Fibre content in moose (*Alces alces*) faeces

A comparison between free-ranging and captive moose in Sweden

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Ada Trapp

Supervisor: **Heidi Rautiainen, Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management**

Assistant supervisor: Annika Felton, Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre

Examiner: Horacio Gonda, Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management

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Keywords: diarrhoea, zoo, browser, ruminant, Alces alces

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Animal Nutrition and Management

Abstract

Animals have evolved adaptations to survive and reproduce in certain environments. Based on these adaptations, different feeding types can be identified among ruminants from the continuum of browsers to grazers. Browsers are assumed to digest forage rich in soluble cell contents, while grazers are more equipped to digest cellulose. The European moose (*Alces alces*), classified as a browser, is a large herbivore with seasonal adaptions to its diet depending on the availability and nutritional composition of forage. Many zoos have continued issues of diarrhoea and trouble maintaining body condition when keeping moose in captivity. One possible reason for the diarrhoea is lack of fibre in the diet. According to the nutritional balancing act, the main goal for moose is to obtain a nutritionally balanced diet. The aim of this study was to compare the proportion of fibre in the faeces of captive and free-ranging moose to use as a for fibre content in the diets is similar. More specifically, the aim was to test if the diet provided to captive moose has similar proportion fibre in their diet as free-ranging moose that have the possibility to balance their intake of fibre. A total of 20 faecal samples from Kolmården Zoo and 10 from free-ranging moose were analysed. The comparison in fibre contents showed that the captive moose had higher contents of cellulose and lower contents of lignin in their faeces. Hemicellulose content showed no significant difference. Based on these findings, it is concluded the diets do not have similar fibre contents. The results from this study can be used as a pilot study for further research and adaptations to zoo diets for moose.

Keywords: diarrhoea, zoo, browser, ruminant, Alces alces

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Abbreviations

ADF	Acid detergent fibre
ADL	Acid detergent lignin
DM	Dry matter
M	Mean
NDF	Neutral detergent fibre
SD	Standard deviation
SLU	Swedish University of Agricultural Sciences
WSC	Wasting syndrome complex

1. Introduction

Animals have evolutionary adaptations to different environments over short or long-term timescales to ensure survival and reproduction (Van Soest 1994; Raubenheimer *et al.* 2012). Depending on the impact severity of the stressor, such as climate or environment, this can lead to behavioural and physiological responses (Raubenheimer et al. 2012). Changes in the environment lead to different foraging behaviours and may ultimately lead to changes in gut morphology (Raubenheimer et al. 2009). In addition, herbivores that inhabit areas with plants evolved by efficient defence mechanisms, tend to have a smaller body mass and lower energy requirements as to survive on the food others avoid (Shipley 2010). Another adaptation can be a low mass-specific metabolic rate (Shipley 2010). Ruminants inhabit areas across the globe in arctic conditions with ice and snow to deserts with high temperatures and low access to water (Hofmann 1989; Van Soest 1994). These differences between the species are a result of Darwinian fitness together with nutritional links causing these large adaptations (Raubenheimer et al. 2012).

Ruminants can be divided into three different feeding types: browsers, intermediate types, and grazers (Hofmann 1989; Clauss et al. 2010). However, many species cross these borders and may be harder to define, some species cross between grazer and intermediate type or between browser and intermediate type (Hofmann 1989). The largest difference in digestive strategy can be found between browsers and grazers, where browsers are often characterized by their unsuitable rumen morphology for grasses and grazers are characterized by their more evolved rumen adapted for a grass diet (Clauss & Dierenfeld 2008; Spitzer et al. 2020). Browsers are oftentimes challenging to keep in captivity, because they are particularly susceptible to metabolic problems and are not adapted to a diet suitable for grazers (Clauss & Dierenfeld 2008; Clauss et al. 2010).

1.1 Browser and moose nutrition

Browsers, such as the European moose (*Alces alces*), are assumed to digest forage rich in soluble cell contents (Hofmann 1989). Moose have a distribution across the northern hemisphere in temperate climates where they must adapt to seasonal changes (Shipley *et al.* 1998). Similar to other ruminants, browsers rely on fermentation by its microbes for the digestion of plant cell walls (Clauss *et al.* 2010). Moose generally feed on twigs and leaves of trees, shrubs, herbs, and forbs throughout the year (Clauss & Dierenfeld 2008). They are an example of an animal that is well adapted to its feeding niche that others tend to avoid (Shipley 2010). Moose often browse on plants high in tannins, which have been known to inhibit protein absorption, but they host tannin-binding salivary proteins as to combat this (Hagerman & Robbins 1993). In fact, when compared to roe deer (*Capreolus capreolus*), and animal seemingly similar in its feeding niche, moose are more efficient in digesting browse throughout the year, especially in winter (Cederlund & Nyström 1981). Their diet varies throughout the year depending on availability and nutritional composition across seasons, being mainly woody stems in winter and leaves in summer (Renecker & Hudson 1985). This is where the roe deer differs from the moose, as the roe deer consumes generally less fibrous browse and only in winter due to environmental challenges, such as snow, steer towards the same fibrous browse as the moose (Cederlund & Nyström 1981). In general, moose do not consume any grasses and have been observed to consume very little, if any, even during the growing season (Spitzer *et al.* 2020). As forage is scarce in winter, they are forced to feed on nutrient poor and fibre rich stems, twig size is of importance. Up to a certain threshold, moose have been seen to prefer larger twigs over smaller twigs, as larger stems provide them with more biomass per bite (Shipley *et al.* 1998). Conversely, this also leads the moose to work harder to turn the stems into a digestible size (Pérez-Barbería & Gordon 1998). With increased twig diameter the fibre content increases and the digestibility decreases (Palo *et al.* 2012).

1.2 Fibres in the diet

Dietary fibre typically refers to the structural carbohydrates in the plant cell wall, most commonly hemicellulose, cellulose, and lignin (Van Soest *et al.* 1991; Felton *et al.* 2018). Out of these lignin is considered entirely indigestible (Van Soest 1994), whereas hemicellulose and cellulose may provide up to 80 % of a ruminant's energy intake (Barboza et al. 2009). The sequential extraction of plant fibres (Van Soest et al. 1991) best describes the different technical fractions of the plant cell wall. However, hemicellulose, cellulose and lignin are often referred to as the functional fractions (Felton et al. 2018). The neutral detergent fibre (NDF) fraction of the cell refers to the fibrous cell wall as the cell contents, proteins, lipids, simple sugars, and starch are soluble in the neutral detergent (Van Soest et al. 1991; Barboza et al. 2009). Acid detergent fibre (ADF) represents the cell wall contents not soluble in an acid detergent, meaning cellulose and lignin, as hemicellulose is soluble in this detergent and is thus removed from the fraction (Van Soest et al. 1991; Barboza et al. 2009). The last chemical treatment is often to determine the lignin fraction, this treatment uses a strong acid to dissolve the cellulose, leaving out lignin (Van Soest et al. 1991). Lignin is a non-carbohydrate found in the cell wall between the carbohydrate components and it assists the movement of water within the plant by obstructing evaporation (Dimmel 2010).

