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# Deterministic modelling of nitrogen utilisation by horses managed under pasture-based, intensive and semi-intensive systems with different levels of pasture intake.

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## Abstract

There are limited data on the average nitrogen (N) intake and N loss for the different classes of equine livestock, and the different equine production systems within New Zealand. Using a deterministic model, the total nitrogen excreted, and nitrogen partitioned into animal requirements, urine and faeces were estimated based on the crude protein requirement, digestible crude protein intake, and crude protein excreted in urine and faeces. Separate models were generated for five different livestock classes managed within three different production systems (commercial breeding farm, sport horse and racehorse). Overall, the N in diet (%), the modelled daily N intake and N losses varied with the percentage of pasture in the diet. The faecal N loss remained consistent (20-25%) across diets and horse classes whereas urinary N loss increased with daily N intake and percentage of pasture in the diet. Total N loss per day was estimated to be 0.18, 0.28, and 0.48 g N/kg body weight in racehorse, sport horse and Thoroughbred mares respectively. The N excretion per unit weight from young horses, racehorses and sport horses were substantially lower than that reported for ruminants. Therefore, horse-specific data should be used when modelling farm-level nitrogen excretion.

**Keywords:** equine; management systems; feeding; protein turnover; nitrogen excretion

## Introduction

Farm animals consume and utilize nitrogen (N) from crop or grain protein for maintenance and production (e.g., milk, growth). Surplus or undigested N will be excreted in urine and faeces. Nitrogen that is not utilised by plants or is deposited on non-fertile surface (e.g., races, bedding) can be converted into reactive form (ammonia, nitric oxide, nitrous oxide, nitrate) which can be volatilised into the atmosphere (ammonia, nitric oxide, nitrous oxide) and leached (nitrate) into ground and surface water (Galloway et al. 2003). Nitrate leaching will negatively affect water quality, and human and ecosystem health (Hubbard et al. 2004).

To monitor N leaching losses, nutrient budget models such as the 'OVERSEER' program are designed to estimate the balance of nutrient inputs and outputs, farm-level N leaching losses, and appropriate amount of fertiliser input (available on www.overseer.org.nz) (Cameron et al. 2017). The model takes account of animal N excretion when estimating farm-level N leaching losses for animal farming systems (Watkins & Selbie 2015).

At present, this model assumes that horses are equivalent to ruminants when estimating animal-level N losses. As a mono-gastric hindgut fermenter, horses utilise N differently from ruminants. Significant digestion and absorption of protein in the form of amino acids occurs in the small intestine, where there is no evidence of ability to utilise microbial protein in the hindgut, so the recycling and utilisation of non-protein N within the animal are considered minimal (Santos et al. 2011; Trottier et al. 2016).

Compounding this, different equine sectors (Thoroughbred, sport horses, racing) have management systems that vary in intensity. On Thoroughbred stud farms, breeding mares are managed on pasture (pasture as predominant feed source) while young horses (weanlings, yearlings) are provided with a mixture of pasture and premix feed or grains (concentrates) (Rogers et al. 2007; Rogers et al. 2017; Stowers et al. 2009). Racehorses and sport horses are managed using intensive (little or no pasture access) or semi-intensive (~50% DE requirement from pasture) systems (Bolwell et al. 2017; Verhaar et al. 2014; Williamson et al. 2007). Different levels of forage and grains, and protein content in the diet can alter the estimates of protein turnover (Karlsson et al. 2000), and subsequently, the N utilisation, and hence, the implications for property-level nitrogen leaching.

Currently, there is a lack of published data on N utilisation and excretion by horses. The objective of this study was to estimate and model the N utilisation and excretion of horses managed under different management systems within New Zealand.

## Methods

A deterministic model was developed to assess protein intake and N output for horses managed under commercial conditions at pasture in New Zealand.

### *Management and diet*

To simulate N excretion specific to management and dietary conditions of different horse classes, the management data and diets for Thoroughbred weanlings, yearlings, broodmares, sport-horses and racehorses were reviewed, collated and summarised in Table 1.

