The management of Miniature horses at pasture in New Zealand

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Abstract

Studies on the demographics, feeding management and health care practices of Miniature horses in New Zealand have yet to be conducted. Thus, the aim of this study is to describe the demographics, feeding management and health care practices of Miniature horses in New Zealand. To achieve the aim of this study, an online survey was conducted using the Qualtrics Survey Software. There were 232 valid responses from respondents who kept 1,183 Miniature horses, representing approximately one third of the New Zealand Miniature horse population. Miniature horses were kept for leisure and companionship (56%), competition (35%) and for breeding (7%). The median number of Miniature horses kept by owners for leisure and companionship was significantly lower (two horses) than those kept for competition (six horses) or for breeding (ten horses) ($p<0.05$). The majority (79%) of Miniature horses were kept at pasture on low (<1,000 kg DM/ha) to moderate (~2,000 kg DM/ha) pasture masses across seasons. Pasture access was more commonly restricted by respondents during spring (60%), summer (60%), and autumn (55%) than in winter (43%). The majority (n=173/198, 87%) of respondents practiced pasture-restriction strategies such as strip grazing (n=118), temporary use of a paddock with little grass (n=99), confinement for part of a day in a stable or yard (n=94), turning out horses to graze in the early morning only (n=42), or fitting a grazing muzzle (n=24). Another pasture restriction strategy cited by respondents (n=15) was provision of a track system. Respondents indicated the mode daily number of hours of stabling was 7-12 hours (n=57/195, 29%). Miniature horses kept primarily for competition were stocked at a significantly higher stocking density (13 horses/ha) compared with those kept for leisure and companionship (10 horses/ha) or for breeding (12 horses/ha) ($p<0.05$). The overall median stocking density was 10 horses/ha, (~1,100 kg live weight/ha). Although the stocking density appeared to be high, on a live weight basis, it was comparable to the stocking density of other classes of equine livestock. In addition to feeding on pasture, most owners provided the horses with additional feed (n=194/232, 84%). Additional feedstuffs were hay (n=180), chaff (n=130), premixed concentrates (n=117), fermented forages (n=51), and other types of feed (n=33) such as oats, copra, soy, molasses, and sugar beet pulp. Respondents (n=200/214, 93%) dewormed their Miniature horses between two and four times annually as a routine preventive measure (n=156/199, 78%), and of the respondents who vaccinated their Miniature horses in the last year (n=41/199, 21%), tetanus and strangles vaccines were the most administered vaccine types (n=20/41, 49%).

Keywords: demographics; deworming; Miniature horses in New Zealand; pasture feeding; vaccination

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Chapter 1: Introduction

The Miniature horse is phenotypically classified by its small stature (Petersen et al., 2013a). And, the genetic basis of the New Zealand Miniature horses is the American Miniature horse, and in some cases Shetland and Timor ponies (Rogers et al., 2006). Miniature horses present a unique management challenge to horse owners due to their small body size and a thrifty phenotype. They can develop obesity, insulin resistance (equine metabolic syndrome, EMS) and laminitis; obesity or excess body weight develops as a result of ration mis-estimation, overfeeding or simply a lack of knowledge on the total amount of feed required (Scherer-Hoock et al., 2011).

An adult Miniature horse weighing 110 kg consuming New Zealand pasture with an energy content of 10 MJ DE/kg DM requires 2 kg (or 1.8% of body weight) of pasture DM per day to meet maintenance digestible energy requirements of 20.2 MJ [DE_m= 5.9 + 0.13 BW] (Catalano et al., 2019a; Hoskin & Gee, 2004; National Research Council (U.S.) Committee, 2007). However, little is known about the actual voluntary feed intake (VFI) of Miniature horses when fed *ad libitum*. Non-obese Welsh Mountain ponies were able to consume a complete, commercially manufactured chaff-based diet, comparable in nutrient profile to moderate quality hay, at 3.5 ± 0.1% (winter) or 4.6 ± 0.3% (summer) of body weight as dry matter when fed *ad libitum,* which was above maintenance requirements (Dugdale et al., 2010; Dugdale et al., 2011b). As a result, their body weight increased rapidly (0.6-0.9 kg/day), leading to obesity (Dugdale et al., 2011b). The results suggest that feed intake must be restricted in ponies or small-sized horses to prevent increased body weight.

Restricting feed intake can be achieved by limiting the amount of time ponies or small-sized horses are kept on good-quality pasture, and/or using various pasture restriction strategies (Glunk et al., 2013). Alternatively, if it is feasible, selective grazing on poor-quality pasture ('poor-quality' here referring to pasture that is high in fibre content and of low nutrient digestibility) can be used to limit nutrient intake of ponies or small-sized horses grazed on pasture (Fleurance et al., 2009). Although pony breeds appear to have a better utilisation of less-nutritious feed (Cuddeford et al., 1995), with the application of pasture restriction or the practice of selective grazing on poor-quality pasture to reduce energy intake, suitable supplementary feeding and/or supplements may be required to ensure that their other nutritional requirements are met (McGowan et al., 2013).

In New Zealand, Miniature horses represent a fast-growing sector of the equine industry. Recent estimates suggest there are 3,000 registered Miniature horses in New Zealand, making up ~3% of the entire horse population in New Zealand, or ~7% of horses involved in other equestrian, leisure or recreational activities (Rogers et al., 2017c). Only one survey on New Zealand Miniature horses, a preliminary study on congenital and reproductive disorders has been carried out (Rogers et al., 2006). At present the demographics, feeding management and health care practices of New Zealand Miniature horses have not been well described. The information gathered from this survey will be a useful reference in identifying the unique challenges in the demographics, feeding management and health care practices of Miniature horses in New Zealand.

I. Objective

The aim of this study is to describe the demographics, feeding management and health care practices of Miniature horses in New Zealand.

II. Hypothesis

There will be significant differences in the demographics and feeding management practices of three identified groups of New Zealand Miniature horses, including those used primarily for i) leisure and companionship, ii) competition and iii) breeding.

Chapter 2: Literature review

I. Number, types and use of horses globally and in New Zealand

According to Food and Agriculture Organization (FAO), Domestic Animal Diversity Information System (DAD-IS) and the Food and Agriculture Organization Statistics (FAOSTAT), there were 58.8 million domestic and feral horses (excluding donkeys and mules), and an average of 8.7 horses per 1,000 people in the world between 2000 and 2008 (Goodwin, 2007; Khadka, 2010). The number of horses has been steeply declining during the last century, with a previous record of 96.4 million horses in the world in 1938 (Goodwin, 2007). Nevertheless, it is possible that the reported estimated total horse population of 58.8 million domestic and feral horses in the world, in the last decades, were an underestimate due to a lack of reporting or under-reporting of the total horse populations in some countries. Hence, the total number of horses in the world today is expected to exceed 60 million (Clarkson, 2017).

According to a report by World Horse Welfare and Eurogroup for Animals in 2015, the number of horses in Europe was estimated at 7 million (Gavinelli, 2015). The equine census conducted by the American Horse Council reported an estimate of 7.2 million horses in the U.S. in 2018 (Lord, 2019). In Australia, it was estimated that there were approximately 1 million domestic horses and several hundred thousand feral horses in 1993 (Pilkington & Wilson, 1993; Smyth & Dagley, 2016). According to Khadka (2010), the total size of the population of horses in each global region, in decreasing order, was: South America (15 million), Asia (13.9 million), North America (9.9 million), Latin America and Caribbean (8.7 million), Europe (6.4 million), Africa (4.5 million) and Oceania (0.4 million). However, the value of 0.4 million horses in the Oceania region (examples of countries: Australia, New Zealand) is likely under-reported (Pilkington & Wilson, 1993; Smyth & Dagley, 2016).

When describing horses in relation to the human population, the Oceania region has more horses (11.8 per 1,000 people) compared with Europe (8.7), Africa (4.6), and Asia (3.4); however, it has less horses per 1,000 people compared with Latin America and the Caribbean (45.7), South America (38.9) and North America (28.7) (Khadka, 2010). In addition, Gilbert et al. (2018) presented a map of global distribution data for horses, from the map, horses were highly concentrated in areas in countries such as Mexico, Cuba, Haiti, Dominican Republic, Argentina, the USA, Colombia, Sierra Leone, Guinea, Senegal (Dakar), Gambia, Ethiopia, Romania, Central Mongolia, and South-West of China.

According to StatsNZ *Tatauranga Aoteoroa* (stats.govt.nz), as of 31st of March 2020, the estimated New Zealand resident population was 5,002,100 (~5 million). An estimation of the total number of horses in New Zealand (based on general agreement) was approximately 100,000 horses (Rogers et al., 2017a). So, there were about 20 to 30 horses per 1000 people (Bolwell et al., 2017; Rogers et al., 2017a). Gronqvist et al. (2016) reported an estimated 110,000 horses in New Zealand. And, according to the data derived from the Agribase Biosecurity database, the estimated number of sport horses in New Zealand was 80,000, and an additional 40,000 horses were racehorses or broodmares and stallions involved in the production of race horses (Thoroughbreds and Standardbreds racehorses), which gives a total of ~120,000 horses in New Zealand (Matheson & Akoorie, 2012). A precise estimate based on consensus, in accordance to the changes in equine industry structure over the last twenty years, generated a more conservative estimation of the number of horses in New Zealand, at 98,868 horses (Rogers et al., 2017c).

According to Domestic Animal Diversity Information System (DAD-IS) in the Food and Agriculture Organization Statistics (FAOSTATS), in 2010, there were 784 horse breeds and of these breeds, 117 were at risk of extinction (Khadka, 2010). Horses can be categorised into four different groups according to their usage: draft or heavy-breed horses, sport horses, racehorses (light breed) and wild or feral horses, with ponies considered as a separate category (Atiq et al., 2018).

Prior to 1940s, a large proportion of horses were used as draft horses in agriculture or for transportation. Today, there has been a shift in the roles or uses of horses; horses are increasingly valued as companion horses, for recreational use, for equestrian sports, as therapy horses or as service animals (Lord, 2019; Medeiros et al., 2020; Raento, 2016; Rogers et al., 2012). In accordance with the shift in the roles or uses of horses across the globe, the history and origin of horses in New Zealand reflected similar changes in the roles or uses of horses, transitioning from labour (providing horse power) to performance and companionship (Meyer, 2008; Mincham, 2008). As such, horses are being repurposed for use in recreational sports, as service animals or therapy horses. They are also considered companion animals, as beloved pet horses, just like dogs and cats (Fifield & Forsyth, 1999; Fraser et al., 2020; Medeiros et al., 2020; Muellner et al., 2016).

II. Trends of horse ownership

The equine industry is an important industry, globally and in New Zealand. In New Zealand, the racing and sport-horse sectors are the drivers for the horse industry. The equine industry generated over NZD 2 billion gross domestic product (GDP) (about 2%) of the New Zealand total GDP, with the racing and sport industries contributing about 1% to GDP (Bolwell et al., 2017). The horse industry in other countries such as in Australia generates AUD 5 to 7 billion GDP annually, which is about 0.5% of the total GDP (Smyth & Dagley, 2016). According to the American Horse Council (AHC), in 2018, the equine industry generated about 0.5% (totalling up to USD 101.5 billion) of the total ~20.5 trillion GDP for the U.S. (Lord, 2019). Within the equine industry in the U.S., it was reported that the horse racing sector generated the highest economic value, followed closely by the competition sector, and then lagging far behind were the recreational, work or other services sectors (Lord, 2019).

The horse industry is volatile and highly influenced by the state of the economy. For instance, in the U.S., during the global financial crisis in 2008, competitive equestrian sports and recreational use of horses (pleasure and trail riding) in the U.S. were affected, the total revenue generated has shown a slight downward trend since then, and the number of idle, non-working or retired horses showed a slight increase by 2015 (Stowe, 2018). In a survey on Australian horse owners and riders conducted within the last five years, only 1% of the Thoroughbreds and Standardbreds horses in the survey were categorised as racehorses and, the rest of the horses were used for non-racing activities (Smyth & Dagley, 2016). The results from the survey showed that there has been a shift in the customs or traditions of equitation, and competitive equestrian sports or recreational activities such as pleasure riding are becoming increasingly popular.

The horse industry in the U.S. has grappled with several issues, in a survey question with multiple selection, respondents indicated that unwanted horses (37.8%), increasing cost of keeping horses (36%), loss of trail and riding areas (29.5%) due to land development and land designation for agricultural purposes (27.8%) were amongst issues they were most concerned about (Stowe, 2018). The cost of keeping horses involves various aspects such as husbandry practices, stable facilities, feeding, equipment or supplies and training (Gordon, 2001). As the cost of keeping horses increases, the major concern would be that the number of horse owners or horse ownership would decline (Gordon, 2001). Other issues within the horse industry include horse welfare and public health concerns for owners or people in contact with horses (Gordon, 2001). These issues may have led to a decreased in horse ownership; in the U.S., it was reported that there was a 21% decrease in horse ownership between 2005 and 2017 (Stowe, 2018). Nevertheless, horse owners, especially those with a strong interest in keeping horses or those who possess a sufficient financial capacity were reportedly still keeping either the same number of horses, or even more horses regardless of the state of economy (Lord, 2019; Stowe, 2018).

III. Profiling horse owners in New Zealand and across the world

According to data extracted from the American Horse Council (AHC) Foundation Reports, over a twelve-year period (2005-2017), the age demographics of horse owners have shifted. There were increasing numbers of horse owners aged 60 years and above, and decreasing numbers of horse owners between 30-59 years of age, signifying an aging population of horse owners in the U.S. (Lord, 2019). Although the age bracket used in the surveys conducted in both years (in 2005 and again in 2017) were slightly different (age brackets of 30-59 in 2005, and 25–59 in 2017), the majority of the horse owners, (76% in 2005 and 65% in 2017) fell in these middle age brackets (Lord, 2019). Another recent survey conducted by the American Horse Publications (AHP) in 2018, reported that 70% of horse owners were aged over 45 years, in which 19% of these people were over 65 years of age, leaving a balance of 51% of respondents were between 45 and 65 years of age (Stowe, 2018). In an online survey on the demographic of Australian horse owners, 3,377 of the 7,000 respondents (48%) were in the 45-54 age group, a statistically higher number than the general population (Smyth & Dagley, 2016). From data reported in previous surveys, it is conceivable that age demographics of horse owners across the globe are typically within the middle age bracket.

The survey conducted by AHP previously in 2015 and again in 2018 revealed that the majority (> 90%) of the respondents were female (Stowe, 2018). This pattern of female-dominated involvement or horse ownership was echoed in several other survey-type of studies: a survey on dressage and eventing horses (91-97% female), the survey on New Zealand Pony Clubs (95% female), a survey on female horse riders (1,324 females) and the survey on demographics of Australian horse owners (64-88% female) (Agar et al., 2016; Burbage & Cameron, 2018; Fernandes et al., 2014; Smyth & Dagley, 2016). Horse-riding and equestrian sports activities drawing involvement primarily from female horse riders is a unique phenomenon (Agar et al., 2016; Burbage & Cameron, 2018). A survey in Scotland reported that 67% of the horse riders were female (The British Horse Society, 2019). Likewise, the Active New Zealand Survey Series found that most equestrian or horse riders (69%) were women, mainly of New Zealand-European ethnicity (Sport New Zealand, 2015). However, in recent years, horse riding activity and the interest in riding horses for recreational reasons has been increasing in the United Kingdom despite the dwindling number of horses there (Sandiford et al., 2013; The British Horse Society, 2019).

According to the AHC Foundation Report 2018, respondents involved in horse-related occupations include horse trainers (20%), horse lesson instructors (17%), horse farm managers (19%), horse breeders (14%), veterinary-related professionals and farrier (5%), and other goods and services providers (23%) such as horse boarding and equine-assisted therapy (EAT) services (Lord, 2019). Similarly, another survey conducted by the AHP in the U.S. on horse owners or people keeping horses, reported the different percentages of the horse-related occupation within the equine industry: farm or barn manager (20.6%), riding instructor (14.1%), horse trainer (15.0%) and horse breeder (12.8%) (Stowe, 2018). The largest category for horse ownership and use were pleasure riders (57%) rather than competitive riders (32.5%) (Stowe, 2018). The same survey by AHP in the U.S. in 2018 revealed that horses were mainly used for pleasure or trail riding (68.6%) (Stowe, 2018). There was a large proportion (31.3%) of horses not in work (idle) or retired, possibly due to an increased number of horses being kept for companionship or as pet horses (Stowe, 2018). In 2017, nearly half of the total 7.2 million horse population in the U.S. (3.1 million) were used for recreational activities, and the remainder were used for showing and racing (1.2 million), working (0.5 million), and other purposes (1 million) (Lord, 2019).

A survey by the American Horse Council (AHC) in the U.S. in 2017 estimated about 7.1 million people comprising of horse owners, service providers, employees or volunteers were involved in the equine industry (Lord, 2019). However, not all these people kept or own horses themselves; there were 7.2 million horses kept by 1.6 million horse owners, representing 1.3% of the total number of households in the U.S. (Lord, 2019). According to published data from study on demographics of New Zealand non-commercial horse population, there were 105,000 rural properties in the database (AgriBase™), of which between 13,072 to 17,430 (17%) of these rural properties housed horses for non-commercial purposes and a smaller proportion of 899 (0.9%) of these rural properties housed horses for commercial use (Gronqvist et al., 2016; Rosanowski et al., 2012). In the 2013/14 Active New Zealand survey, 2,236 people (2.6% of approximately 86,000 people) in New Zealand used their horses for non-commercial purposes and these horse owners have participated in equestrian sports and recreational horse-riding activities at least once over the last 12-months (Sport New Zealand, 2015). Over 90% of the horse riders rode their horses in natural settings such as countryside, farmland, by the sea, and in the forest. They rode for enjoyment (91.6%) (Sport New Zealand, 2015). It was estimated that horse owners who used their horses for recreational purpose spent approximately NZD 13,000 in a year on each recreational horse (NZ Horse Network).

The average number of horses, including foals, yearlings, mature and geriatric horses, owned by horse owners in the U.S. was approximately six and a half or rounded to about seven horses per horse owner. For every seven horses owned by each horse owner, two were not in work (idle) or retired (Stowe, 2018). The number of horses belonging to horse owners in the U.S., who fell within the highest or the lowest income brackets was almost equally high, although horse owners with the highest income bracket tended to keep more horses than those in the lowest income bracket, the horse owners in these two income brackets kept more horses that those in the medium income bracket (Stowe, 2018). By comparison, the National Equestrian Survey 2019 conducted by the British Equestrian Trade Association (BETA) revealed that only about 0.85 million horses were kept by 0.37 million horse owners in the UK, indicating that the average number of horses belonging to horse owners in the U.K. of two horses per household was less than that reported in the U.S. (National Equestrian Survey 2019). In Scotland, 70,000 horses are kept in 22,400 households, giving rise to an average of just three horses per household (The British Horse Society, 2019). The data reported (as above) is likely to be true because we know that the number of horses per 1,000 people in the U.S. was far greater than in the Europe (Khadka, 2010).

IV. New Zealand commercial and non-commercial horses

It was estimated that in New Zealand, 23% of horses (22,910) were Thoroughbreds, 13% (12,800) were Standardbreds, 19% (18,443) were sport horses and the remaining 45% (44,715) were different categories of horses involved in other equestrianism such as Quarter or Western horses, Miniature horses, Stationbreds used in utility or farms, trekking or recreational horses and unregistered horses or ponies (Figure 1) (Rogers et al., 2017c).

From Figure 1, there were an estimated 22% unregistered horses (i.e., horses not registered in any association or society), in New Zealand (Rogers et al., 2017c). It was reported that up to an estimated 30% of the horses, used for other equestrianism, leisure or recreational activities were not registered for competition or recreational activities, hence, they were not represented in New Zealand horse-governing databases such as the Equestrian Sports New Zealand (ESNZ) (George et al., 2013; Rogers & Wickham, 1993; Rosanowski et al., 2012). Similarly, registration of horses in the U.S. were mainly for competition, showing and racing; hence a large proportion of recreational horses not involved in competition, showing or racing were not registered (Lord, 2019). Additionally, it has been reported that in New Zealand, over three quarters (77.1%) of equestrians or horse riders of sport and recreational horses were not a member of any club, or centre, and most (70.7%) of these riders went riding privately, without paying a fee (Sport New Zealand, 2015). In terms of numbers, horses (including unregistered horses) used for other equestrianism, leisure or recreational activities (45%, 44,715 horses) is certainly the largest group of horses in New Zealand (Rogers et al., 2017c).

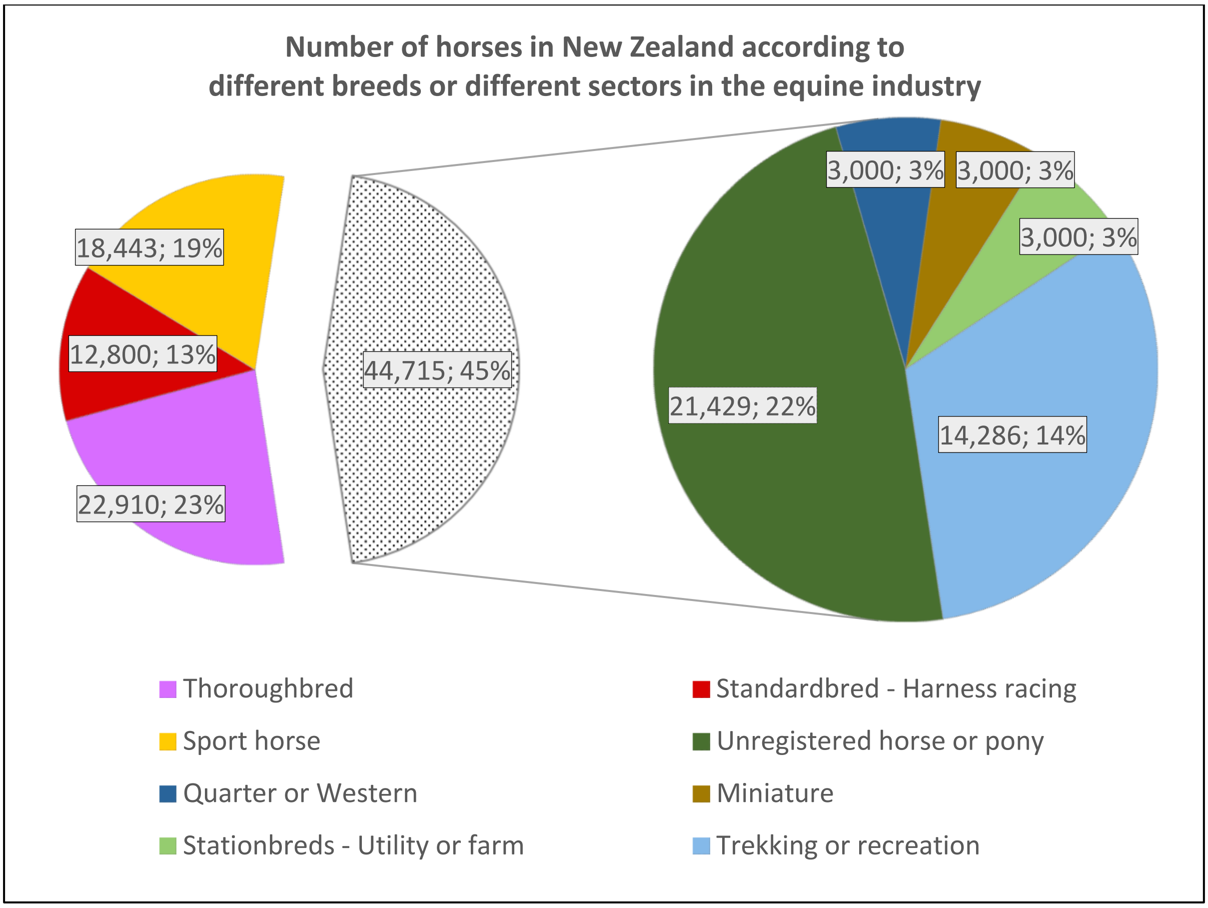


Figure 1 *The number of different horse breeds in different sectors of the equine industry in New Zealand: Thoroughbred, Standardbred, Sport horse and horses used in other equestrianism including unregistered horse or pony, Quarter or Western, Miniature horses, Stationbreds and horses used for trekking or recreation, pie chart was constructed with data presented by Rogers et al. (2017c).*

The non-commercial horses can be used for recreation, competitive sports, dressage, show jumping, eventing, endurance, para-equestrian, racing, showing, hunting, competitive trail riding, western, polo or polocrosse, rodeo (rarely), competitive driving, leisure driving, breeding, stock or farm work or as a pet (Rosanowski et al., 2012). The non-commercial horses (referring to horses other than those used for racing racehorses in commercial horse-breeding centres) in New Zealand are concentrated in several regions such as Auckland, Waikato, Canterbury, Taranaki and Manawatu (Rogers et al., 2017c; Rosanowski et al., 2012). These regions with highly concentrated numbers of non-commercial horses are regions with high concentration of commercial horses (e.g. Thoroughbred, Standardbred racing or racing-related activities such as training or breeding of racehorses). In New Zealand, these commercial activities are concentrated in the upper part of the North Island in Auckland and Waikato (Cambridge and Matamata), in the lower central North Island, and in Canterbury (for Thoroughbred racing) and in

South Auckland, Canterbury and Southland (for harness racing and breeding of commercial horses) (Bolwell et al., 2017).

To date, numerous retrospective and prospective studies and cross-sectional surveys have been conducted on various categories of horses in New Zealand: non-commercial horses, competition horses (a subset of non-commercial horses), recreational Pony club horses (a subset of non-commercial horses), sport horses used for eventing or endurance (a subset of non-commercial horses), Thoroughbred racehorses and Standardbred harness racing horses (commercial horses), and feral horses such as the Kaimanawa residing in the central North Island in the Waiouru Military Training Area (WMTA) (Bolwell et al., 2015a; Bolwell et al., 2015b; Department of Conservation, 2017; Fernandes et al., 2014; George et al., 2013; Legg et al., 2019; Rogers & Firth, 2005; Rogers, 1991; Verhaar et al., 2014; Webb et al., 2020). Prior to 2020, a breed-specific survey on the Miniature horses in New Zealand (a subset of non-commercial horses) has not been published.

V. The Miniature horse breed and its registration in New Zealand

Within the other equestrian, leisure or recreational activities sectors, there are an estimated 3,000 Miniature horses and unknown number of unregistered Miniature horses (grouped under the category: unregistered horses or ponies, Figure 1) in New Zealand (Rogers et al., 2017c). New Zealand Miniature horses have bloodlines from the American Miniature horse, the Shetland and Timor ponies (Rogers et al., 2006). It was estimated that ~3% of the total horse population in New Zealand were Miniature horses (Rogers et al., 2017c). By comparison, the percentage of the Miniature horse population in relation with the total population of horses in the U.S. was lower, at 1.6% (Kilby, 2007).

Miniature horses are described as possessing enjoyable and endearing personality traits. They are often described as being 'radiant, adventurous, confident, playful, stunning, beautiful, magnificent, elegant, gentle, docile, sweet-natured, affectionate, and eager to please or have a willing disposition' (Lynghaug, 2009; Powell, 2015). Affirmative phrases or words that has been used to describe the Miniature horse breed are 'the smallest horse that makes for the biggest smile, mighty Miniatures, great things come in small packages, big fun in a little package, no bigger than a large dog, Lilliputian size, and the minis' (Lynghaug, 2009).

Miniature horses have a strong top line, arched neck, large eyes, sculpted ears and a slightly dished face, and they come in various coat colours, eye colours and markings (Powell, 2015). Akin to dogs or the canine breed, where the smallest sized dog breed being the Chihuahua and the largest being the Great Dane, the body size of horses can be distinguished according to the breeds. The Shire, Clydesdale and Percheron breeds are large draft horse breeds with a heavy, muscular build; in contrast, the Exmoor pony, Shetland pony, and the American Miniature Horse – a classic modern pony breed, are diminutive horse breeds (Bailey & Binns, 1998). The Miniature horses represented an isometric down-scaled version of a full-size horse; they stand at less than 86 cm (Category A / Division A / Type A) or 96 cm (Category B / Division B) of height, measured from the last mane hairs, or, at a constitutionally defined height of 8.2 hands (Eberth et al., 2009; Lynghaug, 2009). They are often described as resembling the scaled-down version of the Arabian horses (Leland, 2009).

The Miniature horses' small stature comes with several advantages, particularly the ease of handling, which is very appealing to Miniature horse owners (Powell, 2015). Any person of any age, regardless of their experience, would feel that when handling horses, handling a Miniature horse is safer than handling a full-size horse. In addition, keeping Miniature horses has many feeding and management advantages compared with a full-size horse. They require a smaller amount of feed, a smaller stable or a smaller paddock, a lower overall maintenance cost and less time to groom (Lynghaug, 2009).

According to the cost estimates presented by the American Miniature Horse Association (AMHA) on its official webpage, the estimated costs to purchase a Miniature horse, feeding costs, professional stabling costs, trainer costs (halter in hand training), equipment costs (tack or halter, harness, blankets, sheets) and the hoof trimming or farrier services costs were markedly less than an average full-sized horse (American Miniature Horse Association, 2020a). However, it was estimated that the cost of purchasing a cart to drive a Miniature horse can be quite high. The costs of purchasing a cart to drive a Miniature horse was at the lower limit of the range of costs to purchase a cart to drive a full-sized horse (American Miniature Horse Association, 2020a). Miniature horses are usually unshod, saving on costs of purchase of horseshoes and the costs of services by a farrier to place horseshoes on them (American Miniature Horse Association, 2020a).