1.3 Challenges with captive diets and occurring issues

Moose have generally been difficult to maintain in captivity as the issue of diarrhoea often occurs. If the macrobiotic balance in the rumen is disturbed, by lack of fibre for example, digestive upset and malnutrition are often the result. Moose in captivity are usually fed a ration of concentrate feeds, often consisting of more easily digested carbohydrates, and a smaller ration of forage which could be the cause of the common occurrence of digestive upset in the animals (Clauss *et al.* 2010). The moose may not have a very adaptable digestive system and is adapted to its narrow nutritional niche, which forms the bulk of its diet (Hofmann 1989; Shipley 2010). It has been suggested other components in the browse, such as lignin, tannins and salicin contribute to the digestive health of the moose (Schwartz 1992a; Shipley 2010). Due to this, these animals should be limited to browse-only diets (Clauss *et al.* 2010). This often not the case due to availability and the workload of staff. A study conducted on captive moose proved findings made in free-ranging moose, that they do not prefer to feed on grass, as grass-hay was avoided when given the choice (Clauss *et al.* 2013). Alfalfa hay was preferred, even when considered low quality, suggesting this is a sufficient feed in fulfilling energy requirements and is palatable enough for the animals to enjoy (Clauss *et al.* 2013). Another study made on captive moose with access to grass pastures and high-fibre moose concentrate feeds found that the health state of the animals deteriorated with time on this diet (Shochat *et al.* 1997). By the animals' fourth year on this diet, signs of wasting was witnessed as well as faeces described as amorphous masses, if the animals survived at all (Shochat *et al.* 1997). Wasting syndrome complex (WSC) is the most common cause of death in captive moose, leading to a predominant death at six years of age across different moose husbandry systems (Clauss *et al.* 2002). The highest incidence of death caused by WSC is at 6 – 8 years of age, suggesting the process is gradual and e.g., chronic diarrhoea during the individuals lifetime leads to irreparable intestine damage, culminating in death (Clauss *et al.* 2002). In addition, parasitic infections are also common with a prevalence of 38 % of whipworm (*Trichuris* spp.) infections in both captive and free-ranging moose (Clauss *et al.* 2002; Grandi *et al.* 2018).

Kolmården Zoo have experimented with different diets and feed formulations and still had continued issues of diarrhoea and trouble maintaining body condition. Kolmården Zoo have now formulated a new diet with higher lucerne ration and a lower concentrate feed ration to attempt to closer resemble the diet of the free-ranging moose (Walldén 2022b). The new diet is expected to reach adequate fibre content for the moose, that is comparable to the free-ranging moose diet. In this study, fibre content in faeces is used as a proxy for proportion fibre in the diet. The purpose is to assess if the chronic diarrhoea persists despite the natural fibre content, as to determine a cause for the loose faeces.

The aim of this project was therefore to compare the fibre content faecal samples from free-ranging and captive moose to determine if the fibre content is similar. More specifically, the aim was to test if the diet provided to captive moose has similar proportion fibre in their diet as free-ranging moose that have the possibility to balance their intake of fibre. The hypothesis was that the samples from captive moose will have the same fibre content as the samples from free-ranging moose.

2. Materials & methods

2.1 Study area

The study is based on a total of 30 samples collected from Kolmården Zoo (58°39’55” N; 16°27’59” E) and within a 50 km area surrounding the zoo (Figure 1). The samples were collected during five weeks between February 19 – March 27, 2022. All samples (N=30) used in the study were collected during this time. The period of five weeks was chosen to represent the nutritional status of moose in late winter. Choice of sample size and collection period was steered by the resources. This radius was chosen to give a large enough range to follow reported moose sightings and aid in collecting fresh samples, while being close enough to Kolmården Zoo to provide a hypothetically natural fibre content in the samples. Kolmården Zoo houses seven moose in an enclosure together with 32 European fallow deer (*Dama dama*) and seven Père David’s deer (*Elaphurus davidianus*) in an area of 5.5 ha (Walldén 2022b). The enclosure also has a small pond in the middle and the gondola track crosses through (Appendix 2).

The enclosure is equipped with four feeding tables that the mixed ration, with concentrate feeds and alfalfa, is served from. The new moose diet at Kolmården Zoo was formulated to decrease the common occurrence of diarrhoea. The animal care staff at Kolmården have developed a faecal scoring system and describe scores 1 – 2 as good faeces consistency and intactness, whereas scores 3 – 5 are considered problematic and too loose (Appendix 1). The new diet consists of 3/8 winter moose concentrate feed (Table 1) and 5/8 alfalfa. The previous diet composition was ½ concentrate feed and ½ alfalfa. The current ratio is prepared before each serving by adding 5 kilos of alfalfa and 3 kilos of moose concentrate feed to a mixing barrel, this is served 11 – 12 times per day. The aim is to offer forage ad libitum and it is placed in piles around the enclosure or hung up as enrichment. In the winter the forage consists mostly of pine and in the summer, Salix spp. is most common. Forage was hard to come by at the time of the study, according to the animal care staff at Kolmården, as many production systems in Sweden were affected by the bark beetle infestation. The animal care staff also mentioned that in the summer forage is easier to come by but is of varying quality as Kolmården does not have their own production and rely heavily on producers in the area.

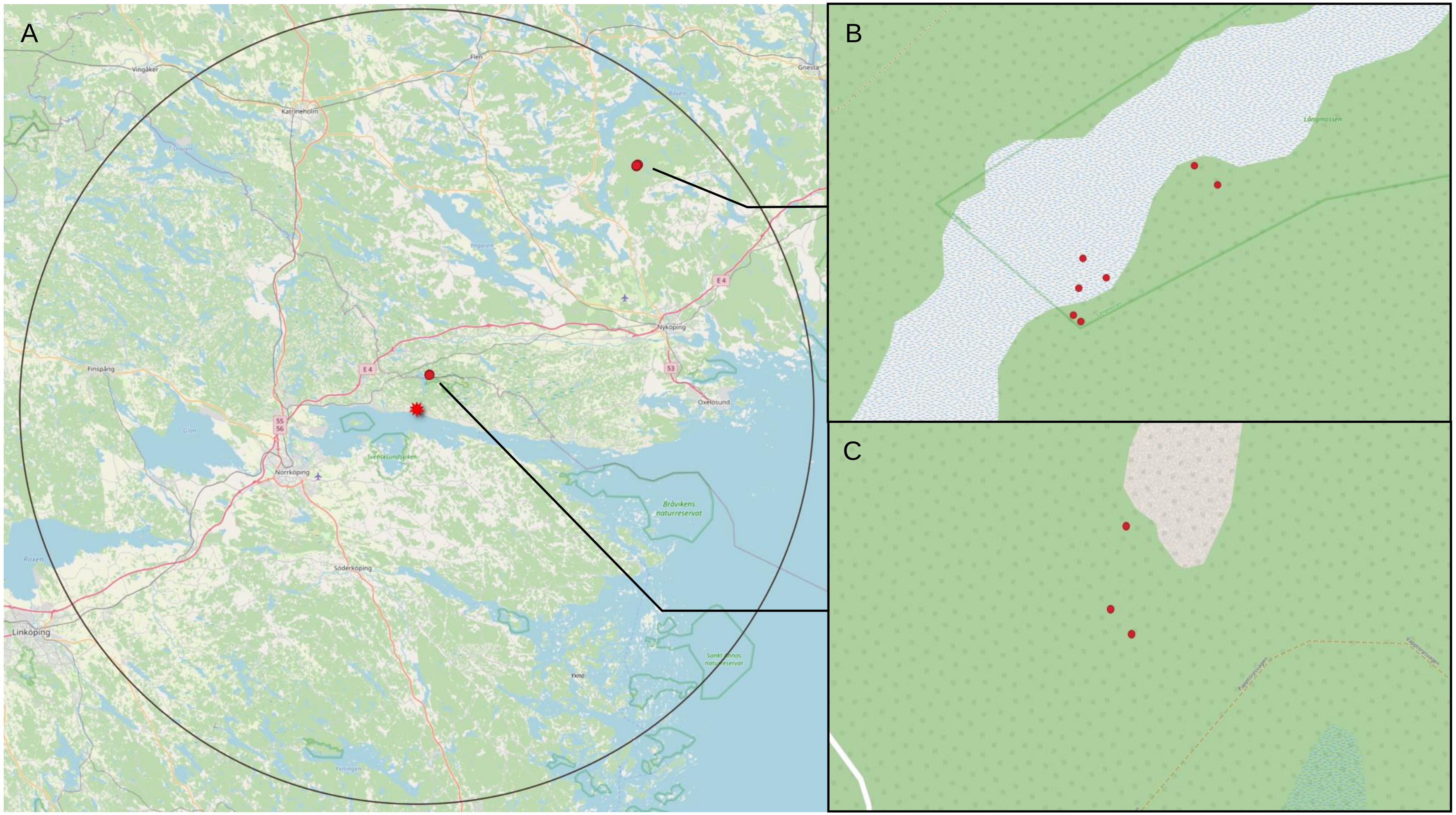

Figure 1 (A) A map showing the 50 km radius marking the sample collection area around Kolmården Zoo. Kolmården Zoo can be seen on the map marked with a red star as well as the free-ranging moose sample collection sites marked with red dots. The provincial border between Östergötland and Södermanland can be seen as a purple line. The highway E4 can also be seen marked with a thick pink line. (B) A closer view of the nature reserve further away from Kolmården Zoo (Samples 4 – 10), the lighter area marked is mire. (C) A closer view of the area closer to Kolmården Zoo (Samples 1 – 3), the lighter area marked is a higher elevated area

Table 1 The formulation of the winter moose concentrate feed at Kolmården Zoo (Walldén 2022a).

