Mapping of feeding strategies in Swedish riding schools with different housing systems and its impact on horse health and body condition

En kartläggning av utfordingsstrategier på svenska ridskolor med olika inhysningssystem och dess påverkan på hästarnas hull och hälsa

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Abstract

With around 500 riding schools, equestrian sport is one of Sweden's largest sports organisations and the second largest youth sport. Horses are traditionally held in individual boxes but can also be kept in groups, so-called group housing. Keeping and feeding horses too far from their basic needs can lead to digestive upsets, stereotypic behaviours and feed-related diseases. Concerning diet, assessing the amount of stored fat in horses by Body Condition Scoring (BCS) (graded 1-9) is essential since obesity is correlated with several diseases. This study examines whether there are differences in the feeding strategies, choice of feed, feed ration composition and body condition scores in horses kept in Swedish riding schools with different housing systems. The study also examines possible differences in the hygienic quality of the feed, feeding routines and possible risks for feed-related diseases. Eight Swedish riding schools with either individual or group housing systems participated in the study. Data about feeding and feeding-related aspects were collected, and 80 horses, ten from each riding school, were scored in body condition. Three out of eight riding schools lacked forage analysis, and there was no difference in average BCS, irrespective of the housing system. However, 25% of all body condition-scored horses were overweight. Individually housed horses lacked water at turnout, spent more hours indoors and had more cases of colic. Compared to this, group-housed horses always had free access to water, many more hours kept outdoors, and significantly fewer cases of colic. Group-housed riding schools also mucked out their paddocks to a larger extent than individually-housed riding schools. The quota between roughage and concentrates regarding energy and protein content could only be calculated in three out of eight riding schools due to free access to forage or lack of a forage analysis. In conclusion, riding school staff needs more education and practical training on how to perform body condition scoring in horses. Differences in body condition were not related to the housing system. However, the frequency of colic differed significantly between systems, and the importance of free access to water and hours kept outdoors was highlighted.

Sammanfattning

Med omkring 500 ridskolor i landet är ridsporten en av Sveriges största sportorganisationer och den näst största ungdomssporten. Traditionellt sett hålls hästar i individuella boxar men de kan också hållas i grupp i lösdriftssystem. Att hålla och utfodra hästar långt ifrån deras grundläggande behov kan leda till störningar i magtarmkanalen, stereotypa beteenden och foderrelaterade sjukdomar. I relation till foderstaten är hullbedömning (BCS, skala 1-9) av hästar av största vikt eftersom fetma är kopplat till flertalet sjukdomar. Studien ämnar undersöka om det finns skillnader i utfodringsstrategier, val av foder, foderstatskomposition och hull för hästar inhysta på svenska ridskolor med olika typ av inhysningssystem. Dessutom, undersöka eventuella skillnader i den hygieniska kvaliteten av foder, utfodringsrutiner och möjliga risker för utfodringsrelaterade sjukdomar. Åtta svenska ridskolor med antingen individuell hållning eller grupphållningssystem deltog i studien. Data rörande utfodring och utfodringsrelaterade faktorer samlades in och 80 hästar hullbedömdes totalt, tio hästar från vardera ridskola. Tre av åtta ridskolor saknade grovfoderanalys och det fanns ingen skillnad mellan det genomsnittliga BCS oavsett inhysningssystem, dock var 25% av alla hullbedömda hästar överviktiga. Individuellt hållna hästar saknade vatten vid utevistelse i större utsträckning, hölls fler timmar inomhus och hade fler fall av kolik. I jämförelse hade grupphållna hästar alltid fri tillgång till vatten, hölls många fler timmar utomhus och hade signifikant färre fall av kolik. Ridskolor med grupphållning mockade dessutom ur hagarna i större utsträckning än ridskolor med individuell inhysning gjorde. På grund av fri tillgång av grovfoder eller avsaknad av grovfoderanalys kunde kvoten mellan grovfoder och kraftfoder i foderstaten med avseende på energi och protein endast beräknas för tre av de åtta ridskolorna. Sammanfattningsvis behöver ridskolepersonal mer utbildning och praktisk övning i hur hästar ska hullbedömas. Skillnader i BCS kunde inte kopplas till inhysningssystem. Det fanns däremot en signifikant skillnad av förekomsten av kolik mellan inhysningssystemen och betydelsen av fri tillgång på vatten och lång utevistelse belystes.

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Abbreviations

BW	Body Weight
BCS	Body Condition Score
DM	Dry Matter
EMS	Equine Metabolic Syndrome
g dCP	Grams of Digestible Crude Protein
IR	Insulin Resistance
ME	Metbolisable Energy
MJ	Megajoules
NRC	National Research Council
SLU	Swedish University of Agricultural Sciences

Introduction

Evolutionarily, horses (*Equus caballus*) live on plains where they graze and live in groups. Being prey animals, they constantly graze with their head positioned low, taking small bites of grass and moving over time while being cognisant of the surrounding environment and group members. Horses are social herbivores relying entirely on their group members for their safety, mutual comfort and probably improved foraging. Thus, an animal that experiences stress or fear if kept isolated (McGreevy, 2012).

Being evolved as pure grazers and having a relatively small stomach compared to their very large intestines (Sisson, 1914; Janis, 1976), horses can survive on fibrous forages thanks to hindgut fermentation (Janis, 1976; MacDonald *et al.*, 2002). Because of this and at the same time being forced to be alert and awake to recognise predators, horses are made to eat and move continuously over time.

The horse industry is one of the biggest sports in Sweden and the second biggest youth sport, which lasts up to over half a million Swedes' interest. Almost 155,000 people are members of the Swedish Equestrian Federation, and there are about 500 riding schools with around 10,000 riding school horses and ponies. Around five million riding hours are performed yearly in the country's riding schools, and 40% of all lessons are ridden on horses and 60% on ponies (Svenska ridsportsförbundet, 2017). Due to the popularity of this sport, the conditions, education and horse welfare in riding schools are of great importance.

The most common housing system for keeping horses in Sweden is individual housing in boxes, followed by group housing (Svala, 2008; Wallberg, 2010), and there are various motives for this. Individual boxes are the traditional way to keep horses and are considered convenient for the owner in many ways. For example, it is considered to provide greater control over the horses' health since it enables more individual care of each horse and a lower risk of injuries in both horses and handlers (Svala, 2008; Wallberg, 2010). Horses are usually fed in meals and have some access to outdoor areas during the daytime. In group housing systems, on the other hand, horses are often fed more evenly throughout the 24 hours and spend most of their time outside. However, group housing systems have been considered problematic at riding schools (Wallberg, 2010) because of the fear of a greater risk of injuries in children. There is also a fear of keeping horses in groups for the risk of injuries to the horses themselves. However, according to Keeling *et al.* (2016), this fear is exaggerated.

If stabled horses are fed *ad libitum* amounts of hay, their time budgets comply with the time budgets of adult feral horses (Sweeting *et al.*, 1985), who spend around 60% of their time foraging (Duncan, 1980). However, when stabled horses are fed restricted amounts of hay, they commonly start to eat non-feed materials such as chewing on wood (Willard *et al.*, 1977) or eating wood shavings, faeces (Sweeting & Houpt, 1987) and straw bedding (McGreevy *et al.*, 1995). Low-fibre/high-concentrate diets are also associated with developing gastric ulcers (Andrews & Nadeau, 1999) and stereotypic behaviours (McGreevy *et al.*, 1995; Redbo *et al.*, 1998). Stereotypies are abnormal, repetitive behaviour patterns performed without an obvious goal or function (Mason, 1991), such as crib-biting and wind-sucking (McGreevy, 2012). These behaviours indicate horses' strong need to chew for a considerable amount of time (Sweeting & Houpt, 1987; McGreevy *et al.*, 1995). The long eating times combined with physical movement distinguishes horses from ruminants, such as cows, that, on the contrary, eat first and then rest to ruminate in one spot. McGreevy (2012), therefore, states that restriction of movement and the implementation of periodic fasting (meal feeding) is probably far worse for equines than for many other animal species. In conclusion, even though horses have been selected throughout history to adapt to the human environment, their natural behaviour and essential needs do not appear to have changed as much from their wild ancestors (Henderson, 2007; McGreevy, 2012).

This thesis is written as part of a larger research project called "Impact of Housing on Horse Welfare, work, safety and Pedagogics at Swedish riding schools". The project is a collaboration between the Swedish University of Agricultural Sciences (SLU), Gothenburg University and the National Equestrian Centre Flyinge. The project compared riding schools keeping their horses in either group housing or individual housing, aiming to investigate if there are differences in the mentioned areas depending on the housing system.

Aim for research

This study examines whether there are differences in feeding strategies, choice of feed, feed ration composition and body condition score in horses housed at Swedish riding schools with different housing systems. The study also examines possible differences in the hygienic quality of the feed, feeding routines and potential risks for feed-related diseases.

Questions

1. Are there differences in body condition scores in Swedish riding school horses kept in different housing systems?

2. Are there differences in feeding management that might affect the horses' health status?

3. Are there differences in feeding strategies between housing systems regarding the quota roughage versus concentrates and concerning energy and digestible crude protein?

Background

Animal welfare legislation and feeding recommendations

The Swedish Board of Agriculture is responsible for the legislation concerning animal welfare. In addition to the Animal Welfare Act (SFS 2018:1192), specific regulations concerning different species exist. The regulation relating to horses is called L 101 (SJVFS 2021:30, saknr L 101), and parts concerning the feeding of horses indicate the following:

Horses should be fed a roughage-based diet that gives the horse enough occupation to prevent stereotypies and prerequisites to prevent disorders and imbalances of the gastrointestinal tract. The diet should correspond to the horse's energy and nutrient requirements and result in a healthy body condition score. The horse should also be given the conditions to eat and drink without stress or risk of injuries. If not provided with free access to water, horses should be offered water to quench their thirst at least twice daily (SJVFS 2021:30, saknr L 101).