The conditions for the registration of Miniature horses in a registry of a society or an association revolve around the height of the horse and having a registered parentage (Kilby, 2007). However, a Miniature horse from unknown bloodline or parentage may be allowed to register under a special circumstance called hardship registration, at the discretion of the society or association for the registry (New Zealand Miniature Horse Association, 2019-2020). Measurements at withers height is critical for the registration of Miniature horses because the Miniature horse breed is primarily defined by its small stature phenotype (Petersen et al., 2013a).

Miniature horses in New Zealand can be registered in one or more of these breed societies or associations including the New Zealand Miniature Horse Association (NZMHA), the National Miniature Horse Society of New Zealand (NMHSNZ), the Association of Independent Miniature Horse Clubs of New Zealand (AIMHCNZ), American Miniature Horse Registry (AMHR) and the American Miniature Horse Association (AMHA). In addition, owners of Miniature horses in New Zealand can register their Miniature horses in these societies or associations that are not exclusive to Miniature horses, but would include Miniature horses in their registry including the Golden Horse Association, the Pinto Horse Society, the American Shetland Association of New Zealand (ASANZ), the Miniature Horse

Association of Australia (MHAA), the Small Horse Breeders Association, the Harness Racing New Zealand (HRNZ) and the Royal Agriculture Society (RAS).

a. New Zealand Miniature Horse Association (NZMHA)

The New Zealand Miniature Horse Association (NZMHA) was founded in 1996. According to the NZMHA webpage, in 1980, Eden Hore imported the first American Miniature horses (5 stallions and 13 mares) into New Zealand. Eight years later, in 1988, David Goudie imported a large shipment of American and English Miniature horses. In 1998, the NZMHA became affiliated with the Royal Agricultural Society of New Zealand (RAS), enabling registered Miniature horses in the NZMHA to participate in the Agricultural and Pastoral (A & P) Shows held across New Zealand. The breed standard of Miniature horses has been well-described; main traits include balanced conformation, symmetry, refinement, strength, alertness and agility. More information about the NZMHA can be found on the official website: www.nzmha.co.nz/.

According to NZMHA (Table 1), the three distinctive categories for Miniature horses are:

Category A	measures 34 inches or less in height
Category B	measures more than 34 inches but not more than 38 inches in height
Category C	foundation mare – breeding mare not exceeding 40 inches in height or exceeding 38 inches but not 40 inches in height. A mare must first be registered with NZMHA under temporary or permanent registration in Category A or B for twelve months before they qualify to be registered in this category.

Table 1 *Category of Miniature horses according to official measure of height and age group either in inches (") or in centimetres (cm).*

Category	Age category	Official measure of height (in inches, " or rounded to the nearest half centimetres, cm)	Metric equivalent after conversion from inches, " to centimetres, cm
A	Adult (at least or ≥ 3 years)	Up to 34" / 86.50 cm	86.36 cm
	Foals / weanlings (at least 2 months, less than 12 months)	Up to 30" / 76.00 cm * 2-4 months old: at least 29"	76.20 cm
	Yearlings (at least 12 months, less than 24 months)	Up to 32" / 81.50 cm	81.28 cm
	Two-year-olds (at least 24 months, less than 36 months or 3 years)	Up to 33" / 84.00 cm	83.82 cm
B	Adult (at least or ≥ 3 years)	Up to 38" / 96.50 cm * at least 33"	96.52 cm
	Foals / weanlings (at least 2 months, less than 12 months)	Up to 33" / 84.00 cm * 2-4 months old: at least 28" * ≥ 5 months: at least 29"	83.82 cm
	Yearlings (at least 12 months, less than 24 months)	Up to 36" / 91.50 cm * at least 31"	91.44 cm
	Two-year-olds (at least 24 months, less than 36 months or 3 years)	Up to 37" / 94.00 cm * at least 32"	93.98 cm
C	Foundation or breeding mares	Up to 38-40" / 96.50 – 101.50 cm	96.52 – 101.60 cm

* additional height conditions for the specific age groups: Category A and Category B

- conversion 1 inch = 2.54 cm rounded to the nearest half (½) cm
- guidelines for category developed for competing in various disciplines: trail at halter, trotting over poles, long reining, hunter, jumper, six-bar jumper, harness, driving, fault and out.
- shod horses with a minimum age ≥ 3 years for competing in harness events are allowed ¼ inches allowance in height

Information sourced from the New Zealand Miniature Horse Association (2002)

b. <u>National Miniature Horse Society New Zealand (NMHSNZ)</u>

The NMHSNZ was founded in April 1990 and the Society was legally formed in 1993. On 11th October 2006, the NMHSNZ was affiliated with the Royal Agricultural Society of New Zealand (RAS). The NMHSNZ maintains a registry of horses, conduct Ribbons days, competitions, shows, and provides information to NZ Miniature horse owners on the management, training and use of their Miniature horses. The NMHSNZ organises three annual shows: The North Island Championship Show, The Grand National Championship Show, and the South Island Championship Show. More information about the NMHCNZ can be found on the official website: www.nmhsnz.org/.

According to NMHSNZ, the three distinctive categories for Miniature horses are:

Category A	measures 34 inches or less in height
Category B	measures more than 34 inches but less than 38 inches in height
Class D	American Miniature Shetland up to 38 inches (introduced in 2017)

c. <u>Association of Independent Miniature Horse Club New Zealand (AIMHCNZ)</u>

The Society was formed on 5th October 2015 and has a similar function to the NZMHA and NMHSNZ. This society introduced halter typing with categories such as foundation, classic and modern. Foundation horses are strong, slightly stocky and compact. Classic horses are finer or more petite, well-muscled and with gentle curves. The modern horses include Miniature horses with the bloodlines from American Shetland or their derivatives. More information about the AIMHCNZ can be found on the official website: www.aimhcnz.org.nz/.

According to AIMHCNZ, the three distinctive categories for Miniature horses are:

Category A	foals and weanlings must not exceed 30" (76.20cm) in height, yearlings must not exceed 32" (81.28cm) in height, two-year-olds must not exceed 33" (83.82cm) in height, three-years-olds and over must not exceed 34" (86.36cm) in height.
Category B	foals and weanlings must be over 30" (76.20cm) and not exceed 33" (83.82cm), yearlings must be over 32" (81.28cm) and not exceed 36" (91.44cm), two-year-olds

must be over 33" (83.82cm) and not exceed 37" (93.98cm), three-year-olds and over must be over 34" (86.36cm) and not exceed 38" (96.52cm).

Category C foals and weanlings must be over 33" (83.82cm) and not exceed 36" (91.44), yearlings must be over 36" (91.44cm) and not exceed 38" (96.52cm), two-year-olds must be over 37" (93.98cm) and not exceed 40" (101.60cm), three-year-olds and over, must be over 38" (96.52cm) and not exceed 42" (106.68cm).

d. American Miniature Horse Registry (AMHR)

The AMHR is one of the three daughter organisations of the American Shetland Pony Club Inc., the other two being the American Shetland Pony Registry and the American Show Pony Registry. During the mid-1950s, raising small-sized horses for fun gained popularity; the AMHR was created by the American Shetland Pony Club in the early 1970s, as the growing interest in these diminutive-sized horses became more apparent. The parent organisation of the AMHR, the American Shetland Pony Club is the oldest small equine registry in existence and one of the oldest equine governing bodies in the United States of America. It was established in 1888 to preserve, promote and perfect the American small equine. More information about this organisation can be found on the official website: www.shetlandminiature.com.

According to AMHR, the two distinctive categories for Miniature horses are:

Division A up to 34" in height, and

Division B between 34" and 38" tall, measured at the last hair of their mane.

e. American Miniature Horse Association (AMHA)

The AMHA aims to preserve the integrity and the accuracy of the Miniature horse breed bloodlines. The AMHA register Miniature horses from owners across the world, in 38 countries and provinces. Apart from the lean type Miniature horses resembling a scaled-down version of a full-sized horse, the AMHA recognises the stock type Miniature horses. It was founded in 1978 in Arlington, Texas, to solely promote the breeding, exhibition, use and perpetuation of a standard of equine excellence in Miniature horses, separating this unique breed from ponies and other types of small equine. The registry for Miniature horses was closed on the 31st December 1987; henceforth, only Miniature horses with AMHA-registered parents can register. Further to that, Miniature foals born after 31st December 1995 must be blood-typed or DNA-tested and then parent-qualified before any of their offspring can be registered.

Broadly speaking, the coat colour of domesticated horses (some of these coat colours can be found in Miniature horses) can be categorised according to five colour categories: basic colours, basic colour dilutions, white patterns, white phenotypes, and grey (Cieslak et al., 2011). The basic colours include black, bay, and chestnut. The basic colour dilutions include bay-dun, bay-silver, amber-bay (champagne) and buckskin (bay with one cream dilution). The white patterns in horses include tobiano, sabino, leopard spotted (blanket), leopard spotted (leopard) and overo. The white phenotypes include dominant white and leopard spotted (homozygote). The grey horse is described as progressive whitening from greying. The AMHA recognises Miniature horses with solid and dilute coat colours (e.g. Bay, Black, Brown, Buckskin, Sorrel, Chestnut, Grey, Grullo, Palomino, Dun, Silver Bay, Roan, Champagne, Cremello, Perlino) or patterns coat colours (e.g. Appaloosa, Silver Dapple, Pinto, Pintaloosa).

The height of a Miniature horse is measured as a vertical distance from the last hairs of the mane to the ground, when it is standing squarely on a level ground. The height is measured three times consecutively, one from each side and an additional measurement from either the left or the ride side; the three measurements are averaged to obtain a final official measurement. A valid measurement is issued for horses aged 5 years (60 months) and older for the year the Miniature horse was measured. More information about the AMHA can be found on the official website: www.amha.org/.

According to AMHA, the one distinctive category for Miniature horses is:

Type A — less than 34" in height at the withers (anatomy landmark: third thoracic vertebra) as measured from the last hairs of the mane. Permanent registration is granted after the Miniature horse is three (3) years old. Measurements for different ages: adult Miniature horse(s) ≤ 34" in height, weanling(s) ≤ 30", yearling(s) ≤ 32", two-year-old(s) ≤ 33".

VI. The history and genetic origin of the Miniature horse breed

The survival of small-sized horses and their existence has been sustained by periods in history such as during the late pre-historic periods, ~1478 – 1200 Before Common Era, B.C.E., proto-historic periods, ~1200 – 30 B.C.E, the middle or the medieval periods (476 Anno Domini, A.D.– 1453) through to the early modern period (1500 – 1800). The existence of small-sized horses is documented in archeological findings or old writing and scriptures depicting historical events. The remains of a small horse were found in the tombs of the Egyptian Pharaohs dated back in 2500 B.C.E. during archeological excavation (Plummer & Ramsey, 2011). In the 1650s, pint-sized horses were kept in the zoo at Versailles by King Louis XIV of France, as his personal collection of unusual wild animals (Graae, 2016). Similarly, in the 16th century, the royal court in Spain (the Habsburg Royal Family) and in England (Queen Victoria, 1837-1901) kept small-sized horses or ponies (Wright, 2013). The use of small-sized horses could have been influenced by man's creative exploitation of these horses, largely due to a feeling of novelty towards them. Small-sized horses had been used as pets, in circus, zoos, in public exhibits, for the purpose of showing during horse shows, or as gifts to Royalty (Lynghaug, 2009).

Until now, the origin of the Miniature horse breed is not known. Presumably, the Miniature horse breed is developed from other breeds, mainly small-sized pony breeds, at several different geographic locations around the world. There were anecdotal reports suggesting that this breed could have originated from the Welsh Pit Pony while some believe that the Miniature horse was a cross between the Argentinian Falabella horse and the Dutch and English mining ponies. Others suspect that the breed is influenced by horse or pony breeds such as the Shetland, Dartmoor, Pony of Americas, Hackney and the Falabella horses (Lynghaug, 2009; Wright, 2013). It was a common belief that the Miniature horses originated from Argentina, where the Falabella originated or from the Northern Europe (Wright, 2013). Then, the refinement of the Miniature horse breed has likely taken place in the U.S, leading to the well-recognised and popular American Miniature horses (Wright, 2013). Anecdotal reports or informal historical accounts on the origin of the Miniature horse breed are not reliable sources of information. Henceforth, a look at the genetic similarities of the Miniature horse breed with other horse breed(s) could provide clues to the origin of the Miniature horse breed.

Within the last decade, genetic studies on horse breeds showed that the Shetland, the Miniature horse and the Falabella are in the same cluster of related horse breeds; furthermore, the closest relative or genetic makeup to the American Miniature horse is the Shetland (Petersen et al., 2013a; van de Goor et al., 2011). Both Shetland and the American Miniature horse breeds belong to the Scandinavian and Northern European breed of horses (Petersen et al., 2013a). Likely, they were closely related to the ancient Scandinavian pony because the Shetland Islands were physically connected to Scandinavia until the end of the last Ice Age (Weaver, 2010). Horse breeds similar to the American Miniature horses (ranked in order of the closest to the most distant, in terms of genetic makeup) are: Shetland, Icelandic, North Swedish Horse, Norwegian Fjord, Finnhorse, Mongolian and Tuva (Petersen et al., 2013a). These horse breeds all sit on the same branch of the neighbour joining tree (NJT) to the American Miniature Horse breed, according to Figure 2 in Petersen et al. (2013a). Due to the genetic similarity between the Shetland and the American Miniature horse, it is worthwhile to investigate the origin of the Shetland. This might provide us with further clues in tracing the origin of the Miniature horse breed from the bloodlines of the Shetland (or the Shetland Pony).

The earliest records on breeding of the Shetland ponies were carried out by Lord Londonderry, a merchant who owned a coal mining business, and by Lady Estella Hope and her sister Dorothea Hope, daughters of the 6th Earl and Countess of Hopetoun in Scotland during mid and late 1800s (Mead, 2018; Weaver, 2010). The acquisition of their first Shetland ponies can be traced back to the Shetland Isles, a subarctic archipelago in the Northern Isles of Scotland. According to the Shetland Pony Studbook Society (S.P.S.-B.S.), the Shetland *Isles* of Scotland was mentioned as the origin of the Shetland pony, and their existence can be traced back to the Bronze Age. The Shetland pony is believed to be a cross of the Cob Type of Tundra and the Mountain Pony type from Southern Europe, and the Celtic people introduced the bloodlines of Oriental horses by crossing the same Mountain Pony type with Oriental horses (Shetland Pony Stud-Book Society).

From here onwards, what happened in history is less certain because of a lack of accurate documentation from reliable sources. According to anecdotal reports, a surplus of Shetland ponies, initially bred for assisting the coal mines in the United Kingdom (U.K.) were sold to the U.S. (Mead, 2018; Weaver, 2010). Ponies were bred extensively to be used for coal mining (1874-1880s) in the UK, after the release of the Mines and Collieries Act 1842 prohibited young children working in coal mines. Incidentally, in 1888, it was reported that a very small size horse, which stood only 31 inches (79 cm) tall were amongst the ponies on sale to be purchased for work in the Appalachian coal mines in the

U.S. (Leland, 2009; Lynghaug, 2009; Plummer & Ramsey, 2011; Weaver, 2010). These small sized ponies were called 'pit ponies' or 'midget ponies' (Leland, 2009; Weaver, 2010).

A well-known American horse trainer or horse whisperer in the 19th Century named John Rarey purchased five Shetland ponies from the Shetland Isles in 1860 and took four of them back home to Ohio where he lived (Kearney & Wray, 2016; *More history of the breed*; Rarey, 1859, 1996). During this time, notable people such as Norman Fields from Bedford, Virginia and Walter Smith McCoy, from West Virginia also took the opportunity to collect small horses as a hobby, and selectively bred them to the smallest size during the early 1900s because they discovered that these small horses would fetch greater prices (monetary reward) than the bigger ones (Weaver, 2010). Amongst the cohort of small-sized horses owned by Walter Smith McCoy, a mare named 'Sugar Dumpling', was reported to be only 20 inches (51 cm) tall and weighed only 30 pounds (14 kg) (Weaver, 2010). By 1967, sales of small-sized horses became very popular and profitable for breeders in the U.S.; henceforth, these animals were likely the founding stock, serving as a primary genetic pool for the American Miniature horse (AMH) (Weaver, 2010).

VII. Genetics of height, coat colour, thriftiness and dwarfism in the Miniature horses

a. Height

The American Miniature horse (AMH) breed has the lowest median height at the withers amongst forty-six other horse breeds (Brooks et al., 2010). The American Miniature horses have a wider range of withers height (<75 cm to >100 cm) compared with the Falabella horses (>75 cm to <90 cm), according to Figure 1 in Brooks et al. (2010). It is not known whether the Falabella, originating from Argentina have distinctive genes or genes that are like the AMHs. From the range of horses' withers height reported by Brooks et al. (2010), horses with the smallest height at the withers would be those from the AMHs breed (not the Fallabella).

Genetic studies on the (American) Miniature horses were performed by several researchers (Ghosh et al., 2014; Petersen et al., 2013a; Petersen et al., 2013b; van de Goor et al., 2011). In addition, genes responsible for small stature or height at the withers have been studied in various horse breeds (Achilli et al., 2012; Al Abri et al., 2018; Frischknecht et al., 2015; Kader et al., 2015; Makvandi-Nejad et al., 2012; Metzger et al., 2013; Metzger et al., 2018; Norton et al., 2019; Petersen et al., 2013b; Signer-Hasler et al., 2012). However, based on the literature, only one specific gene related to the small stature of the Miniature horse breed has been reported in recent years. The gene is called Ankyrin Repeat Domain 1 (ANKRD1) located at ECA[1] 1:37 676 322, which is a transcription factor involved in myocyte growth and differentiation, with a dominant mode of inheritance (Al Abri et al., 2018). The other genes linked to small stature in the Miniature horse requires more extensive research.

These loci, namely: ligand dependent nuclear receptor corepressor-like (LCORL) or the NCAPG gene at ECA 3, HMGA2 at ECA 6, zinc finger and AT hook domain containing (ZFAT) at ECA 9, LIM and SH3 protein 1 (LASP1) gene at Equine Chromosome 11 (ECA 11) and Ankyrin repeat domain 1 (ANKRD 1) at ECA 1 have been identified to be the genes responsible for the greatest majority, (more than 50%, between 72 and 83%) of horse size variation (Al Abri et al., 2018; Makvandi-Nejad et al., 2012; Metzger et al., 2013; Metzger et al., 2018; Signer-Hasler et al., 2012). Furthermore, the gene called [2]LIM and SH3 protein 1 (LASP1) locus at ECA 11, with its expression regulated by insulin-like growth factor 1 (IGF1), could potentially be responsible for height differences between a draft horse and a Miniature horse (Achilli et al., 2012; Petersen et al., 2013b).

In Shetland and other pony breeds such as Welsh pony (not the Miniature horse breed, unfortunately), the gene variant of HMGA2, c83G>A (p.G28E) on ECA 6 with a missense mutation in exon 1 shows a peak and the resultant phenotype is reduced growth and smaller stature (Frischknecht et al., 2015; Metzger et al., 2018; Norton et al., 2019). In one study, the four gene variants, namely LCORL, ZFAT, LASP1 and ANKRD1 were reported to contribute ~72% in limiting height of the Miniature Shetland ponies to 34.25 inches (87 cm) (Metzger et al., 2018). The same study reported that two of the fifteen Shetland ponies and three of the forty-four Miniature Shetland ponies recruited in the study harboured a permanent deletion of a copy number variant (CNV) located in the gene called the diaphanous related formin 3 (DIAPH 3) on ECA 17. The presence of this gene, i.e., the DIAPH 3 was likely to be responsible for greater height in full-sized horses (Metzger et al., 2018). Other genes

[1] ECA refers to *Equus caballus* or equine chromosome

[2] LIM is an abbreviation used to denote zinc-binding proteins called Lin-11, Isl-1 and Mec-3 or Lin / Isl / Mec

identified to be responsible for small body size exist and include the TBX3 gene which was found in the Debao pony breed in the mountainous regions of the Guangxi Mountains of Southern China (Kader et al., 2015).

b. Coat colours and coat patterns

Miniature horses may carry various genes responsible for different coat colors or coat patterns. The champagne coat colour in Miniature horses is the result of a nucleotide substitution in exon 2 of the SLC36A1 (Cook et al., 2008). The white spotting patterns in Miniature horses, called tobiano and sabino is the result of genetic variations at the Kit locus at ECA 3 (tobiano) and W locus (sabino) (Brooks & Bailey, 2005; Brooks, 2006). Appaloosa-spotted Miniature horses carrying the homozygous alleles of the leopard complex spotting patterns located on ECA 1 are susceptible to congenital stationary night blindness (CSNB). A single nucleotide polymorphisms (SNP) or a DNA test for CSNB may become available to owners to help identify horses at risk of CSNB or horses with CSNB (Bellone, 2010; Brooks, 2006; Sandmeyer et al., 2012). The silver, SILV or silver homolog (referred to as pre-melanosomal protein 17 or PMEL17) coat colour in the Silver Dapple locus is, either presented as heterozygous or homozygous allelic forms, and is inherited as a dominant allele. The gene for the silver coat colour is hypothesised to be responsible for multiple congenital ocular abnormalities (MCOA) in Miniature horses (Bellone, 2010; Brunberg et al., 2006; Plummer & Ramsey, 2011).

Miniature horses could carry the Lys118 allele commonly found in the Paint horse breed; however, the gene is usually carried by Miniature horses in the heterozygous form (Santschi et al., 2001). As a result, a Miniature horse may look like a Paint horse, with Pinto marking, or they could have no white markings at all when modifier gene(s) are present along with the Lys118 allele (Santschi et al., 2001). The overo lethal white syndrome (whole white coat colour) is expressed when a horse is homozygous for the lethal gene mutation called Ile118Lys EDNRB, inherited from parents with white pattern markings such as: splashed white (overo), sabino, tobiano, bald-face, medicine-hat, overo blend, combinations (tobiano + overo = tovero or tobero) (Metallinos et al., 1998; Santschi et al., 2001; Vrotsos et al., 2001). Since the Miniature horses are unlikely to be carrying Lys118 allele in the homozygous form, and even less likely to be carrying the lethal gene mutation called Ile118Lys EDNRB, Miniature foals are not at risks of expressing the overo lethal white syndrome.

c. Thriftiness

A collection of genes or a single gene could be responsible for the thriftiness of the Miniature horse breed (Johnson et al., 2009). The breed possesses a trait known or described as thrifty which is an increase in feed conversion (metabolic) efficiency. It was developed as a result of natural selection, as an adaptive response to survive harsh environmental conditions including food scarcity (Johnson et al., 2009). Thrifty horses acquire additional adiposity more easily than depleting it (Johnson et al., 2009). The endocrinological chemicals in the body are released in ways which are considered appropriate, adaptive endocrinological responses to the harsh, cold, and uncertain environment, oscillating between seasons with available food sources (feasting) and seasons without food source (fasting or famine) (Johnson et al., 2009). When thrifty horses live in environments enriched with abundance of food sources, they quickly develop high levels of body adiposity (Johnson et al., 2009). Moreover, when these horses are exposed to stressors from the environment or subjected to physiological stressors including obesity, pregnancy, colic , colitis, periods of inappetence or periods of starvation, they tend to exhibit signs of abnormality, such as glucose tolerance, insulin resistance, or lipid dysregulation (hypertriglyceridemia due to defective catabolism, hypercholesterolemia) (Johnson et al., 2009; Waitt & Cebra, 2009).

d. Dwarfism

Dwarfism is a problem recognised by the AMHA and breeders were urged to do everything that they could to minimize the occurrence of the dwarf trait. In general, the dwarf Miniature horses exhibit abnormal physical traits indicating disproportionate body conformation (e.g., longer or larger head than the body), or asymmetry. The common dwarf traits include bulging forehead, extreme dished face, nostrils set too high or too close together (brachycephalic), overly large and protruding eyes, undershot (bulldog) or overshot (monkey) mouth, very short neck, bloated belly appearance (potbellies), spinal vertebra deviation (scoliosis, kyphosis, lordosis), misaligned shoulders (shoulders higher, not at the same level as the croup), mental retardation, inactivity or depression, short and stubby legs with club feet or deformed feet (retracted tendon, swollen joint, cow hocks, juvenile arthritis) (American Miniature Horse Association; Eberth et al., 2009).

The Aggrecan (ACAN) gene in the region of ECA1 has been identified as responsible for Type 1 chondrodysplasia-like dwarfism in Miniature horses (Eberth et al., 2009; Eberth, 2013; Eberth et al., 2018). It is now possible to perform DNA-based tests for at least four of the mutations in the aggrecan (ACAN) gene associated with dwarfism traits in Miniature horses. The four mutations in the ACAN gene are designated D1 - g.95291270del (rs1095048841), D2 - g.95284530C>T (ERP107353), D3 - g.95282140C>G (rs1095048823), and D4 - g.95257480_952 57500del (rs1095048839) and it is a recessive trait while the capital N is used to denote the normal copy of the ACAN gene (Eberth et al., 2018). Individuals carrying just one copy of the mutation will appear normal, while individuals carrying two copies of the mutation will be a dwarf (Metzger et al., 2017). Apart from the four identified mutations: D1, D2, D3, and D4, the allele (c.6465A > T), a missense SNP in coding exon 11 in the ACAN exons (EquCab3.0) was discovered as a new marker contributing to dwarfism trait, but it is not a definitive marker, as two dwarf Miniature horses in the study did not possess the variant, and fifteen dwarf Miniature horses possessed only one of the variants (de Andrade et al., 2020).

Recently, a new genotype of the Aggrecan (ACAN) gene mutation, D4/D4 in two dwarf Miniature horses has been found (Andrade et al., 2020). The new finding increased the number of dwarf phenotype to five (5), the other four are: D2/D2, D2/D3, D2/D4, D3/D4 (Eberth et al., 2009; Eberth et al., 2018). All of these dwarfs Miniature horses exhibited similar dwarf traits as the other dwarfs phenotypes such as having a disproportionately short stature, a malformed skull, a shortened nasal bone and mandibular prognathism, but abnormal front and hind cannon lengths appeared to be unique to the D4/D4 dwarfs (Andrade et al., 2020). The lethal allele combination of: D1/D1, D1/D2, D1/D3, D1/D4 would lead to abortion or absorption of the embryo or foetus of a Miniature horse (Eberth et al., 2018). Hence, a Miniature horse identified as a D1 carrier should not be bred with another Miniature horse carrying the genetic mutation of the ACAN gene. Information on the genetic defective combinations of the ACAN gene can be sourced online (Genetic Testing at Gluck).

A dwarf Miniature Shetland pony was identified with a homozygous mutant genotype C/C of the ACAN: g.94370258G>C variant, and its normal parents, full and half siblings were carrying heterozygous G/C (Metzger et al., 2017). The SHOX / CRLF2 gene and the B4GALT7 is responsible for the dwarf trait in Shetland ponies and in Friesian horses respectively, resulting in clinical signs of skeletal atavism or chondrodysplasia (Boegheim et al., 2017; Rafati et al., 2016). However, whether these genes are carried in Miniature horses remains unknown.

e. Other genetic abnormalities

There are probably other unidentified abnormal genes or genetic mutations which may cause abnormal conditions or diseases in Miniature horses. According to the literature, Miniature horses have been reported to have tracheal collapse, familial narcolepsy, patella luxation, skeletal atavism and neurodegenerative disorders, which may have been related to the expression of defective genetic traits (Aleman et al., 2008; Engelbert et al., 1993; Every et al., 2020; Fox et al., 2000; Lunn et al., 1993; Tyson et al., 2004). The condition of tracheal collapse occurred in ~5.6% of all the American Miniature horses admitted to a referral hospital, with the pathological changes such as chondromalacia (degenerative process or a breakdown) of the tracheal cartilaginous rings (Aleman et al., 2008).

VIII. Feeding the Miniature horses

a. Energy requirements

Most literature on the feeding requirement of Equidae focused on the feeding requirement of large-sized horses or pony breeds, consequently, studies on the feeding requirement of a specific horse breed such as the Miniature horse breed are limited. According to the standard feeding requirements formula recommended by the National Research Council (NRC), Miniature horses in lean, ideal body condition with a body condition score (BCS) of 5, weighing 110 ± 21 kg require only 2.0 ± 0.3 kg (1.8%) of dry matter of feed a day (Goh et al., 2020). This translates into feeding ~13 kg of total wet weight of forages per day (assuming forages consumed contained 85% moisture and 15% dry matter) (Rogers et al., 2017a). The calculated value of 2.0 ± 0.3 kg DM/day (1.8%) assumes the digestible energy for maintenance (DE_m ,in MJ) is 5.9 + 0.13 BW (this formula is used for calculating the estimated feeding for horses in general), and the pasture energy content is 10 MJ DE/kg DM (Hoskin & Gee, 2004; National Research Council (U.S.) Committee, 2007).

The digestible energy for maintenance (DE_m) is experimentally derived from bomb calorimetry, using the differences between the energy in feed and the energy in the faeces (Rogers et al., 2017a). Calculating metabolizable energy for maintenance (ME_m) is more complex in practice where additional information including the digestibility of the feed, live weight changes of the horse, energy loss in faeces, urine and fermentation gas is required (Rogers et al., 2017a). A study reported that the ME_m

for ponies can be derived using the formula: ME_m (in MJ) = 0.40 $BW^{0.75}$ (Kienzle et al., 2010). The ME_m for Warmblood, and Thoroughbred per unit body weight will be higher, being 0.52 MJ/kg $BW^{0.75}$ and 0.64 MJ/kg $BW^{0.75}$ respectively (Kienzle et al., 2010).

