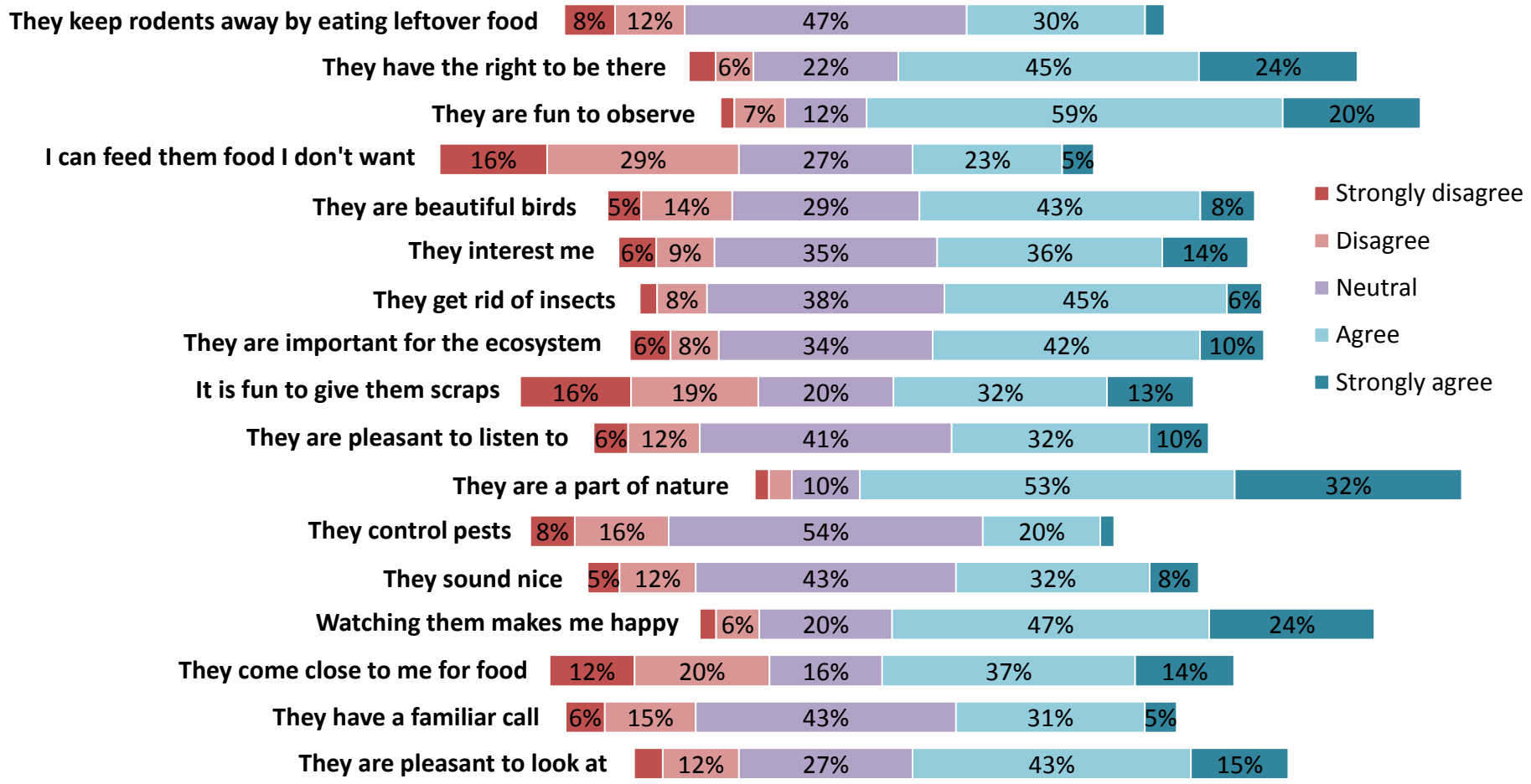
If you answered yes to either of the statements above, please enter your **email address** below:

_____

By clicking submit I declare that I provide consent to have the data used and that I am older than 16 years.

Appendix H: General public survey Likert data (complete sets)

Participants' perceptions of benefits of sparrows at cafés (complete set). Values under 5% were not displayed with labels.



Participants' perceptions of the negative impacts of sparrows at cafés (complete set). Values under 5% were not displayed with labels.