To facilitate the feeding of horses according to the regulation (SJVFS 2021:30, saknr L 101), feeding recommendations have been prepared by researchers (Jansson, 2013) at the Swedish University of Agricultural Sciences, based on The Dutch Nutrient Recommendations for Horses - a description of the system (Austbø, 1997) and NRC (National Research Council: Nutrient requirements for horses, National Academy Press, Washington D.C. (2007) and current research. In summary, these rules of thumb should be followed:

- Provide roughage before feeding concentrates.
- A minimum amount of forage: 1 kg dry matter (DM)/100 kg body weight (BW). Recommended amount: 1.5-2.0 kg DM/100 kg BW.
- Maximum 0.4 kg cereal-based concentrates/100 kg BW and meal.
- Maximum 150 g starch/100 kg BW and meal (<500 g/100 kg BW and day).
- Maximum 75 g oil/100 kg BW and day.

- If water is provided in automatic water cups, a water flow of at least 6 litres/minute is recommended. A water flow of 8 litres/minute is equivalent to providing water through a bucket (Jansson, 2013).

Feeding of horses and the importance of hygienic quality

Horses should be fed feeds of good hygienic quality to stay healthy and perform well (Jansson, 2013). As obligate grazers (Janis, 1976), horses can survive solely on pastures. However, feeding forage to horses in Sweden comes with some limitations. Being situated between the latitudes 55˚N and 69˚N means a cold temperate climate where winter damages in the grasslands are common. Due to this cold climate and long winter seasons, pasture time is limited, and summer grass must be preserved. Traditionally, grass has been dried into hay (MacDonald, 2002). It can also be preserved as silage, which is very common (Müller, 2007; Halling, 2011). Hay must be dried down to a water content of around 15%, in other words, a dry matter (DM) content of 85%, to be stored hygienically and prevent microbial growth (MacDonald, 2002). If not dried quickly enough, or if the hay is exposed to moisture after drying, microbial growth of bacteria or fungi may occur. Fungi can produce mycotoxins and emit fungal spores. Inhalation of fungal spores harms horses and humans (NRC, 2007) and can cause airway and lung disease in horses (Robinson, 1996). Mouldy hay has also been associated with colic (Hudson *et al.*, 2001) and should never be used for horse feed (NRC, 2007). Therefore, hay of good hygienic quality should be dust and mould-free (NRC, 2007). In contrast to hay, silage is preserved by anaerobic fermentation of non-water soluble carbohydrates by lactic acid bacteria, which causes a decrease in pH. The decrease in pH acts as a preservative and counteracts the growth of clostridium and enterobacteria (NRC, 2007). An opened haylage bale will generally maintain good hygienic quality for at least five days (DM content between 55-60%) (Müller, 2009). Exposure to moisture and heat before harvest and during storage can also contribute to the production of mycotoxins in grains. Hence, dry storage is also essential for grains (NRC, 2007).

Feed analysis is necessary to assess whether the roughage is a suitable option to feed horses with, as well as the individual horse (NRC, 2007). To complete an insufficient feed ration, grains and grain-based concentrates are often used to increase the energy (NRC, 2007) or protein content. The most commonly used concentrates fed to horses in Sweden are commercially produced pellets or muesli. Most stables have more than two types of concentrates, and after pellets or muesli, oats and beet pulp are the most commonly used types (Wallberg, 2010).

Energy

In Sweden, the energy content of feeds and horses' energy needs are calculated in metabolisable energy (ME) and megajoules (MJ) (Jansson, 2013). Metabolisable energy is the amount of energy left in a feed after the fraction of faeces, urine and intestinal gases have been subtracted from the gross energy (NRC, 2007). A horse's energy needs are calculated as maintenance energy and additional energy. Maintenance energy is the amount of energy needed to survive and be able to perform essential needs such as eating, breathing, standing, and urinating. It is calculated according to body weight (BW) with the equation $0,5MJ*BW^{75}$. The additional energy needs are defined as the energy needed to perform something more than the maintenance need, such as pregnancy, lactation, growth or work, all containing different percentages of added energy needed (NRC, 2007; Jansson, 2013). Energy needs will also vary depending on the breed or type of horse. Heavier breeds and ponies often have a lower energy need than warmbloods and thoroughbred horses, which have 5% and 10% higher energy requirements, respectively. There are also differences between genders, where stallions are calculated to have 10% higher energy requirements than mares and geldings. Regardless of the allotted amount of energy, the only way to determine if the horse is fed an appropriate amount of energy is to score its body condition (Jansson, 2013), a way to assess stored body fat, which is dealt with later in this thesis.

Protein

Protein is needed to build and repair body tissues (NRC, 2007). Protein deficiency contributes to weight loss and bad appetite in the horse, making fur, hair, and hooves grow slower (NRC, 1989). A healthy horse can handle excess protein, but a long-term deficit affects the horse. The maintenance need for an adult horse is 6 grams of digestible crude protein/MJ ME (g dCP/MJ ME), supplemented with extra protein, depending on how much work the horse performs. The protein requirement for additional work is an extra 6 g dCP/MJ ME (Jansson, 2013).

When selecting feedstuff, the type of feedstuff must be chosen, and the protein quality needs to be considered. The quality is determined based on the amino acids the protein consists of and the composition of these. For all monogastric animals, horses included, there are ten essential amino acids, meaning that horses cannot synthesise these in sufficient quantities but must receive them via feed (NRC, 2007). An ideal protein can thus be defined as a protein that includes the minimum value of each essential amino acid and the maximum utilisation of the protein as such (NRC, 2007). The essential amino acids are arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine (NRC, 1998).

Therefore, the amino acid composition is more important than the actual content of crude protein in the feed (NRC, 2007). A well-balanced protein concerning the amino acid composition also contributes to more efficient utilisation of these for tissue formation, giving lower levels of urea in the blood (Graham *et al.*, 1994). Elevated levels of urea in the blood are excreted via the urine and increase urine excretion in the horse, thus increasing the need for water, according to Meyer (1987). Increased urinary excretion due to surplus protein in the feed ration can also have a negative environmental impact as it leads to nutrient leakage, which in turn can lead to the eutrophication of lakes and seas (NRC, 2007; Parvage, 2015; Parvage *et al.*, 2015).

Minerals

Minerals play an important role in the body's function to work normally, for example, by being involved in the acid-base balance, enzymatic cofactors and energy transfer, and being part of some vitamins, hormones and amino acids. Normally, horses get most of the necessary minerals from their feed. However, mineral levels will vary depending on harvest conditions, where it has been grown, the soil concentration of minerals at that specific place, and plant maturity and species (NRC, 2007).

Minerals must be provided through the feed ration. Because of this, it is important to consider the horse's mineral status and the balance between different minerals since they often interact and affect how the body takes care of other nutrients (NRC, 2007). The needs can be exceeded to some extent without negatively impacting the horses' well-being. Deficiencies for more extended periods, however, have adverse effects. Because of this, forage should be analysed for calcium-, phosphorus- and magnesium levels. Furthermore, as there are insufficient amounts of sodium in the horse's feed, sodium must always be added to the feed ration (Jansson, 2013).

Obesity/Overweight and How to assess it

Body condition scoring is a way to assess stored fat in horses. Performing this is important since obesity is correlated with several diseases (Henneke *et al.*, 1983; Johnson, 2002; Treiber *et al.*, 2006; Carter *et al.*, 2009; Frank *et al.*, 2010).

Henneke *et al.* (1983) constructed a system that made it possible to assess the amount of stored body fat in horses (i.e. body condition). The system is divided into a nine-point scale: one is extremely emaciated, and nine is extremely fat. The assessment is done through palpation in six different areas (Fig. 1) of the horse's body: neck, withers, behind the shoulder, ribs, back and tail head. A total body score then follows this. Some horses' conformation makes them harder to judge fairly, such as having very prominent withers or flat backs. In these cases, more focus can be put on the remaining areas (Henneke *et al.*, 1983). Different breeds might also store fat differently in different parts of the body, which need to be considered (Geor & Harris, 2009).

Moreover, Martinson *et al.* (2014) state that the terminology for BCS is used differently amongst researchers, causing confusion about which BCS is to be interpreted as under and overweight. To standardise the interpretations of BCSs, Martinson *et al.* (2014) concluded BCS≤4 as underweight and BCS≥7 as overweight, which has been used as standards in this thesis.

Feeding-related diseases

Colic

Colic describes abdominal pain in horses (Tinker, 1995; Archer & Proudman, 2006; Egenvall *et al.*, 2008), and altogether, it seems to be associated with sudden changes in routines such as various dietary and management-related aspects. These types of changes have been shown to include sudden changes in diet, type of hay, hay batch or hay with poor hygienic quality (Cohen *et al.*, 1999; Hudson *et al.*, 2001; Kaya *et al.*, 2009), feeding grains and/or concentrates, changing the type of grains or concentrates, increasing the amount, or introducing it in the horse's diet (Tinker *et al.*, 1997; Hudson *et al.*, 2001; Hillyer *et al.*, 2002; Kaya *et al.*, 2009). Furthermore, time spent outdoors at pasture has shown a lowered risk of colic (Hudson *et al.*, 2001; Hillyer *et al.*, 2002; Scantlebury *et al.*, 2014) and corresponding to that, increased time spent indoors or changes in exercise post a history of lameness or injury have shown to increase the risk for colic (Hillyer *et al.*, 2002). Access to water at all times and a sufficient water intake were also shown to have a big impact on the risk for colic (Reeves *et al.*, 1996; Kaya *et al.*, 2009) as well as intestinal parasites, speaking for routinely performed mucking of paddocks and deworming of horses (Proudman *et al.*, 1998; Cohen *et al.*, 1999; Back *et al.*, 2013).