A study suggested that the energy requirements for maintenance, either metabolizable (ME_m) or digestible (DE_m) of overweight or obese horses is expected to be ~15% lower than lean horses (the estimated ~15% has factored in the activity levels and the body temperature regulation for horses) (Kienzle et al., 2010). The formulae such as DE_m (in MJ) = 5.9 + 0.13 BW and ME_m (in MJ) = 0.40 $BW^{0.75}$ can used to calculate the total maintenance energy required for lean Miniature horses in ideal body condition.

As for an overweight or obese Miniature horse, using the body weight to calculate the total maintenance energy requirement will result in an over-estimation of the energy requirement for maintenance. For example, applying the above DE_m formula, an overweight Miniature horse weighing 140 kg fed New Zealand pasture (10 MJ DE/kg DM), at 100% of its digestible energy requirement, will require 24 MJ [DE_m= 5.9 + 0.13 BW] or 2.4 kg of feed as dry matter (or 1.7% BW as dry matter intake (DMI)) when grazed on New Zealand pasture with an average energy content of 10 MJ DE/kg DM. However, this is not accurate.

If they receive ~15% lower energy intake from the total 20.2 MJ DE_m of a lean Miniature horse, it equates to 17.2 MJ DE_m for an overweight Miniature horse (Hoenig & Ferguson, 2002; Kienzle et al., 2010). Assuming New Zealand pasture energy content is 10 MJ DE/kg DM (Hoskin & Gee, 2004), the calculated DMI of a lean Miniature horse would be 2 ± 0.3 kg DM/day (~1.8% as DMI), and that of an overweight Miniature horse would be ~1.7 kg DM/day (1.2% BW as DMI) (Hoenig & Ferguson, 2002). The lower estimated energy requirement of overweight or obese horses, and therefore, a decrease in the calculated DMI of overweight or obese horses has been supported by a study. Ponies in an obese state (BCS 7-9/9) has half the appetite of non-obese ponies in summer and their food intake (measured as digestible energy intake, DEI, in MJ/kg BW) was half of that of the non-obese ponies during summer (Dugdale et al., 2011b).

Moore et al. (2019) reported that there were no differences in terms of the net energy acquisition (energy intake minus expenditure) between horses in different physiological states (obese or lean). This may be that the DMI and energy expenditure of obese horses were low whereas the DMI and energy expenditure of lean horses were high. Although it is difficult to measure or to estimate the total amount of feed ingested or the VFI in the same study, it is likely that the obese horses were eating less feed (reduced DMI) and acquiring a lesser amount of energy from pasture feeding compared with their lean counterpart. Therefore, on a per unit body weight basis, the energy intake of obese ponies will be less than lean ponies. It was reported that obese ponies decreased their total daily digestible energy intake (DEI, MJ/kg BW/day) and decreased their rate of energy acquisition from food (J DEI/kg BW/min) (Dugdale et al., 2011b). The lower appetite and the reduced total dietary feed consumption, in part, would have likely resulted in a lower magnitude of weight change in obese ponies and an increased in their ease of maintenance of body weight, irrespective of season (Dugdale et al., 2011b). A lower basal metabolism in obese or overweight ponies may explain the observed reduction in appetite, decreased time spent on feeding, and increased time spent on non-eating activities, such as moving around or interacting with other horses (Dugdale et al., 2011a; Moore et al., 2019).

b. Requirements on pasture feeding

When Miniature horses have access to pasture, the NSC content of pasture on offer should be less than ten percent (<10%) or at most, between 10 and 12% of the total nutrient content of pasture to be considered a safe range to prevent pasture-associated laminitis (Lindåse et al., 2018). It has been reported that the recommended NSC content (water soluble carbohydrate + starch) of pasture that is grazed by horses prone to obesity or over-conditioning, must not exceed 100 g/kg DM (10% of total pasture nutrient content) (Longland et al., 2016). Different types of feed contain different content of NSC. For instance, the NSC content of alfalfa hay and teff[3] hay was ~12% NSC whereas for wheat and oats, the NSC was higher, at ~30% (Rodiek & Jones, 2012). The level of NSC in the pasture and hay can be determined by at least one of these three factors including species of grass or legumes, management practices employed (seed sowing, fertilization and irrigation practices) and the

[3] Teff is a fine grain, even smaller than the size of poppy seeds. It is a warm season annual grass originally developed and grown in Ethiopia, the horn of Africa and in Eritrea.

environment (climate, humidity, temperature, precipitation) (Longland & Byrd, 2006; Undersander, 2013).

Reports suggest that 8 g/kg BW per day of NSC is the upper normal limit for horses or ponies (Burns et al., 2015; Longland & Byrd, 2006; Potter et al., 1992). Meyer et al. (1995) reported that the maximal starch intake for horses is ~2 g/kg BW per meal, or 4 g/kg BW per daily feeding of two meals of starchy feeds, either oats, corn, barley, potatoes, or manioc[4], with alfalfa or hay. Similarly, Potter et al. (1992) reported that the maximum capacity of starch digestion in the small intestine (pre-caecal) is 0.35%-0.4% of body weight per feeding. The critical limit of starch digestion in the small intestine of horses is 3.5-4 g starch/kg BW/meal (Kienzle, 1994). A safer lower limit of 2 g starch/kg body weight /meal is preferred for starch with low digestibility, such as corn starch (Kienzle, 1994).

If a Miniature horse (110 kg) requires 2 kg of daily DMI, the total daily intake of NSC[5] must not exceed 880 g (or 0.88 kg), which is ~44% of total DMI (Burns et al., 2015; Longland & Byrd, 2006; Potter et al., 1992). The consumption of hydrolysable carbohydrates (CHO-H)[6], a fraction of the NSC, which include sugars such as hexoses, disaccharides, some oligosaccharides, and some non-resistant starches must not exceed 440 g or 0.44 kg (0.4% of body weight) (Potter et al., 1992). A Miniature horse weighing 110 kg may consume up to ~205 g of water-soluble carbohydrate (WSC)[7] in autumn, within three

[4] Manioc (or Cassava, or Yuca by Latin Americans) is a shrub. It belongs to the Spurge family of plants and it grows in tropical climates. It is cultivated for its edible root.

[5] Non-structural carbohydrate (NSC) is a measure of hydrolysable carbohydrate, which includes sugars and starches. NSC may be specifically fractionalized as ethanol soluble carbohydrate (ESC, mainly sugars), water soluble carbohydrates (WSC, which includes sugars and fructan), and starches.

[6] Hydrolysable carbohydrate (CHO-H) includes simple sugars (glucose, fructose, galactose), disaccharides (sucrose, maltose, lactose), oligosaccharides (maltotriose), and starches that are rapidly digestible or slowly digestible.

[7] Water soluble carbohydrates (WSC), include simple sugars (glucose, fructose, galactose), disaccharides (sucrose, maltose, lactose), oligosaccharides (maltotriose) and fructans. It does not include starches. Fructan, a polymer of the fructose molecules has either a short chain length of less than ten monosaccharide units (called fructo-oligosaccharides) or has more than ten monosaccharide units (called polysaccharides)

Source: Hoffman, R. M. (2016). *Carbohydrates*. https://veteriankey.com/carbohydrates/

hours of grazing, with an estimated DMI of up to 1% of body weight (Longland et al., 2016). It is difficult to make comparison from the values reported in these two studies because fructan is a fraction of the WSC, but it is not a component of the CHO-H, a fraction of the NSC, and, non-resistant starches, which are included as a fraction in the CHO-H, are excluded from the WSC. Nevertheless, both the CHO-H and the WSC includes sugars. Therefore, in six hours of grazing, they may consume enough sugars component in WSC (~205 g X 2 = ~410 g) (especially in autumn), which may be close to the limit of the 440 g of the sugar component in the CHO-H.

When Miniature horses are feeding on pasture, owners must take precautionary measures to prevent the occurrence of excessive ingestion of NSC. There are numerous precautionary steps suggested, such as 1) employing pasture restriction strategies, 2) avoiding fast-growing pasture, 3) avoiding 'stressed' pasture or pasture exposed to extreme environmental conditions or climate, 4) avoiding clover-dominant pasture, 5) avoiding plants in the reproductive state or plants that have 'gone to seed' because seed heads contain high levels of starch content, 6) avoiding recently harvested pasture, 7) avoiding supplementation with sweet feeds such as high sugar and starch concentrate, 8) encouraging grazing in shaded area, and 9) encouraging grazing on long grass where the tip of the leaves contain the lowest NSC content (Catalano et al., 2019b; Goh et al., 2020; Harris, 2017; Hoffman et al., 2001; Longland & Byrd, 2006)

IX. Effect of size, age and work levels of horses on its DE demand

c. Size

The effect of size of mature horses on digestible energy (DE) demand is directly proportional, i.e., it has a linear relationship (Ralston, 2015). Assuming all horses are lean or in ideal body condition, as the size of the horse increases, the DE demand increases linearly (Ralston, 2015). There is no difference in the DE per unit body weight for mature horses of different body sizes (Ralston, 2015). Pregnant or lactating broodmares have higher DE requirement than non-pregnant mares (Ralston, 2015). As their body size increases, the DE requirement increases. The increase is in a linear fashion for lactating mare, with consistent DE per unit body weight regardless of their size or their body weight (Ralston, 2015). However, the total increase in required DE as the body size increases is non-linear, i.e., exponential for pregnant mares. For instance, a 600 kg pregnant mare will require a greater (exponential) amount of DE per unit body weight than a 220 kg pregnant mare (Ralston, 2015).

d. Age

Age of a horse is an important factor in determining its DE requirement (Ralston, 2015). Young, growing horses between 4 and 24 months of age require increased DE as their size or body weight increases (Ralston, 2015). However, their DE requirement per unit body weight gradually decreases with increase in age, similar to growth curves used for describing daily weight gain (DWG) in growing horses, where the rate of DWG decreases with increase in age (Ralston, 2015).

Younger or older animals may require a higher plane of nutrition or energy sources in order to maintain their body core temperature during exposure to environmental stressors. Young growing horses such as yearling require *ad-libitum* feeding or adequate feeding in order to achieve thermo-neutrality when exposed to cold environmental temperature, close to the freezing point (Ralston, 2015). Below the freezing point, the DE_m for growing horses such as yearlings should be increased by 1.3% for every degree Celsius lowered in environment temperature (Cymbaluk, 1994). On the other hand, mature horses should still be receiving the same recommended DE intake when exposed to cold environmental temperatures above the freezing point, because adult horse can withstand temperatures of up to minus fifteen degrees Celsius (-15 °C) (Cymbaluk, 1994; Ralston, 2015). When experiencing severe cold, they increase their metabolic rates by 70% above resting metabolic rate (Cymbaluk, 1994). The digestible energy for maintenance (DE_m) or the calorie intake of adult horses should only be increased by 2.5% for every degree Celsius decrease in environmental temperature from anywhere below -1 to -5 °C (Cymbaluk, 1994; McBride et al., 1985). Although the estimated percentage increase in the required DE_m for every degree Celsius lowered in environment temperature for young, growing horses appeared less (1.3%) by comparison with adult horses (2.5%), in fact, they require a higher DE or DE_m per unit body weight (Ralston, 2015).

e. Work levels

The DE demand for horses increases according to the work levels. An idle horse requires only DE_m while horses used for low level competition, pleasure trail riding, performance or show at high level (show jumping, dressage, polo, racing) or for strenuous farm work require DE_m plus DE for exercise or for work (Ralston, 2015). A study reported that performance or exercising horses with increased body condition (BCS of 7.5) required 2.3 kg/d more total feed, more total energy intake (11.12 kcal/kg BW/d), and a higher calculated DE for maintenance (11.3 kcal/kg BW/d) than those with a moderate body condition (BCS of 5.2) (Webb et al., 1990). The data from performance or exercising horses is in contrast to evidence-based reporting in several recent studies that obese, sedentary ponies have a lower capacity to consume feed, likely due to a lower maintenance energy requirements or a lower basal metabolic rate after gaining weight (Dugdale et al., 2011b; Kienzle et al., 2010; Moore et al., 2019). Since the results from previous studies by Ralston (2015) and Webb et al. (1990) clearly showed that exercising or increased workload has a direct impact on increase in the feeding and energy requirement for maintenance for horses with higher BCSs (BCS 7-9), the lower energy requirements for obese or overweight ponies is attributed to decreased energy expenditure as a result of a lack of rigorous activity or intensive work (i.e., living a sedentary lifestyle). The decrease in energy expenditure necessitate physiological adjustments for lower energy consumption, lower feed intake, resulting in an apparent reduction in appetite.

X. Pasture as a primary source of energy supply to horses in New Zealand

Previous published works describes that the production of horses, including young horses in New Zealand is pasture based (Gee et al., 2017; Hoskin & Gee, 2004; Randall et al., 2014; Rogers et al., 2004; Rogers et al., 2007; Rogers et al., 2017b; Rogers et al., 2018; Stowers et al., 2009; Verhaar et al., 2014). This means that most horse owners in New Zealand rely heavily on pasture to supply adequate nutrients and energy for their horses due to the availability of pasture throughout the year with the moderate temperate climate (Rogers et al., 2017a; Rogers et al., 2017b). Horses selectively graze on pasture for about two-thirds of a day (16 hours) and travel between 7 and 15 kilometres per day, (Kenny et al., 2019; Rogers et al., 2017a; Rogers et al., 2017b). Young horses grazed on pasture may enhance and optimise their musculoskeletal growth and production (Rogers & Dittmer, 2019).

Pastures with high DE, high nutrient digestibility and low in fibre are considered good quality pasture. Good quality pasture, when ingested in enough quantities, provides a higher plane of nutrition for the grazing horse compared with poor quality pasture. Furthermore, the selective grazing behaviour of horses increases the consumption of pasture of different types, composition, taste and texture (Rayburn & Sharpe, 2019). Apart from being the primary source of energy supply to horses, pasture-based production systems have tremendous benefits such as allowing horses to socialize and to express their natural behaviour, so it is welfare-enhancing and, it is an economical practice for feeding horses for horse owners in New Zealand (Harris, 2017).

However, there are several counter-beneficial effects of a pasture-based equine production system such as increased risks of pasture-associated laminitis, obesity, gastrointestinal parasitic worm infection, or exposure to various types of toxins from plants or weeds. An uncontrolled grazing environment may increase the risks of horses and ponies becoming obese and developing laminitis (Burns et al., 2015; Carter et al., 2009b; Menzies-Gow et al., 2010; Menzies-Gow et al., 2017; Taylor et al., 2014). Furthermore, several publications have described that obesity in horses has been associated with pasture-based management practices (Becvarova & Pleasant, 2012; Buckley et al., 2018; Giles et al., 2014; Lindåse et al., 2016; Moore et al., 2019). In addition, a tapeworm (*Anoplocephala sp.*) infection was associated with horses with access to pasture for grazing (Kornas et al., 2010). The ingestion of *Lolium* endophyte toxins from pasture pre-dominantly consist of Perennial ryegrass species causes ryegrass staggers (tetanic muscle spasm) in horses (Cunningham & Hartley, 1959; Fletcher & Harvey, 1981).

XI. Dry matter intake (DMI), feeding pattern of ponies and small-sized horses

To the author's knowledge, no studies on the voluntary feed intake (VFI), dry matter intake (DMI) or the feeding patterns of Miniature horses have been carried out. However, previous studies reported the total feed consumption or voluntary feed intake (VFI), quantified in terms of the total dry matter intake (DMI). For two groups of six Welsh Mountain pony mares, when fed *ad libitum* ranged between 4.6 ± 0.3% of their body weight (in summer) and 3.5 ± 0.1% of their body weight (in winter) (Dugdale et al., 2011b). For a group of five pony geldings, 80% of their total daily feed consumption were reported to be 2.9 ± 0.41% of their body weight (Ralston et al., 1979). From the results of these two studies, the DMI for pony breeds ranged between ~3% and ~5% of their body weight (Dugdale et al., 2011b; Ralston et al., 1979). The voluntary feed intake (VFI) of Miniature horses may be influenced by season, existing body condition, presence of a history of laminitis and the total time spent on feeding (Dugdale et al., 2011b; Harrison & Murray, 2016).

It was estimated that the average daily DMI of horses is 2-2.5% of body weight (Longland et al., 2016). The DMI of ponies can be higher, at up to 5% of their body weight (BW) (Longland et al., 2016). In one study, the DMI of ponies have exceeded 1% of their body weight in at least one three-hour grazing episode across seasons (Longland et al., 2016). It was reported that ponies grazing on pasture across seasons for three hours consume, on average, 0.64% dry matter of their body weight across seasons (highest in autumn, ~0.8%) Longland et al. (2016). And, they consume 205 g/100 kg BW of WSC (autumn), 131 g/100kg BW of WSC (spring) and 121 g/100 kg BW of WSC (summer) during the three-hour grazing Longland et al. (2016). The data presented by Longland et al. (2016) showed that seasonality affected the water-soluble carbohydrate intakes (WSCI) of ponies, the WSCI were significantly higher in autumn, compared with summer. A Miniature horse weighing 110 kg may voluntarily consume ~205 g of, ~131 g, and ~121 g WSC in autumn, spring, and summer respectively, within 3 hours of grazing, with DMI of up to ~1% of their body weight (Longland et al., 2016).

The feeding pattern of ponies and horses kept at pasture is not clear. However, the feeding pattern for ponies kept in stalls or stables have been described as 80% eaten as discrete meals (~40 minutes) and 20% as nibbles (~5 minutes), with 7.2 to 10.8 hours a day spent eating (Dugdale et al., 2011b; Ralston et al., 1979). In a study where ponies were kept in stalls and fed a complete pelleted diet *ad libitum*, meal intervals can span from nearly an hour and a half (84 ± 10 minutes) to a maximum of three hours (Ralston et al., 1979). The ponies kept in stalls spent the evening and overnight consuming slightly higher proportion of the meal (58%) compared with during the day (42%) (Ralston et al., 1979).

XII. Pasture feeding in New Zealand

Good pasture management practices allow sustainable pasture production and optimisation of the production of horses on pasture in New Zealand, including Miniature horses (Kenny et al., 2019; Rogers et al., 2017b; Rogers & Dittmer, 2019). Data on pasture feeding management practices of horse, especially the non-commercial horses in New Zealand is currently limited (Rogers et al., 2017a). Although the pasture used for commercial horses in New Zealand are identified as predominantly perennial ryegrass (*Lolium perenne*), tall fescue (*Festuca arundinacea*) and white clover (*Trifolium repens*), there are various other species of grasses, legumes, herbs and weeds in pasture grazed by horses in New Zealand (Hirst, 2011; Hoskin & Gee, 2004; Metson & Saunders, 1978; Radcliffe, 1974; Rogers et al., 2017a).

An estimate of pasture utilisation (which is the proportion or percentage of pasture area used by horses for grazing) for commercial horses is 70%, enabling the practice of mixed grazing with ruminant species to enhance pasture utilisation efficiency (Rogers et al., 2017a). However, pasture utilisation for horses kept for recreational purposes may be varied depending on various factors such as the duration of access to pasture (varying forms of pasture restriction practices), the rate of voluntary feed intake (VFI) of horses of different breeds and sizes, the stocking density within a paddock or the stocking rate of other farmed animals on the farm and the pasture management practices (strip grazing, rotational grazing, mixed grazing, harrowing, topping, and mowing pasture). All these factors potentially influence pasture utilisation for recreational horses.

The study of pasture feeding, nutritive value or quality of pasture for horses has become more extensive in recent times due to the recognition of the problem of obesity or over-conditioning in recreational horses, particularly the pony breeds. The quality of pasture ('good quality' here referring to pasture with high DE, high nutrient digestibility and low fibre content) is an important factor to consider, particularly for pony breeds because the feed conversion efficiency of pony breeds, heavy breeds (draft horses) and sport breeds (warmblood horses) may be higher than light breed horses (Rogers et al., 2017a). Horses were found to prefer good quality pasture with high nutritive value due to high sugar content (high in carbohydrate and energy) and low fibre content over poor quality pasture with low nutritive value due to high fibre content and low sugar content (Randall et al., 2014). Horses increases their intake of good quality pasture compared to poor quality pasture (Randall et al., 2014).

XIII. Seasonal pasture growth or the availability of NZ pasture across seasons

Seasonality affects the rate of pasture growth, and hence, pasture density or availability (Radcliffe, 1974). During summer, pasture growth is inhibited by diminished soil moisture content due to high heat or ambient temperature (Owen et al., 1978). In addition to soil moisture, climate and soil fertility affects pasture growth across seasons (Baars' et al., 1990; Radcliffe, 1974). Referencing pasture used for ruminants, the derived metabolizable energy (ME) of pasture (calculated using formulae generated from data collected from previous ruminant studies), the ME of pasture during summer is very low due to increase dead matter content of pasture (Rogers et al., 2017a). The percentage of ryegrass species on pasture was lowest (~42%) in summer, and the percentage of dead matter was highest at (~20%) amongst the four seasons (Hirst, 2011). Summer pasture may be suitable for feeding Miniature horses due to its reduced sugar content, which in turn is due to decreased in high sugar-containing ryegrass species on summer pasture (Rogers et al., 2017a).

In the North Island of New Zealand, a deficit in pasture availability occurs during the winter months of July and August (Rogers et al., 2017a). Similarly, in the Southland region in the South Island, there can be no visible pasture during winter months of July and August (Rogers et al., 2017a). In a seasonal botanical composition of New Zealand pasture was conducted by Hirst (2011). Hirst (2011) described the relative proportion of grasses, clover (legumes), weed, and dead matter across seasons, though the total quantity of pasture or the pasture mass was not described in the study. The study revealed that during winter, the percentage of ryegrass was highest (~80%) whereas and the percentage of clover (legume species) was lowest (2.5%) (Hirst, 2011). During winter, the percentage of weed content of pasture was lowest (~3%) (Hirst, 2011). Although pasture growth is limited during winter in the North Island, winter season may not be the suitable season to offer *ad libitum* pasture feeding to Miniature horses. During winter, the pasture botanical composition may consist predominantly of perennial ryegrass species, and we know that the perennial ryegrass grass species contain high levels of NSC.

The highest pasture growth is during spring, which coincides with the horses' breeding seasons (September-December) (Rogers et al., 2017a). Similarly, a study conducted in Bulls, North Island of New Zealand confirmed that the growth rates of pasture is typically low in winter (10 – 30 kg DM/ha/day) around July and August, and highest in spring and early summer (50 – 70 kg DM/ha/day) (Brown-Douglas et al., 2005). It is difficult to determine which season(s) would be most suitable for grazing of pasture by the Miniature horses. Horses or ponies at risk of obesity or laminitis grazed on seasonal pasture with a high ratio of fermentable (CHO_F) to structural carbohydrate (CHO_{struc}), i.e., CHO_F: CHO_{struc} [8], may be a management issue for owners (Randall et al., 2014).

XIV. NZ pasture nutrient digestibility across seasons and the digestible energy (DE) derived from ingested pasture

According to trials conducted on pasture fed to horses in New Zealand, the digestibility coefficients of pasture for broodmares and youngstock ranges between 0.46-0.55 (grass hays) and 0.86-0.90 (cereals and grains) (Rogers et al., 2017a). The digestibility of each nutrient component of pasture: crude protein, carbohydrate, acid detergent fibre (ADF), neutral detergent fibre (NDF), lipid, and minerals is within the range from ~0.41-0.96, highest being the carbohydrate: 0.96 ± 0.01 (Rogers et al., 2017a).

From autumn through to winter and spring, forage dry matter digestibility increases, and forage is mainly in the leafy or vegetative growth stage (Hirst, 2011). During late spring or early summer, the dry matter digestibility of forages gradually decreases because the forages in pasture turn stemmy and the plants enter the reproductive or mature growth stage (no longer in the vegetative or immature growth stage) with production of seed heads which contain high levels of starch (Hirst, 2011). By late summer, there is increase in dead matter in pasture and therefore the percentage of digestibility of dry matter is the lowest (Hirst, 2011). As plants mature, the sugar and crude protein content decreases by 20-25%, while the fibrous components, such as cellulose, hemicellulose and lignin increase by 19-25% (Waghorn & Barry, 1987). A study reported that during summer, the protein content of pasture is decreased whereas the fibre content of pasture is increased, as the pasture matures (Owen et al., 1978). The seasonal variation in the WSC (sugar) content of pasture is due to factors such as plant maturity, and sward height. The water-soluble carbohydrate content of pastures is reduced as plant mature. Taller swards on pasture contained more dispersed water-soluble carbohydrate than the shorter swards (Longland et al., 2016).

[8] Fermentable carbohydrate refers to hot water-soluble carbohydrate (HWSC) and pectin. Structural carbohydrate includes cellulose and hemicellulose.

A proportion of the DE extracted from the fibre content of pasture comes from the complex process of microbial fermentation in the horses' caecum (fermentation vat). The higher the fibre content of pasture, the more DE will be derived from the fermentation of ingested pasture in the caecum and the hindgut (Rogers et al., 2017a). The DE derived from the fermentation of fibrous material in the caecum differ from the nutrient digestibility of pasture, which is mainly assimilated in the villi of the stomach, duodenum, jejunum, ileum. The nutrient digestibility of pasture describes the proportion of the nutrient in the total dry matter that is assimilated into the villi of the horses' digestive tract whereas DE derived from pasture is from the energy content of the pasture plus the energy generated from mainly undigested fibre component in the diet that undergo fermentation in the horses' caecum after travelling past the small intestine. With increase in VFI or DMI (or when more pasture volume is ingested), more DE can be derived from fermentation of ingested pasture (mainly fibre component) in the hindgut (Rogers et al., 2017a).

XV. Methods to restrict pasture intake

Methods employed to restrict pasture intake for horses involves limiting pasture consumption. When pasture feeding is restricted, the total daily DE consumed will be lowered to various degrees, depending on the amount of feed ingested. Pasture intake or pasture feeding can be restricted by limiting daily consumption of pasture to 1.25% of body weight on a dry mater basis, which equates to feeding ~0.115 MJ/kg BW/day (Argo et al., 2012). Long-term pasture restriction (e.g. 5 – 7 months) at 80 – 90 % of the total DE requirement is effective in achieving weight loss for horses (~5 ± 3% body weight reduction) (Gill et al., 2016). Pasture restriction of up to 1.25% BW on a DMI basis is equivalent to restricting pasture intake of up to 70-75% of the total DE requirement; this shortened the length of time to achieving weight loss, and it is still considered a safe regimen for weight loss without compromising horse health (Geor, 2013). When restricted pasture feeding at very low DE or at an extremely low dry matter content, there could be undesirable consequences such as hypertriglyceridemia, negative energy balance, gastric ulceration and the development of stereotypic behaviour such as coprophagy (Argo et al., 2012; Bruynsteen et al., 2015; Curtis et al., 2011; Hughes et al., 2004; McGreevy et al., 1995; Murray & Eichorn, 1996; Owen et al., 1978; Redbo et al., 1998; Robie et al., 1975).

Several studies have reported that horses refractory to weight loss may be fed a restrictive diet of up to 1% BW DMI or up to 60% DE for maintenance, in order to achieve short-term, overall weight loss of ~10% initial body weight in about 16.5 weeks (4 months) (Argo et al., 2012; Bruynsteen et al., 2015). When horses are on a restricted diet or pasture feeding, they will be expected to lose an average of ~1% of body weight on a weekly basis, with the greatest percentage of weight loss at the start of the feeding restriction plan (the percentage of body weight loss reported in the first initial weeks was about 3-5%, thereafter 0.6-0.8%) (Dugdale et al., 2010; Van Weyenberg et al., 2008).

Weight loss in Miniature horses can be supported using a grazing muzzle (Davis et al., 2020). A study reported that all pasture-grazed Miniature horses which worn a grazing muzzle for 24 hours daily had a small, but significant decrease in their body weight by the third week (Davis et al., 2020). The study reported that the body weight of Miniature horses which were allowed to graze without wearing a grazing muzzle and those which were allowed to graze wearing a grazing muzzle for only 10 hours in a day increased significantly to a similar extent by the third week (Davis et al., 2020). According to two studies on ponies, when a grazing muzzle is used, the amount of forage intake consumed is lowered by 30% (during spring), 23% (during summer) and 17% (during winter) (Glunk et al., 2014; Longland et al., 2016). Varying the horses' access to pasture across seasons by the number of hours kept on pasture, and the practice of pasture restriction strategies such as strip grazing, use of paddock with little grass or limiting access to pasture entirely by stabling the horse are other different forms of pasture restriction practices. Apart from restricting pasture intake, the following strategies promote energy expenditure in a horse: winter coat-clipping, exposure to cold environment or outdoor-living and exercise (Argo et al., 2012; Kubiak et al., 1987).

XVI. Recognition of obesity: The body condition scoring systems

The 9-point Henneke body condition scoring system has been used to access the body condition of Miniature horses: where 1 is poor, 2 very thin, 3 thin, 4 moderate thin, 5 moderate, 6 moderately fleshy, 7 fleshy, 8 fat, 9 extremely fat (Bruce et al., 2010; Catalano et al., 2019a; Henneke et al., 1983; Henneke, 1985). It is frequently used with the Kohnke modification which comprises three subcategories including BCS 1-3: thin, BCS 4-6: moderate, BCS 7-9: fat (Dugdale et al., 2011a; Kohnke, 1992; Kohnke et al., 1999). A whole or a whole plus half-point scores can be used during assessment of the body condition of a Miniature horse (Cantarelli et al., 2018). Another body condition scoring system with a scale of 0 (very poor body condition) to 5 (very fat body condition), called the Carroll and Huntington BCS has been developed (Carroll & Huntington, 1988). When the Carroll and Huntington BCS is used with a half-point score, it is equivalent to the 9-point Henneke body condition scoring system. The body condition scoring system is recognised as an independent assessment, it is unaffected by body conformation, body length and height, and has been previously validated for use in pony breeds such as Welsh, Dartmoor, or crossbred ponies (Carter et al., 2009a; Henneke et al., 1983).