Ingredient	**kg/tonne**
Beet pulp	300
Distiller's grains	290
Aspen bark	220
Fibre pellets	54
Fat 85%	26
Brewer's yeast	50
PMX	50
Molasses	10

2.2 Sample collection

The samples from Kolmården Zoo were collected by the animal care staff during the collection period. Multiple samples were collected, and all individuals presented at least one sample. At the start of the collection period eight moose were present at Kolmården Zoo, one adult bull, two adult cows, four born 2021 and one born 2020. The individual born in 2020 was transferred in the end February and was therefore disregarded in the study. Samples from the adult bull (Mike), one adult cow (Freja) and one young cow (Husavik) were used, as these ranged over the entire collection period (Appendix 3). Freja had three calves during the collection period. Mike and Freja had whipworm infections in the week prior to the collection period, but not during. During March 12 – 17 all animals in the enclosure were given a five-day treatment of antiparasitic, in a higher dose than usual, as parasites are a continued issue and resistance is speculated (Walldén 2022f). The samples from these individuals were also chosen to range over the entire collection period, which led to some samples being disregarded as they were collected close to each other in time. The samples were stored in -20ºC until analysis. Samples varied in consistency and amount (
Figure 2).

Figure 2 Examples of captive moose faeces found at Kolmården Zoo. To the left is what the animal care staff would describe as good and consistent faeces and to the right is what the animal care staff describe as loose and problematic faeces. Photo credit: Left: Ada Trapp, right: Walldén 2022e.

Ten samples from free-ranging moose were collected during the collection period in two different areas within the 50 km radius (Figure 1). The areas were chosen based on sightings reported in Artdatabanken (SLU Artdatabanken 2022). The aim was to collect from more than one location to ensure several individuals were included and to widen the population. The first three samples were collected closer to Kolmården Zoo, while the rest were collected in a nature reserve further away. The nature reserve showed signs of active moose inhabitation, such as multiple fresh droppings, tracks and signs of feed searching behaviour. The samples were all similar in consistency (Figure 3). The samples were stored in -20ºC until analysis.

Figure 3 Example of typical faeces found from free-ranging moose in Södermanland, Sweden during February – March 2022. Photo credit: Ada Trapp

2.3 Fibre analyses

NDF, ADF and acid detergent lignin (ADL) were analysed in SLU facilities. The samples were thawed, freeze dried and ground in a coffee grinder in preparation for the analyses. Sequential fibre analysis was performed with 10 samples at a time, accompanied by two forage control samples.

NDF extraction was performed according to (Van Soest *et al.* 1991; Mertens 2002). 0.6 – 0.7 g of dried and ground up sample was weighed out into crucibles. After placing the crucibles in the sequential fibre analysis machine, 100 ml of the neutral detergent solution was poured into the crucibles. The samples were boiled for one hour. The solution was filtered out and rinsed with hot deionized water, four to five times, until no solution remained. The samples were lastly rinsed twice with acetone, before being placed in 103ºC overnight.

The following morning the crucibles were weighed, and the weight recorded (v_1). ADF extraction was performed according to (AOAC 1990). After placing the crucibles in the sequential fibre analysis machine, 100 ml of the acid detergent solution was poured into the crucibles. The samples were boiled for one hour. The solution was filtered out and rinsed with hot deionized water, four to five times, until no solution remained. The samples were lastly rinsed twice with acetone, before being placed in 103ºC overnight.

The following morning the crucibles were weighed, and the weight recorded (v_2). ADL extraction was performed according to (Robertson & Van Soest 1981). 15 ml of 72% sulfuric acid was measure into each of the crucibles. After stirring, a further 20 ml of sulfuric acid was added. The samples were stirred every 15-20 minutes for a total of an hour. The acid was then filtered out and a further 20 ml of the sulfuric acid was added. The samples were stirred every 15-20 minutes for a total of an hour. The solution was filtered out and rinsed with deionized water, four to five times, until no solution remained. The pH was ensured with litmus paper. The samples were lastly rinsed twice with acetone, before being placed in 103ºC overnight.

The following morning the crucibles were weighed, and the weight was recorded (v_3). Lastly, the crucibles were placed in 500ºC for three hours to ash. The weight of the cooled crucibles was recorded (v_4). To calculate the different fibre fractions in the samples, the weights from each stage were divided by sample weight (Table 2).

Table 2 The equations used to calculate the dry matter (DM), neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin, cellulose and hemicellulose fractions in faecal samples from free-ranging and captive moose (N=30) collected February– March 2022 from Södermanland, Sweden and Kolmården Zoo, Sweden. (HUV 2022).

Equation	Description
$DM\ \% = \frac{dry\ weight}{fresh\ sample\ weight} \times 100$	DM is calculated by dividing the fresh sample weight by the sample weight after drying.
$NDF\ \%DM = \frac{v_1 - v_4}{sample\ weight} \times 100$	NDF is calculated by dividing the weight of sample in the crucible with the weight after the treatment with the weight of ash subtracted (v_1-v_4). NDF is comprised of hemicellulose, cellulose, and lignin.
$ADF\ \%DM = \frac{v_2 - v_4}{sample\ weight} \times 100$	ADF is calculated by dividing the weight of sample in the crucible with the weight after the treatment with the weight of ash subtracted (v_2-v_4). ADF is comprised of cellulose and lignin.
$Lignin\ \%DM = \frac{v_3 - v_4}{sample\ weight} \times 100$	Lignin is calculated by dividing the weight of sample in the crucible with the weight after the treatment with the weight of ash subtracted (v_3-v_4).
$Cellulose\ \%DM = ADL\ \%DM - Lignin\ \%DM$	The cellulose fraction is calculated by subtracting the lignin fraction from the ADF fraction.
$Hemicellulose\ \%DM = NDF\ \%DM - ADF\ \%DM$	The hemicellulose fraction was calculated by subtracting the ADF fraction from the NDF fraction.

2.4 Statistical analysis

Sample number 2 (Appendix 4) was considered an outlier and was not included in the statistical analysis, as its DM content was above of the upper limit of the data

(Q3+(1.5*IQR)). One-way ANOVA was performed with the R-studio cloud software (R Core Team 2017). ANOVA was used to compare the three individuals' results, from Kolmården, with each other to ensure no significant differences within the group. The one-way ANOVA was performed with a 95% confidence interval.

Welch two sample t-test was performed with the R-studio cloud software (R Core Team 2017). This test was used for all analysis comparing the free-ranging group to the Kolmården group. The test was chosen to account for the unequal variances in the two groups, as well as compare them as groups instead of pairs. The Welch two sample t-tests were all performed with a 95% confidence interval. The mean value for the group is here forth marked as M and the standard deviation is marked as SD.