Insulin resistance

Insulin resistance (IR) is a physiological state where normal concentrations of the hormone insulin produce less than a normal biological response in the body (Kahn, 1978). The state is more common in obese horses, and the sensitivity towards the hormone as a biological response decreases when these horses are fed a sugar- and starch-rich diet compared to a diet richer in fibre and fats (Hoffman *et al.*, 2003). To summarise, to lower the risk of getting a horse with insulin resistance, a proper diet high in fibre and low in sugar is crucial, as well as keeping a healthy body condition score (Henneke *et al.*, 1983; Hoffman *et al.*, 2003).

Laminitis

Laminitis is the most severe disease in the horse hoof and causes severe pain and loss of function for the horse. Laminitis develops pathological changes in the hoof that cause the attachment between the inner hoof wall and distal phalanx to fail, forcing the bone down and rotating into the hoof capsule and damaging arteries and veins (Pollitt 1999, 2004).

The cause of laminitis is not fully understood, but some obvious risk factors correlate to the disease. These risk factors are, among others, linked to diet and nutrition due to high amounts of sugar and pasture starch (Garner *et al.*, 1977; Treiber *et al.*, 2006). Obese horses, high-fat accumulation in the neck, and insulin resistance have also been shown to be a clear risk for laminitis (Treiber *et al.*, 2006; Carter *et al.*, 2009). Because of this, horses prone to laminitis should preferably be kept in a slimmer body condition and fed a low-starch diet, which points to the importance of an accurate forage analysis while constituting feed rations for laminitis-prone horses (Longland & Byrd, 2006).

Equine Metabolic Syndrome

Equine Metabolic Syndrome (EMS) is a syndrome where horses are heavily overweight with distinct fat deposits in the neck (called cresty neck) and rump, as well as accumulating adipose tissue in the abdomen. While suffering from obesity and having difficulties losing weight, these horses are also insulin-resistant and suffer from laminitis (Johnson, 2002; Frank *et al.*, 2010). Because of this, horses with EMS should be on a strict diet without starch- or sugar-rich feeds, avoiding pastures and exercising regularly (Frank, 2009; Johnson *et al.*, 2010).

Oesophageal Impaction

Oesophageal impaction, also called “choke”, occurs when horses ingest inappropriate feeds, such as insufficiently soaked sugar beet pulp, ingesting dry hay too fast, or difficulty chewing properly due to bad teeth health, leading to difficulties swallowing (Hillyer, 1995). The horse often shows signs of oesophageal impaction through coughing with a nasal discharge of feed and saliva, distress and anxiety, an extension of its head and neck, or repeatedly arching the neck muscles (Hillyer, 1995; Feige *et al.*, 2000). The impaction is associated with insufficient water intake (Hillyer, 1995), so water flow in automatic water cups or access to water is essential.

In conclusion, many feed-related diseases and problematic aspects should be considered while keeping horses. Inevitably, the housing of horses affects their time budget and potentially affects the risk of feed-related diseases.

More detailed information about Obesity/overweight and How to assess it and the Feeding-related diseases can be found in Appendix 1.

Materials & Method

Eight riding schools were visited in four regions of Sweden between February and March 2017. The criteria to participate in the project were that the riding schools had been in business for at least six months and had a minimum of ten horses. Riding schools were matched pairwise according to region, profile, size and type of horses. In each pair, one riding school kept their horses in a group housing system, and the other kept them in individual housing. In total, 171 horses were held in the eight riding schools: 81 horses (43 ponies and 38 horses) in group housing and 90 horses (40 ponies and 50 horses) in traditional individual housing. Beyond this, ten horses from each riding school were chosen to be body condition scored, described further down. Data concerning the feeding of the horses were collected through interviews with the operation managers and staff and by personally collecting data from the feeding chambers and hay barns. The questionnaire used can be seen in Appendix 2.1. The interview questions concerned three main areas: feeding rations, hygienic quality of the feed, diseases/veterinary records, and two short questions about the perception of their horse's body condition score. Appendix 2.2 - 2.3 contains the aspects that the author checked. The author performed all registrations, and data was collected with help from an iPad, mobile telephone, pen and paper. All data was later transferred and compiled in Excel 2016. When a statistical test was used, the Kruskal-Wallis test was chosen as data were not normally distributed. The statistical programme used was MiniTab-18.

Body condition scoring

In each riding school, ten horses were selected semi-randomly to be body condition scored. Only horses that had stayed at the riding schools for at least six months and been active in the business during the same time were chosen to be part of the study, thus guaranteeing that all horses had eaten the given feed since the previous summer pasture and adjusted their BCS to the diet/feed ration. When possibility was given, five out of ten horses were ponies, and five were horses. What also impacted the selection of horses was whether horses were supposed to attend riding lessons and, therefore, could not participate in the body condition scoring and study.

Henneke *et al.* body condition scoring system (1983) was used as a basis for assessing the body condition by palpation and the amount of fat in the horses' fat deposits according to the body condition scale (1-9). A description of this can be found in Appendix 3. Some palpated areas were modified, such as the accumulation of fat behind the shoulder, which has been assessed behind the shoulder blades (according to Jansson, 2013), approximately 10-15 cm above the area pointed out by Henneke *et al.* (1983). The assessment of fat cover over the ribs has been done by firmly pressing the thumb along the ribs at about the same height as the point of the hip. In addition, all horses were given a total body score, i.e. a combined score for the entire body.

Figure 1. Picture visualising the areas of palpation while body condition scoring horses. Photo: Jasmine Lindholm

Hygienic quality

Poor hygienic feeds (such as yeast, mouldy or dusty hay or lumpy concentrates) were examined by smelling and visually looking at the different feed types. If found in the roughage, the area of mould or yeast was to be compared with the number of A4-sized paper as a reference. Spontaneous warming was searched for in those riding schools where haylage was fed to the horses, and it was done by searching for warm spots inside the haylage by hand. Any findings of warm areas were to be measured using a thermometer (C°). Storage of concentrates and their hygienic quality were also investigated since moisture and heat can contribute to the production of mycotoxins (NRC, 2007).

Water flow

Water flow was measured in four water cups at each riding school unless they only used water buckets. By measuring four water cups per stable, the water flow in each corner of the stable was examined (depending on how each stable was built and positioned) to see if the water flow differed throughout the building. Measuring the water flow was done using a 10L bucket and pushing the water cup flap for 30 seconds by hand while using a timer on a mobile telephone. After 30 seconds, the amount of water was noted and doubled to get the flow per minute (L/minute). The height of the water cups was also registered and compared to the size of the horse drinking from it.

Results

The results of this study, comparing feeding strategies in Swedish riding schools with different housing systems and their impact on horse health and body condition, are presented below. The key takeaways were that:

- No difference in average BCS was found between the different housing systems.
- 25% of all participating horses had a BCS≥7.
- Colic was more frequent in individual housing than in group housing.
- Group-housed horses had access to water at all times.

Table 1. Overview of feeding and management strategies in the two housing systems.

	Group housing (n=4)	Individual housing (n=4)
Use of forage analysis	2	3
Free access to forage	3	1
Restricted amount of forage	1	3
Salt lick or salt in feed ration	4	4
Water at turnout/in paddocks	4	0
Faecal samples for parasite analysis	3	2
Deworming	4	4
Hours kept indoors, incl. working hours	4.7 (mean value)	17.5 (mean value)

Table 1 gives an overview of part of the results comparing the two types of housing systems. More detailed results are shown further down.

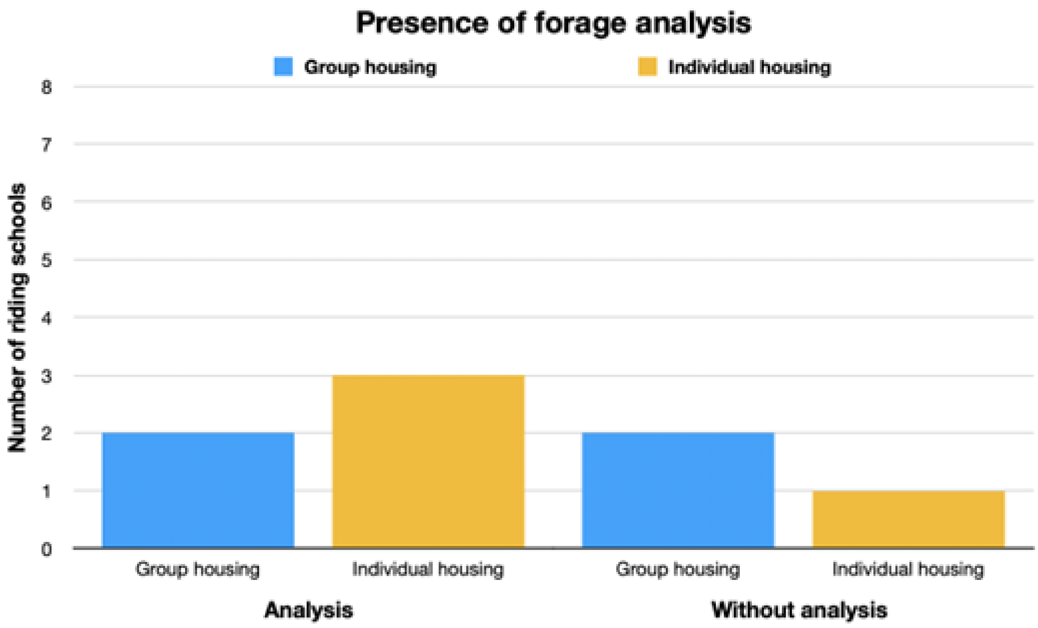

Figure 2. The presence of forage analysis in the two housing systems.