The average body weight for an adult Miniature horse with a body condition score (BCS) of 5 out of 9, on a 9-point body condition scoring system was 110 ± 21 kg (Catalano et al., 2017; Catalano et al., 2019a). During the study on the estimation of the actual and ideal body weight of Miniature horses, for each BCS of 6, 7, and 8, adult Miniature horses are required to lose at least 5 kg (5-14kg), 9 kg (9-18kg), and 19 kg (19-25 kg) (estimated based on calculated ideal body weight), in order to achieve the ideal body condition and body weight (Catalano et al., 2019a).

XVII. Recognition of regional obesity: The cresty neck score (CNS)

The cresty neck score (CNS) was first introduced by Carter et al. (2009a). It is a 6-point scoring system, with a scale of 0 to 5. Score 0 represents no crest observed or palpated; score 1 represents no crest observed but crest can be felt slightly; score 2 represents crest observed and felt with side-to-side flexibility, but it is evenly distributed along the neck; score 3 represents crest observed and felt but the side-to-side flexibility is loss and its' mass is heavier at midline of the neck length; score 4 represents an enlarged crest observed and felt, the crest can be bent from side-to-side easily with loss of elasticity plus the presence of vertical wrinkles or creases and score 5 represents the presence of a severely enlarged crest that falls to one side.

The neck crest height (CNH), and neck circumference (NC) can be used in tandem with the CNS to access regional neck adiposity in Miniature horses (Carter et al., 2009a; Frank et al., 2006; Martin-Gimenez et al., 2018). However, currently, no scientific work has published evaluating the measurements for the CNS, CNH and NC in Miniature horses. In horses and ponies, crest neck height

(CNH) was associated with CNS and both the CNH and CNS are used to access the nuchal fat deposited along the dorsal neck region, or to aid assessment of neck crest adiposity (Carter et al., 2009a). Seven obese horses with insulin resistance (breeds: Morgan horse, Paso Fino, Quarter Horse and Tennessee Walking Horse) have a significantly higher ($p<0.01$) neck circumference than five non-obese mares (breeds: Quarter horse, Appaloosa and Mustang) (Frank et al., 2006). A study reported that Andalusian horses with high cresty neck scores were reported to have increased NC at 25% and 75% neck length (Martin-Gimenez et al., 2018). The nuchal fat (i.e., the fat deposited at the nuchal ligament), giving rise to a higher CNS, is independent of the body total fat (white adipose tissue) (Dugdale et al., 2011a). Certain risk factors or indication for high cresty neck score (CNS ≥ 3/5) identified were: native cobs and pony breeds, provision of supplementary hay, history of laminitis, and small herd sizes (Giles et al., 2015).

XVIII. Recognition of obesity: The body mass index (BMI)

The body mass index (BMI) has not been evaluated in the Miniature horse breed. It may be a useful tool to describe obesity or over-conditioning in the Miniature horses, as other studies have shown that the BMI is positively correlated with increased body fat, increased body condition score and obesity (Carter et al., 2009a; Hill et al., 2020; Kearns et al., 2006; Thatcher et al., 2008; Thatcher et al., 2012). The equation [BMI = estimated body weight (kg) ÷ (withers height, m^2)] was first evaluated in horses by Donaldson et al. (2004)]. By substituting the estimated body weight in the BMI equation with morphometric measurements, which is the squaring the heart girth and multiply by the body length, gives the following equation: BMI ≈ [(heart girth)^2 X body length] ÷ (withers height)^2 (Carroll & Huntington, 1988). The BMI can be expressed as estimated body weight (kg) ÷ (withers height, m X body length, m) (Carter et al., 2009a; Hoenig & Ferguson, 2002). In this form, when the same morphometric measurements are substituted into the original equation; BMI ≈ [(heart girth)^2 X body length] ÷ (withers height X body length), equals to BMI ≈ [(heart girth)^2] ÷ (withers height). Interestingly, the heart girth (HG): withers height (WH) ratio is noticeably embedded in the equations: BMI ≈ [(heart girth)^2 X body length] ÷ (withers height)^2 and BMI ≈ [(heart girth)^2] ÷ (withers height). Hence, the heart girth (HG): withers height (WH) ratio is correlated with the BMI (Donaldson et al., 2004).

XIX. Seasonal changes in body weight and body condition

No studies have been published on seasonal changes in the body weight of Miniature horses. Nevertheless, several other studies reported that the body weight and the body condition of horses, or even the neck circumference (or the thickness of horses' and ponies' neck) varies across seasons (Bailey et al., 2008; Bertolucci et al., 2008; Dugdale et al., 2011b; Giles et al., 2014; Giles et al., 2015; Lewis et al., 2014). Studies have described the patterns of seasonal changes in body weight of horses (Fitzgerald & McManus, 2000; Salazar-Ortiz et al., 2011; Staub et al., 2019; Takahashi & Takahashi, 2017). Briefly, the body weight of horses fluctuates in spring and summer months (higher in spring and lower in summer), but with a trend of overall increase, with the highest recorded body weight in autumn. A loss of body condition usually occurs during winter, and, by the end of winter, horses have their lowest body weight. Sex differences in body weight changes across season were observed. For instance, a study on Thoroughbred racehorses in Japan reported that the body weight of these racehorses peaked in Autumn for both sexes, however the geldings took a longer period of time (over the next summer) to attain their lowest body weight, compared with mares, which attained their lowest body weight sooner in the next spring (Takahashi & Takahashi, 2017). The delay in achieving nadir body weight for these racehorses across seasons, i.e., the transition from late winter to spring or summer may be due to a tight regulation in their feeding management practices.

XX. Conclusion

There is clearly a gap in the literature on published research on the Miniature horse breed in New Zealand. Hence, a survey will be conducted to describe the demographics, feeding management and health care practices of Miniature horses. The data gathered from this survey will allow further research in investigating the inter-relationship between pasture management and obesity or over-conditioning in Miniature horses.

Chapter 3: Materials and methods

An online survey was created using the Qualtrics Survey Software (https://massey.qualtrics.com/) and was published between 4th July 2019 and 26th November 2019. Recruitment of respondents was achieved via snowball sampling technique. The link to the survey was published on social media pages of Miniature horse special-interest and breeder groups within New Zealand. In addition, key industry participants known to the authors were involved in disseminating the link of the survey via social media.

The survey consisted of eighty-five succinctly crafted questions, which were a combination of closed and open-text responses. The questions addressed four main subject areas; demographics, feeding, management practices and health care practices for Miniature horses in New Zealand. The survey was approved by the Massey University Human Ethics committee as low risk (notification number: 4000021167).

The dataset from the survey was subsequently coded and cleaned for analysis within Microsoft Excel. Continuous data were examined for normality using histograms and the Shapiro-Wilk test. If data were non-parametric, the median, 1st quartile, 3rd quartile or mode frequency of the data series were reported. Differences between groups for non-parametric data were examined using Kruskal-Wallis test one-way analysis of variance, significant differences between the groups were further tested using a pairwise Mann-Whitney test. Differences in distribution between groups were tested using the Chi-square test. All statistical tests were performed, and significance was accepted at $p<0.05$ using SPSS Statistics 26.0 (IBM Corp., Armonk, N.Y., USA).

Chapter 4: Results

I. Daily response rate and time taken by respondents to complete the survey

Of the 247 survey attempts, 232 resulted in valid responses, of which 153 had a 100% question completion rate and a further 41 responses had 97-99% question completion rate (n=194/232, 84%) (Figure 2). Most responses (90%) were gathered after the first seeding of the survey on the 5th of November 2019. The highest response rate was gathered on the second day after the first seeding (n=119/232, 51%). A second seeding of the survey was performed on the 18th of November 2019, twelve days after the first seed, but the response rate was not as high compared to the first seed (Figure 2). The median (interquartile range) time taken to complete the survey for 232 respondents was 10 (8-14) minutes. Respondents have taken between 1 minute (minimum time) and more than 217 minutes (maximum time) to complete the survey (Figure 3). A hundred respondents (n=100/232, 43%) provided their contact email addresses upon completing the survey. The results from the survey were summarised and forwarded to these respondents.

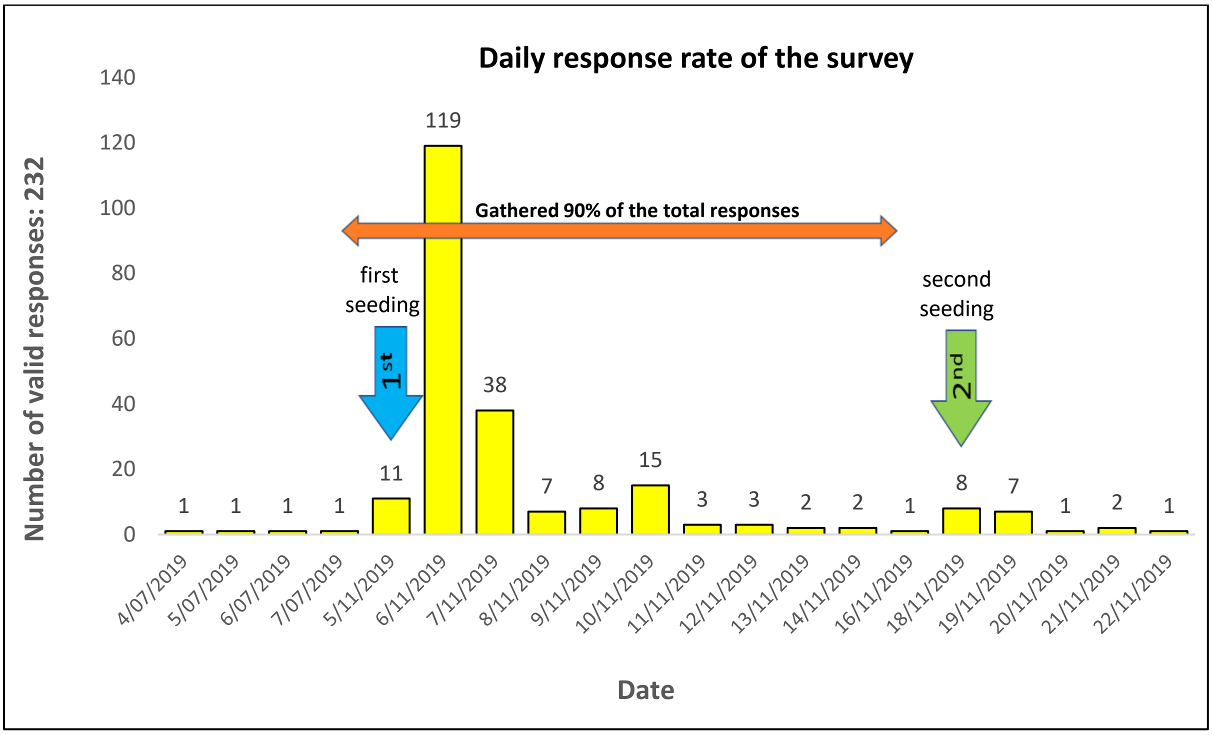
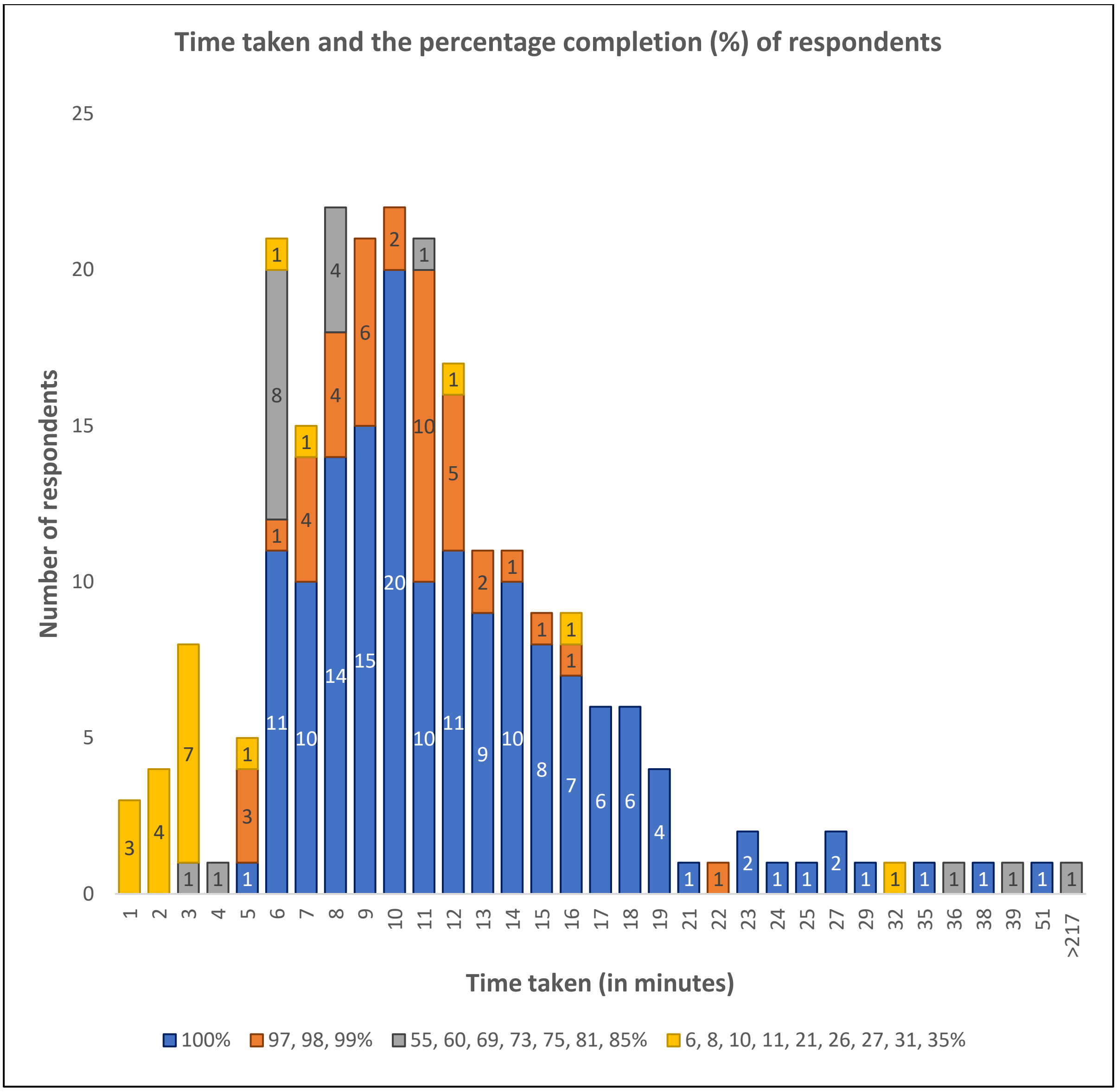


Figure 2 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The number of responses gathered daily from 4th July 2019 to 22nd November 2019 (the period where the link to the survey was active), an overview of the daily response rate.*



	Mean	Median	1st quartile	3rd quartile	Range
Time taken (in minutes)	11.4	10	8	14	1 - >217

Figure 3 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: Time taken by respondents to do the survey and the percentage completion (%) by respondents in the survey.*

II. Demographics

Most respondents were female (n=226/232, 97%) aged 35-64 years (n=152/232, 66%), with the highest number of respondents in the 45-54 age bracket (n=65/232, 28%), followed by respondents in the age brackets of 55-64 (n=45/232, 19%) and 35-44 (n=42/232, 18%)[9] (Figure 4). Most Miniature horse owners had at least five years of experience with keeping Miniature horses (n=176/232, 76%). The number and percentage of respondents (n=99/176, 56%) who kept their Miniature horses for more than 10 years was the highest[10] (Figure 5). Most respondents kept their Miniature horses on a lifestyle block (n=172/232, 74%) (a lifestyle block refers to a land area of ~4 hectares (ha) or ~10 acres). Responses were obtained from all regions in New Zealand: Canterbury (n=37), Waikato (n=29), Taranaki (n=28), Auckland (n=28), Manawatu-Whanganui (n=23), Northland (n=18), Wellington (n=15), Bay of Plenty (n=13), Hawke's Bay (n=11), Otago (n=9), Nelson-Marlborough (n=6), Tasman (n=6), West Coast (n=3), and Wairarapa (n=3).

Most respondents (n=164/232, 71%) registered their Miniature horses (n=1,137) with the New Zealand Miniature Horse Association (NZMHA) registry. As Miniature horses can be registered with multiple breed registries or societies, 131 respondents indicated that their horses had more than one registration. They registered their horses with one or several of these societies: National Miniature Horse Society of New Zealand (NMHSNZ), Association of Independent Miniature Horse Club New Zealand (AIMHCNZ), American Miniature Horse Registry (AMHR) and the American Miniature Horse Association (AMHA). In a column text entry, respondents cited other societies or association for the registration of Miniature horses, which include New Zealand Pinto Horse Society, American Shetland Association of New Zealand (ASANZ), New Zealand Golden Horse Society and Miniature Horse Association of Australia (MHAA). There were 23% of respondents (n=54/232) who did not register their horses with any breed society.

[9] The age bracket for respondents' age demographic was: 16-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65 years or more.

[10] The age bracket for the number of years of experience with keeping Miniature horses was less than 2 years, 2-4 years, 5-7 years, 8-10 years and more than 10 years.

Respondents were provided with multiple options to describe the reasons for keeping Miniature horses: as pets (n=143), for showing (n=135), as a companion for other horses (n=81), for leisure driving (n=71), for breeding (n=64), for competitive driving (n=57), to be ridden by children (n=41), and as a therapy horse (n=25) (Figure 6). Miniature horses were grouped into three categories: leisure and companionship, competition, and breeding, based on the primary purpose for the horse-keeping (Figure 7, Table 2).

The management practices of these three groups of Miniature horses were significantly different from one another; owners who kept Miniature horses for leisure and companionship kept significantly fewer number of horses ($p<0.05$), with a median (interquartile range) of 2 (IQR 1-4) horses compared to owners who kept Miniature horses for competition, 6 (IQR 3-11) horses or for breeding, 10 (IQR 4-16) horses (Table 2). Some respondents who used Miniature horses primarily for competition (45%, n=37/82) or leisure and companionship (8%, n=11/130), were involved in breeding Miniature horses (Figure 6).

A total of 1,183 Miniature horses were kept by 218 respondents (Figure 8, Table 2). Over half of the Miniature horses were between 6-15 years of age (n=658, 56%) (Figure 9, Table 2), with the remainder evenly divided between the other age categories. Few respondents (n=81/223, 36%) kept Miniature horses exclusively, with the majority (n=134/223, 60%) kept horses of other breeds. There were 134 respondents with Miniature horses who kept 444 horses or ponies of other breeds, refer to Figure 10. Of the eighty-one respondents who only kept Miniature horses, 62/81 respondents (77%) had kept Miniature horses alone for at least 5 years. Of the 134 respondents who kept Miniature horses and horses of other breeds, 100/134 respondents (75%) had kept them for at least 5 years. The overall median number of Miniature horses kept per respondent was 3 (IQR 2-7) (Table 2).

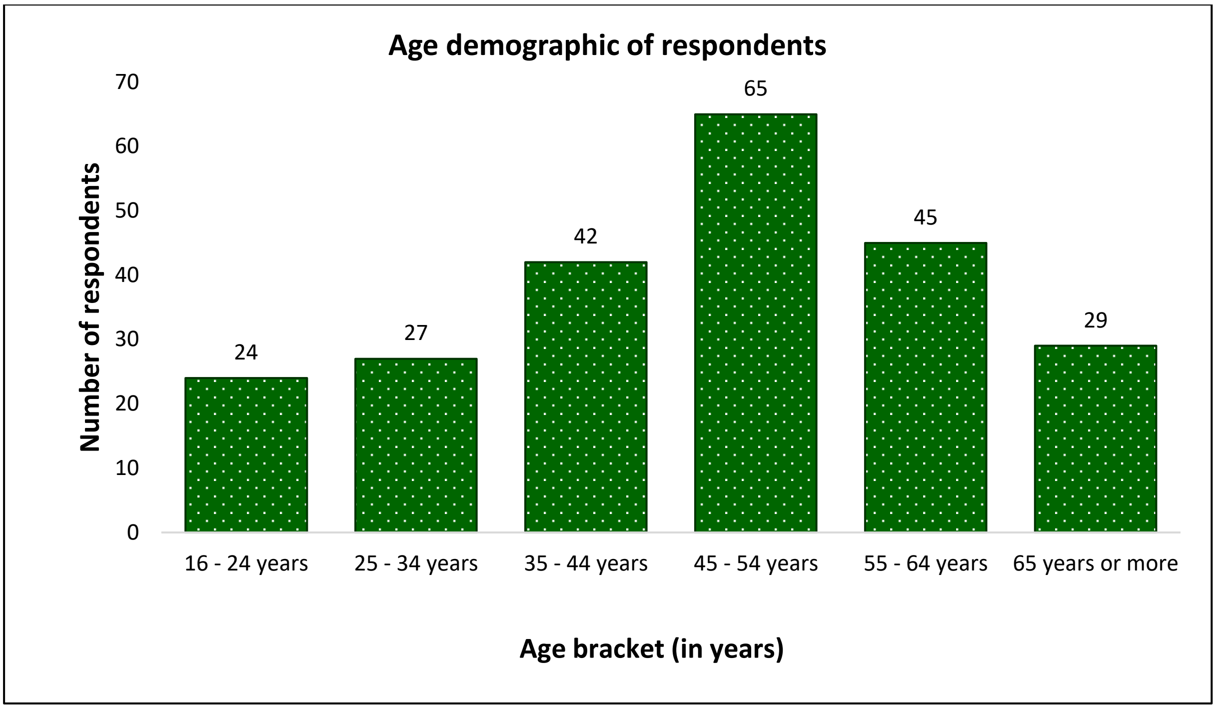


Figure 4 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: Age demographic of respondents.*

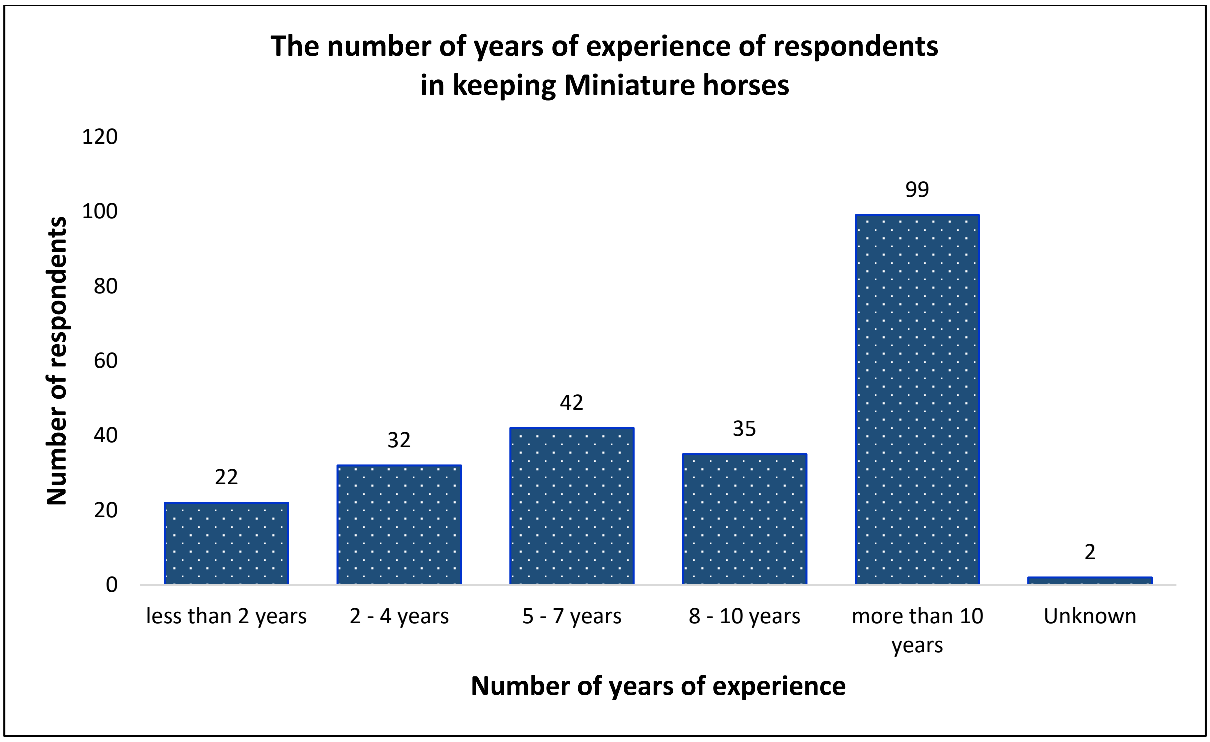


Figure 5 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The number of years of experience of respondents in keeping Miniature horses.*

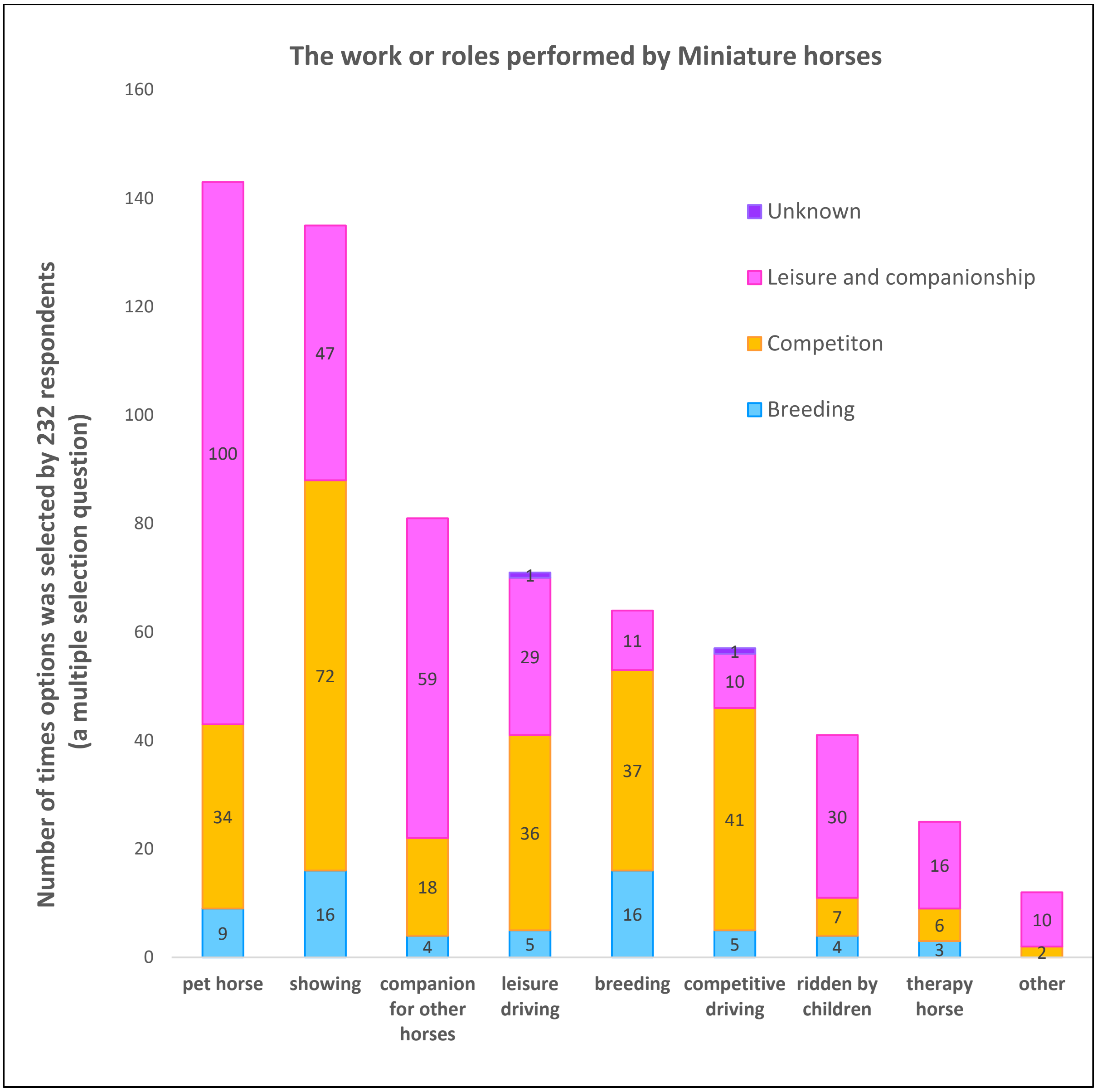


Figure 6 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The work or roles performed by Miniature horses.*