3. Results

Overall, there were statistically significant differences between the captive moose faecal samples and the free-ranging moose faecal samples, but no differences between the captive moose individuals (Table 3; Figure 4). The one-way ANOVA resulted in no significant difference in DM ($F_{2;17} = 0.65$, $p = 0.54$), NDF ($F_{2;17} = 3$, $p = 0.08$), ADF ($F_{2;17} = 1.91$, $p = 0.18$), lignin ($F_{2;17} = 3.55$, $p = 0.05$) or cellulose ($F_{2;17} = 0.88$, $p = 0.43$) between the faecal samples from three captive moose.

The DM of faecal samples from free-ranging moose (M = 25.40, SD = 3.24) was found to be significantly higher ($t(24.16) = 3.10$, $p = 0.01$) than faecal samples from captive moose (M = 20.43, SD = 5.17; Appendix 4).

There were statistically significant differences in the NDF, ADF, Cellulose and Lignin fractions between the faecal samples from free-ranging and captive moose (Table 3; Figure 4). Hemicellulose contents in the faecal samples showed no statistical difference between the free-ranging and captive moose (Table 3; Figure 4F).

Table 3 Fibre composition (mean ± standard deviation) in faecal samples from free-ranging and captive moose. Welch two-sample t-test results are indicated by t-value, degrees of freedom (df) and significance level (p). Based on faecal samples collected in Södermanland, Sweden and Kolmården Zoo, Sweden, February – March 2022.

Fibre fraction %DM	**Free-ranging moose (n = 10)**	**Captive moose (n = 20)**	**t**	**df**	**p**
NDF	69.57 ± 4.10	58.28 ± 4.32	6.74	16.37	< 0.001
Hemicellulose	15.50 ± 3.13	16.10 ± 1.01	– 0.57	8.76	0.583
ADF	54.07 ± 5.75	42.18 ± 3.47	5.73	10.87	< 0.001
Cellulose	25.93 ± 2.86	29.29 ± 2.00	– 3.18	11.89	0.008
Lignin	28.15 ± 5.07	12.89 ± 1.61	8.81	8.78	< 0.001

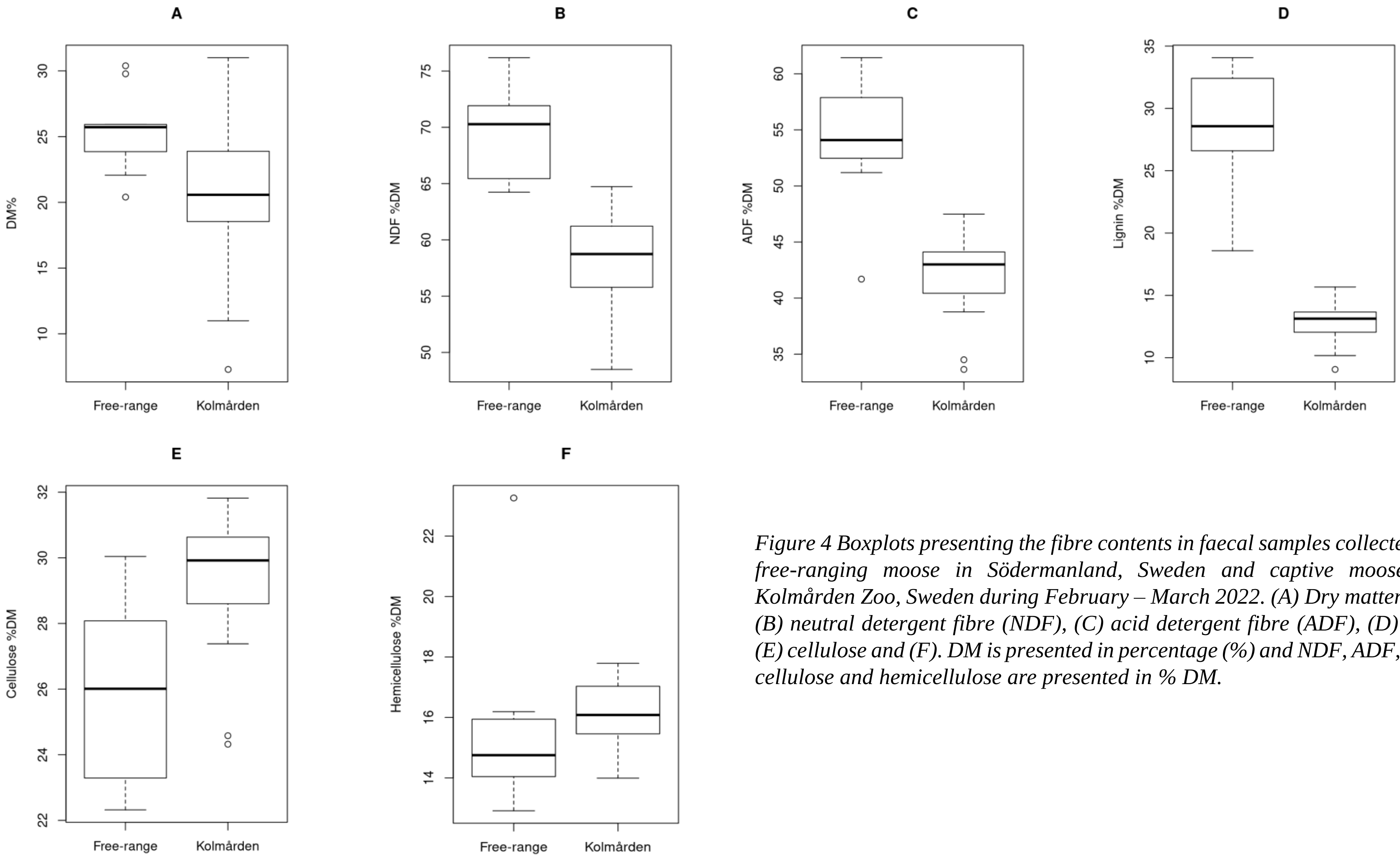

Figure 4 Boxplots presenting the fibre contents in faecal samples collected from free-ranging moose in Södermanland, Sweden and captive moose from Kolmården Zoo, Sweden during February – March 2022. (A) Dry matter (DM), (B) neutral detergent fibre (NDF), (C) acid detergent fibre (ADF), (D) lignin, (E) cellulose and (F). DM is presented in percentage (%) and NDF, ADF, lignin, cellulose and hemicellulose are presented in % DM.

4. Discussion

The aim this project was to compare faecal samples from free-ranging moose with faecal samples from captive moose at Kolmården Zoo to determine if the fibre content in the new diet at Kolmården Zoo is alike to the fibre content in the diet of free-ranging moose. The results showed 1) DM, NDF, ADF and lignin contents were higher in faecal samples from free-ranging moose compared to faecal samples from captive moose and 2) cellulose contents were higher in faecal samples from captive moose compared to the free-ranging moose faecal samples.