Three out of four group-housed riding schools provided their horses' with free access to forage (Fig. 2). Two of these had forage analysis and used these to calculate feed rations. Among the individually housed riding schools, conditions were different. Only one provided their horses' free access to forage, and three had a restricted ration. All three individually housed riding schools providing a limited amount of forage also had a forage analysis and were calculating feed rations. The one lacking forage analysis did consequently not calculate feed rations either.

Feeding of concentrates and minerals

In two of the eight riding schools (one from each housing system), horses were primarily fed with a roughage-only diet since it was considered more in line with their natural diet. The individually housed riding school provided only one horse with concentrates, and the group-housed riding school fed all horses minimal amounts (approximately 1 decilitre) to get them to eat minerals (algae and lime, explained further down). The remaining six riding schools fed their horses with concentrates.

Minerals were given either as an individual or a general ration, not differing between the housing systems. In riding schools having a forage analysis, three out of five fed the minerals individually, and two out of five provided all horses the same amount. All riding schools with a forage analysis used the analysis to calculate the feed ration.

Calculations of individual feed rations

In those cases where forage analysis was lacking, or horses were provided free access to forage (irrespective of having a forage analysis), calculating the actual energy and protein intake was impossible. As a result, feed rations would only be possible to calculate for three riding schools; hence, there is not enough data to conclude from, and therefore, it was excluded. What could be said, however, was that all riding schools primarily fed their horses a roughage-based diet.

Table 2. Hygienic quality of forage (hay or haylage)

Findings	Number of riding schools
Mould in forage[1]	0 riding schools
Mould on walls in hay barn	1 riding school, individual housing
Yeast in haylage bales	2 riding schools, group housing

Figure 3. Mould on the windowsill close to where straw bales were kept. Photo: Jasmine Lindholm

[1] Mould found on the windowsill in one group housed riding school located right next to where a straw bale was placed (Fig. 3).

Figure 4. Yeast found on haylage bales. Photo: Jasmine Lindholm

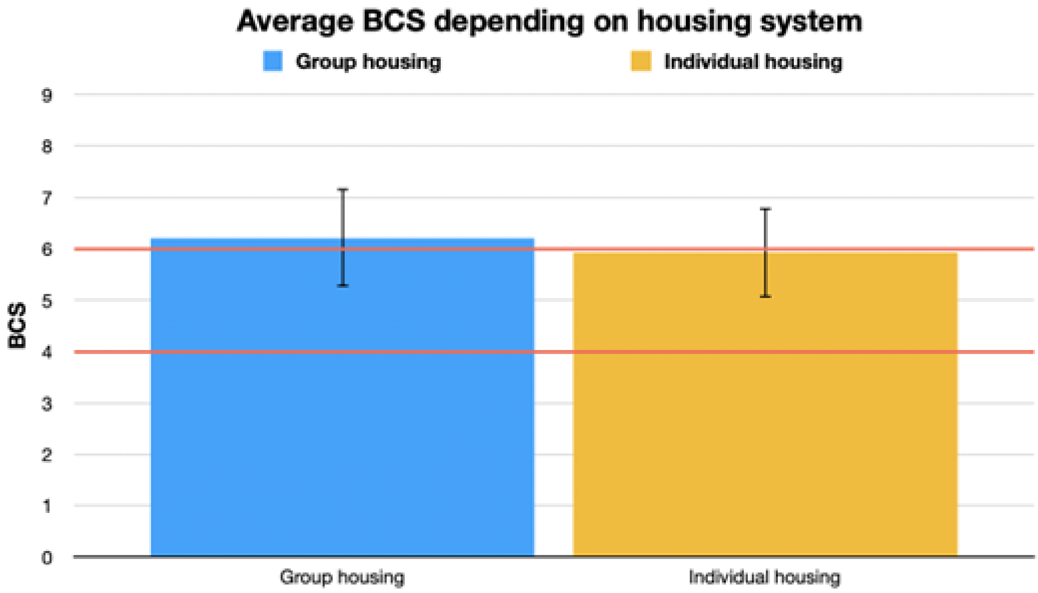

Figure 5. Comparison of the average body condition score (BCS) (mean ± STD) between group-housed and individually housed riding schools. The red lines mark the range of healthy BCSs.

The mean values of body condition scores (BCS) (Fig. 5) for each system were 6.2 versus 5.9. BCS≤4 was considered underweight, and BCS≥7 as overweight. None of the horses was underweight. Breed-specific adipose tissue accumulation in different body parts was noted, such as the characterising accumulation of adipose tissue in the neck of heavier breeds and Spanish PRE horses.

The number of overweight horses (BCS≥7), depending on the housing system

Six out of eight riding schools had overweight horses. The riding schools without overweight horses were one group housed and one individually housed. Out of 80 body-scored horses, 20 were considered overweight (BCS≥7), in other words, 25%. Eleven of these 20 horses were group-housed, and nine were individually kept.

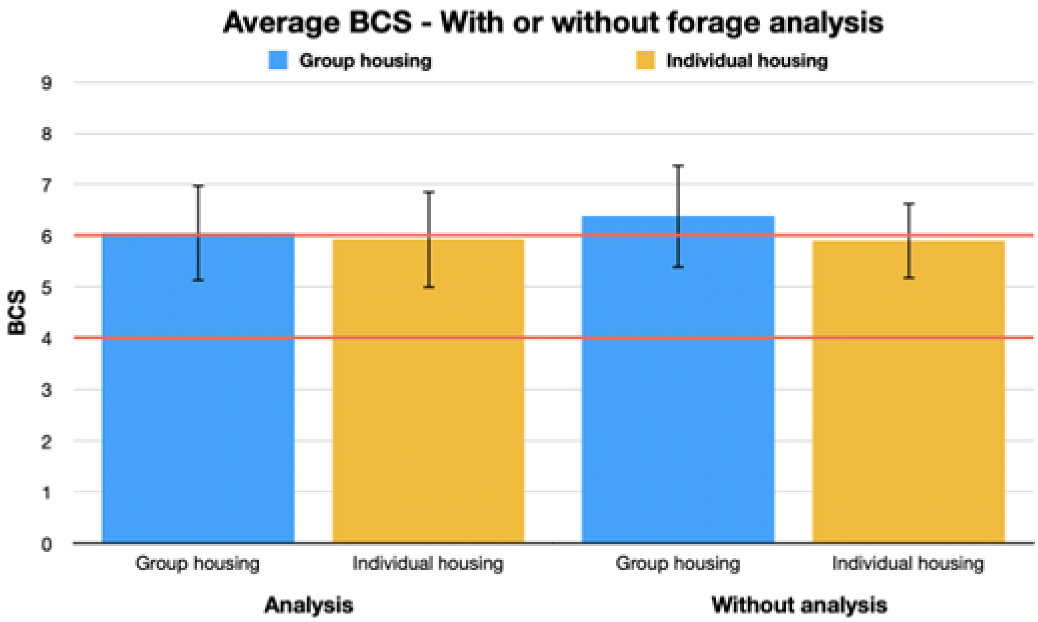

Figure 6. Comparison of the average BCS (mean ± STD) between group-housed and individually housed riding schools in relation to having or not having a forage analysis. The red lines mark the range of healthy BCSs.

In riding schools with forage analysis (Fig. 6), group-housed horses had an average BCS of 6.05 and individually-housed horses of 5.93. In riding schools without forage analysis, group-housed horses had an average BCS of 6.38 and individually-housed horses 5.90. No significant differences can be seen between the housing system and having a forage analysis. However, the largest numerical difference (although small) was between group-housed horses with and without forage analysis. While group-housed, those horses eating non-analysed forage had the highest body condition scores.

Riding schools' perception of having overweight horses or not

All riding schools stated that they performed body condition scoring. The scoring was, however, done continuously by looking at the horses rather than as a specific task performed regularly. In one riding school, this was a topic at staff meetings. Another riding school said they looked at the horses but lacked a systematic way of doing it. All four riding schools with individual stabling had the perception that some or all their horses were overweight. The average BCS of these riding schools were 5.3, 6.6, 5.9 and 6.0. The highest-scored horses in this group scored BCS 8. The average values for riding schools with group housing systems were 6.5, 6.6, 6.2 and 5.6. Two of these four riding schools did not perceive their horses as overweight, and their average BCS was 5.6 and 6.2, respectively. However, the highest score given to a horse in the latter was BCS 7.5.

Availability of water – water flow and the height of water cups

All group-housed riding schools provided their horses with water at all times (Table 3). All horses in individually housed riding schools lacked water at turnout, which lasted 5 to 7.5 hours, corresponding to 5.43 hours on average. In Region 1 (individual housing), it was stated that the water provision at turnout depended on the staff due to different staff members prioritising different chores during their work shifts. Due to the different priorities, these horses had irregular access to water at turnout.

Table 3. Number of hours without access to water at turnout

Region	Time without water Group housing	Time without water Individual housing
1	0 h	0 or 7 h
2	0 h	5 h
3	0 h	5–6.5 h
4	0 h	7.5 h

All riding schools except one had water cups positioned suitably to the size of the horses. One of the individually housed riding schools had water cups placed high on the walls. E.g., one water cup was set at 150 cm in height while the horse drinking from it had a withers height of around 155 cm (Fig. 7). One riding school solved the problem of ill-situated water cups by providing a water bucket.