### *Model details*

The calculations used to obtain the total N excreted are as described in Table 2. Briefly, crude protein intake (Equation 4) and crude protein digested (Equation 5) were calculated to obtain crude protein excreted in faeces

**Table 1** Management and diets for different classes of horses (Thoroughbred weanlings and yearlings, pregnant and lactating Thoroughbred broodmares, sport horses and racing Thoroughbreds).

| Class | Management | Diet |
|---|---|---|
| Thoroughbred weanlings (179d) | [1,3,5]Weaning at 4-6 months of age | [3,5]Weanlings were kept on pasture and receive on average 2.9 (range 1-6) kg of concentrates. |
| Thoroughbred yearlings (360d) | [2]Yearling preparation begins between October and November. Ends at yearling sales in January-February the following year. | [1,2]Most farms used both stabling and pasture turn out allowing yearlings access to pasture up to 12 hrs per day. Fed premixed diets specified for yearling sales preparation providing up to 75% of daily digestible energy requirement. |
| Mature horses, broodmares (pregnant) | [3]Kept on pasture | [3]Solely pasture diet up to late pregnancy. Supplements fed are intended to meet other nutrient requirements (vitamins, minerals) rather than macronutrients and energy. |
| Broodmares (lactating) | [3]Kept on pasture | [3]Solely pasture diet. |
| Sporthorses | [6]Kept on pasture | [6]Pasture, concentrates (either in the form of premix feed or grains), with or without additional roughage, and conserved forages (hay/haylage). |
| Racehorses | [7]Stabled for >12 hours/day in a confined area (<5x5m) | [7]Fed 2-8 kg concentrate and <2.25-4.5 kg hay with little or no access to pasture. |

[1]Rogers et al. (2017), [2]Bolwell et al. (2010), [3]Rogers et al. (2007), [4]Fernandes et al. (2015), [5]Stowers et al. (2009), [6]Verhaar et al. (2014), [7]Williamson et al. (2007)

(Equation 3). Crude protein digested was then deducted with crude protein requirements to obtain crude protein excreted in urine. Protein requirements for different horse classes were calculated using Equation 8-17. The nitrogen excreted in faeces and urine was calculated by dividing urinary and faecal protein excretion values by 6.25 (Equation 2 and 6). Finally, total nitrogen excreted is nitrogen excreted in faeces plus nitrogen excreted in urine.

The crude protein intake was calculated based on DMI and crude protein content of food (Equation 4). Total daily DMI of animal was estimated based on percentage body weight (BWT). Modelling assumptions for BWT and DMI are as listed in Table 3. The assumptions for DMI were based on data from the published literature. The dry matter intake of Thoroughbred weanlings and yearlings raised in New Zealand were reported to be 2% BWT (Bishop 2013; Grace et al. 2002a; Grace et al. 2003). There is no available information on DMI of pregnant Thoroughbred broodmares fed pasture. However, the recommended DMI from NRC (2007) is 2% BWT for mature and pregnant horses. In addition, deterministic modelling has identified that the energy requirement of mature and pregnant horses fed pasture can be met with DMI of 2% BWT (Chin 2018). Cross sectional surveys of Thoroughbred racehorses in New Zealand have reported they were fed concentrate and conserved forages at around 2% BWT, with limited, or no, access to pasture (Williamson et al. 2007). For horse classes where diet consists of multiple feedstuffs, estimates of the amount fed for each feedstuff were obtained from the literature. The pasture DMI was then calculated by difference between total DMI and the known feed intake of other feeds consisted in the diet.

## Results

The N percentage in the diet, modelled N intake (kg/day), N losses in urine and faeces (kg/day, percentage N intake), N loss (g) per kg BWT, and % of N intake utilised in young Thoroughbred horses ($P_{100Y}$) and broodmares receiving 100% pasture ($P_{100m}$), young Thoroughbred horses ($P_{50y}$) and sport horses receiving 50% pasture ($P_{50s}$), and racehorses ($P_{11}$) receiving 11% pasture are presented in Table 4. Overall, the N in diet (%), the modelled daily N intake and N losses decreased with the percentage of pasture in the diet.