4.1 Seasonal adaptations to forage composition

Moose are adapted to seasonal variations in forage composition and show changes in feed intake and feeding behaviour also when kept in captivity (Kochan 2007; Clauss *et al.* 2013; Felton *et al.* 2016). Among free-ranging moose, previous studies have shown the proportion of NDF in their diets range from 30% DM in summer to 40 – 50% DM in the winter (Renecker & Hudson 1985; Schwartz 1992b). Similarly, the DM contents in the free-ranging moose diet increase from 25% in the winter to 60% in summer (Renecker & Hudson 1985). In general, summer diets are up to three times more nutritious than winter diets (Schwartz 1992a). DM intake and mean daily consumption is the highest in the summer when foliage is abundant and becomes the most important feed source (Renecker & Hudson 1985). Both DM intake and daily consumption decline during the autumn and into the winter as forage becomes less available, leading the moose to spend more time searching for available forage, especially in winter (Renecker & Hudson 1985). NDF intake increases in the winter (Palo *et al.* 2012), suggesting an increase in overall fibre contents in the browse. Cellulose and lignin content specifically increase in browse plants in winter (Cederlund & Nyström 1981). A population of free-ranging moose in Södermanland, Sweden was shown to have mainly a conifer based diet (Felton *et al.* 2020). The described conifer diet consists mainly of *Pinus sylvestris*, *Calluna vulgaris* and *Juniper communis* (Felton *et al.* 2020). An older study presented the diet of free-ranging moose in northern Sweden to base their diet on up to 75% *P.sylvestris*, together with *Salix* spp. and *Junipers communis* (Shipley *et al.* 1998). The study found the winter composition of *P.sylvestris* to contain 57% DM NDF and have a digestibility of 36%, *J.communis* contained 46% DM NDF and had a digestibility of 42% (Shipley *et al.* 1998). The study by Felton *et al.* (2021) analysed the winter nutritional composition in different food plants common in the free-ranging moose diet, presenting the common nutritional fractions as well as the digestible fraction of NDF (dNDF). *P.sylvestris,* accounting for 44% of the diet, contains 43.1% DM NDF, 21.3% DM dNDF, 9.7% DM hemicellulose, 25.6% DM cellulose and 9.5% DM lignin (Felton *et al.* 2021). The second largest fraction (9%) of the diet was of *Calluna vulgaris*, which contains 42.1% DM NDF, 24.3% DM dNDF, 8.3% DM hemicellulose, 23.3% DM cellulose and 12.5% DM lignin (Felton *et al.* 2021). *J.communis*, which represents an abnormally large fraction compared to other diets, has a winter nutritional composition of 42.6% DM NDF, 19.7% DM dNDF, 3.6% DM hemicellulose, 30.2 %DM cellulose and 10.8% DM lignin (Felton *et al.* 2021). Together, these three plants account for over 50% of the free-ranging moose population's diet in the studied area in Södermanland, Sweden (Felton *et al.* 2021). The two studies analysing the winter nutritional composition of the browse species resulted in quite different amounts, the analysis methods and geographical location may be cause to this. Supposing the free-ranging moose in the current study, also from Södermanland, had a similar diet as the one presented by Felton *et al.* (2021), *P.sylvestris* would account for 49.5% DM NDF in the faecal samples. Considering, the faecal samples from free-ranging moose presented almost 70% DM NDF, this amount could be to expect if the diet did consist of that large amount of *P.sylvestris*. Similarly, would lignin, the indigestible fibre, represent 21% DM in the faecal samples, if 44% of the diet consisted of *P.sylvestris*. The current study presented a lignin content of 28.25% DM in the faecal samples of free-ranging moose. Both, NDF and lignin, amounts presented by Felton *et al.* (2021) could be considered a bit high when compared to the current study's totals in free-ranging moose faecal samples, but the amounts would vary heavily on the other components in the diet. Based on the results, it is likely the diet of the free-ranging moose used in the study was a conifer-based diet and the fibre intake could be comparable to the values presented in Felton *et al.* (2021) and Shipley *et al.* (1998).

Perhaps the most remarkable factor in the current study is the lignin contents. As it has been suggested, lignin seems to be of importance in the digestive health of the moose (Shipley 2010). Also considering, the lignin contents in browse plants increases in winter (Cederlund & Nyström 1981), there is reason to assume captive moose also should consume a relatively large lignin amount from their diet. Particularly seeing as lignin is indigestible (Van Soest 1994), the faecal lignin content should be comparable between captive and free-ranging moose if it were comparable in the diet.

4.2 Free-ranging diets compared to the captive diet

When studying moose in captivity and comparing their seasonal feed intake, their nutrient consumption decreased on all parameters towards winter (Kochan 2007). Interestingly, cellulose and digestible cellulose fractions were almost halved in winter when compared to the levels in summer (Kochan 2007). This suggests that moose choose to feed on low-nutrient forage in the winter as their biology steers them to, even when given the choice. The same study also showed a decreased digestibility of cellulose and increase in its ruminal concentration, as lignin increased in the forage in winter (Kochan 2007). Moose also seem to be more flexible with their hemicellulose contents in feed as large variations may appear in feed compositions across winter (Felton *et al.* 2021). Though seemingly different diets between the free-ranging and captive moose, the hemicellulose contents in their faeces showed no difference in the current study. The flexibility in hemicellulose intake could explain the similar hemicellulose contents present in the faecal samples from free-ranging and captive moose in the present study. Another explanation could be the varying digestibility of the diets between captive and free-ranging moose affect the hemicellulose digestion, making the faecal hemicellulose content appear similar. Though it has been suggested, that moose cannot digest cellulose that efficiently (Hofmann 1989), studies have found moose are capable of digestion cellulose and host cellulolytic bacteria (Cederlund & Nyström 1981).

Traditionally, moose concentrate feeds have been formulated from cereal grains (corn, oats and barley), soybean meal for protein and sawdust or hay as a source of fibre (Schwartz 1992a). Some attempted improvements have comprised of different fractions of aspen wood sawdust, beet pulp and canola meal (Shochat *et al.* 1997). At Kolmården Zoo, the conifers provided to moose in the winter could be compared to the conifers in the free-ranging diet. However, the captive moose do not seem to be as interested in the conifers as they are in the mixed feed ration according to the animal care staff. One reason for this could be that as the concentrate feed and alfalfa at Kolmården offer a steady intake of nutrients, the moose are used to satisfying their needs by regulation of the same feed, whereas the forage varies in nutritional composition. In fact, it has been found that captive moose, when giving the opportunity, are able to balance their nutrient intake according to their needs (Felton *et al.* 2016). The study suggests that moose undergo an active regulation of their macronutrient intake, switching between feeds that cater to either their protein or energy needs (Felton *et al.* 2016). The mixed feed ration could also be considered more efficient to digest, as the conifers, with their needles, bark, and twigs, require more work to get to a digestible size (Pérez-Barbería & Gordon 1998) especially since these conifer forages offer a larger intake per bite (Shipley *et al.* 1998).

Some zoos have choose to ensile their forage in the summer, as to be able to offer their animals the same forage outside of the growing season as well (Hatt & Clauss 2006). Ensiling the common food plants for moose does not seem to significantly affect the nutritional contents either, suggesting this to be a suitable alternative to use as forage in winter (Hatt & Clauss 2006). This alternative does require production on a larger scale during the summer. Nonetheless, the ensiled forage could be a solution for lack of preferable forage in winter. However, the lack of forage at Kolmården Zoo this winter seems to have been a rare occasion because of the bark beetle infestations across all of Sweden causing damage and production losses (Walldén 2022b).

4.3 Feeding regimes at Kolmården Zoo

At Kolmården Zoo, the concentrate feed has a DM of 92%, crude fibre of 20.3% DM and NDF of 38.4% DM (Walldén 2022c). The ration was formulated based on old analysis results and a slight difference can be seen when comparing them, recipe for concentrate feed has remained the same (Table 1), but a slight difference in nutritional value is observed (Walldén 2022c). The feed ration per animal is calculated to equal to about 2% DM for a moose (Walldén 2022a). In addition, Kolmården Zoo have developed guidelines to formulate a well-rounded diet for their animals, where the aim is to feed 10 – 14% DM raw protein, 2 – 5% DM fat, 25 – 40% DM NDF, < 5% DM starch and 7 –15% DM sugar (Walldén 2022a). A study comparing different feeds for captive moose, though keeping the fibre concentration stable in the different treatments, found the average intake of digestible NDF to be around 41% DM (Felton *et al.* 2016). The NDF in the concentrate feed is lower than the preferred amount of digestible NDF, suggesting the digestible NDF from the concentrate is even lower, though the actual amount was not disclosed. The moose will have to complete their preferred level with other feeds, such as the alfalfa or forage. The moose winter concentrate feed at Kolmården Zoo has three main ingredients: beet pulp, aspen bark, and distiller’s grains and was formulated by Kolmården Zoo in 2017 (Table 1; Walldén 2022a). As only crude fibre and NDF are analysed it is not possible to estimate the proportion of cellulose and lignin within the crude fibre. The source of the high cellulose in the diet is likely to be the concentrate feed, but a more detailed analysis is needed for a proper conclusion.