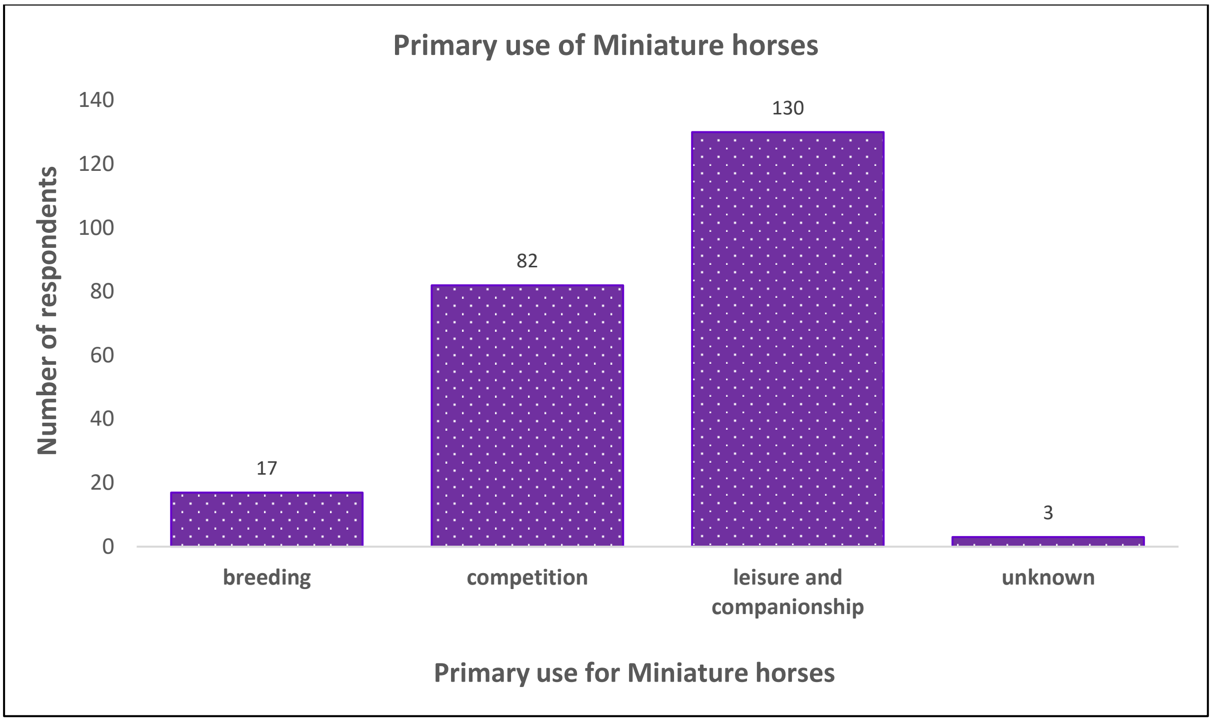


Figure 7 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The number of respondents according to primary use; the primary uses of Miniature horses were for breeding (n=17 respondents), for competition (n=82 respondents) and for leisure and companionship (n=130 respondents).*

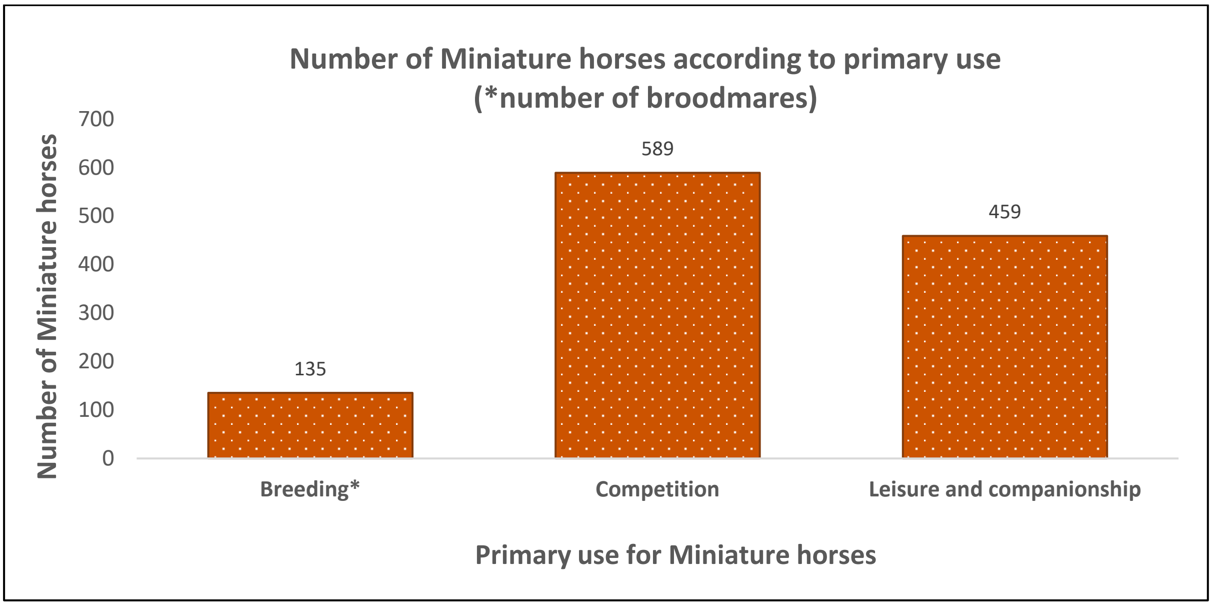
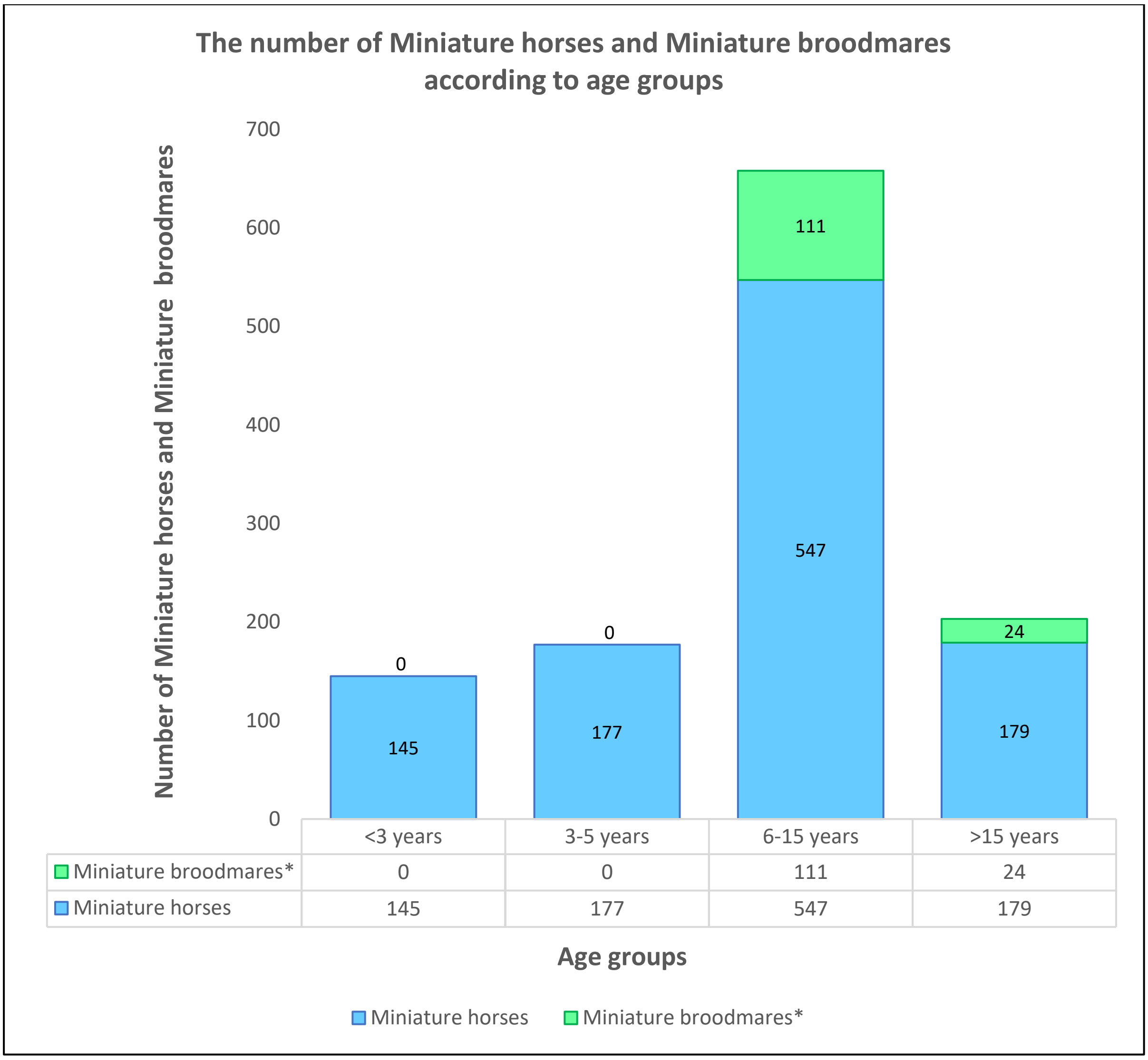


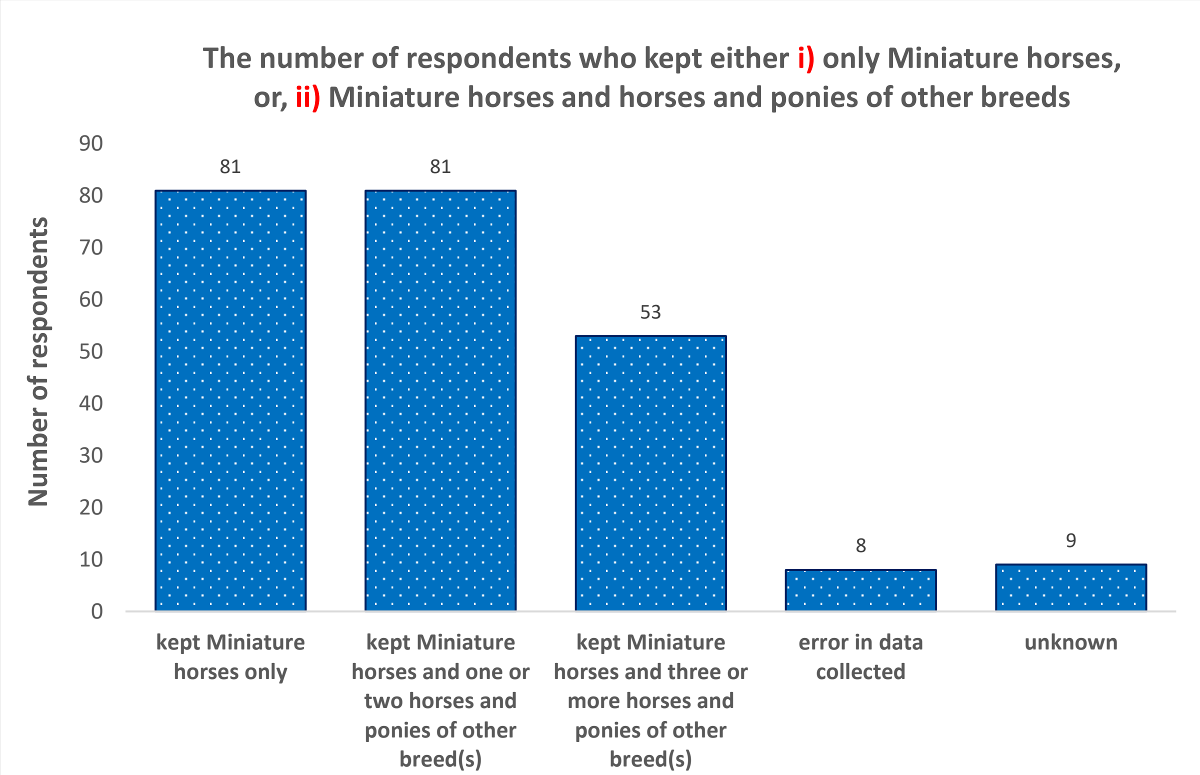
Figure 8 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The number of Miniature horses according to primary use; the primary uses of Miniature horses were for breeding (n=135 Miniature broodmares), for competition (n=589 Miniature horses) and for leisure and companionship (n=459 Miniature horses). The total number of Miniature horses: 1,183.*



Age group	Miniature horses	Miniature broodmares*	Total
young or immature, <3 years	145	-	145
young adult, 3-5 years	177	-	177
adult, 6-15 years	547	6 - 12 years: 30 13 - 15 years: 81 subtotal: 111	658
geriatric, >15 years	179	24	203
Total	1,048	135	1,183

*Miniature broodmares kept by Miniature horse breeders or respondents who indicated their primary use for Miniature horses was breeding

Figure 9: *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The number of Miniature horses and Miniature broodmares according to age groups.*



	kept Miniature horses only	kept Miniature horses and one or two horses and ponies of other breed(s)	kept Miniature horses and three or more horses and ponies of other breed(s)	error in data collected	unknown	Total
Number of respondents	81	81	53	8	9	232
percentage %	34.9%	34.9%	22.8%	3.4%	3.9%	100.0%

The total number of horses and ponies (including Miniature horses)	1,627*
The total number of Miniature horses	1,183*

Figure 10 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The number of respondents who kept only Miniature horses and the number of respondents who kept Miniature horses and horses and ponies of other breeds.*

Table 2 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: a) the number of Miniature horses per respondent, b) the age distribution, c) the stocking density, and d) the number of hours of stabling, of three groups of Miniature horses: i) leisure and companionship, ii) competition and iii) breeding.*

	Leisure and companionship	**Competition**	**Breeding ***	**Total**	**P**
Percentage of respondents (n, number of respondents)	56% (n=130)	35% (n=82)	7% (n=17)	100% (n=232 [§])	-
Total number of Miniature horses	459 (data from 126 respondents)	589 (data from 79 respondents)	135 (data from 13 respondents)	1,183 (data from 218 respondents)	-
Median (IQR) of the Miniature horses owned by each respondent	2 (1-4)[b] (data from 126 respondents)	6 (3-11)[a] (data from 79 respondents)	10 (4-16)[a] (data from 13 respondents)	3 (2-7) (data from 218 respondents)	P <0.05
Age distribution of Miniature horses (in brackets: the number of horses, n)	<3 yrs (n=28) 3-5 yrs (n=57) 6-15 yrs (n=280) >15 yrs (n=94)	<3 yrs (n=117) 3-5 yrs (n=120) 6-15 yrs (n=267) >15 yrs (n=85)	6-12 yrs (n=30) 13-15 yrs (n=81) >15 yrs (n=24)	1183 (data from 218 respondents)	P <0.05
Median (IQR) of the stocking density, or, the number of Miniature horses per hectare, horses/ha	10 (5-17)[a]	13 (7-22)[b]	12 (4-13)[a]	10 (5-20)	P <0.05
Number of hours, h of stabling (in brackets: the number of respondents, n)	0 h (n=29) 1-6 h (n=17) 7-12 h (n=30) 13-18 h (n=14) 19-24 h (n=22) (data from 112 respondents)	0 h (n=13) 1-6 h (n=18) 7-12 h (n=24) 13-18 h (n=8) 19-24 h (n=10) (data from 73 respondents)	0 h (n=6) 1-6 h (n=1) 7-12 h (n=2) 13-18 h (n=0) 19-24 h (n=0) (data from 9 respondents)	0 h (n=48) 1-6 h (n=36) 7-12 h (n=57^) 13-18 h (n=22) 19-24 h (n=32) (data from 195 respondents)	ns
Subset data: number of hours, h of stabling for the purpose of restricting pasture access (in brackets: the number of respondents, n)	0 h (n=3) 1-6 h (n=10) 7-12 h (n=23) 13-18 h (n=11) 19-24 h (n=8) (data from 55/112 respondents)	0 h (n=0) 1-6 h (n=7) 7-12 h (n=16) 13-18 h (n=6) 19-24 h (n=4) (data from 33/73 respondents)	0 h (n=1) 1-6 h (n=1) 7-12 h (n=2) 13-18 h (n=0) 19-24 h (n=0) (data from 4/9 respondents)	0 h (n=4) 1-6 h (n=18) 7-12 h (n=42^) 13-18 h (n=17) 19-24 h (n=12) (data from 93/195 respondents)	

* refers to broodmares only

[§] includes data from three respondents with unknown primary purpose of Miniature horse ownership

^ includes data from one respondent with unknown primary purpose of Miniature horse ownership

[a,b] denotes significant difference within row (p<0.05) using the Mann-Whitney pairwise comparison between three different data series.

III. Feeding and management practices

The overall median stocking density of Miniature horses was 10 (IQR 5-20) horses/ha. The stocking density appeared high, however, on a live weight basis, it was comparable to the reported values in other classes of equine livestock (Rogers et al., 2007). From the survey, it was found that the stocking density differed according to the primary use of horses (Table 2). Miniature horses kept for competition were stocked at a significantly higher stocking density ($p<0.05$) of thirteen horses/ha compared with those kept for leisure and companionship (ten horses/ha) or for breeding (twelve horses/ha).

The majority (n=919/1,119, 82%) of Miniature horses were kept at pasture; few horses had no, or limited[11] access to pasture (n=153/1,119, 14%) (Table 3). In terms of percentages, Miniature horses used for breeding (71%) were more likely to be kept exclusively at pasture across seasons, compared with horses used for leisure (28%) and competition (37%) (Table 3). The majority (n=815/1,036, 79%) of Miniature horses were kept on low (<1,000 kg DM/ha) to moderate (~2,000 kg DM/ha) pasture masses across seasons (Table 4).

Pasture access was more commonly restricted during spring (n=125/208, 60% of respondents, n=625/1,119 horses, 55%), summer (n=125/208, 60% of respondents, n=632/1,119 horses, 56%), and autumn (n=115/208, 55% of respondents, n=567/1,119 horses, 51%) compared to winter (n=89/208, 43% of respondents, n=403/1,119 horses, 36%). Approximately half (n=105/208, 50%) of the respondents kept their Miniature horses (n=656/1,119, 59%) exclusively at pasture during winter. A smaller percentage of respondents provided their Miniature horses unrestricted pasture during spring (n=62/208, 30% respondents, n=419/1,119, 37% horses), summer (n=70/208, 34% respondents, n=437/1119, 39% horses) and autumn (n=76/208, 37% respondents, n=488/1119, 44% horses).

The majority (n=173/198, 87%) of respondents practiced pasture-restriction strategies such as strip grazing (n=118), the temporary use of a paddock with little grass (n=99), confinement for part of a day

[11] Limited referring to Miniature horses managed by respondents predominantly in stables (or in stalls) and away from pasture, either mostly stabled or yarded all seasons or always stabled or yarded all seasons, refer to Table 3.

in a stable or yard (n=94), turning out horses to graze in the early morning only (n=42), or fitting a grazing muzzle (n=24). Another pasture restriction strategy cited by respondents (n=15) was provision of a track system (where fencing is placed around the centre of the paddock so that horse(s) walk on the outside of the fences during grazing). Strategies used for pasture maintenance included picking up horse manure from pasture (n=138/198, 70%), rotational grazing (n=125/198, 63%) or mixed grazing (n=92/198, 46%), harrowing pasture (n=77/198, 39%) or topping or mowing pasture (n=57/198, 29%). One respondent cited the use of dung beetles and two respondents cited fertilisation of empty paddock for maintenance of pasture, in a column text entry.

Respondents that stabled their horses used varying hours of confinement per day (1-6 hours, 7-12 hours, 13-18 hours and 19-24 hours), with the highest number of respondents stabling their Miniature horses or Miniature stallions for 7-12 hours/day (n=57/195, 29%) (Table 2). Respondents kept their horses either in a standard stable size of 3.6 metre x 3.6 metre (n=39/147, 27%), larger-than-standard stable size (n=31/147, 21%), smaller-than-standard stable size (n=16/147, 11%), or not in a stable but in a yard, arena or shed, but away from pasture access (n=22/147, 15%). One-quarter of the respondents (n=39/147, 26%) indicated that the question on stable size was not applicable or it was irrelevant. Respondents mostly kept their horses singly when stabling their horses (n=55/144, 38%) or in pairs (n=31/144, 22%). Horses were rarely stabled or yarded in groups of three or more horses (n=16/144, 11%). Close to one-third of the respondents (n=42/144, 29%) indicated that the question on stable companion is not applicable or irrelevant.

In addition to pasture, most owners provided the horses with additional feed (n=194/232, 84%). Additional feedstuffs were hay (n=180), chaff (n=130), premixed concentrates (n=117), fermented forages (n=51), and other types of feed (n=33) such as oats, copra, soy, molasses, sugar beet pulp. In a column text entry, respondents cited Lucerne hay and timothy chaff as an example of the type of hay and chaff provided to their horses. There were seventeen other types of conventional and unconventional ingredients that were provided to Miniature horses, as cited by respondents in column text entries (Table 5). Respondents (n=131) would offer up to six different types of supplements to their Miniature horses, however, respondents (n=38, 37) usually offered either one or two different types of supplements. The most common categories of supplements reportedly fed were vitamin and mineral supplements (n=114) and hoof and coat supplements (n=55).

Table 3 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The number of Miniature horses managed with at least six different management strategies across seasons according to three primary groups i) leisure and companionship, ii) competition and iii) breeding.*

Management strategies	**Total number of respondents (N) (Data from 208 respondents)**	**Primary use of Miniature horses**			**Total (Data from 1,119 horses) Number of horses, n (%)**
		Leisure and companionship (Data from 445 horses) Number of horses, n (%)	**Competition (Data from 580 horses) Number of horses, n (%)**	**Breeding (Data from 94 horses) Number of horses, n (%)**	
Always on pasture all seasons	59	124 (28%)	212 (37%)	67 (71%)	403 (36%)
Have variable access to pasture in spring, summer and autumn, but always on pasture in winter	45	86 (19%)	165 (28%)	0 (0)	251 (22%)
Mostly on pasture all seasons	37	92 (21%)	117 (20%)	22 (23%)	231 (21%)
Either on pasture or stabled or yarded (half-and-half) all seasons	12	22 (5%)	12 (2%)	0 (0)	34 (3%)
Mostly stabled or yarded all seasons	33	51 (11%)	58 (10%)	5 (5%)	114 (10%)
Always stabled or yarded all seasons	8	37 (8%)	2 (0.3%)	0 (0)	39 (3%)
Other strategies	14	33 (7%)	14 (2%)	0 (0)	47 (4%)
Total	**208**	**445 (~100%)**	**580 (~100%)**	**94 (~100%)**	**1,119 (~100%)**
Unknown strategies	24	-	-	-	64
Grand total	**232**	-	-	-	**1,183**

Table 4 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: Seasonal pasture masses or pasture availability across seasons of three groups of Miniature horses i) leisure and companionship, ii) competition and iii) breeding.*

Seasonal pasture mass or seasonal pasture availability				**Total number of respondents (N) (Data from 196 respondents)**	**Primary use of Miniature horses**			**Total**
Spring	**Summer**	**Autumn**	**Winter**		**Leisure and companionship (Data from 381 horses) Number of horses, n (%)**	**Competition (Data from 555 horses) Number of horses, n (%)**	**Breeding (Data from 100 horses) Number of horses, n (%)**	**(Data from 1,036 horses) Number of horses, n (%)**
Low	Low	Low	Low	35	49 (13%)	65 (12%)	0 (0)	114 (11%)
Moderate	Moderate	Moderate	Moderate	20	20 (5%)	82 (15%)	18 (18%)	120 (12%)
Mostly low	Mostly low	Mostly low	Mostly low	35	101 (27%)	81 (15%)	13 (13%)	195 (19%)
Mostly moderate	Mostly moderate	Mostly moderate	Mostly moderate	22	55 (14%)	99 (18%)	16 (16%)	170 (16%)
Low or moderate	Low or moderate	Low or moderate	Low or moderate	19	70 (18%)	33 (6%)	5 (5%)	108 (10%)
Low or moderate	Low or moderate	Low or moderate	High	11	16 (4%)	44 (8%)	0 (0)	60 (6%)
High	Low or moderate	Low or moderate	Low or moderate	5	3 (0.8%)	8 (1%)	4 (4%)	15 (1%)
Low or moderate	Low or moderate	High	Low or moderate	3	2 (0.5%)	11 (2%)	0 (0)	13 (1%)
Low	No pasture (barren) or low	Moderate	Low or moderate	3	1 (0.3%)	19 (3%)	0 (0)	20 (2%)
Other pasture masses combination across seasons				19	19 (5%)	85 (15%)	4 (4%)	108 (10%)
Incomplete information on seasonal pasture masses, respondents kept their horses on pasture at certain seasons only (their horses were not kept on pasture all seasons)				24	45 (12%)	28 (5%)	40 (40%)	113 (11%)
Total				196	381 (~100%)	555 (~100%)	100 (~100%)	1,036 (~100%)
Unknown pasture availability				36	-	-	-	147
Grand total				232	-	-	-	1,183

Table 5 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: The different category of supplements and the different ingredients provided by respondents (n, %) to three groups of Miniature horses i) leisure and companionship, ii) competition and iii) breeding.*

Different types of supplements or ingredients incorporated into the diet of Miniature horses	**Leisure and companionship** **Data from 71 respondents** **(Percentage, %)**	**Competition** **Data from 52 respondents** **(Percentage, %)**	**Breeding** **Data from 8 respondents** **(Percentage, %)**
vitamins and minerals	25 (35%)	7 (13%)	2 (25%)
vitamins and minerals, hoof and coat supplement	2 (3%)	7 (13%)	2 (25%)
vitamins and minerals, hoof and coat supplement & *one or more supplements	17 (24%)	17 (33%)	3 (38%)
hoof and coat supplement & *one or more supplements	2 (3%)	5 (10%)	0 (0%)
vitamins and minerals & *one or more supplements	17 (24%)	14 (27%)	1 (13%)
other or not applicable	8 (11%)	2 (4%)	0 (0%)
^respondents did not contribute data	59	30	9
[§]ingredients	• Apple cider vinegar • Brown seaweed (kelp) • Calcium magnesium carbonate (Dolomite) • Chia seed • Copper sulphate • Diatomaceous earth (DE) • Dried herbs • Egg shell • Flaxseed or linseed and oil • Golden paste • Himalayan mineral salt block or salt • Manuka honey • MSM (Methylsulfonylmethane) • Raw garlic or garlic granules • Rice bran and oil • Sunflower seed or black sunflower seeds • Vegetable oil		

*one or more supplements: electrolyte, joint supplement, probiotics, other categories

^ excludes data from three respondents with unknown primary purpose of Miniature horse ownership, which did not provide data on supplementation for Miniature horses

[§] these ingredients were cited by respondents in the space provided within column text entries, the amount or quantities offered to Miniature horses are not known from the survey, and whether these ingredients have beneficial effects, neutral or placebo effects. or undesirable harmful effects on Miniature horses after consumption are not known. It is quite probable that the use of some of the listed ingredients for Miniature horses may not have been proven to be effective or safe for them.

IV. Weight-monitoring and health care practices

Most respondents did not objectively assess their horse's weight using either a weighbridge (n=198/213, 93%) or a weight tape (n=170/214, 79%). A few respondents (n=15/213, 7%) used the weighbridge at least once annually to monitor their Miniature horses' weight, and about one-fifth of respondents (n=44/214, 21%) used a weight tape once or twice annually to monitor their Miniature horses' weight. Half (n=102/202, 50%) of the respondents indicated they observed body condition of their horses frequently but may not have used a formal quantification process.

Respondents (n=200/214, 93%) dewormed their Miniature horses between 2 and 4 times annually as a routine preventive measure (n=156/199, 78%). The majority (n=153/183, 84%) of the respondents had changed the brand, or the active ingredient, of the wormer in the last year, and the wormer was frequently administered without seeking the advice from veterinary professionals (n=140/199, 70%). Most respondents (n=166/215, 77%), did not perform faecal egg counts (FEC) using faecal samples from their Miniature horses.

Most respondents did not vaccinate their Miniature horses (n=147/199, 74%). Most respondents in the Breeding category did not vaccinate their Miniature stallions (n=8/10, 80%), Miniature broodmares (n=10/12, 83%) and Miniature youngstock (n=7/11, 64%). There were differences in the types of vaccines received for different classes of Miniature horses. Of the respondents who vaccinated their Miniature horses in the last year (n=41/199, 21%), tetanus and strangles vaccines were most administered (n=20/41, 49%), followed by tetanus vaccine alone (n=15/41, 37%). Miniature stallion, Miniature broodmares and Miniature youngstock would receive either Tetanus vaccine alone (n=5) or Tetanus and Strangles vaccine (n=3) (data from respondents in the Breeding category).

Most respondents (mode/median n=124/212, 58%) had dental care performed on their Miniature horses or broodmares once annually. A small proportion of respondents did not perform dental care on their Miniature horses or broodmares (n=46/212, 22%). The remainder of respondents (n=42/212, 20%) indicated that they performed dental care for their horses at least twice annually. Dental care was performed on Miniature horses and broodmares mainly by horse dentists (n=113/166, 68%), followed by veterinarians (n=39/166, 23%) and horse dentist and veterinarians (n=10/166, 6%). Dental care was not usually performed by respondents themselves (n=1/166, 0.6%). The remainder of respondents (n=3/166, 2%) did not provide information on who performed dental care for their Miniature horses.

Respondents (n=205/213, 96%) performed hoof care on their Miniature horses at least once annually. The median (IQR) frequency of hoof care performed by all 213 respondents is 8 times (6-10) annually. Hoof care was performed mainly by farrier alone (n=111/205, 54%) or by veterinarian alone (n=1/205, 0.5%). The remainder of respondents had hoof care performed on their Miniature horses by themselves or by someone they knew (n=57/205, 28%) or with assistance from farriers, veterinarians or both (n=31/205, 15%). The remainder of respondents cited others (n=5/205, 2.4%) who performed hoof care for their Miniature horses. In the column text entries, barefoot trimmers were cited by respondents (n=9) as the hoof care professionals who performed hoof care for Miniature horses.

V. Breeding management practices

Few respondents (n=17) identified breeding as their primary reason for keeping Miniature horses. These respondents reported having 101 broodmares bred (n=13, 8 broodmares per breeder), 72 foals born (n=12, 6 foals per breeder) and 84 youngstock (n=14, 6 foals per breeder). Foaling took place mostly at farm (n=9/10). A mare in labor can be alerted with the aid of foaling alarms (n=7), regular night checks (n=5), or a camera in stable which is linked to a mobile device (n=1). In addition, mare going into labour can be predicted with manual inspection of the udder and rump muscle (n=1) or monitored by respondent observing the foaling process (n=1). The age of weaning for foals occurred at 4 months (n=5), 5 months (n=2), 6 months (n=1) or 8 months (n=1). Weaning occurred either abruptly with all mares removed or with just one mare remaining (n=6) or progressively where just a few mares were removed at a time (n=2). Weaning occurred either in a box (n=3) or in a paddock or a grass pen (n=6).