Figure 7. Picture presenting the high-positioned water cup at one of the individually held riding schools. Photo: Jasmine Lindholm

Water flow was measured in five riding schools where horses were provided water through automatic water cups. The flow was not measured if water was provided in buckets or automatic dispensers with a constant water surface. In the remaining five riding schools (three individual housing and two group-housed riding schools), the measures varied between 4, 6, 10 and 20 litres/minute. In one individually housed riding school, one of the water cups showed a water flow of 4 litres/minute, resulting in a colic seizure for the horse kept in this box. This horse was also provided a water bucket to compensate for the low water flow.

Access to water at turnout, number of colic seizures and hours kept indoors

Access to water at turnout is given in Table 3. Individually housed riding schools were kept indoors at an average of 17.5 hours per day, compared to 4.5 hours for group-housed horses. The number of colic seizures in individually housed horses was twelve, corresponding to 13.33% of all individually kept horses. Two colic seizures were found, corresponding to 2.47% of the group housed horses, both from one riding school. This riding school stated that this most likely was caused by accidentally feeding straw of poor hygienic quality. Data from one group housed riding school is missing for hours kept indoors, but since the figures are mean values, they are comparable. In total, 14 out of 171 participating horses had had colic during the last six months, corresponding to 8.2 % of all horses independently of the housing system.

Laminitic horses in the two housing systems

Among the individually housed riding schools, two had two laminitic horses each. Therefore, these horses were kept on a stricter diet and partly not allowed on summer pasture. In group-housed riding schools, there were no laminitic horses. However, in one of the group-housed riding schools, there was a suspected case of laminitis. However, a veterinarian had not diagnosed the horse, and it was, therefore, not included in the data.

Equine metabolic syndrome and oesophageal impaction

Two riding schools (one from each housing system, and both riding schools lacking a forage analysis) had one respective two horses that were thought to be prone to (or have) equine metabolic syndrome (EMS). However, none of them had been diagnosed with the syndrome. Neither had oesophageal impaction occurred in any of the riding schools.

Performance of mucking out paddocks depending on the housing system

Due to the correlation between colic and intestinal parasites, this study was interested in investigating the riding schools' routines for mucking out paddocks. Results showed that if not considering the weather, all group-housed and two out of four individually housed riding schools mucked out their paddocks regularly. Considering the weather, however, two group-housed riding schools mucked out their paddocks daily, independently of the weather. The two other group-housed riding schools and two individually housed riding schools only mucked out the paddocks as long as the temperature was above zero. In comparison, it was only in individually housed riding schools (two) where mucking out the paddocks was not performed regularly. It was stated to be opted out solely due to lack of time.

Discussion

Are there differences in body condition scores in Swedish riding school horses kept in different housing systems?

Body Condition Scoring and Obesity

No difference in average BCS was found between the different housing systems. However, 25% of all scored horses had a BCS≥7, which might indicate how common overweight and obesity are among Swedish riding school horses. Using a six-graded body condition scale, Wyse *et al.* (2008) found that 45% of the UK horse population was fat or very fat. The study was conducted during summer when horses naturally have a higher BCS (Wyse *et al.*, 2008), whereas my observations occurred during winter, potentially explaining this difference.

Thatcher *et al.* (2012) conducted a study in Virginia, USA, using a nine-graded scale where 51% of the horses were over-conditioned or obese. The terminology was slightly different, where BCS 7 was defined as over-conditioned (32.3%), and BCS 8-9 (18.7%) was defined as obese. The study by Thatcher *et al.* (2012) was also performed during the summer months, similar to the study by Wyse *et al.* (2008). Thatcher *et al.* (2012) state that the study was conducted after many of the horses had access to spring pasture. It was, therefore, likely that the occurrence of overweight and obesity was maximally represented. The results between these studies could have been more similar if Thatcher *et al.* (2012) had used the same terminology as in this study and Martinson *et al.* (2014) and if the studies had been performed during the same season of the year. Thatcher *et al.* (2012) also used a random sample of light-bred horses, whereas this study represents scores from both light and heavy breeds, making it difficult to interpret how similar the results are. Obesity should, on the other hand, be scored similarly regardless of breed, even though breed differences can make the scoring difficult (Henneke *et al.*, 1983).

When looking at average BCSs in riding school horses, fed forage with or without a forage analysis, it showed a similar result as the average BCSs between the housing systems. A numerical difference could, however, be seen in group-housed riding school horses fed non-analysed forage (two riding schools), where 7/20 (35%) of the horses had a BCS≥7. Compared to the only individually housed riding school lacking forage analysis, 1/10 (10%) were considered overweight. The reason might be that the group-housed riding schools more or less had free access to roughage (forage and straw), making it impossible to control how much energy the horses consumed. Also, it might be an indication of the importance of having a forage analysis. Looking at the horses' body condition scores, one can conclude that they consumed more energy than needed for maintenance and work. However, individually housed riding school horses who ate analysed forage also had 8/30 horses (26.67%) with a BCS≥7 , indicating an unbalanced feed ration in terms of energy expenditure for these horses. The reason for this might be several. When asked about the horses' body condition score, some riding schools stated that they preferred horses with a higher BCS over a lower one, partly because of earlier experiences of complaints from unskilled visitors and beginner pupils while having leaner horses. It might indicate a social and economic pressure that continues to be maintained, regardless of whether it negatively impacts the horses' health. It might also indicate an acceptance and ignorance towards the risks correlated with a higher BCS, but also that one gets blind to flaws at home. One example of this could be laminitis. Two of the individually housed riding schools had two cases of laminitis each. In the group-housed riding schools, only one undiagnosed horse was suspected of being prone to laminitis; hence, it was not included in the data. One question is why there were horses with laminitis in the individually housed riding schools but not in the group-housed ones. Horses with laminitis should be kept lean (non-obese) and avoid dietary carbohydrates such as starch (Trieber *et al.*, 2006). Perhaps these horses can function in the business of individually held riding schools just because the housing system enables individually adapted feeding according to their specific needs. Maybe group-housed riding schools need to replace a horse with a tendency for laminitis since it was more common to have free access to roughage, and limiting these horses' intake can become more complex.

Moreover, the amount of data between riding schools in this study is relatively small, and statistically, there were no differences between having a forage analysis and not when comparing BCSs. In those riding schools where forage analyses were lacking, or forage was fed *ad libitum* (irrespective of a present forage analysis), the energy and protein intake could not be calculated. However, with some horses being overweight according to Henneke's body condition scoring system (Henneke *et al.*, 1983) and the standardised terminology according to Martinson *et al.* (2014), the result of the body condition scoring reveals that the feed rations were not optimally adapted for many horses, in terms of energy need and energy expenditure. Also, three horses (two in group housing and one in individual housing) were suspected of having equine metabolic syndrome. They were not diagnosed with the syndrome.

However, interestingly enough, they all came from riding schools where forage analysis was not used. This study's findings and data need to be more extensive. However, it would be interesting to examine if these horses' health would be different if they had been provided with a forage where the nutritional content was known to be suitable.

Hitchens *et al.* (2016) found that obesity was less common in professional equine keepers such as riding schools and studs, probably because these are more likely to employ staff with significant horse experience and their needs. Compared to private horse owners, Wyse *et al.* (2008) showed that they generally are bad at estimating and perceiving their horses as fat. In line with this, the present study showed that six out of eight riding schools had one or more horses defined as overweight (BCS≥7) according to the standardised BCS limits by Martinson *et al.* (2014). Six out of eight riding school managers (all individually housed and two group-housed riding schools) also had the perception of having overweight horses. Surprisingly, one had no overweight horses according to the body condition scoring, which might indicate that this specific riding school had previously paid extra attention to body condition scoring. Bearing in mind that every fourth horse was considered overweight and although the perception of having overweight horses was common, this could indicate a need for objective assessment of body condition scoring as a service, preferably in connection with feed advising. In addition to increasing the horses' welfare, objective and accurate body condition scoring could decrease the riding schools' costs. For example, a well-adapted and efficient feed ration could lead to reduced feed costs, healthier BCSs and more sustainable horses due to decreased risk for metabolic diseases.

Current systems for body condition scoring might be less suitable for some breeds since different breeds vary in conformation (Henneke *et al.*, 1983) or accumulate fat differently from one another (Geor & Harris, 2009). Due to the difficulties (see chapter Obesity/Overweight and How to assess it) with Henneke *et al.* (1983) BCS system (although very applicable in most cases) and the diseases correlated to the accumulation of adipose tissues in the body, continued development of how to body condition score horses in a more breed specific way are probably needed. Moreover, body condition scoring needs to be user-friendly and applicable for horse owners to do themselves, in addition to objective assessment by professionals. For example, developing and improving applications and similar future solutions could be a required tool to help horse owners determine their horses’ body condition scores, making it easier to keep their horses in shape.

Are there differences in feeding strategies between housing systems regarding the quota roughage versus concentrates and concerning energy and digestible crude protein?

Management differences and choices concerning feeding in relation to the housing system

Feeding large groups of horses, such as at a riding school, often comes with difficulties. Different horses have different needs for healthily assimilating the feed. The conditions for how the horses are fed can vary depending on whether the horses are stabled individually or kept in groups. Primarily, the question is to what extent the horses are fed an individually fitted and limited feed ration, free access (*ad libitum*) feed ration, or variations in between. There are different strategies and ways to approach the same problem. The advantage of feeding *ad libitum* roughage among group-kept horses is that it is time-efficient for the stable owner since all horses are fed the same roughage. Moreover, free access to forage automatically provides a long eating time and a higher fibre intake since the horses choose when and how much they want to eat. A challenge with providing horses free access to forage is that a group of horses often have different conditions and needs as well as levels of exercise. A consequence might be that so-called "easy keepers" become overweight and increase the risk for feed-related diseases, while it might suit a harder-fed horse all the better.