Kolmården had their alfalfa analysed in 2015, but they use the same values when estimating feed rations today. The nutritional contents used for the feed ration today are 84.8% DM and 39% DM NDF (Walldén 2022d).

The conifer diet has been associated with low calf body mass (Felton *et al.* 2020), suggesting Kolmården Zoo’s strategy of feeding their mixed moose ration as the main feed could be key in ensuring proper calf growth and survival. However, the study implies a diverse diet consisting of various forages, mainly broad-leaved species, had a positive correlation of calf body mass (Felton *et al.* 2020). A reason for the conifer diet being associated with low calf body mass could be because boreal forages are in general tannin rich (Spalinger *et al.* 2010). However, it has been suggested that diet selection by browsing ruminants is affected by a certain body phenolic burden, creating a balance between detoxification and intake (Robbins *et al.* 1987). The concentration of tannins appears to be what affects the protein digestion, if the balance is maintained, the presence of tannins does not seem to bother the moose (Robbins *et al.* 1987; Spalinger *et al.* 2010). Kolmården Zoo have in the past struggled with tannin-rich feed, as tannins can be growth retardant to calves, likely due to the reduction of protein digestion (Spalinger *et al.* 2010), leading to the lactating moose avoiding these feeds and losing body mass as a result (Walldén 2022b). Before Kolmården Zoo formulated their new moose concentrate feed in 2017 they used aspen bark pellets, apparently high in tannins, but found the issue prevalent as calves were not growing and lactating moose were losing body mass (Walldén 2022b). It seems Kolmården Zoo needs to broaden their forage offering with various species, giving the moose the possibility to choose their diet according to need and to ensure proper calf growth.

The new diet was started January 22, a month before the study which should have given the animals' digestive systems time to acclimate to the new diet. Therefore, the old diet will not be considered.

Something to note is that crude fibre content does not always equal low quality, as it does not determine the fractions of cellulose and lignin, which differ greatly in their digestibility (Felton et al. 2018). An interesting finding from the analysis is the difference in ash colour after combustion. The Kolmården Zoo samples all resulted in white ash, while the free-ranging samples resulted in black ash. Kolmården Zoo's concentrate feed has a known mineral contents, through feed analysis (Walldén 2022c). A study did note less acid soluble ash in browse compared to grasses (Clauss & Dierenfeld 2008), maybe causing the difference in ash colouring.

4.4 Additional factors and potential causes for diarrhoea

Whipworms are a continued issue at Kolmården and was found in various animals during the study period. Out of the subjects included in the study, Mike and Freja had whipworms in the week leading up to the collection period, but not during. During March 12-17 all animals in the enclosure were given 5 days of antiparasitic, in a higher dose than usual, as parasites are a continued issue and resistance is speculated (Walldén 2022f).

A study estimating the connection between emaciation and poor body condition with parasitic levels in Swedish moose found that 38% of the free-ranging moose faecal samples, with parasitic eggs, contained whipworm eggs (Grandi *et al*. 2018). Another study establishing causes for WSC in captive moose, found that 38 % of the animals included had a documented presence of whipworms (Clauss *et al.* 2002). The study stated a parallel between WSC and whipworm infections, as 48 % of their subjects that died of WSC also had a documented whipworm infection (Clauss *et al.* 2002).

WSC is the most common cause of death in captive moose, leading to a predominant death at age 6 across different moose husbandry systems (Clauss *et al.* 2002). The highest incidence of death caused by WSC is at 6 – 8 years of age, suggesting the process is gradual and e.g., chronic diarrhoea during the individuals lifetime leads to irreparable intestine damage, culminating in death (Clauss *et al.* 2002). An earlier study also found digestive upset to be the leading cause of death in captive moose, while also proving it may not be caused entirely by lack of fibre (Schwartz 1992). Some facilities reported death by WSC despite feeding a high fibre diet sawdust-based or hay-based (Schwartz 1992a). This led to the hypothesis shifting from a lack of fibre to an array of different causes, all while a definite cure has not been found (Schwartz 1992a; Shochat *et al.* 1997). Schwartz (1992) even suggests the anti-nutrients, part of the plants' defence mechanisms, ingested by free-ranging moose might be something that aids their digestive system and those could be lacking in a great extent in captive moose diets. WSC has also been reported to have a higher incidence in moose kept in grass pasture enclosures, this paired with the fact that whipworm infections easily transmit through pasture systems as well, calls for concern (Clauss *et al.* 2002). It is hypothesised this is because moose in the wild hardly consume grass, which could have led to a less evolved defence for parasitic infections transmitted by faeces (Clauss *et al.* 2002). Kolmården have had reported issues with WSC over the years, but have chosen to euthanize the affected animals before allowing it to become cause of death (Walldén 2022f). Kolmården houses their moose in a grass pasture like enclosure, as well as oftentimes place forage on the ground for the moose to consume (Walldén 2022b). The cases at Kolmården also correlate with the snow cover melting, allowing the animals access to the grass pasture below. Based on the studies stated above, the grass pasture, or the ground, offers a likely pathway for parasites and other pathogens.

Kolmården also reported having had a problem with ruminal acidosis on an earlier diet of solely concentrate feed and forage, without the addition of alfalfa (Walldén 2022f). The issue seemed to be significant enough to encourage the conversion to the mixed diet with alfalfa. Rumen acidosis is considered a common issue when keeping moose in captivity, especially on concentrate feeds (Hofmann & Nygren 1992). The same study found signs of acidosis in all its captive moose subjects, together with a reduction in papillary dimensions (Hofmann & Nygren 1992). When comparing captive moose rumen samples to free-ranging moose rumen samples, there were differences to the mucosal surface within papillae dimensions and amount absorptive papillae, suggesting captive moose have reduced absorption of nutrients (Hofmann & Nygren 1992). In addition, they found these signs in captive moose with different feeding regimes and from different origins, stating that moose suffer from not having access to the natural diversity of forage plants with their seasonal changes which the moose digestive system naturally responds to (Hofmann & Nygren 1992). A more recent study did not find signs of ruminal acidosis in all its captive subjects, and stated this finding as striking, as the precedent of all captive moose having ruminal acidosis was already established (Clauss *et al.* 2002). In case ruminal acidosis is still as prevalent as earlier suggested, a cause for wasting and diarrhoea could be low absorption of nutrients as the ruminal mucosa and papillae are disturbed.

Mike (Appendix 4) was anaesthetised for hoof maintenance and removal of papilloma on March 21, but there was no notable difference between the samples from that day or the day after. However, this study did not consider anaesthesia as a parameter.

This study included a variation in the sex and age of the captive study subjects. Husavik is a young cow born in June 2021, Mike is a bull born in 2016, Mike has been at Kolmården since 2017, Freja is a cow born 2013 and has been at Kolmården since 2014. Mike is sire to Husavik and Freja had three calves at the time of the study. The animal care staff noted that before the study and switch to the new feed ration, Freja was fed a ration of giraffe concentrate feed in addition to the old ration, in order to fulfil the energy requirement of lactating for three calves (Walldén 2022b). This study did not find a significant difference within the individuals from Kolmården, despite the differences in age and sex. This is supported by earlier findings by Pehrson & Faber (1994) who foung no difference in digestibility of various forages despite age or sex. In addition, they did not find the feed type to be related to sex or age (Pehrson & Faber 1994), suggesting the calves at Kolmården Zoo select their feed similar to the adults and therefore have similar faeces consistency and contents.