VI. Age when gelded

Respondents (n=143/232, 62%) provided data on age of Miniature colts or geldings when gelded. Of all the respondents who provided data, 20 have more than one colt or gelding gelded at different age ranges, such as between 1 and 2 years, and, between 2 and 3 years. Miniature colts or geldings were most likely gelded between 6 months and 1 year (n=63) (Figure 11).

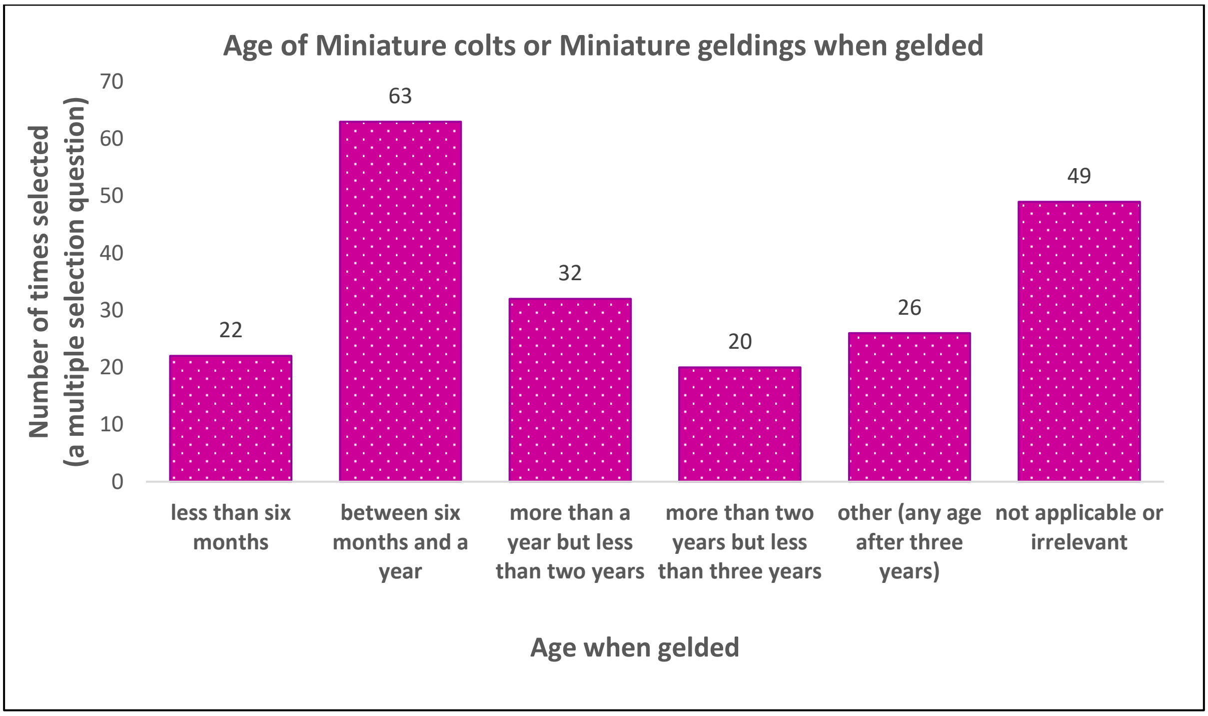


Figure 11 *Data from the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand: Age of Miniature colts or Miniature geldings when gelded.*

Chapter 5: Discussion

The respondents to this survey were mostly women, which agreed with other studies that have shown they tend to be over-represented in equestrian sport and breeding (Agar et al., 2016; Burbage & Cameron, 2018; Fernandes et al., 2014). Additionally, most respondents were semi-experienced or experienced horse owners (more than 5 years of working with horses). Respondents who have kept Miniature horses and other horses or ponies were likely to possess general equestrian skills. This was similar to the profile described in other surveys, where the majority of the survey respondents and their families had many years of experience working with horses in general (Agar et al., 2016; Fernandes et al., 2014). The highest number of responses were gathered from the upper North Island (Waikato and Auckland), the Central-West of the North Island (Taranaki), and Central-East of the South Island (Canterbury). The greater responses obtained from these regions reflected the estimates of the distribution and density of horses in New Zealand (Bolwell et al., 2017; Rosanowski et al., 2012).

The majority (97%) of Miniature horses were always kept at pasture or had restricted access to pasture (Table 3), with owners generally utilising some form of confinement as a method to restrict pasture access. Pasture restriction is seen as necessary; pony breeds are reported to consume between 2.6% and 4.9% of BW as DM/day (Dugdale et al., 2011b; Ralston et al., 1979), which is greater than their nutritional requirements. Assuming a moderate pasture-energy content (10 MJ DE/Kg DM), a typical Miniature horse requiring only 20.2 MJ of maintenance energy could consume their ration requirement of ~2 kg DM of pasture (~1.8% of BW as DM/day) in as little as six hours of grazing (Dugdale et al., 2011b).

From the survey results, respondents incorporated a variety of ingredients as supplementary feedstuffs into the diet of their Miniature horses. Data on quantities fed were not collected, and the assumption from the answers was that supplementary feeds were provided in a similar manner to that reported by Fernandes et al. (2014) where concentrates and premixes were provided at low levels to 'balance the ration' or to provide additional energy. Approximately half the respondents provided mineral or vitamin supplements to their Miniature horses, this level was similar to a report for sport horses in New Zealand (Verhaar et al., 2014). Data on quantities of minerals supplements provided were not collected; nevertheless, care must be taken by horse owners to avoid excessive mineral supplementation. An online survey on the mineral supplementation for horses reported that the calculated intake of minerals was higher than the intake recommended by the National Research Council (NRC) and were mainly sourced from forage component of the diet (not from additional supplementation) (Grimwood et al., 2016). In addition, horse owners need to be aware that the beneficial effects of using supplements is not guaranteed and, the efficacy of the oral supplements does not require the approval by the relevant regulatory authorities (e.g. New Zealand Ministry for Primary Industries (MPI), the United States Food and Drug Administration (FDA)) (Contino, 2018).

Respondents indicated that they provided salt or salt licks to their Miniature horses. Although the benefits of such practices have been recognised in horses (most diets are low in sodium and exercising horses will need a sodium and chloride supplementation to replace the loss of these minerals in sweat), ponies appear to prefer diets with low levels of salt (NaCl) or $NaHCO_3$ as a source of sodium (Hoyt et al., 1995; Schryver et al., 1987). Additionally, a few respondents indicated that they supplemented the diet of their Miniature horses with omega-3 long-chain polyunsaturated fatty acids (eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) levels) using ingredients such as chia seed or fish oil. Studies shown that omega-3 fatty acids reduce inflammatory responses, alleviate hyperlipemia and decrease serum triglyceride and cholesterol in Miniature horses (Dinnetz et al., 2013; Dominguez et al., 2009; Furtney et al., 2009; McHaney et al., 2013).

More than half of the Miniature horses in this survey were between 6-15 years of age, which coincided with the age range where health concerns for equine metabolic syndrome (EMS) or insulin resistance have been raised (Frank et al., 2010). Although data on insulin sensitivity of Miniature horses is not available, ponies and some horse breeds were reported to be more insulin resistant than horses and can have a higher insulin response to glucose than horses (Bamford et al., 2014; June et al., 1992; Rijnen & van der Kolk, 2003). Consequently, for small-sized horse breeds, feeds high in fibre and fat such as sugar beet or beet pulp would moderate the metabolic fluctuation in glucose and insulin in these horses better than other high-glycaemic-index feeds (Hoffman et al., 2003; Williams et al., 2001). If starchy or high energy feed must be used, adding a small amount of oil into the diet could ameliorate the glycaemic and insulinemic response from diet containing high starch and sugar content. When soybean oil (7% of the total grain meal weight) is included to a grain meal consisting of 72% oats, 20% corn and 8% molasses, the glucose and insulin response to feeding were less abrupt, with the responses being moderated by a change in the rate of gastric emptying (Pagan et al., 1995).

The positive insulin responses to glucose (being less abrupt) seemed to be independent from the amount of carbohydrate content in the grain meal (Pagan et al., 1995).

The median stocking density for Miniature horses from this study was ten (IQR 5-20) horses/ha, with the assumption of a mature weight of 110 kg ± 21 kg (Catalano et al., 2019a), equating to approximately 1,100 kg LWT/ha. This value is similar to the typical stocking density of full-sized horses (~500 kg each): ~1,000 kg LWT/ha or ~2 horses/ha (0.8 horses/acre) (Bengtsson et al., 2018; Cohen et al., 2005; Rogers et al., 2007; Singer et al., 2001). As the majority of horses were kept on pasture with low (<1,000 kg DM/ha) to moderate (~2,000 kg DM/ha) pasture masses, pasture growth rate of 20 kg DM/ha/day would meet maintenance requirement of ten Miniature horses (2 kg DM/horse) kept on a hectare of land (Baars' et al., 1990; Brown-Douglas et al., 2005). Pasture growth rates of 20 kg DM/ha/day are typical seen during winter seasons in the moderate temperate climate in New Zealand (Brown-Douglas et al., 2005).

A high proportion of respondents from this survey indicated that they undertook mixed grazing as a pasture-management practice. This is not surprising as Thoroughbred and Standardbred horses in breeding farms in New Zealand are commonly managed with mixed grazing with cattle or sheep (Bolwell et al., 2015c). Most likely, Miniature horses were mixed-grazed with small-sized ruminants and other livestock. Mixed grazing of horses with sheep or cattle has recently been reported to have benefits in controlling strongylosis in horses (Eysker et al., 1986; Forteau et al., 2019).

Although weight monitoring was regularly practiced, very few Miniature horse owners used weight scales to monitor their horses' body weight; with body condition scoring and weight tape used more frequently, which is similar to data reported by Murray et al. (2015). Respondents appeared to prefer a non-structured, daily 'visual appraisal' to gauge their Miniature horses' body condition or estimating their Miniature horses' body weight by experience. Both methods lack the precision of the formal body condition scoring or use of a weight scale. However, even on commercial farms there is often limited use of the formal body condition scoring or weighing to monitor growth and body weight. The lack of body-weight monitoring may be a risk factor for obesity, over-conditioning, or severe clinical diseases such as equine metabolic syndrome (EMS) and laminitis.

The survey uncovered several concerns on deworming practices for Miniature horses. There was a high frequency of anthelminthic treatment, a lack of evidence-based dosing of anthelminthic and changing of anthelminthic products on a whim; similar to the concerns reported in previous studies (Bolwell et al., 2015c; Hotchkiss et al., 2007; Rosanowski et al., 2016). Increased drenching frequency could prevent young horses from acquiring natural immunity against nematode infection (von Samson-Himmelstjerna et al., 2009) and increased risks of anthelminthic resistance in New Zealand (Bishop et al., 2014; Bolwell et al., 2017; Lowe, 2010; Morris & Colgan, 2012; Rogers et al., 2017b; Scott et al., 2015). Since anthelmintic sensitivity testing (faecal egg count reduction tests, FECRTs and egg reappearance period tests, ERPs) were less frequently discussed with clients when concerns on anthelmintic resistance were raised (Easton et al., 2016), awareness on anthelmintic sensitivity testing may alter the current preferred practices of frequent dosing of wormer. In Europe, increased awareness on evidence-based anthelmintic treatment amongst horse owners have helped to increase frequency of performing FECs prior to drenching, leading to a reduction in the intensity of anthelminthic usage (Becher et al., 2018; Tzelos et al., 2019).

There are several limitations with online surveys, one of the main ones being the non-response bias and the social-desirable bias from this survey. In this survey, respondents were gathered using the snowball sampling technique[12], a reflection of the 'convenience sampling' technique where samples are drawn from a pool that is close at hand. As the responses were mostly gathered from respondents actively involved in social media pages for Miniature horses, there is a small risk that the data gathered in this survey are skewed towards respondents who are cognizant of the suitable or appropriate management practices or strategies for their Miniature horses. Whether the remainder two-thirds of the non-respondents used feeding management practices or strategies that was similar or different from the respondents in this survey remained unknown. In addition, another possible limitation with this online survey is recall bias. Respondents were required to provide information in a time frame of one year. As the survey responses were largely gathered in mid-spring (early November), respondents may be able to provide more accurate response or data on seasonal pasture access during spring, compared with during summer, autumn or winter. Nevertheless, this sampling methodology (online

[12] Snowball sampling (or chain-referral sampling) is a non-probability sampling technique. It is useful when selecting for (or sampling for) traits that are rare to find. This sampling technique can go on forever, in theory, to collect many samples over time, similar to a snowball, which increase in size/mass as more snow are gathered around it.

survey) provided an efficient method of targeting the population of horse owners or horse keepers of Miniature horses in a timely and cost-effective manner.

Chapter 6: Conclusion

Across the non-commercial equine sector there is limited documentation of feeding and management practises. The lack of information makes it difficult for regional councils to understand land management use and for Veterinarians and industry consultants to provide targeted advice on feeding and management practices. Data gathered from this survey provides a useful reference point for further investigations on the inter-relationship between feeding management practices and the body weight of Miniature horses in New Zealand.

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I. Appendix A Questionnaire for the survey on demographics, feeding management and health care practices of Miniature horses in New Zealand

Survey Flow

Block: Default Question Block (88 Questions)

Standard: Block 1 (1 Question)

EmbeddedData

Q_TotalDurationValue will be set from Panel or URL.

Q_BallotBoxStuffingValue will be set from Panel or URL.

Q_RecaptchaScoreValue will be set from Panel or URL.

Q_RelevantIDDuplicateValue will be set from Panel or URL.

Q_RelevantIDDuplicateScoreValue will be set from Panel or URL.

Q_RelevantIDFraudScoreValue will be set from Panel or URL.

StartDateValue will be set from Panel or URL.

enddateValue will be set from Panel or URL.

Filter questions (number in brackets are reference for question display conditions)

Q1 Do you currently care for at least one miniature horse?

This includes those that you own and those that you are looking after.

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Q1 = 2

Q2 Are you 16 years of age or older?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Q2 = 2

Questions (numbers in bracket serve as reference for questions display conditions)

Q4 Are you:

- ◯ Male (1)
- ◯ Female (2)
- ◯ Prefer to self-identify: __________ (3)

Q5 Your age group is:

- ◯ 16 - 24 years (1)
- ◯ 25 - 34 years (2)
- ◯ 35 - 44 years (3)
- ◯ 45 - 54 years (4)
- ◯ 55 - 64 years (5)
- ◯ 65 years or more (6)

Q7 Please indicate what region you live in:

- ○ Northland (1)
- ○ Auckland (2)
- ○ Waikato (3)
- ○ Bay of Plenty (4)
- ○ Gisborne (5)
- ○ Taranaki (6)
- ○ Manawatu - Whanganui (7)
- ○ Hawke's Bay (8)
- ○ Wellington (9)
- ○ Tasman (10)
- ○ Nelson - Marlborough (11)
- ○ West Coast (12)
- ○ Canterbury (13)
- ○ Otago (14)
- ○ Southland (15)
- ○ other, please specify: ____________ (16)

Q8 How long have you been keeping miniature horse(s)?

- ◯ less than 2 years (1)
- ◯ 2 - 4 years (2)
- ◯ 5 - 7 years (3)
- ◯ 8 - 10 years (4)
- ◯ more than 10 years (5)

Q11 Where do you usually keep your miniature horse(s)?

- ◯ on a commercial livestock farm (1)
- ◯ on a lifestyle block (2)
- ◯ on a leased property or paid grazing (3)
- ◯ other, please specify: __________ (4)

Q12 What is your main reason for keeping miniature horse(s)?

Please select only one option.

- ◯ breeding (1)
- ◯ competition (2)
- ◯ leisure and companionship (3)
- ◯ other reason(s), please specify: __________ (5)

Q117 What type of activities are your miniature horse(s) used for?

Use multiple selection if relevant.

- ☐ breeding (10)
- ☐ showing (1)
- ☐ competitive driving (3)
- ☐ leisure driving (2)
- ☐ ridden by children (5)
- ☐ companion for other horses (6)
- ☐ therapy horse (7)
- ☐ pet horse (8)
- ☐ other(s), please specify: __________ (9)

Q124 What breed societies are your miniature horses registered with?

If your miniature horses are not registered with a breed society, simply select ‘not registered with a breed society’.

	Please select (5)
NZ Miniature Horse Association (NZMHA) (138)	◯
National Miniature Horse Society of New Zealand (NMHSNZ) (139)	◯
Association of Independent Miniature Horse Clubs of New Zealand (AIMHCNZ) (140)	◯
American Miniature Horse Registry (AMHR) (141)	◯
American Miniature Horse Association (AMHA) (142)	◯
Other breed societies: ____________(143)	◯
not registered with a breed society (145)	◯

Display This Question:

If Q124 = 138 [5]

Q73 How many of your miniature horses are registered in NZMHA as Category A, B, or C?

_______ Category A (1)

_______ Category B (2)

_______ Category C (3)

Display This Question:

If Q124 = 139 [5]

Q119 How many of your miniature horses are registered in NMHSNZ as Category A, B, or Class D?

________ Category A (1)

________ Category B (2)

________ Class D (6)

Display This Question:

If Q124 = 140 [5]

Q123 How many of your miniature horses are registered in AIMHCNZ as Category A, B, or C?

________ Category A (1)

________ Category B (2)

________ Category C (6)

Display This Question:

If Q124 = 141 [5]

Q74 How many of your miniature horses are registered in AMHR as Division A or B?

________ Division A (1)

________ Division B (2)

Display This Question:

If Q124 = 142 [5]

Q75 How many of your miniature horses are registered in AMHA as Type A?

________ Type A (1)

Display This Question:

If Q124 = 143 [5]

And Q124 = 145 [5]

Q76 How many of your miniature horses are within the height ranges specified below?

________ less than 34 inches (86.4 cm) (1)

________ 34-38 inches (86.4 - 96.5 cm) (2)

________ over 38 inches (96.5cm) and not exceeding 40 inches (101.6 cm) (5)

________ over 38 inches (96.5cm) and not exceeding 42 inches (107 cm) (4)

Display This Question:

If Q12 = 1

Q29 Currently, do you have miniature stallion(s)?

○ yes (138)

○ no (140)

Display This Question:

If Q12 = 1

Q127 Currently, do you have miniature broodmare(s)?

○ yes (138)

○ no (140)

Display This Question:

If Q12 = 1

Q125 Currently, do you have miniature youngstock?

- yes (139)
- no (141)

Display This Question:

If Q12 != 1

Q77 How many of your miniature horses are in the following age groups?

________ less than 3 years (1)

________ 3 - 5 years (2)

________ 6 - 15 years (3)

________ more than 15 years (4)

Display This Question:

If Q127 = 138

Q16 How many of your **miniature broodmares** are in the following age groups?

________ 3 - 5 years (1)

________ 6 - 12 years (2)

________ 13 - 15 years (3)

________ more than 15 years (4)

Display This Question:

If Q127 = 138

Or Q125 = 139

Q66 During the last year, how many of your **miniature broodmares** were bred? And, how many **miniature foals** were born in the last year?

________ Number of miniature broodmares bred (3)

________ Number of miniature foals born (2)

Display This Question:

If Q125 = 139

Q85 During the last year, how many **miniature youngstock** did you have on your farm?

Youngstock includes foals, weanlings, yearlings, 2-to-3-year-olds.

________ Number of miniature youngstock (1)

Q125 Currently, how many horses and ponies are you keeping in total?

This include horses and ponies that are not necessarily miniature horses.

________ Total number of horses and ponies (1)

Display This Question:

If Q127 = 138

Q17 In the last year, how many times have you monitored the body weight of any one **miniature broodmare(s)**, using each of the following methods?

_______ weighbridge or electronic weighing scale (1)

_______ weight tape (2)

_______ by observation and then using the body condition scoring chart to determine the body condition score (BCS) (3)

_______ other technique(s), please specify: ___________ (5)

Display This Question:

If Q12 != 1

Q78 In the last year, how many times have you monitored the body weight of any one **miniature horse(s)**, using each of the following methods?

_______ weighbridge or electronic weighing scale (1)

_______ weight tape (2)

_______ by observation and then using the body condition scoring chart to determine the body condition score (BCS) (3)

_______ other technique(s), please specify: ________ (5)

Display This Question:

If Q127 = 138

Q18 In the last year, how many times have you dewormed or conducted a faecal egg count(s) on any one of your **miniature broodmare(s)**?

_______ deworming (1)

_______ faecal egg counts (FEC) (2)

Display This Question:

If Q12 != 1

Q79 In the last year, how many times have you dewormed or conducted a faecal egg count(s) on any one of your **miniature horse(s)**?

________ deworming (1)

________ faecal egg counts (FEC) (2)

Display This Question:

If Q18 [1] > 0

Or Q79 [1] > 0

Q19 What was the main reason for deworming your miniature horse(s)?

Please select only one option.

- ○ as a routine preventive measure (2)
- ○ it was the time of the year or season with high worm burden (3)
- ○ horse looked thin and unthrifty (4)
- ○ horse had colic (5)
- ○ faecal egg count results indicated a need to deworm (1)
- ○ other(s), please specify: __________ (6)

Display This Question:

If Q18 [1] > 1

Or Q79 [1] > 1

Q20 In the last year, have you used different brands of dewormer or dewormer with different active ingredients?

○ yes (1)

○ no (2)

○ not sure (3)

Display This Question:

If Q18 [1] > 0

Or Q79 [1] > 0

Q21 In the last year, have you sought advice from a veterinarian regarding the use of dewormers?

○ yes (1)

○ no (2)

○ not sure (3)

Display This Question:

If Q127 = 138

Q22 In the last year, how many times have you provided dental care or hoof care for any one of your **miniature broodmare(s)**?

________ dental care (1)

________ hoof care (2)

Display This Question:

If Q12 != 1

Q81 In the last year, how many times have you provided dental care or hoof care for any one of your miniature horse(s)?

_______ dental care (1)

_______ hoof care (2)

Display This Question:

If Q22 [1] > 0

Q23 Who performed dental care for your **miniature broodmare(s)** during the last year?

Use multiple selection if relevant.

▢ horse dentist (1)

▢ veterinarian (2)

▢ myself or someone I know (3)

▢ other(s), please specify: ________ (4)

▢ not applicable or irrelevant (5)

Display This Question:

If Q81 [1] > 0

Q82 Who performed dental care for your miniature horse(s) during the last year?

Use multiple selection if relevant.

- ☐ horse dentist (1)
- ☐ veterinarian (2)
- ☐ myself or someone I know (3)
- ☐ other(s), please specify: ________________ (4)
- ☐ not applicable or irrelevant (5)

Display This Question:

If Q22 [2] > 0

Q24 Who performed hoof care for your **miniature broodmare(s)** during the last year?

Use multiple selection if relevant.

- ☐ farrier (1)
- ☐ veterinarian (2)
- ☐ myself or someone I know (3)
- ☐ other(s), please specify: _______________ (4)
- ☐ not applicable or irrelevant (5)

Display This Question:

If Q81 [2] > 0

Q83 Who performed hoof care for your **miniature horse(s)** during the last year?

Use multiple selection if relevant.

- farrier (1)
- veterinarian (2)
- myself or someone I know (3)
- other(s), please specify: ________ (4)
- not applicable or irrelevant (5)

Display This Question:

If Q29 = 138

Q28 Did you vaccinate all or most of your **miniature stallion(s)** during the last year?

- yes (50)
- no (51)
- not applicable or irrelevant (52)

Display This Question:

If Q127 = 138

Q86 Did you vaccinate all or most of your **miniature broodmare(s)** during the last year?

- yes (5)
- no (6)
- not applicable or irrelevant (7)

Display This Question:

If Q125 = 139

Q87 Did you vaccinate all or most of your **miniature youngstock** during the last year?

- yes (5)
- no (6)
- not applicable or irrelevant (7)

Display This Question:

If Q12 != 1

Q85 Did you vaccinate all or most of your miniature horse(s) during the last year?

- yes (6)
- no (7)
- not applicable or irrelevant (8)

Display This Question:

If Q28 = 50

Q25 During the last year, which of these vaccines were given to your **miniature stallion(s)**?

Use multiple selection if relevant.

- ☐ Tetanus vaccine (1)
- ☐ Strangles vaccine (2)
- ☐ other(s), please specify: ________ (3)

Display This Question:

If Q86 = 5

Q26 During the last year, which of these vaccines were given to your **miniature broodmare(s)**?

Use multiple selection if relevant.

- ☐ Tetanus vaccine (1)
- ☐ Strangles vaccine (2)
- ☐ Equine herpes virus vaccine (3)
- ☐ Salmonella vaccine (4)
- ☐ Rotavirus vaccine (5)
- ☐ other(s), please specify: ____________ (6)

Display This Question:

If Q87 = 5

Q27 During the last year, which of these vaccines were given to your **miniature youngstock**?

Use multiple selection if relevant

- ☐ Tetanus vaccine (1)
- ☐ Strangles vaccine (2)
- ☐ Equine herpes virus vaccine (3)
- ☐ other(s), please specify: ________________ (4)

Display This Question:

If Q85 = 6

Q86 During the last year, which of these vaccines were given to your miniature horse(s)?

Use multiple selection if relevant.

- ☐ Tetanus vaccine (1)
- ☐ Strangles vaccine (2)
- ☐ Equine herpes virus vaccine (3)
- ☐ Salmonella vaccine (4)
- ☐ Rotavirus vaccine (5)
- ☐ other(s), please specify: ________________ (6)

Display This Question:

If Q29 = 138

Q99 During the last spring, was your **miniature stallion(s)** kept on pasture or stabled/yarded?

A yard refers to grassless, enclosed area.

- always on pasture (111)
- mostly on pasture (112)
- mostly stabled/yarded (113)
- always stabled/yarded (114)
- not applicable or irrelevant (115)

Display This Question:

If Q29 = 138

Q94 During the last summer, was your **miniature stallion(s)** kept on pasture or stabled/yarded?

A yard refers to grassless, enclosed area.

- always on pasture (1)
- mostly on pasture (2)
- mostly stabled/yarded (3)
- always stabled/yarded (4)
- not applicable or irrelevant (5)

Display This Question:

If Q29 = 138

Q95 During the last <u>autumn</u>, was your **miniature stallion(s)** kept on pasture or stabled/yarded?

A yard refers to grassless, enclosed area.

- ○ always on pasture (1)
- ○ mostly on pasture (2)
- ○ mostly stabled/yarded (3)
- ○ always stabled/yarded (4)
- ○ not applicable or irrelevant (5)

Display This Question:

If Q29 = 138

Q96 During the last <u>winter</u>, was your **miniature stallion(s)** kept on pasture or stabled/yarded?

A yard refers to grassless, enclosed area.

- ○ always on pasture (1)
- ○ mostly on pasture (2)
- ○ mostly stabled/yarded (3)
- ○ always stabled/yarded (4)
- ○ not applicable or irrelevant (5)

Display This Question:

If Q12 != 1

Q103 During the last spring, was your miniature horse(s) kept on pasture or stabled/yarded?

A yard refers to grassless, enclosed area.

- always on pasture (1)
- mostly on pasture (2)
- mostly stabled/yarded (3)
- always stabled/yarded (4)
- not applicable or irrelevant (5)

Display This Question:

If Q12 != 1

Q104 During the last summer, was your miniature horse(s) kept on pasture or stabled/yarded?

A yard refers to grassless, enclosed area.

- always on pasture (1)
- mostly on pasture (2)
- mostly stabled/yarded (3)
- always stabled/yarded (4)
- not applicable or irrelevant (5)

Display This Question:

If Q12 != 1

Q105 During the last <u>autumn</u>, was your miniature horse(s) kept on pasture or stabled/yarded?

A yard refers to grassless, enclosed area.

- ○ always on pasture (1)
- ○ mostly on pasture (2)
- ○ mostly stabled/yarded (3)
- ○ always stabled/yarded (4)
- ○ not applicable or irrelevant (5)

Display This Question:

If Q12 != 1

Q106 During the last <u>winter</u>, was your miniature horse(s) kept on pasture or stabled/yarded?

A yard refers to grassless, enclosed area.

- ○ always on pasture (1)
- ○ mostly on pasture (2)
- ○ mostly stabled/yarded (3)
- ○ always stabled/yarded (4)
- ○ not applicable or irrelevant (5)

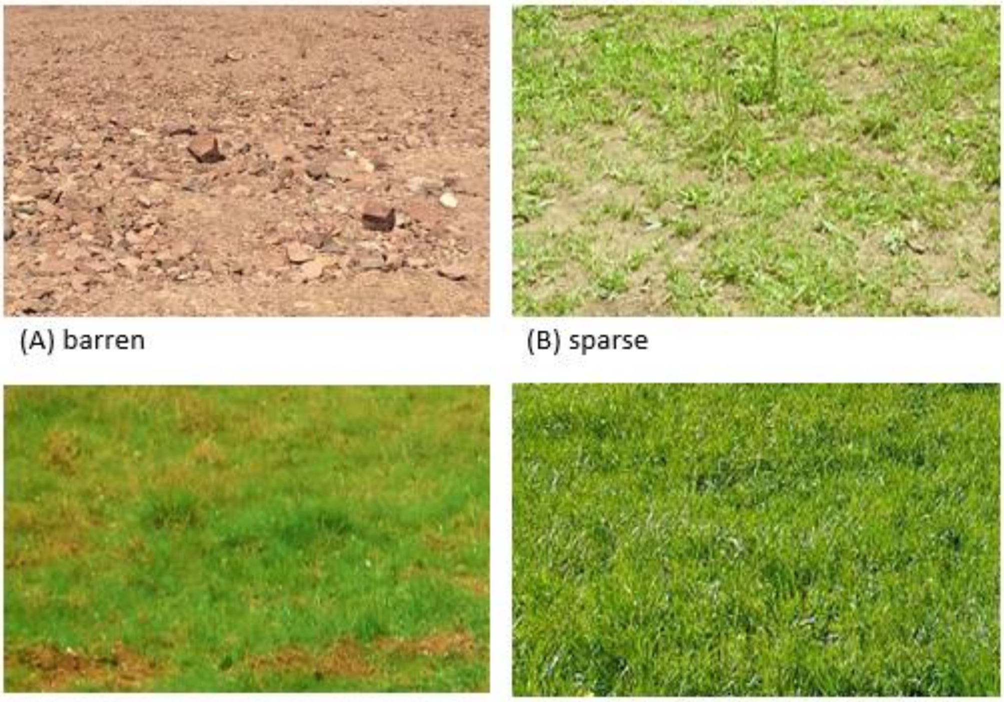
Display This Question:

If Q127 = 138

Q121 What would be the typical pasture cover when your **miniature broodmare(s)** were on pasture last spring?