To make this work and provide the conditions to keep all horses in the group healthy, it is essential to group horses with similar conditions and needs as possible in a group together. If this cannot be done, it is better to have a forage that suits the most easy-kept horse and then supplement feed the horses whose needs require it. Another critical factor for keeping horses in group housing with free access to forage is to evaluate the feeding through frequent body condition scoring. Recurring body condition scoring must be done even in individual stabling with limited forage. Still, it gets even more critical if horses are fed *ad libitum* in groups since they can eat how much they want. Free access to forage in group housing makes it more difficult to check that the horse has eaten and detect a horse that is about to get sick. Therefore, a good eye for animals and being attentive as an owner or staff are of the utmost importance.

Compared to group-housed horses and a more free access-based feeding strategy, individually adapted feed rations can be more time-consuming for the owner/staff since each horse has its mixed feed ration. However, individual feeding allows the owner to control what and how much the horse eats. It also enables the owner to quickly discover if the horse has not eaten its last meal (because the feed will remain in the box), indicating whether something is wrong with a horse at an earlier stage. An individually customised feed ration in individual stabling also enables easy regulation of a horse's feed ration in the event of changes such as degree of exercise, age, pregnancy, convalescence, *et cetera*. A heavily trained horse can be provided with supplemental feed if needed, and an old horse with worse teeth can eat in peace without having other horses competing for the same feed.

Depending on the forage's nutritional content, a difficulty with a limited feed ration may be that an easy-bred horse receives too short eating times, increasing the risk of behavioural disorders (Sarrafchi & Blokhuis, 2013). In those cases, solving how to provide these horses with less nutritious feed while giving them long eating times is crucial. An example of this is mixing forage with straw. However, straw also contains a relatively high amount of energy. Hence, it is essential to analyse the nutritional content even here.

Forage analysis in relation to the feed ration

As stated above, there are different strategic ways to feed horses, and each system has advantages and disadvantages. Analysing the feed regarding energy, protein, and minerals is advantageous to ensure the chosen feed is suitable for the horse(s). Knowing how to construe the analysis is also essential to use it correctly. In addition to just calculating an appropriate feed ration, the result of a forage analysis is the basis for knowing beforehand that a specific harvest is ideal for the group of horses to be fed. The consequence of whether the roughage is balanced regarding energy- and protein content may be that the horse owner/staff can choose to buy forage from another harvest instead. Alternatively, there is an opportunity to modify the feed ration in advance to avoid a horse becoming over- or underweight, for example, by adding a concentrate or a protein feed. A possible disadvantage of a roughage analysis is that no result of a forage analysis is better than the feed sample on which the forage analysis is based. That said, the forage sample from each harvest must be carried out thoughtfully and correctly. The feed ration calculations will only give the desired outcome if this is addressed.

In this study, 3 out of 8 riding schools had analysed their forage and provided individual feed rations. Using a forage analysis to calculate feed rations ensures a complete feed ration regarding nutritional content and prevents the overfeeding of concentrates. Forage analysis can also provide a sufficient mineral content in the feed ration since the mineral content of the forage varies depending on where and under what conditions the feed has been produced. The riding schools in this study, providing individual feed rations, also gave individual amounts of minerals to their horses, concluding that these three riding schools used the analysis reports to constitute feed rations.

An advantage of calculating feed rations based on a forage analysis is also that it enables estimations of how much the horses will eat and, thus, how long the feed will last during the year. Forage analysis could be of economic importance for riding schools since fodder can be used more wisely, horses are not fed more than necessary, and riding schools can control their costs better. Hence, an analysis of the forage can have an economic value despite the initial cost to carry out the analysis. To sum up, forage analysis provides the conditions for choosing a suitable forage for a specific group of horses. A prerequisite for riding schools' economy is that the horses feel good, are healthy, and can be used in the business, making the riding school financially sustainable. Therefore, a well-adapted feed ration should be of the utmost importance to prevent horses from becoming overweight or underweight and ensure they are given the right conditions to keep healthy.

Group housing vs individual housing in relation to having a forage analysis or not

As one of the aims, this project wanted to investigate any differences in feed ration composition. As mentioned above, five of eight riding schools had a forage analysis, and seven of eight riding schools fed their horses with individual feed rations. However, some had free access to forage with limited amounts of concentrate, and others had limited quantities of both feed. The only riding school that could be classified as not feeding individual feed rations was providing their horses with only minimal amounts of concentrates to cover the taste of algae since these small amounts of concentrates were insignificant. From the three riding schools lacking a forage analysis, only one of them fed concentrates as a considerable part of the feed ration.

The results did not show a significant difference in body condition scores compared to either the housing system or having a forage analysis. However, the largest numerical difference for BCSs (although small) was between group-housed horses fed forage with and without forage analysis. Those horses eating a non-analysed forage while being group-housed had the highest BCSs. The result might indicate that free access to non-analysed forage results in horses with a higher BCS. The numerical difference also strengthens the argument that having an analysed forage gives the staff/owner more control over the feeding. In individual housing, this is simplified since the staff decides when and how much the horses eat. In contrast, group-housed horses with free access to forage autonomously choose this, thus making it harder to control. The possibly higher body condition scores seen in the results might, therefore, show a tendency when horses ingest too large amounts of a non-analysed forage that probably is not entirely adapted to their needs. Consequently, an analysed forage regarding the energy- and protein content, chosen with the specific group of horses in mind, can at least function as a threshold against getting overweight horses.

Similar to the choice of not having a forage analysis, the strategy of how minerals were fed differed between riding schools. The most common approach was to provide minerals individually while having a forage analysis. However, one riding school where minerals were fed individually had a forage analysis that excluded mineral content, which seems contradictory. Durable horses are a cornerstone to keeping a riding school business ongoing. Having this in mind while considering minerals' role in the body's functions (NRC, 2007) and the fact that mineral deficiencies for more extended periods will have adverse effects (Jansson, 2013), opting out of forage analysis seems like an unnecessary risk.

Are there differences in feeding management which might affect the horses' health status?

Colic

Factors such as many stable hours, less time at pasture and absence of water have been associated with increasing the risk for colic in studies made by Reeves *et al.*, 1996; Hudson *et al.*, 2001; Hillyer *et al.*, 2002; Kaya *et al.*, 2009; Scantlebury *et al.*, 2014. In the present study, these parameters were linked to individual-housed riding schools. The results showed a significant difference in colic seizures between the two housing systems. Individually housed riding schools had six times more colic seizures than group-housed riding schools, corresponding to 13.33% versus 2.47% of all horses, respectively. Only two colic seizures originating from the same riding school were found among the group-housed horses. This riding school had bought new straw only two weeks before our visit. The batch of straw proved to be of poor hygienic quality and was thought to cause the colic seizures. Prior to these seizures, not a single horse had suffered from colic since 2011. However, this was also the riding school where small amounts of yeast could be seen in some haylage bales. Even though not considered dangerous, yeast has been linked to increasing the risk of colic (Kaya *et al.*, 2009). Due to the tiny amounts of yeast, it may be assumed negligible. However, suppose the straw of poor hygienic quality or yeasty haylage (or both) caused the colic seizures. In that case, the correlation between how the individually housed horses were kept and the occurrence of colic could be even stronger than shown in this study.

Another major difference between the housing systems and how they were managed was the possibility of free movement, hours spent at turnout versus indoors, and water access. Group-housed horses had water at all times, and except for the above, they had no colic seizures. They also had an average of 4.5 hours indoors. Compared to the individually housed riding schools, these had considerably more hours indoors (an average of 17.5 hours) and lacked water for an average of 5.43 hours when kept outside. One of the individually housed riding schools where low water flow was found in a box also had a confirmed case of colic for the horse kept in the same box. Although this only concerned one horse, it was exciting that there was a case of colic where the background to the onset of the colic was shown so clearly.

Colic has also been shown to be associated with intestinal parasites (Proudman *et al.*, 1998), where parasitic pressure can be controlled by mucking out pastures or paddocks at least twice weekly (Lindqvist *et al.*, 2007; Corbett *et al.*, 2014). Mucking out pastures will not eliminate parasites but aims to interrupt parasites' possibility of completing a full-time lifecycle and reproducing, hence avoiding the reinfection of horses (Corbett *et al.*, 2014). In other words, deworming horses is probably little to no point if mucking is not performed. Manure removal can be seen as daily maintenance to increase the effectiveness of deworming. Increasing the grazing area can also be a good idea since horses often reject tufts of grass near manure (Herd, 1993; Lindqvist *et al.*, 2007). Despite this, half of the individually housed riding schools did not muck out their paddocks due to lack of time. Beyond this, these riding schools did not provide their horses with water at turnout, mainly because of the same reason. Since intestinal parasites and water access are linked to colic (Reeves *et al.*, 1996; Proudman *et al.*, 1998), it could be argued to reconsider daily priorities. A suggestion would be to start providing water for the horses and, while waiting for the water to fill up, the staff performing this could take the opportunity to muck out the paddocks. Of course, there is a risk for the paddock or pasture to be too big to finish. However, since the importance of water intake has been proved (Reeves *et al.*, 1996; Kaya *et al.*, 2009) and some mucking out probably is better than none, it can still be argued for a re-prioritisation of everyday tasks.