4.5 Environmental factors

The two areas from which the free-ranging moose faecal samples were collected in were quite different. The first sampling sites (Figure 1) closer to Kolmården Zoo, were in a clearcutting with young spruce trees and Ericaceous dwarf shrubs, such as lingonberry and bilberry. The area was also surrounded by various deciduous plants, such as birch. The second area (Figure 1), further north of Kolmården Zoo, was an old conifer forest dominated by pine beside a mire. The second area also had plenty of Ericaceous dwarf shrubs, both bilberry and lingonberry, especially in the mire. Exact species of trees and plants is difficult to determine, as only a brief visual evaluation was conducted in conjunction with the sample collection. Kolmården Zoo is situated by Bråviken and the surrounding area is filled with rough old pine, rocks and cliffs as it is a coastal area (Länsstyrelsen Östergötland 2022). This landscape, in its most natural state, could be compared to the second sample collection area, as it is more dominated by old pine. Even though the first sample collection area is much closer, one could argue for the environmental differences caused by the unnatural clearcutting and all it entails. The second area was also, as forementioned, surrounded by deciduous trees, which are not as common in the old-growth forest of Bråvikenbranten nature reserve adjacent to Kolmården Zoo. Based on visual differences of the environment, one could assume the moose in the two areas have a slight difference in their diet, which can slightly be seen in the lignin contents of the samples. However, with both areas being in Södermanland and without more extensive knowledge of the specific individuals or their rumen contents, this study assumes the conifer diet (Felton et al. 2020) is consumed by the moose from both areas.

Moose have been known to prefer a young forest, younger than 30 years, to older forests and mires (Månsson *et al.* 2011). This was something also kept in mind during the sample collection. Despite this notion, the old forest and mire showed far more signs of ongoing moose activity. Estimating moose habitats using pellet counts is a common method used and has been proven to be effective (Månsson *et al.* 2011). When taking pellet count into consideration, the current study found that the old conifer forest and mire, were much preferred by moose over the young forest. However, the snow covering in the young clearcut forest was more apparent, due to the open ground allowed by the small trees, and it could have been hiding several faeces pellets.

It is not likely that the samples from the two collection areas were from the same individual or individuals. Typically, moose movement is at its lowest during the precalving season (1 February – 30 April) (Vander Wal & Rodgers 2009; Wikenros *et al.* 2016). Even if it were a season associated with a higher movement rate, such as calving season in the summer (Wikenros *et al.* 2016), moose rarely migrate the distance required in this case. It has been suggested, most moose only migrate an average of 11 km from winter to summer habitat (Seiler *et al.* 2003). This would make it highly unlikely that the same individuals have migrated 40 km during the season proven to show the least moose movement.

4.6 Limitations

This study has some limitations. The sample size (N = 30) is quite small, when compared to the entire moose population of Sweden. A larger sample size could give a more accurate picture of the population. A possible sampling error occurred in the case of sample no 2 (Appendix 4). This may be due to it being an older sample that looked fresh as it was well preserved due to the below freezing temperature. The temperature kept the sample from visible degradation; however, the DM content of the sample revealed its true nature. This sampling error drove the low sample size even lower, but it is not likely this was a significant matter.

The method, only analysing fibre fractions in faeces, used in the study may also not have been optimal for investigating causes of diarrhoea. NDF is not the best predictor of digestibility as other factors affect it, such as the ratio of faecal matter output of the feed intake (Van Soest 1994). Studying only the fibre fractions of feed, while giving information in support of the theory that low fibre content is the cause for diarrhoea, does not give a complete picture of the feed. Moose balance their protein and energy requirements and often use these parameters when determining their feed intake (Felton *et al.* 2016). Even though hemicellulose and cellulose are used for energy by the moose, the cell contents, such as pectin, are too of value. This study does not distinguish between the different cell contents as they are all flushed away during the first treatment of neutral detergent. There is still large uncertainty about the causes of diarrhoea and WSC in moose and several alternative theories have been proposed above for these illnesses. To investigate these questions further, a comparison between faeces and feed is imperative, as what goes in impacts what comes out. The feed for the captive moose is on record and conclusions are easier to make for the group, as for the free-ranging group literature and faeces together give an estimation of the feed consumed by the subjects.

During the analysis two of the samples leaked. The leakage did not seem to cause any effect, as one of the samples was a control sample and no difference was determined. Therefore, a reanalysis was not deemed necessary.

4.7 Sustainability and ethical considerations

This study was conducted in cooperation with Kolmården Zoo. The study was approved by their zoologists, who in agreement with the Swedish Board of Agriculture deemed no ethical review or approval was required. The study required no special procedures be inflicted upon the animals in the study. However, it did require some manpower, for the collection of samples, which was happily provided. The results from this study are relevant toward the improvement of moose husbandry at Kolmården Zoo.

From a sustainability standpoint, the analysis did cause some chemical waste which cannot be handled as normal waste. The laboratory facilities at SLU have protocols for this type of waste and its disposal, aiming to dispose of it in the most sustainable way. Kolmården Zoo too have protocols regarding waste and faeces management and the removal of faeces could have alleviated their burden regarding this. Removing faeces from nature could be seen as unsustainable as faeces acts as a natural fertilizer, making the locations the samples were collected from less fertile growing grounds for plants.

5. Conclusion

Captive moose in this study do not have the same proportion fibre in their faeces as free-ranging moose do. This indicated that the feed is different to that of free-ranging moose, as the fibre fractions of NDF, ADF and lignin are lower in faecal samples from captive moose and issues with diarrhoea persist. Thus, the results of this study indicate that the predictions of the animal care staff at Kolmården Zoo were justified. It does seem as though the new diet does not fulfil the fibre content equivalent to the free-ranging moose diet, so further adjustment to the diet is needed. However, to state that these issues occur solely because of lack of fibre, is an oversimplification. The significantly higher proportion of cellulose found in captive moose faecal samples compared to free-ranging moose faecal samples indicate that the diet is not an appropriate diet for moose in winter. In terms of lignin, the proportion was found to be much higher in the faecal samples from free-ranging moose than from captive moose. Lignin is considered important for the moose digestive health and a low lignin content could be due to the lack of appropriate browse in the diet. In conclusion, these results indicate that the fibre composition in the current feed at Kolmården Zoo is not suitable for captive moose, but more investigations with larger sample sizes are required for generalisable results and to make recommendations. However, there are indications that moose husbandry practices need to be reconsidered and the feeding practices can be adjusted. Therefore, this study can help to increase the understanding of improved animal welfare for captive moose by extending the research toward future studies comparing both intake and output in captive as well as free-ranging moose, with larger sample sizes and longer data collection periods.

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Populärvetenskaplig sammanfattning

Älgar i djurpark har i åratal haft problem med diarré. Många studier har ägnats till att undersöka orsakerna och flera olika teorier har vuxit fram. En lösning har dock ännu inte funnits.

Älgar är växtätare och betar framför allt blad, örter och buskar. Näringssammansättningen hos växterna varieras mellan årstiderna. Under våren är andelen fibrer lägst medan de successivt ökar och är högst under vintern. Fibrer utgör de strukturella kolhydraterna i växternas cellväggar och brukar i stort sett delas upp i tre olika typer: hemicellulosa, cellulosa och lignin.

De främsta utmaningarna med älgar i djurpark är att behålla kroppsvikt och uppehålla träckkonsistens. Kolmårdens djurpark är en av många djurparker som håller älgar idag och som många andra har de länge haft problem med diarré. Som en ny lösning har de formulerat en ny foderblandning åt älgarna, med 3/8 älgpellets och 5/8 lucern. De hoppas denna nya mängd älgpellets, som är mindre än i tidigare blandningar, kommer minska diarrén hos älgarna. Genom att öka lucernmängden hoppas Kolmården att mängden hela fibrer i fodret ökar, vilket de tror kan vara orsak till diarrén.

Syftet med denna studie var att jämföra fiberhalten i totalt 30 träckprover från Kolmårdens älgar (n = 20) med träckprover från vilda älgar (n = 10). Detta är för att undersöka ifall fiberhalten i den nya foderblandningen är jämförbar med den i det vilda. Träckproverna samlades in över en period på fem veckor under februari – mars 2022. De olika fibertyperna hemicellulosa, cellulosa och lignin, analyserades kemiskt sedan och statistiska jämförelser utfördes.