Please select by clicking on one of the photos.

You can skip this question if it is not relevant to you.



(A) barren

(B) sparse

(C) moderate

(D) dense

Photos taken from:
https://www.flickr.com/photos/mother_muffins/34131540711
https://njaes.rutgers.edu/fs938/
http://sunlinescholarship.blogspot.com/2012/03/freemason-lodge-beech-hurst.html
https://www.bostonseeds.com/products/1/Grass-Seeds/2/Paddock-Grass-Seed/

Display This Question:

If Q127 = 138

Q122 What would be the typical pasture cover when your **miniature broodmare(s)** were kept on pasture last <u>summer</u>?

Please select by clicking on one of the photos.

You can skip this question if it is not relevant to you.

(A) barren

(B) sparse

(C) moderate

(D) dense

Photos taken from:
https://www.flickr.com/photos/mother_muffins/34131540711
https://njaes.rutgers.edu/fs938/
http://sunlinescholarship.blogspot.com/2012/03/freemason-lodge-beech-hurst.html
https://www.bostonseeds.com/products/1/Grass-Seeds/2/Paddock-Grass-Seed/

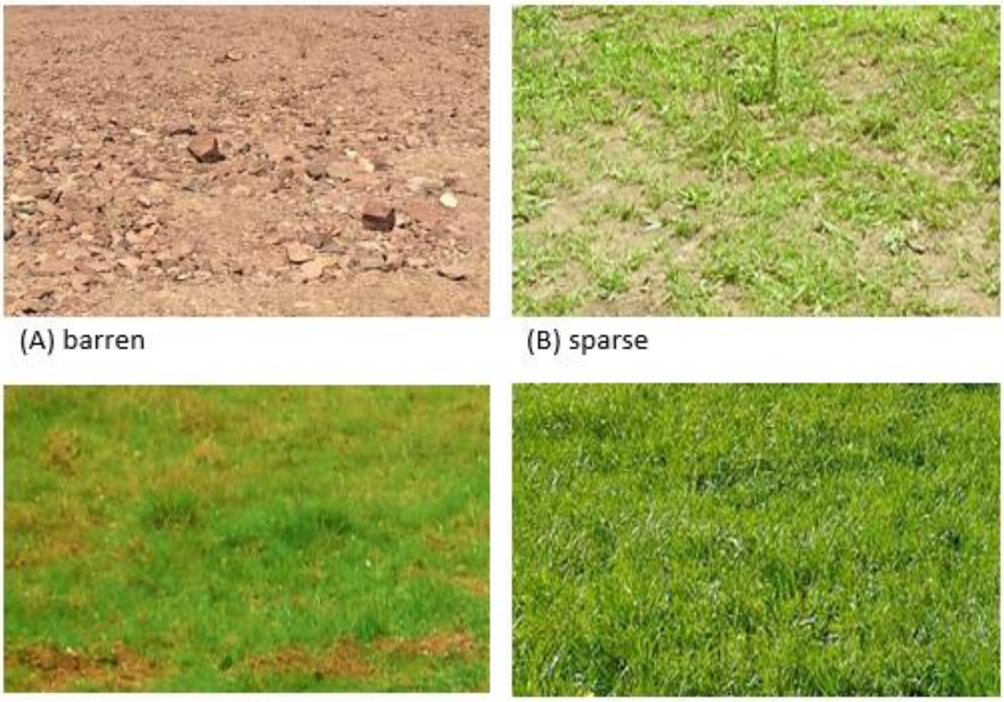
Display This Question:

If Q127 = 138

Q123 What would be the typical pasture cover when your **miniature broodmare(s)** were kept on pasture last <u>autumn</u>?

Please select by clicking on one of the photos.

You can skip this question if it is not relevant to you.



(A) barren (B) sparse

(C) moderate (D) dense

Photos taken from:
https://www.flickr.com/photos/mother_muffins/34131540711
https://njaes.rutgers.edu/fs938/
http://sunlinescholarship.blogspot.com/2012/03/freemason-lodge-beech-hurst.html
https://www.bostonseeds.com/products/1/Grass-Seeds/2/Paddock-Grass-Seed/

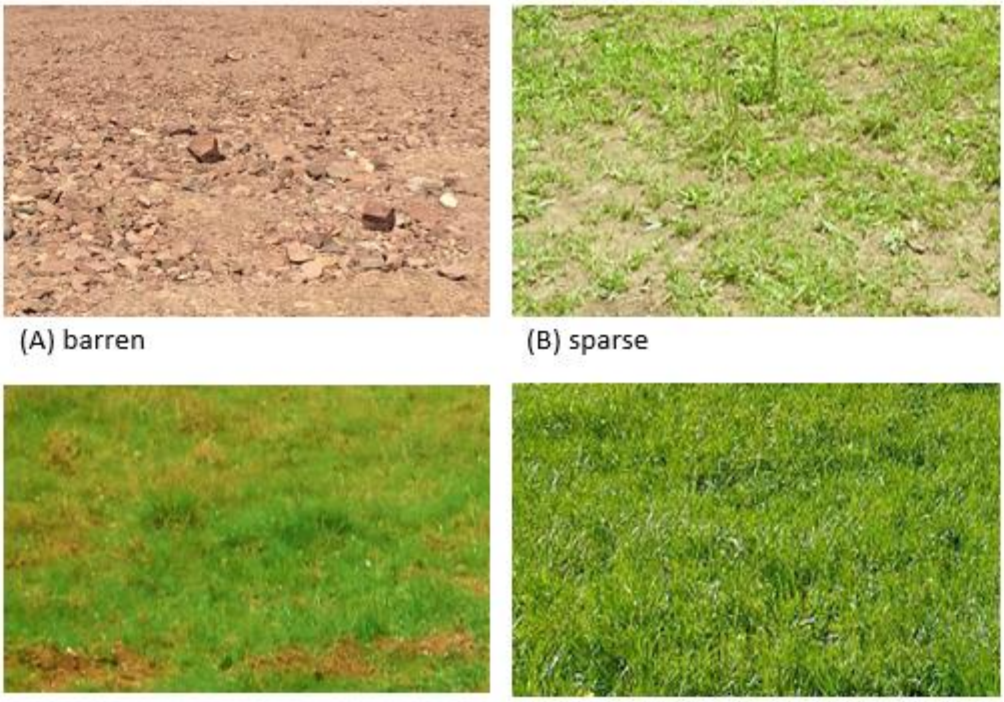
Display This Question:

If Q127 = 138

Q124 What would be the typical pasture cover when your **miniature broodmare(s)** were kept on pasture last <u>winter</u>?

Please select by clicking on one of the photos.

You can skip this question if it is not relevant to you.



(A) barren
(B) sparse
(C) moderate
(D) dense

Photos taken from:
https://www.flickr.com/photos/mother_muffins/34131540711
https://njaes.rutgers.edu/fs938/
http://sunlinescholarship.blogspot.com/2012/03/freemason-lodge-beech-hurst.html
https://www.bostonseeds.com/products/1/Grass-Seeds/2/Paddock-Grass-Seed/

Display This Question:

If Q103 = 1

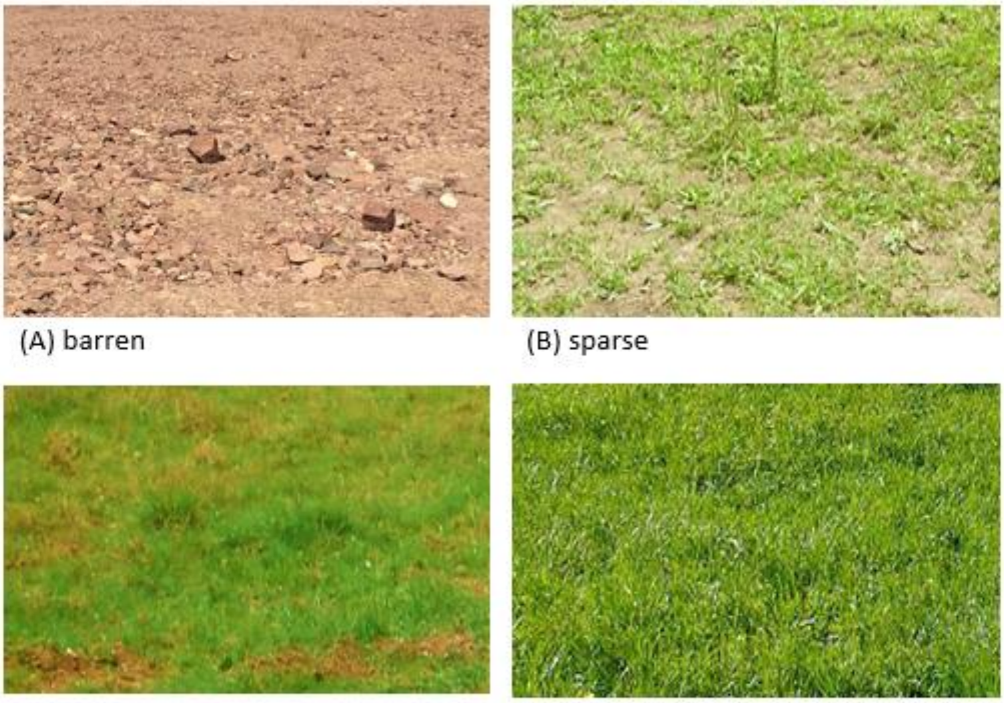
Or Q103 = 2

Or Q103 = 3

Q113 What would be the typical pasture cover when your miniature horse(s) were kept on pasture last spring?

Please select by clicking on one of the photos.

You can skip this question if it is not relevant to you.



(A) barren (B) sparse

(C) moderate (D) dense

Photos taken from:
https://www.flickr.com/photos/mother_muffins/34131540711
https://njaes.rutgers.edu/fs938/
http://sunlinescholarship.blogspot.com/2012/03/freemason-lodge-beech-hurst.html
https://www.bostonseeds.com/products/1/Grass-Seeds/2/Paddock-Grass-Seed/

Display This Question:

If Q104 = 1

Or Q104 = 2

Or Q104 = 3

Q114 What would be the typical pasture cover when your miniature horse(s) were kept on pasture last summer?

Please select by clicking on one of the photos.

You can skip this question if it is not relevant to you.


(A) barren


(B) sparse


(C) moderate


(D) dense

Photos taken from:
https://www.flickr.com/photos/mother_muffins/34131540711
https://njaes.rutgers.edu/fs938/
http://sunlinescholarship.blogspot.com/2012/03/freemason-lodge-beech-hurst.html
https://www.bostonseeds.com/products/1/Grass-Seeds/2/Paddock-Grass-Seed/

Display This Question:

If Q105 = 1

Or Q105 = 2

Or Q105 = 3

Q115 What would be the typical pasture cover when your miniature horse(s) were kept on pasture last autumn?

Please select by clicking on one of the photos.

You can skip this question if it is not relevant to you.

(A) barren

(B) sparse

(C) moderate

(D) dense

Photos taken from:
https://www.flickr.com/photos/mother_muffins/34131540711
https://njaes.rutgers.edu/fs938/
http://sunlinescholarship.blogspot.com/2012/03/freemason-lodge-beech-hurst.html
https://www.bostonseeds.com/products/1/Grass-Seeds/2/Paddock-Grass-Seed/

Display This Question:

If Q106 = 1

Or Q106 = 2

Or Q106 = 3

Q116 What would be the typical pasture cover when your miniature horse(s) were kept on pasture last winter?

Please select by clicking on one of the photos.

You can skip this question if it is not relevant to you.

(A) barren

(B) sparse

(C) moderate

(D) dense

Photos taken from:
https://www.flickr.com/photos/mother_muffins/34131540711
https://njaes.rutgers.edu/fs938/
http://sunlinescholarship.blogspot.com/2012/03/freemason-lodge-beech-hurst.html
https://www.bostonseeds.com/products/1/Grass-Seeds/2/Paddock-Grass-Seed/

Display This Question:

If Q127 = 138

Q119 What is the average paddock size grazed by your **miniature broodmare(s)**?

Please provide answer in either hectares or acre and indicate the measurement unit for the answer you have provided.

	▼ select one
Average paddock size: ________ (7)	Hectare (26)
	Acre (27)
	Not relevant (28)

Display This Question:

If Q12 != 1

Q111 What is the average paddock size grazed by your miniature horse(s)?

Please provide answer in either hectares or acre and indicate the measurement unit for the answer you have provided.

	▼select one
Average paddock size: _________ (7)	Hectare (10)
	Acre (11)
	Not relevant (12)

Display This Question:

If Q127 = 138

Q120 What is the average number of **miniature broodmares** kept in a paddock at any one time?

________ **Number of miniature broodmares** (1)

Display This Question:

If Q12 != 1

Q112

What is the average number of **miniature horses** kept in a paddock at any one time?

________ **Number of miniature horses** (1)

Q47 Which of the following **pasture-management strategies** did you use during the last year?

Use multiple selection if relevant.

- ☐ harrowing pasture (1)
- ☐ topping/mowing pasture (2)
- ☐ picking up horse manure from pasture (3)
- ☐ rotational grazing (moving horses between pasture or between paddocks, as needed or on a regular basis) (4)
- ☐ cross grazing or mixed grazing (allowing different species of livestock to use the same land area, whether together or separately) (5)
- ☐ other, please specify: ____________ (6)
- ☐ not applicable or irrelevant (7)

Q102 During the last year, which of these **pasture-restriction measures** have you adopted?

Use multiple selection if relevant.

- [ ] place temporarily on paddock with little grass (8)
- [ ] fit a grazing muzzle (9)
- [ ] strip grazing (fencing off a small strip of pasture and moving the fences regularly to allow access to fresh grass) (10)
- [ ] turning out horses to graze in the early morning only (the pasture has used up yesterday's energy and have the least concentration of sugars) (14)
- [ ] place in a stable/yard (11)
- [ ] other strategy or strategies: __________ (12)
- [ ] not applicable or irrelevant (13)

Display This Question:

If Q29 = 138

Q108 How many hours per day, on average, was your **miniature stallion(s)** stabled or yarded or placed in a barren paddock over the last year?

- 0 hour (21)
- 1 - 6 hours (14)
- 7 - 12 hours (15)
- 13 - 18 hours (16)
- 19 - 24 hours (17)

Display This Question:

If Q12 != 1

Q109 How many hours per day, on average, was your miniature horse(s) stabled or yarded or placed in a barren paddock over the last year?

- 0 hour (18)
- 1 - 6 hours (14)
- 7 - 12 hours (15)
- 13 - 18 hours (16)
- 19 - 24 hours (17)

Display This Question:

If Q108 = 14

Or Q108 = 15

Or Q108 = 16

Or Q108 = 17

Q31 If your **miniature stallion(s)** was stabled during the last year, what is the size of the stable used?

Please select only one option.

- standard (3.6 metre x 3.6 metre) stable size (1)
- smaller than the standard stable size (2)
- larger than the standard stable size (5)
- other, please specify: ____________ (3)
- not applicable or irrelevant (4)

Display This Question:

If Q109 = 14

Or Q109 = 15

Or Q109 = 16

Or Q109 = 17

Q107 If your miniature horse(s) was stabled during the last year, what is the size of the stable used?

Please select only one option.

- ○ standard (3.6 metre x 3.6 metre) stable size (31)
- ○ smaller than the standard stable size (32)
- ○ larger than the standard stable size (35)
- ○ other, please specify: ________________ (33)
- ○ not applicable or irrelevant (34)

Display This Question:

If Q109 = 14

Or Q109 = 15

Or Q109 = 16

Or Q109 = 17

Q104 If your miniature horses were stabled last year, were they kept singly, in pairs or in groups of three or more horses in a stable?

Please select only one option.

- singly (35)
- in pairs (36)
- in groups of three or more horses (37)
- other, please specify: __________ (38)
- not applicable or irrelevant (39)

Display This Question:

If Q29 = 138

Q56 In the last year, what supplementary feeds were provided to your **miniature stallion(s)**?

Use multiple selection if relevant.

- ☐ hay (48)
- ☐ fermented forages (baleage, haylage) (49)
- ☐ chaff (50)
- ☐ premix feed (51)
- ☐ supplements (52)
- ☐ other, please specify: ________________ (53)
- ☐ not applicable or irrelevant (54)

Display This Question:

If Q127 = 138

Q57 In the last year, what supplementary feeds were provided to your **miniature broodmare(s)**?

Use multiple selection if relevant.

- ☐ hay (8)
- ☐ fermented forages (baleage, haylage) (9)
- ☐ chaff (10)
- ☐ premix feed (11)
- ☐ supplements (12)
- ☐ other, please specify: ____________ (13)
- ☐ not applicable or irrelevant (14)

Display This Question:

If Q125 = 139

Q60 In the last year, what supplementary feeds were provided to your **miniature youngstock**?

Use multiple selection if relevant.

- ☐ hay (8)
- ☐ fermented forages (baleage, haylage) (9)
- ☐ chaff (10)
- ☐ premix feed (11)
- ☐ supplements (12)
- ☐ other, please specify: ____________ (13)
- ☐ not applicable or irrelevant (14)

Display This Question:

If Q12 != 1

Q97 In the last year, what supplementary feeds were provided to your miniature horse(s)?

Use multiple selection if relevant.

- ☐ hay (8)
- ☐ fermented forages (baleage, haylage) (9)
- ☐ chaff (10)
- ☐ premix feed (11)
- ☐ supplements (12)
- ☐ other, please specify: ________________ (13)
- ☐ not applicable or irrelevant (14)

Display This Question:

If Q56 = 52

Q58 Please indicate the type of **supplement(s)** provided to your **miniature stallion(s)** during the last year.

Use multiple selection if relevant.

Please provide more information on the supplement(s) you use if you wish.

- ▢ vitamins and minerals (e.g. vitamin E, magnesium): ____________ (17)
- ▢ electrolytes: ____________ (18)
- ▢ probiotics: __________ (19)
- ▢ hoof and coat supplement (e.g. omega fatty acids): __________ (20)
- ▢ joint supplement (e.g. glucosamine, chondroitin sulphate): __________ (21)
- ▢ other, please specify: __________ (22)
- ▢ not applicable or irrelevant (23)

Display This Question:

If Q57 = 12

Q59 Please indicate the type of **supplement(s)** provided to your **miniature broodmare(s)** during the last year.

Use multiple selection if relevant.

Please provide more information on the supplement(s) you use if you wish to.

- ☐ vitamins and minerals (e.g. vitamin E, magnesium): __________ (17)
- ☐ electrolytes: __________ (18)
- ☐ probiotics: __________ (19)
- ☐ hoof and coat supplement (e.g. omega fatty acids): __________ (20)
- ☐ joint supplement (e.g. glucosamine, chondroitin sulphate): __________ (21)
- ☐ other, please specify: __________ (22)
- ☐ not applicable or irrelevant (23)

Display This Question:

If Q60 = 12

Q61 Please indicate the type of **supplement(s)** provided to your **miniature youngstock** during the last year.

Use multiple selection if relevant.

Please provide more information on the supplement(s) you use if you wish to.

- ☐ vitamins and minerals (e.g. vitamin E, magnesium): __________ (10)
- ☐ electrolytes: __________ (11)
- ☐ probiotics: __________ (12)
- ☐ hoof and coat supplement (e.g. omega fatty acids): __________ (13)
- ☐ joint supplement (e.g. glucosamine, chondroitin sulphate): __________ (14)
- ☐ other, please specify: __________ (15)
- ☐ not applicable or irrelevant (16)

Display This Question:

If Q97 = 12

Q100 Please indicate the type of **supplement(s)** provided to your miniature horse(s) during the last year.

Use multiple selection if relevant.

Please provide more information on the supplement(s) you use if you wish to.

- ☐ vitamins and minerals (e.g. vitamin E, magnesium): __________ (17)
- ☐ electrolytes: __________ (18)
- ☐ probiotics: __________ (19)
- ☐ hoof and coat supplement (e.g. omega fatty acids): __________ (20)
- ☐ joint supplement (e.g. glucosamine, chondroitin sulphate): __________ (21)
- ☐ other, please specify: __________ (22)
- ☐ not applicable or irrelevant (23)

Display This Question:

If Q127 = 138

Or If

Q125 = 139

Q67 In the last year, did **foaling** normally take place on your farm or elsewhere?

- ○ at farm (1)
- ○ elsewhere (broodmares sent away to a specific foal-down location) (2)
- ○ other, please specify: __________ (3)
- ○ not applicable or irrelevant (5)

Display This Question:

If Q127 = 138

Or If

Q125 = 139

Q68 In the last year, how did you anticipate **foaling**?

Use multiple selection if relevant.

- ☐ foaling alarms (1)
- ☐ night checks (2)
- ☐ send a mare to a foaling facility off farm (3)
- ☐ other, please specify: __________ (4)
- ☐ not applicable or irrelevant (5)

Display This Question:

If Q125 = 139

Q62 At what age do you usually wean your **miniature youngstock**?

_______ age (in months) (17)

Display This Question:

If Q125 = 139

Q63 In the last year, how do you usually wean your **miniature youngstock**?

- ○ abrupt weaning (remove all mares or leave with just one mare, all at once) (46)
- ○ progressive weaning (remove one mare or just a few mares at a time) (47)
- ○ other, please specify: __________ (48)
- ○ not applicable or irrelevant (49)

Display This Question:

If Q125 = 139

Q105 In the last year, where did weaning of your **miniature youngstock** take place?

- ○ box-wean (40)
- ○ paddock-wean (41)
- ○ other, please specify: __________ (42)
- ○ not applicable or irrelevant (43)

Display This Question:

If Q125 = 139

Q64 What is the typical age range of your **miniature colt(s)** when gelded?

- ○ less than six months (190)
- ○ between six months and a year (191)
- ○ more than a year but less than two years (192)
- ○ more than two years but less than three years (193)
- ○ other: __________ (195)
- ○ not applicable or irrelevant (194)

Display This Question:

If Q12 != 1

Q103 What are the typical age range(s) of your miniature gelding(s) when gelded?

Use multiple selection if relevant.

- ☐ less than six months (49)
- ☐ between six months and a year (50)
- ☐ more than a year but less than two years (51)
- ☐ more than two years but less than three years (52)
- ☐ other: __________ (54)
- ☐ not applicable or irrelevant (53)

Q110 You have completed the survey! Thank you for your time.

Please tell a friend or a relative about this survey to help us increase the survey response rate. The number of survey responses from this survey is crucial in determining whether the data collected would be a good representative data for the entire population of miniature horses in New Zealand. Would you like a summary of the results from this survey? Please leave your email address if you do.

____

End of Block: Default Question Block

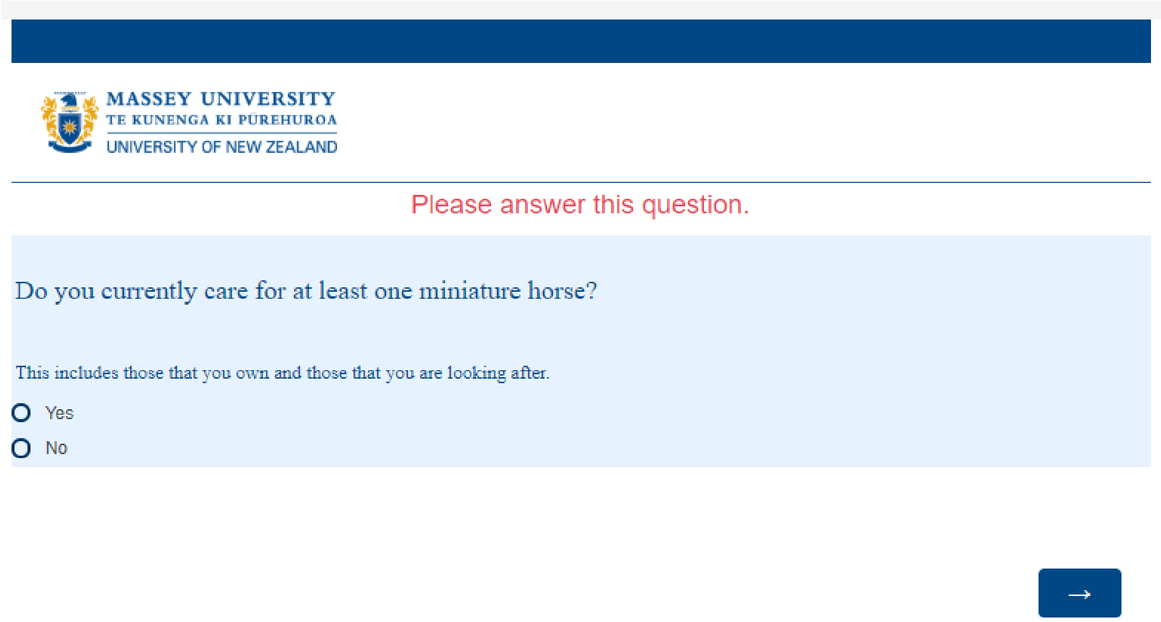
Start of Block: Block 1

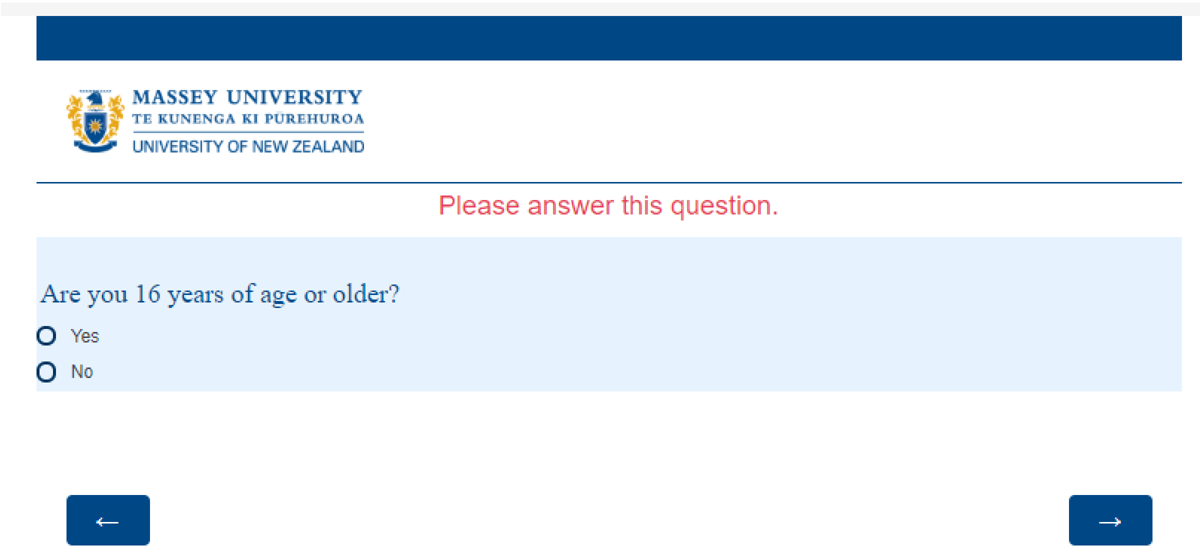
Q92 If you have any questions, please contact s.y.goh@massey.ac.nz. You can leave feedback regarding this survey below.