The present study showed management differences between the two housing systems. The results probably reveal quite a clear correlation to why there were so many more horses with colic in the individually housed riding schools compared to the group housing ones. However, it might be rash to say that individual housing is always associated with colic since individually housed horses can be kept outdoors for many more hours than in these riding schools and have full-time access to water. In other words, the higher frequency of colic is probably associated with management routines provided at the individually housed riding schools rather than the housing system itself. Anyhow, the need for long-time turnout and free access to water is still as important to emphasise, confirmed by the results of this study and was more common in group-housed riding schools. Because of this, the author looks forward to seeing more studies examining management differences, how horses are kept in different housing systems, and their relation to common horse diseases. These results suggest more studies in the area and its relation to common horse diseases.

Conclusions

This thesis did not find differences in the BCS of Swedish riding school horses in different housing systems. However, with 25% of all participating horses being overweight, it seems as if more education on the negative impact on horse health and welfare is needed. Educating riding school staff on the importance of regularly practising body condition scoring would potentially be a preventative measure against obesity in riding school horses and, hence, be positive for the horses' health and welfare in the long run. The result may also indicate a need for a service offered for riding schools and other equestrians, similar to consulting the farrier or the veterinarian.

In this small study, colic occurred significantly more frequently in individually housed riding schools. Horses suffer from colic for several reasons, but these results, combined with earlier research, highlight the importance of free movement and access to water.

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Appendix 1

1.1 Obesity/Overweight and How to assess it

Body condition scoring is a way to assess stored fat in horses. Performing this is important since obesity is correlated with several diseases (Henneke *et al.*, 1983; Johnson, 2002; Treiber *et al.*, 2006; Carter *et al.*, 2009; Frank *et al.*, 2010), which are common findings in horses in today's modern management systems (Johnson, 2002). According to Geor (2008) and Geor & Harris (2009), a universally accepted definition of obesity in horses does not exist, but "an excessive accumulation of adipose tissue in the body" is one (Geor, 2008).

Henneke *et al.* (1983) constructed a system that made it possible to assess the amount of stored body fat in horses (i.e. body condition). The system was first developed to score broodmares before covering, but the procedure can also be applied to other horses. The system is divided into a nine-point scale: one is extremely emaciated, and nine is extremely fat. The assessment is done through palpation in six different areas (Fig. 1) of the horse's body: neck, withers, behind the shoulder, ribs, back and tail head. A total body score then follows this. Some horses' conformation makes them harder to judge fairly, such as having very prominent withers or flat backs. In these cases, more focus can be put on the remaining areas (Henneke *et al.*, 1983). Different breeds might also store fat differently in different parts of the body, which need to be considered (Geor & Harris, 2009).

Wyse *et al.* (2008) report that horse owners and responsible managers need to gain knowledge on how to assess body conditions. It seems common to underestimate horses' actual body condition, especially if having an obese horse (Wyse *et al.*, 2008). These results point to the importance of regularly evaluating the horses' body condition in connection to their feed ration, advantageously by minimising the intake of concentrates (Garner *et al.*, 1977; Hudson *et al.*, 2001; Hoffman *et al.*, 2003; Longland & Byrd, 2006; Treiber *et al.*, 2006) or else increasing the amount of exercise and workload. Even though Wyse *et al.* (2008) looked at privately owned horses and the owners' perception of body condition scoring, this is also relevant for riding school managers since riding school pupils one day might be horse owners. Moreover, several researchers call on the need for more education and training of horse owners in this area (Pratt-Phillips *et al.*, 2010; Harker *et al.*, 2011; Martinson *et al.*, 2014; Hitchens *et al.*, 2016).

Moreover, Martinson *et al.* (2014) state that the terminology for BCS is used differently amongst researchers, causing confusion about which BCS is to be interpreted as under and overweight. Henneke *et al.* body condition scoring was developed in 1983, and since then, several researchers have modified or interpreted the system (Pratt-Phillips *et al.*, 2010; Harker *et al.*, 2011; Thatcher *et al.*, 2012; Martinson *et al.*, 2014). Henneke *et al.* (1983) defined horses with a BCS≤3 as thin, 5 as moderate, 7 as fleshy and BCS≥8 as obese. In comparison, Pratt-Phillips *et al.* (2010) also defined horses as underweight at BCS≤3 but as overweight already at a BCS≥6 and >7 as obese. Harker *et al.* (2011) considered horses to be underweight at BCS≤4, BCS≥6 as overweight, but obese first at BCS≥8. To standardise the interpretations of BCSs, Martinson *et al.* (2014) concluded BCS≤4 as underweight and BCS≥7 as overweight, which has been used as standards in this thesis.

1.2 Feeding-related diseases

Colic

Colic is a generic term used to describe abdominal pain in horses (Tinker, 1995; Archer & Proudman, 2006; Egenvall *et al.*, 2008), associated with various dietary and management-related aspects described below.

Change in diet and type of hay (Cohen *et al.*, 1999) or hay batch (Hudson *et al.*, 2001) is significantly associated with colic. Sudden changes in the amount of forage or feeding of hay of poor hygienic quality have also been shown to have an impact and should, therefore, be avoided (Cohen *et al.*, 1999; Hudson *et al.*, 2001; Kaya *et al.*, 2009). For example, hay contaminated with bacteria or yeast growth increases the risk of colic (Kaya *et al.*, 2009). Hudson *et al.* (2001) state that feeding hay from round bales also has a connection with colic because of the difficulty in controlling the amount the horse eats and the hygienic quality of the hay, which might have been exposed to moisture and caused mould growth (Hudson *et al.*, 2001). Colic is also associated with feeding grains and/or concentrate, changing the type of grains and/or concentrate, as well as increasing the total concentrate intake (Tinker *et al.*, 1997; Hudson *et al.*, 2001; Hillyer *et al.*, 2002; Kaya *et al.*, 2009). Horses fed more than 2.7 kilos of oats per day were at major risk compared to those fed less than 2.7 kg per day. Introducing grains into the diet was associated with colic, unlike horses that were not fed grains and seemed protected from colic (Hudson *et al.*, 2001).

Colic has also been shown to occur more frequently in crib-biting, wind-sucking or weaving horses (Hillyer *et al.*, 2002; Scantlebury *et al.*, 2014). These abnormal behaviours are associated with low-fibre diets and high concentrate intake (Redbo *et al.*, 1998; Hockenhull & Creighton, 2014).

Longer time at pasture per day lowers the risk for colic, and a decreased acreage or less time on pasture is associated with a significantly greater risk for colic (Hudson *et al.*, 2001; Hillyer *et al.*, 2002; Scantlebury *et al.*, 2014). However, horses kept in pastures with loose sandy soils or sand paddocks while feeding from the ground are at higher risk for sand colic since ingested sand then gets caught and accumulates in the colon (Udenborg, 1979; Ragle *et al.*, 1989). Furthermore, exercise only once per week has also been associated with an increased risk of colic compared to horses on full-time pastures (Hudson *et al.*, 2001). Horses with a previous history of lameness or orthopaedic-related problems were also at higher risk of colic (Hillyer *et al.*, 2002), probably due to changes in management such as increased time spent indoors, reduced level of exercise and changes in feeding. Moreover, decreased water intake (Kaya *et al.*, 2009) or absence of water at turnout were shown to more than double the risk for colic (Reeves *et al.*, 1996) as well as decreased amount of water intake in total (Kaya *et al.*, 2009).

Colic is also associated with intestinal parasites. Proudman *et al.* (1998) showed a strong connection between intestinal tapeworms (*Anoplocephala perfoliata*) and colic in horses. The study also showed that the colic risk increases with the tapeworm infection's intensity. This result agrees with the findings of Back *et al.* (2013), who found that the risk for colic was 16 times higher when eggs from *A. Perfoliata* were present in faeces. In line with this, Cohen *et al.* (1999) showed a decreased risk for colic when horses were dewormed regularly. However, recent deworming and the number of dewormings also increase the risk for colic (Kanaane *et al.*, 1996; Cohen *et al.*, 1999; Hillyer *et al.*, 2002; Kaya *et al.*, 2009). To control the parasitic pressure and reduce the risk of colic, mucking out pastures is recommended twice weekly as a preventative measure as it significantly reduces the number of parasite eggs in faeces (Corbett *et al.*, 2014).

Other associated risk factors related to colic are changes in stabling or weather and previous colic seizures or abdominal surgery due to colic (Cohen *et al.*, 1999). However, Cohen *et al.* (1999) commented that weather changes were to be cautiously taken since the interpretation of weather conditions might be biased. Increased age and horses of the Arabian breed were also associated with colic, according to Cohen *et al.* (1999). However, Hudson *et al.* (2001) and Kaya *et al.* (2009) did not confirm this.

Insulin Resistance

Insulin resistance (IR) was defined by Kahn (1978) as a state said to exist "whenever normal concentrations of hormone produce a less than normal biological response" and "should be regarded as a "generic" term" (Kahn, 1978). IR is more common in obese horses than non-obese ones, and the sensitivity towards insulin (as a biological response) decreases when horses are fed a sugar- and starch-rich diet compared to a diet richer in fibre and fat (Hoffman *et al.*, 2003). Consequently, providing horses with grains or other starch-rich feeds increases the risk of developing insulin resistance (Hoffman *et al.*, 2003). Moreover, these feeds are also associated with an increased risk for laminitis (Garner *et al.*, 1977; Treiber *et al.*, 2006). Because of this, horses prone to obesity, insulin resistance, and metabolic syndromes linked to this should all be kept in optimal body condition according to the body condition scale (Henneke *et al.*, 1983) and hence not be fed sugar or starch-rich feeds (Hoffman *et al.*, 2003).

Laminitis

Laminitis is the most severe disease in the horse hoof and causes severe pain and devastating loss of function due to pathological changes in the hoof. Laminitis causes the attachment between the distal phalanx and the inner hoof wall to fail. This, in turn, causes the bone to be forced, or rotated, down into the hoof capsule, damaging arteries and veins and crushing the corium of the sole and coronet (Pollitt 1999, 2004). Since laminitis is one of the most common causes of death from orthopaedic damage, it clearly impacts horse welfare (Harrison & Murray, 2016).