Statistiskt signifikanta skillnader visades i flera olika fibertyper bland de två olika provgrupperna. Cellulosa var betydligt högre i proverna från Kolmårdens djurpark och lignin var betydligt lägre. Hemicellulosa visade ingen skillnad Dessa skillnader tyder på att fodret på Kolmårdens djurpark inte innehåller samma andel fiber som vilda älgar under vintern när de kan välja sin föda själva.

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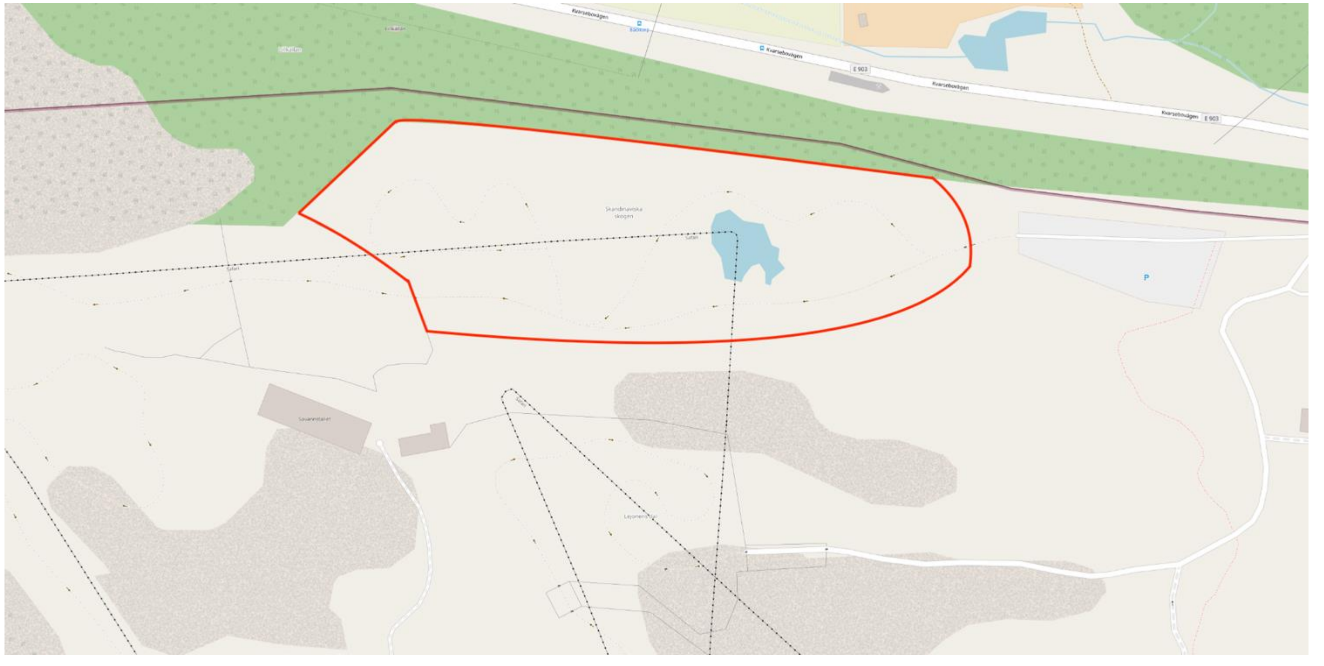
Appendix 1

Score 1 Well-formed and intact pellets.	
Score 2 Soft, but intact pellets.	
Score 3 Very soft and less defined shape but showing some texture.	
Score 4 Some texture but mostly loose and shapeless.	
Score 5 Loose, liquid, and shapeless diarrhoea.	

(Walldén 2022e)

Appendix 2



The enclosure is marked with a red line. The pond in the middle of the enclosure can be seen as well as the gondola track marked with a dotted line. The stables can be seen (Savannstallet) beneath the enclosure, the feed is prepared and transported to the enclosure. (QGIS.org 2022)

Appendix 3

Samples collected from free-ranging moose as well as samples collected from Kolmården Zoo are presented. The collection date is presented and the coordinates of the collection point or the name of the individual. All samples were collected during the collection period of 19th February – 27th March 2022.

Date	Sample				
19.2	Husavik	Freja			
21.2	Husavik	Mike			
25.2	Mike				
26.2	58.7014264, 16.4867150				
1.3	Freja				
3.3	Mike				
4.3	Husavik				
5.3	58.7009941, 16.4865350	58.7008644, 16.4867771	Freja	Mike (1)	Mike (2)
9.3	Husavik				
10.3	Mike				
14.3	58.9371888, 16.9381744	58.9353276, 16.9355019			
17.3	Mike				
19.3	58.9357262, 16.9354536	58.9358506, 16.9360994	58.9369592, 16.9387192		
21.3	Mike	Husavik			
22.3	Mike	Husavik			
27.3	58.9354037, 16.9353269	58.3960817, 16.9355509			

Appendix 4

Fibre analyses results of faecal samples from free-ranging moose in Södermanland, Sweden and captive moose from Kolmården Zoo, Sweden collected during February – March 2022. The sample name or collection location is presented as well as collection date. Dry matter (DM), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), cellulose and hemicellulose are all presented. DM is presented in percentage (%) and NDF, ADF, lignin, cellulose and hemicellulose are presented in % DM.

Sample no.	**Date**	**Sample name**	**DM**	**NDF**	**ADF**	**ADL**	**Cellulose**	**Hemicellulose**
1	26.2	58.7014264,16.4867150	24.53	64.95	41.69	18.58	23.11	23.26
2	5.3	58.7009941,16.4865350	75.17	70.07	49.93	23.11	26.81	20.15
3	5.3	58.7008644,16.4867771	25.88	68.41	52.47	22.43	30.04	15.94
4	14.3	58.9353276,16.9355019	30.39	70.28	54.09	26.60	27.49	16.20
5	14.3	58.9371888,16.9381744	25.93	71.66	56.39	34.07	22.32	15.27
6	19.3	58.9357262,16.9354536	25.72	64.24	51.19	27.89	23.29	13.06
7	19.3	58.9358506,16.9360994	29.78	65.44	52.53	28.57	23.96	12.90
8	19.3	58.9369592,16.9387192	23.86	71.92	57.88	29.80	28.08	14.04
9	27.3	58.9354037,16.9353269	22.07	76.19	61.44	32.41	29.03	14.75
10	27.3	58.3960817,16.9355509	20.40	73.02	58.97	32.96	26.01	14.05
11	19.2	Freja	25.21	62.80	45.57	15.14	30.43	17.23
12	1.3	Freja	22.04	61.54	44.71	14.26	30.45	16.83
13	5.3	Freja	26.41	64.06	46.65	15.34	31.31	17.41
14	17.3	Freja	19.00	60.90	43.11	13.46	29.65	17.79
15	21.2	Mike	20.23	53.23	38.77	11.38	27.38	14.46
16	22.2	Mike	15.66	57.89	42.53	13.37	29.16	15.36
17	25.2	Mike	18.78	61.71	44.34	13.18	31.16	17.36
18	3.3	Mike	19.07	60.23	43.80	13.20	30.60	16.43
19	5.3	Mike	10.99	59.78	43.38	13.09	30.28	16.40
20	5.3	Mike	31.01	58.44	42.36	13.22	29.14	16.08
21	10.3	Mike	16.99	54.72	39.52	11.04	28.48	15.20
22	17.3	Mike	21.79	49.62	33.64	9.06	24.58	15.98
23	21.3	Mike	21.38	64.73	47.49	15.67	31.82	17.24
24	22.3	Mike	22.84	58.99	42.84	13.87	28.96	16.16
25	19.2	Husavik	20.60	56.84	41.34	12.61	28.72	15.50
26	21.2	Husavik	7.29	48.49	34.50	10.17	24.32	13.99
27	4.3	Husavik	20.55	58.49	42.92	12.74	30.19	15.57

28	9.3	Husavik	18.30	58.49	43.08	12.42	30.66	15.41
29	21.3	Husavik	25.48	59.97	43.89	12.83	31.07	16.07
30	22.3	Husavik	24.93	54.73	39.12	11.67	27.44	15.62

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