*Nitrogen intake*

The percentage of N in the diet was 2.2% in the $P_{100}$ diets, 1.7-1.8% in $P_{50y}$ diets, 1.6-1.8% in $P_{50s}$ diets and 1.3% in $P_{11}$ diet. The daily N intake of $P_{50y}$ was 0.15 kg/day and 35% lower than $P_{100Y}$ (0.23 kg N/day). The daily N intake of $P_{100m}$ was 0.40 kg/day, and was 33% and 45% higher compared to $P_{50s}$ (0.29 kg N/day) and $P_{11}$ (0.22 kg N/day).

*Total, urinary, and faecal nitrogen losses*

In $P_{100Y}$, 57% (0.13 kg N/day) of daily N intake was excreted where 33% (0.07 kg N/day) was lost in urine and 24% (0.05 kg N/day) lost in faeces. These N loss values are higher than those modelled for $P_{50y}$ where 34% (0.05 kg N/day) of daily N were excreted, with 14% (0.02 kg N/day) lost in urine and 21% (0.03 kg N/day) lost in faeces. For adult horses, the N loss in $P_{100m}$ was 69% (0.27 kg N/day) where 43% (0.17 kg N/day) was lost in urine and 25% (0.1 kg N/day) lost in faeces. Fifty percent of daily N intake was excreted by $P_{50s}$. The urinary loss was 28% (0.08 kg N/day) and the faecal loss was 22% (0.06 kg N/day). $P_{11}$ receiving lowest proportion of pasture in the diet (11%) had lowest N loss (41%, 0.09kg N/day) with 21% (0.046 kg N/day) urinary loss and 20% faecal loss (0.046 kg N/day). The faecal N loss remained consistent (20-25%) across diets and stock classes whereas urinary N loss increased with daily N intake and percentage of pasture in the diet. The N loss in grams per kg BWT showed a similar trend in response to changes in N intake and percentage of pasture in the diet (0.18g/kg BWT ($P_{11}$); 0.28g/kg BWT ($P_{50s}$); 0.48g/kg BWT ($P_{100m}$); 0.17g/kg BWT ($P_{50y}$); 0.40g/kg BWT ($P_{100y}$).

**Table 2** Equations used to model protein requirement, protein intake, protein digested, protein and nitrogen excreted in faeces and urine (kg/horse/day) by different classes of horses (Thoroughbred weanlings and yearlings, pregnant and lactating Thoroughbred broodmares, sport horses and racing Thoroughbreds).