The cause of laminitis is not yet fully understood. Still, it has been linked to equine nutrition for many years, such as lactic acidosis due to carbohydrate overload (Garner *et al.*, 1977) and pasture starch content (Treiber *et al.*, 2006). Other highly associated factors are the presence of obesity and obesity-correlated factors such as high body condition score (BCS), high-fat accumulation along the neck and elevated insulin and leptin concentrations (Treiber *et al.*, 2006; Carter *et al.*, 2009). The results from Treiber *et al.* (2006) showed that insulin resistance is a clear risk factor for laminitis, and it seems as if it could be linked to gender since mares were at greater risk than stallions. To reduce the risk of laminitis, horses should be kept in slimmer (non-obese) body condition and fed dietary carbohydrates with caution, particularly starch. Because of this, an accurate forage analysis is of great importance when constituting feed rations for horses prone to laminitis (Longland & Byrd, 2006).

Equine Metabolic Syndrome

Equine Metabolic Syndrome (EMS) was first defined by Johnson (2002) after wanting to examine the connection between mature obese horses that suffer from laminitis since this combination seems to have another explanation than a result of a digestive disturbance, such as starch overload. Horses with EMS are commonly between 8 and 18 years old and described as being distinctly overweight, having a cresty neck and fat deposits in the rump, and accumulating adipose tissue in the abdomen. They are also insulin-resistant and suffer from laminitis (Johnson, 2002; Frank *et al.*, 2010). Johnson (2002) states that getting these horses to lose weight is typically very hard, hence called "easy-keepers". There are exceptions where affected horses are thin, which often occurs if the horse has suffered from laminitis for a long time. However, horses suffering from EMS must generally lose weight and be on a strict diet, without starch- or sugar-rich feeds, avoiding pastures and exercising regularly (Frank, 2009; Johnson *et al.*, 2010). Besides the fact that the disease affects the well-being and ability of the horse to perform, it can also affect the fertility of broodmares (Johnson, 2002).

Oesophageal Impaction

Oesophageal impaction, or "choke", occurs when horses ingest inappropriate materials, such as insufficiently soaked sugar beet pulp, too fast ingestion of dry hay, or insufficiently chewed feed due to bad teeth health. The most common sign of oesophageal impaction is difficulties for the horse to swallow feed (Hillyer, 1995), with a nasal discharge of feed and saliva as a result (Hillyer, 1995; Feige *et al.*, 2000). The horse may also show signs of coughing, excessive salivation, distress and anxiety, an extension of its head and neck or repeated arching of the neck muscles, fever and bad breath (Hillyer, 1995; Feige *et al.*, 2000). The impaction can occur shortly after feeding or several hours later and is also associated with insufficient water intake. The inability to swallow will also contribute to an even bigger water and electrolyte loss for the horse since the ability to swallow saliva will be hindered (Hillyer, 1995). Due to this, access to water and water flow in automatic water cups should be of interest and a priority, provided that one's horses are not supplied with water from water buckets and have free access.

Appendix 2

2.1 Interview questions

Area of concern	Question	Answer	Supplementing question	Example
Feed ration	Type of forage?		Why this type?	
Feed ration	Is there a forage analysis?		If No, why not?	
Feed ration	Feeding of cereals or concentrates, or minerals only?		Why was the chosen type chosen?	
Feed ration	Does each horse have an individual feed ration?			
Feed ration	Feeding straw? Free access?			
Feed ration	How are feed rations calculated? On a dry matter basis? Per kilo feed?		Describe the method	
Feed ration	How does the feed ration change to cover potential energy deficiencies? (With forage, concentrates/cereals, a combination of these two, other?)			

Feed ration	Where/or by whom is the forage bought?			
Feed ration	Where or from whom is the forage supplied? Self-produced?			
Feed ration	Is forage fed from the ground indoors, from a hay rack, hay net, or other?			
Feed ration	Feeding interval: Number of times a day? Hours in between meals? During how many hours do the horses have fodder to eat?			
Feed ration, other	What kind of bedding is used, straw, wood shavings, peat, peat mixes, other?			
Feed ration	Do horses have access to forage at turnout?			
Feed ration	If forage is provided at turnout, is it fed from the ground, hay rack, hay net, or other?			
Other	Are paddocks mucked out regularly?		How often?	
Other	What deworming routines are performed? Faecal samples?			

Access to water	Are the horses provided water from an automatic water cup or by a water mirror (such as a bucket etc.)?			
Access to water	Do horses have access to water at turnout?			
Feed ration	Access to a salt lick?			
Feed ration	Are minerals added to the feed ration?			
Hygienic quality of feed	If feeding haylage bales, for how many days is a bale open until a new one is needed?			
Hygienic quality of feed	At what time is the feed prepared, and how many hours are there before feeding?			
Hygienic quality of feed	Does the staff register if a horse does not eat all their feed?			
Hygienic quality of feed	Group housing: Is there any registration system to check that all horses eat?			
Hygienic quality of feed	Who controls the quality of the feed?			
Hygienic quality of feed	Does the staff have sufficient knowledge of how bad cereals/concentrates and forage look and smell?		How is this ensured?	

Diseases/ veterinary records	Do you keep records of health status about health conditions that do not require a veterinarian to be called? May we look at them?		Fever, suppressed appetite, colic warnings, slack/apathetic etc.	
Diseases/ veterinary records	Have there been any cases of colic?			
Diseases/ veterinary records	Have there been any cases of laminitis?			
Diseases/ veterinary records	Have there been any cases with EMS?			
Diseases/ veterinary records	Have there been any cases with esophageal impaction?			
Diseases/ veterinary records	Any other feed-related events/sicknesses?			
Body condition scoring	Is body condition scoring performed regularly? (Notices about changes in appearance?)			
Body condition scoring	Do you consider one or more horses to be under or overweight?		What strategy is used to get horses to lose or gain weight?	
Additional information:				

2.2 Questions controlled by the author

Area of concern	Question	Answer	Supplementing answer	E.g
Storage	How/where is the roughage stored?			
Storage	How/where are cereals/concentrates stored?			
Roughage, Hygienic quality	Any visible mould in hay or on haylage bales? If yes, the number of A4 papers (in size) and the number of visible spots:			
Roughage, Hygienic quality	Is there any visible yeast (white spots) in hay or haylage bales? If yes, estimate the number of A4 papers (in size) and the number of visible spots:			
Roughage, Hygienic quality	Smell of forage?			
Roughage, Hygienic quality	Colour of forage?			
Roughage, Hygienic quality	Structure of forage?			
Roughage, Hygienic quality	Any findings of spontaneous warming? (Yes/no)		Temperature:	

Access to water	Automatic water cup or water mirror?			
Access to water	Water flow in water cups (L/min)			
Access to water	Height of water cups compared to the withers height of the horses (Normal/problematic)			
Access to water	Any horses with water buckets? If yes, what is the number:			
Feed ration	Salt lick? If not, how many horses lack salt lick?			
Other	Foundation in the paddocks?			
Other	Are there any signs of horses eating/gnawing on trees, fence posts or interiors?			
Other	Competition for feed between horses at turnout (individual/group housing) (Yes/no)			
Weather condition:				

2.3 Body condition scoring

Riding school number:	
Housing system:	
Horse number/Name:	
Withers height & weight according to weight band:	
Neck score:	
Withers score:	
Shoulder score:	
Ribs score:	
Back score:	
Tail head area score:	
Full body BCS:	

Appendix 3

Description of Henneke *et al.* (1983) Body condition scoring system

Poor	Animal extremely emaciated. Spinous processes, ribs, tail head, tuber coxae and ischii projecting prominently. The bone structure of withers, shoulders and neck is easily noticeable. No fatty tissue can be felt.
Very thin	Animal emaciated. Slight fat covering the base of spinous processes, transverse processes of lumbar vertebrae feel rounded. Spinous processes, ribs, tail head, tuber coxae, and ischii are prominent. Withers, shoulders and neck structures are faintly discernible.
Thin	Fat builds up about halfway on spinous processes; transverse processes cannot be felt. A slight fat cover over the ribs is easily discernible. The tail head is prominent, but individual vertebrae cannot be visually identified. Tuber coxae appear rounded but easily discernible. Tuber ischii is not distinguishable. Withers, shoulders and neck accentuated.
Moderately thin	Negative crease along the back. A faint outline of ribs is discernible. Tail head prominence depends on conformation; fat can be felt around it. Tuber coxae not discernable. Withers, shoulders and neck are not obviously thin.
Moderate	Back level. Ribs cannot be visually distinguished but can be easily felt. Fat around the tail head begins to feel spongy. Withers appear rounded over spinous processes. Shoulders and neck blend smoothly into the body.

Moderately fleshy	May have a slight crease down the back. Fat over the ribs feels spongy. Fat around the tail head feels soft. Fat begins to be deposited along the side of the withers, behind the shoulders and along the sides of the neck.
Fleshy	May have a crease along the back. Individual ribs can be felt, but noticeable filling between ribs with fat. Fat around the tail head is soft. Fat is deposited along withers, behind shoulders and along the neck.
Fat	Crease down back. Difficult to feel the ribs. Fat around the tail head is very soft. The area, along with withers, is filled with fat. The area behind the shoulder is filled with fat. Noticeable thickening of the neck. Fat is deposited along the inner thighs.
Extremely fat	Obvious crease down back. Patchy fat appearing over ribs. Bulging fat around the tail head, along withers, behind shoulders and along the neck. Fat along the inner thighs may rub together. Flank filled with fat.