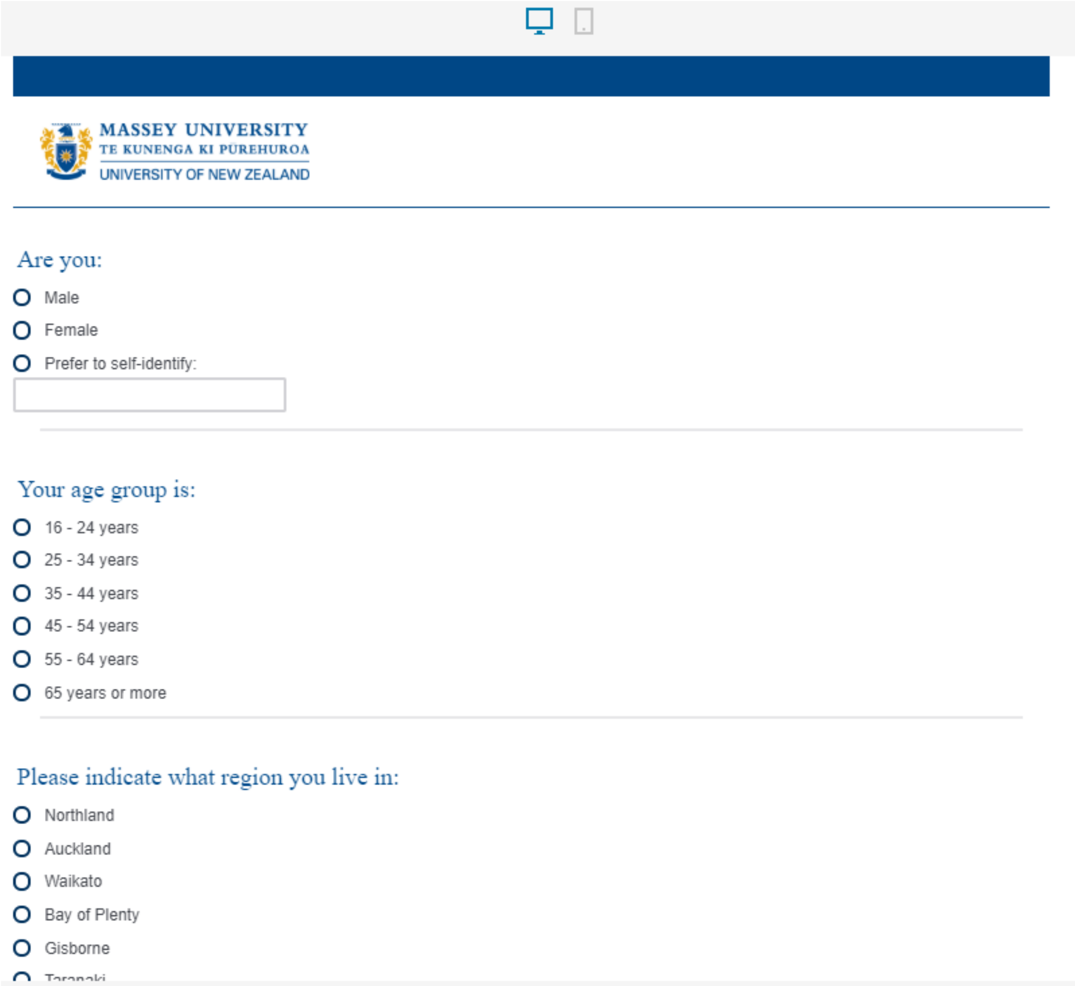
____

End of Block: Block 1

II. Appendix B Examples of the actual layout of the questionnaire







MASSEY UNIVERSITY
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UNIVERSITY OF NEW ZEALAND

Are you:

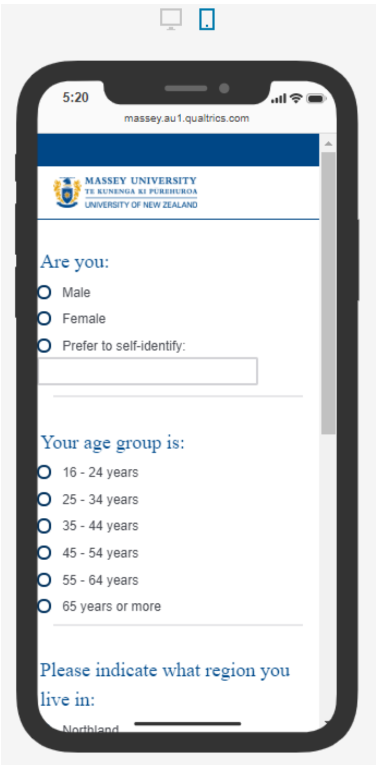
- Male
- Female
- Prefer to self-identify:

Your age group is:

- 16 - 24 years
- 25 - 34 years
- 35 - 44 years
- 45 - 54 years
- 55 - 64 years
- 65 years or more

Please indicate what region you live in:

- Northland
- Auckland
- Waikato
- Bay of Plenty
- Gisborne
- Taranaki



5:20
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MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Are you:

- Male
- Female
- Prefer to self-identify:

Your age group is:

- 16 - 24 years
- 25 - 34 years
- 35 - 44 years
- 45 - 54 years
- 55 - 64 years
- 65 years or more

Please indicate what region you live in:

- Northland

III. Appendix C Raw data

*Refer to electronic copy

*In folder: File > Data

IV. Appendix D Publication from the survey

*See attached publication in the following pages

Miniature horses in New Zealand: demographics and feeding management

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Abstract

An online survey on demographics and feeding management of Miniature horses in New Zealand was conducted using the Qualtrics Survey Software. There were 232 valid responses from respondents who kept 1183 Miniature horses, representing ~ ⅓rd of the New Zealand Miniature horse population. Miniature horses were kept for leisure and companionship (56%), competition (35%) and for breeding (7%). The majority (79%) of Miniature horses were kept at pasture on low (< 1000 kg DM/ha) to moderate (~ 2000 kg DM/ha) pasture masses across seasons. Pasture access was more commonly restricted by respondents during spring (60%), summer (60%), and autumn (55%) than in winter (43%). Most respondents (87%) practiced pasture-restriction strategies such as strip grazing, use of a paddock with little grass, and stabling/yarding. Respondents indicated the mode daily number of hours of stabling was 7-12 hours (n=57/195, 29%). The median stocking density was 10 horses/ha, (~1100 kg live weight/ha). The stocking density appeared high, however, on a live weight basis, it was comparable to the reported values in other classes of equine livestock.

Keywords: horse, Miniature horse; demographics; feeding; pasture

Introduction

The Miniature horse is phenotypically classified by its small stature (Petersen et al. 2013). The genetic basis of the New Zealand Miniature horses is the American Miniature horse, and in some cases Shetland and Timor ponies (Rogers et al. 2006). Miniature horses present a unique management challenge due to their small body size and a thrifty phenotype. These small equines can develop obesity, insulin resistance (equine metabolic syndrome, EMS) and laminitis; excess body weight developed as a result of ration mis-estimation, overfeeding or a lack of knowledge on the total amount of feed required (Scherer-Hoock et al. 2011).

Based on published New Zealand pasture energy content of 10 MJ DE/kg DM, an adult Miniature horse weighing 110 kg would only require 2 kg (or 1.8% of body weight) of pasture DM per day to meet maintenance energy requirement of 20.2 MJ [DE_m= 5.9 + 0.13 BW] (Hoskin & Gee 2004; National Research Council (U.S.) Committee 2007). However, little is known about the actual voluntary feed intake (VFI) of Miniature horses when fed *ad libitum*. Non-obese Welsh Mountain ponies were able to consume a complete, commercially manufactured chaff-based diet, comparable in nutrient profile to moderate quality hay, at 3.5 ± 0.1% (winter) or 4.6 ± 0.3% (summer) of body weight as dry matter when fed *ad libitum*, which was above maintenance requirements (Dugdale et al. 2010; 2011). As a result, their body weight increased rapidly (0.6-0.9 kg/day) (Dugdale et al. 2011). Therefore, feed intake must be restricted in ponies or small-sized horses to prevent increased body weight.

Restricting feed intake can be achieved by limiting the amount of time horses are kept on pasture (Glunk et al. 2013), or selective grazing on poor-quality pasture (Fleurance et al. 2009). Although pony breeds appear to have a better utilisation of less-nutritious feed (Cuddeford et al. 1995), with restriction of feed intake, suitable supplementary feeding and/or supplements may be required to ensure that their nutritional requirements are met.

In New Zealand, Miniature horses represent a fast-growing sector of the equine industry. Recent estimates suggest there are 3000 registered Miniature horses in New Zealand, making up ~3% of the entire horse population in New Zealand, or ~7% of horses involved in other equestrian, leisure or recreational activities (Rogers et al. 2017). Only one survey on New Zealand Miniature horses (a preliminary study on congenital and reproductive disorders) has been carried out (Rogers et al. 2006). At present the demographics and feeding management of New Zealand Miniature horses have not been well described. Thus, the aim of this study is to describe the demographics and feeding management of Miniature horses in New Zealand. The information gathered will be a useful reference in identifying the unique challenges in feeding and management of Miniature horses.

Materials and methods

An online survey was created using the Qualtrics Survey Software (https://massey.qualtrics.com/) and was published between 4th July 2019 and 26th November 2019. Recruitment of respondents was achieved via the snowball sampling technique. The link to the survey was published on social media pages of Miniature horse special-interest and breeder groups within New Zealand. In addition, key industry participants known to the authors were involved in disseminating the link of the survey via social media.

The survey consisted of eighty-five succinctly crafted questions, which were a combination of closed and open-text responses. The questions addressed four main subject areas; demographics, feeding, management practices and health care practices for Miniature horses in New Zealand. The survey was approved by the Massey University

Human Ethics committee as low risk (notification number: 4000021167).

The dataset from the survey was subsequently coded and cleaned for analysis within Microsoft Excel. Continuous data were examined for normality using histograms and the Shapiro-Wilk test. If data were non-parametric, the median, 1st quartile, 3rd quartile or mode frequency of the data series were reported. Differences between groups for non-parametric data were examined using Kruskal-Wallis test one-way analysis of variance, significant differences between the groups were further tested using a pairwise Mann-Whitney test. Differences in distribution between groups were tested using the Chi-square test. All statistical tests were performed, and significance was accepted at $P < 0.05$ using the SPSS Statistics 26.0 (IBM Corp., Armonk, N.Y., USA).

Results

Demographics

Of the 247 survey attempts, 232 resulted in valid responses, of which 153 had a 100% question completion rate and a further 41 responses had 97-99% question completion rate (n=194/232). Most respondents were female (n=226/232, 97%) aged 35-64 years (n=152/232, 66%), with the highest number of respondents in the 45-54 age bracket (n=65). Most Miniature horse owners had at least five years' experience of keeping Miniature horses (n=176/232, 76%), and kept their Miniature horses on a lifestyle block: land area ~4 hectares (ha) or ~10 acres (n=172, 74%). Responses were obtained from all regions in New Zealand: Canterbury (n=37), Waikato (n=29), Taranaki (n=28), Auckland (n=28), Manawatu-Whanganui (n=23), Northland (n=18), Wellington (n=15), Bay of Plenty (n=13), Hawke's Bay (n=11), Otago (n=9), Nelson-Marlborough (n=6), Tasman (n=6), West Coast (n=3), Southland (n=3) and Wairarapa (n=3).

Most respondents (n=164/232, 71%) registered their Miniature horses (n=1137) with the New Zealand Miniature Horse Association (NZMHA) registry. As Miniature horses can be registered with multiple breed registries or

Table 1 Data from the survey on demographics and feeding management of Miniature horses in New Zealand: the number of Miniature horses per respondent, the number of Miniature horses according to age, and the stocking density of Miniature horses, categorized according to primary use.

Primary purpose of Miniature horse ownership	Leisure and companionship	Competition	Breeding [*]	Total	P
Number of responders (%)	130 (56%)	82 (35%)	17 (7%)	232[‡] (100%)	-
Total number of Miniature horses	459 (data from 126 respondents)	589 (data from 79 respondents)	135 (data from 13 respondents)	1183 (data from 218 respondents)	-
Median(IQR) Miniature horses per respondent	2 (1-4)[b] (data from 126 respondents)	6 (3-11)[a] (data from 79 respondents)	10 (4-16)[a] (data from 13 respondents)	3 (2-7) (data from 218 respondents)	P <0.05
Age distribution of Miniature horses (number of horses, n)	<3 yrs (n=28) 3-5 yrs (n=57) 6-15 yrs (n=280) >15 yrs (n=94)	<3 yrs (n=117) 3-5 yrs (n=120) 6-15 yrs (n=267) >15 yrs (n=85)	6-12 yrs (n=30) 13-15 yrs (n=81) >15 yrs (n=24)	1183 (data from 218 respondents)	P <0.05
Median (IQR) stocking density or the number of Miniature horses per hectare, ha	10 (5-17)[a]	13 (7-22)[b]	12 (4-13)[a]	10 (5-20)	P<0.05
Number of hours, h of stabling (number of respondents, n)	0 h (n=29) 1-6 h (n=17) 7-12 h (n=30) 13-18 h (n=14) 19-24 h (n=22) (data from 112 respondents)	0 h (n=13) 1-6 h (n=18) 7-12 h (n=24) 13-18 h (n=8) 19-24 h (n=10) (data from 73 respondents)	0 h (n=6) 1-6 h (n=1) 7-12 h (n=2) 13-18 h (n=0) 19-24 h (n=0) (data from 9 respondents)	0 h (n=48) 1-6 h (n=36) 7-12 h (n=57[^]) 13-18 h (n=22) 19-24 h (n=32) (data from 195 respondents)	ns
Subset data: number of hours, h of stabling for the purpose of restricting pasture access (number of respondents, n)	0 h (n=3) 1-6 h (n=10) 7-12 h (n=23) 13-18 h (n=11) 19-24 h (n=8) (data from 55/112 respondents)	0 h (n=0) 1-6 h (n=7) 7-12 h (n=16) 13-18 h (n=6) 19-24 h (n=4) (data from 33/73 respondents)	0 h (n=1) 1-6 h (n=1) 7-12 h (n=2) 13-18 h (n=0) 19-24 h (n=0) (data from 4/9 respondents)	0 h (n=4) 1-6 h (n=18) 7-12 h (n=42[^]) 13-18 h (n=17) 19-24 h (n=12) (data from 93/195 respondents)	

[*] refers to broodmares only.

[‡] includes data from three respondents with unknown primary purpose of Miniature horse ownership

[^] includes data from one respondent with unknown primary purpose of Miniature horse ownership

[a,b] denotes significant difference within row ($p<0.05$) using the Mann-Whitney pairwise comparison between three different data series.

societies, 131 respondents indicated that their horses had more than one registration. There were 23% of respondents (n=54/232) who did not register their horses with any breed society.

Respondents were provided with multiple options to describe the reasons for keeping Miniature horses: as pets (n=143), for showing (n=135), as a companion for other horses (n=81), for leisure driving (n=71), for breeding (n=64), for competitive driving (n=57), to be ridden by children (n=41), and as a therapy horse (n=25). Miniature horses were grouped into three categories i.e., leisure and companionship, competition, and breeding, according to owner's primary purpose of horse-keeping (Table 1). Some respondents who used Miniature horses primarily for competition (45%, n=37/82) or leisure and companionship (8%, n=11/130), were also involved in breeding Miniature horses.

A total of 1183 Miniature horses were kept by 218 respondents (Table 1). Over half of the Miniature horses were between 6-15 years of age (n=658, 56%), with the remainder evenly divided between the other age categories listed in Table 1. Few respondents (n=81/223, 36%) kept Miniature horses exclusively, with the majority (n=134/223, 60%) also kept horses of other breeds. The overall median number of Miniature horses kept per respondent was 3 (IQR 2-7).

Feeding and management practices

The overall median stocking density of Miniature horses was 10 (IQR 5-20) horses per hectare. The stocking density differed according to the horse's primary uses (Table 1). The majority (n=919/1119, 82%) of Miniature horses were kept at pasture; few horses had no, or limited access to pasture (n=153/1119, 14%) (Table 2). In terms of percentages, Miniature horses used for breeding (71%) were more likely to be kept exclusively at pasture across seasons, compared with horses used for leisure (28%) and competition (37%) (Table 2). The majority (n=815/1036, 79%) of Miniature horses were kept on low (< 1000 kg DM/ha) to moderate (~ 2000 kg DM/ha) pasture masses across seasons (Table 3).

Pasture access was more commonly restricted during spring (n=125/208, 60% of respondents, n=625/1119 horses, 56%), summer (n=125/208, 60% of respondents, n=632/1119 horses, 56%), and autumn (n=115/208, 55% of respondents, n=567/1119 horses, 51%) compared to winter (n=89/208, 43% of respondents, n=403/1119 horses, 36%). Approximately half (n=105/208, 50%) of the respondents kept their Miniature horses (n=656/1119, 59%) exclusively at pasture during winter.

The majority (n=173/198, 87%) of respondents practiced pasture-restriction strategies such as strip grazing (n=118), the temporary use of a paddock with little grass (n=99), confinement for part of a day in a stable or yard (n=94), turning out horses to graze in the early morning only (n=42), or fitting a grazing muzzle (n=24). Another pasture restriction strategy cited by respondents (n=15) was provision of a track system (where fencing is placed around the centre of the paddock in order that the horse(s) walk on the outside of the fences during grazing). Strategies

Table 2 Data from the survey on demographics and feeding management of Miniature horses in New Zealand: total number of Miniature horses managed with different types of pasture management strategies across seasons, subcategorised according to primary use of Miniature horses.

Pasture-management strategies	Total number of respondents (N) (Data from 208 respondents)	Primary use of Miniature horses: Leisure and companionship (Data from 445 horses) Number of horses, n (%)	Competition (Data from 580 horses) Number of horses, n (%)	Breeding (Data from 94 horses) Number of horses, n (%)	Total (Data from 1119 horses) Number of horses, n (%)
Always on pasture all seasons	59	124 (28%)	212 (37%)	67 (71%)	403 (36%)
Have variable access to pasture in spring, summer and autumn, but always on pasture in winter	45	86 (19%)	165 (28%)	0 (0)	251 (22%)
Mostly on pasture all seasons	37	92 (21%)	117 (20%)	22 (23%)	231 (21%)
Either mostly on pasture or mostly stabled/yarded all seasons	12	22 (5%)	12 (2%)	0 (0)	34 (3%)
Mostly stabled/yarded all seasons	33	51 (11%)	58 (10%)	5 (5%)	114 (10%)
Always stabled/yarded all seasons	8	37 (8%)	2 (0.3%)	0 (0)	39 (3%)
Other strategies	14	33 (7%)	14 (2%)	0 (0)	47 (4%)
Total	208	445 (~100%)	580 (~100%)	94 (~100%)	1119 (~100%)
Unknown strategies	24	-	-	-	64
Grand total	232	-	-	-	1183

Table 3 Data from the survey on demographics and feeding management of Miniature horses in New Zealand: seasonal pasture mass or seasonal pasture availability for three groups of Miniature horses.

Seasonal pasture mass or seasonal pasture availability				Total number of respondents (N)	Primary use of Miniature horses			
Spring	Summer	Autumn	Winter		Leisure and companionship	Competition	Breeding	Total
				(Data from 196 respondents)	(Data from 381 horses)	(Data from 555 horses)	(Data from 100 horses)	(Data from 1036 horses)
					Number of horses, n (%)	Number of horses, n (%)	Number of horses, n (%)	Number of horses, n (%)
Low	Low	Low	Low	35	49 (13%)	65 (12%)	0 (0)	114 (11%)
Moderate	Moderate	Moderate	Moderate	20	20 (5%)	82 (15%)	18 (18%)	120 (12%)
Mostly low	Mostly low	Mostly low	Mostly low	35	101 (27%)	81 (15%)	13 (13%)	195 (19%)
Mostly moderate	Mostly moderate	Mostly moderate	Mostly moderate	22	55 (14%)	99 (18%)	16 (16%)	170 (16%)
Low or moderate	Low or moderate	Low or moderate	Low or moderate	19	70 (18%)	33 (6%)	5 (5%)	108 (10%)
Low or moderate	Low or moderate	Low or moderate	High	11	16 (4%)	44 (8%)	0 (0)	60 (6%)
High	Low or moderate	Low or moderate	Low or moderate	5	3 (0.8%)	8 (1%)	4 (4%)	15 (1%)
Low or moderate	Low or moderate	High	Low or moderate	3	2 (0.5%)	11 (2%)	0 (0)	13 (1%)
Low	No pasture (barren) or low	Moderate	Low or moderate	3	1 (0.3%)	19 (3%)	0 (0)	20 (2%)
Other pasture masses combination across seasons				19	19 (5%)	85 (15%)	4 (4%)	108 (10%)
Incomplete information on seasonal pasture masses, respondents kept their horses on pasture at certain seasons only (their horses were not kept on pasture all seasons)				24	45 (12%)	28 (5%)	40 (40%)	113 (11%)
Total				196	381 (~100%)	555 (~100%)	100 (~100%)	1036 (~100%)
Unknown pasture availability				36	-	-	-	147
Grand total				232	-	-	-	1183

used for pasture maintenance included picking up horse manure from pasture (n=138/198, 70%), rotational grazing (n=125/198, 63%) or mixed grazing (n=92/198, 46%), harrowing pasture (n=77/198, 39%) or topping or mowing pasture (n=57/198, 29%).

Respondents that stabled their horses used varying hours of confinement per day (1-6 hours, 7-12 hours, 13-18 hours and 19-24 hours), with the highest number of respondents stabling their Miniature horses for 7-12 hours/day (n=57/195, 29%) (Table 1).

In addition to pasture, most owners provided the horses with additional feed (n=194/232, 84%). Additional feedstuffs were hay (n=180), chaff (n=130), premixed concentrates (n=117), fermented forages (n=51), and other types of feed (n=33) such as oats, copra, soy, molasses, sugar beet pulp. Respondents (n=131) would offer up to six different types of supplements to their Miniature horses, however, respondents (n=38, 37) usually offered either one or two different types of supplements. The most common categories of supplements reportedly fed were vitamin and mineral supplements (n=114) and hoof and coat supplements (n=55).

Most respondents did not objectively assess their horse's weight using either a weighbridge (n=198/213, 93%) or a weight tape (n=170/214, 79%). A few respondents (n=15/213, 7%) used the weighbridge at least once annually to monitor their Miniature horses' weight, and almost one-fifth of respondents (n=44/214, 21%) used a weight tape once or twice annually to monitor their Miniature horses' weight. Half (n=102/202, 50%) of the respondents indicated they observed body condition of their horses frequently but may not have used a formal quantification process.

Discussion

The respondents to this survey were mostly women, which is in agreement with other studies that have shown they tend to be over-represented in both equestrian sport and breeding (Fernandes et al. 2014; Agar et al. 2016; Burbage

& Cameron 2018). Additionally, most respondents were semi-experienced, or experienced, horse owners who have also kept horses of other breeds. This was similar to the profile described in other surveys, where the majority of the survey respondents and their families had many years of experience working with horses in general (Fernandes et al. 2014; Agar et al. 2016). The highest number of responses was gathered from respondents residing in the upper North Island (Waikato and Auckland), in the Central-West of the North Island (Taranaki), and in Central-East of the South Island (Canterbury). The greater number of responses received from these regions reflected the estimates of the distribution and density of horses in New Zealand (Rosanowski et al. 2012; Bolwell et al. 2017).

The majority (97%) of Miniature horses were kept at pasture (Table 2), with owners generally utilising some form of confinement as a method to restrict pasture access. Pasture restriction is seen as necessary; pony breeds had been reported to consume between 2.6 to 4.9% of BW as DM/day (Ralston et al. 1979; Dugdale et al. 2011), which is greater than their nutritional requirements. Assuming a moderate pasture-energy content (10 MJ DE/Kg DM), a typical Miniature horse requiring only 20.2 MJ of digestible energy for maintenance could consume their ration requirement of ~2 kg DM of pasture (~1.8% of BW as DM/day) in as little as six hours of grazing (Dugdale et al. 2011).

From the survey results, respondents have incorporated a variety of ingredients as supplementary feeds into the diet of their Miniature horses. Data on quantities fed were not collected, and the assumption from the answers was that supplementary feeds were provided in a manner like that reported by Fernandes et al. (2014) where concentrates and premixes were provided at low levels to "balance the ration" or to provide additional energy. Approximately half the respondents provided mineral or vitamin supplements to their Miniature horses. This level was similar to a report for sport horses in New Zealand (Verhaar et al. 2014). Data on quantities of minerals supplements provided were not collected; nevertheless, care must be taken by horse owners to avoid excess mineral supplementation. An online survey on the mineral supplementation for horses reported that the calculated intake of minerals was higher than the intake recommended by the National Research Council (NRC) (Grimwood et al. 2016)

The median stocking density for Miniature horses from this study was ten (IQR 5-20) horses per hectare, with the assumption of a mature weight of 110 kg ± 21 kg (Catalano et al. 2019) equating to approximately 1100 kg LWT/ha. This value is similar to the typical stocking density of full-sized horses (~500 kg each): ~1000 kg LWT/ha or ~2 horses per hectare, ha (or 0.8 horses per acre) (Singer et al. 2001; Cohen et al. 2005; Rogers et al. 2007; Bengtsson et al. 2018). As the majority of horses were kept on pasture with low (< 1000 kg DM/ha) to moderate (~2000 kg DM/ha) pasture masses, pasture growth of 20 kg DM/ha/day would meet maintenance requirement for ten Miniature horses (2 kg DM/horse) kept on a hectare of land (Baars' et al. 1990).

A high proportion of respondents from this survey indicated that they have undertaken mixed grazing as a pasture-management practice. This is not surprising as Thoroughbred and Standardbred breeding farms in New Zealand commonly utilise mixed-grazing practice with cattle and/or sheep (Bolwell et al. 2015). Most likely, Miniature horses were mixed-grazed with small-sized ruminants and other livestock. Mixed grazing of horses with sheep or cattle has recently been reported to have benefits in controlling strongylosis in horses (Eysker et al. 1986; Forteau et al. 2019).

Although weight monitoring was regularly practiced, very few Miniature horse owners used weight scales to monitor their horses' body weight; body condition scoring and weight tape were used more frequently, similar to data reported by Murray et al. (2015). Instead, respondents preferred a non-structured, daily "visual appraisal" to gauge their Miniature horses' body condition or described estimating their Miniature horses' body weight by experience. Both methods lack the precision of the formal body condition scoring. However, even on commercial farms there is often limited use of formal body condition scoring or weighing to monitor growth and body weight. The lack of body weight monitoring may be a risk factor for obesity, over-conditioning or severe clinical diseases such as equine metabolic syndrome (EMS) and laminitis.

There are several limitations with online surveys, one of the main ones being the non-response bias and the social-desirable bias from this survey. Respondents were gathered using the snowball sampling technique, a reflection of the "convenience sampling" technique where samples are drawn from a pool that is close at hand. As the responses were mostly gathered from respondents actively involved in social media pages for Miniature horses, there is a small risk that the data gathered in this survey are skewed towards respondents who are cognizant of the suitable/appropriate management practices or strategies for their Miniature horses. However, this sampling methodology provided an efficient method of targeting the population of owners/keepers of Miniature horses in a timely and cost-effective manner.

Across the non-commercial equine sector there is limited documentation of feeding and management practises. This lack of information makes it difficult for regional councils to understand land management use and for Veterinarians and industry consultants to provide targeted advice on feeding and management practices. The information gathered from this survey provides a useful reference point for further investigations on the inter-relationship between feeding management practices and the body weight of Miniature horses in New Zealand.

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V. Appendix E The history of horse domestication

(the author's favourite section, excluded from the literature review)

The domestication of horses (*Equus Caballus*) had likely occurred during the early Bronze Age through to the Iron age and to the Medieval period (Cieslak et al., 2010; Librado et al., 2017). However, traces of archaeological evidences found in the Cemetery of horse keepers during the Copper Age (Eneolithic, the last pre-historic period of the stone ages) suggest that the domestication of horses could have begun even earlier, about 5000 years ago B.C.[13] or B.C.E[14], before the Bronze and Iron ages (Levine, 2005; Telegin, 1986). The pre-domestication period for horses is the Pleistocene age (or the Ice Age) that occurred between 2.58 and 0.012 million years ago (Cieslak et al., 2010).

Archaeological remains dated back in 3500 BCE suggest that the Eneolithic Botai Culture of Kazakhstan used the domesticated Botai horses for harnessing and for milking (mare's milk) and these horses were obtained by hunting (it is quite likely that female horses are easier to be hunted and tamed as domestic livestock) (Levine, 1999; Outram et al., 2009). Furthermore, following the discovery of the structure of horses' bones and teeth remains, particularly the lower second premolars from two Eneolithic sites in the central Eurasian Steppe including The northern Kazakhstan (the Botai horses) and the Ukraine (Dereivka horses), these ancient horses could have been accustomed to wearing a bit (Levine, 1999).

It was estimated that the domestication of horses was successfully achieved over 5500 or around 6000 years ago in the Eurasian steppe, in countries known today as the Kazakhstan, Ukraine and Mongolia (Bailey & Binns, 1998; Bruford et al., 2003; Levine, 1990; Olsen, 2006; Schubert et al., 2014; Vilà et al., 2001; Warmuth et al., 2012). A study suggested that the domestication of horses occurred as a result of the spread of wild horses from the east to the west of the Eurasian Steppe about 160 000 years ago (or 160 kya), in the area known as the modern-day Kazakhstan and Ukraine (Warmuth et al., 2012). Moreover, a study estimated that the beginning of the expansion of the population size for horses

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[13] Before Christ

[14] Before Common Era

occurred ~7000 years ago, coinciding with the period when wild horses was successfully domesticated (Achilli et al., 2012; Lippold et al., 2011). Prior to the expansion of the population of horses ~7000 years ago, there was a shrinkage or diminished in the population of horses. The shrinkage or diminished in the population of horses has occurred in a similar time frame of roughly ~5000 - 7000 years before the expansion of the population of horses, causing an undesirable 'bottle neck' effect, potentially limiting the genetic diversity of horses (Achilli et al., 2012). The genetic of domestic horses was influenced by the greatest number of diversity of the maternal lineages (evidenced from the mitochondrial DNA, mtDNA); however, there was a reported extreme homogeneity or a lack of nucleotide diversity on the Y-Chromosome on the paternal lineages (Cieslak et al., 2010; Cieslak et al., 2011; Kavar & Dovč, 2008; Lau et al., 2008; Librado et al., 2017; Lindgren et al., 2004; Orlando, 2020; Schubert et al., 2014; Vilà et al., 2001).

In Europe, the domestication of horses started in East Europe in the Neolithic period, expanded to the Carpathian Basin and Moravia in the west, Caucasus in the southeast and Mesopotamia in the Near East, and lastly, reaching western Europe in the Bronze Age (Bokonyi, 1987). The eastern horses were much bigger than the horses in the western half of Europe, which were represented by the small, slender Celtic horses (Bokonyi, 1987). Although the domestication of horses has benefited mankind, there will be 'invisible costs or trade-offs' to the domestication of horses such as inbreeding and deleterious, undesirable genetic mutations (Schubert et al., 2014).

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