| Total Nitrogen excreted | N excreted in faeces + Nitrogen excreted in urine | | Equation |
|---|---|---|---|
| Total N excreted (kg/horse/day) | Nitrogen excreted in faeces+ nitrogen excreted in urine | | 1 |
| N excreted in faeces (kg/horse/day) | Protein excreted in faeces/6.25 | | 2 |
| Protein excreted in faeces (kg/horse/day) | Crude protein intake – Crude protein digested | | 3 |
| Crude protein intake (kg/day) | DMI x Crude protein in food<br>Crude protein content: [1]22% (pasture), [2]13% (premixed diet, grains, hay) | | 4 |
| Crude protein digested (kg/day) | Crude protein intake x crude protein digestibility<br>Crude protein digestibility: [3]76% (pasture), [4]80% (concentrates, grains), [4]70% (hay/haylage),[5] 62% (yearling preparation diet) | | 5 |
| N excreted in urine (kg/horse/day) | (Protein digested – protein requirement)/6.25 | | 6 |
| Protein requirement (kg/day) | Maintenance requirement + physiological requirements | | 7 |
| Protein requirement (Growing horses) | [6]Maintenance | BWT x 1.44 g CP/kg BWT | 8 |
| | [6]Growth | ADG x 0.2<br>[7]ADG: 0.85 kg/day (150d), [7,8]0.63 kg/day (350d)<br>0.2: assuming 20% of daily gain is protein | 9 |
| Protein requirement (Mature horses) | [6]Maintenance | BWT x 1.26 g CP/kg BWT | 10 |
| Protein requirement (Pregnancy) | [6]Maintenance | BWT x 1.26 g CP/kg BWT | 11 |
| | [A]Pregnancy (2nd and 3rd Trimester) | Fetal gain = 0.283 kg/day | 12 |
| Protein requirement (Lactating broodmares) | [6]Maintenance | BWT x 1.44 g CP/kg BWT | 13 |
| | [6]Lactation | milk yield x [9,10,11,B]30 g CP/kg milk | 14 |
| | | [C]Milk yield: 13.6 kg/day | 15 |
| Protein requirement (Exercise) | [6]Maintenance | BWT *1.44g CP/kg BWT | 16 |
| | [6]Exercise | (BWT x muscle gain) + (BWT x sweat loss x 7.8g CP/kg sweat) | 17 |
| | | Muscle gain (moderate exercise): 0.177 g CP/kg BWT<br>Sweat loss (moderate exercise): 0.5% BWT | |

[1]Seasonal average CP% of equine pasture reported in Hirst (2011), [2]Pagan (1998), [3]Grace et al. (2002a), [4]Kienzle et al. (2002), [5]Bishop (2013), [6]NRC (2007), [7]Morel et al. (2007), [8]Grace et al. (2003), [9]Mariani et al. (2001), [10]Csapó et al. (2009), [11]Malacarne et al. (2002)
[A] Fetal gain was modelled using the model proposed by NRC (2007) and an average fetal gain was obtained for 2nd and 3rd trimester.
[B] Crude protein per kg milk fluctuated around 20-32 g/kg milk with highest CP content during early lactation and decreases as pregnancy progress.
[C] Milk yield was modelled using mare lactation curve proposed by NRC (2007) and an average value was obtained for the first 5 months of lactation.
BWT=body weight
CP=crude protein

## Discussion

To date, this is the first deterministic equine model for N utilisation. The DMI, crude protein content of feed, and crude protein digestibility used in this model were based on a limited number of available reports (Table 2 and 3). The substitution of supplement for pasture and its effect on DMI in horses has not been well described in the literature and may vary due to pasture quality and quantity on offer. Therefore, this model assumes that animals will consume food to their recommended total daily DMI. Using this assumption, pasture DMI is the residual value after the DE from all other feed sources is deducted from recommended DE requirement. This assumption has been previously used when estimating the relative contribution of different feed sources to total DE (Verhaar et al. 2014). These values do not represent the actual amount consumed. Feeding levels did not affect digestibility of crude protein in horses (Martin-Rosset & Dulphy 1987). However, the modelled N intake could be affected by potential disparity between amount of feed offered and the actual amount eaten.

Studies in ponies showed that protein from hay of different quality affected the relative, small and large intestine protein digestion and affected the N utilisation. High-protein alfalfa hay had a greater pre-caecal digestibility compared to other types of hay, and promoted more-efficient N utilisation (Gibbs et al. 1988). In this

**Table 3** Modelling assumptions for body weight (kg), the total daily dry matter intake (kg DM/day), the dry matter intake (kg DM/day) from pasture, and other feed supplements (concentrates and conserved forages) of different classes of horses (Thoroughbred weanlings and yearlings, pregnant and lactating Thoroughbred broodmares, sport horses and racing Thoroughbreds).

| Diet | Weight (kg) | Total Daily DMI (% BWT) | [A]Daily DMI (kg/day) | DMI from other supplements (kg/day) | Pasture (kg DM/day) |
|---|---|---|---|---|---|
| Thoroughbred model | | | | | |
| Pasture | | | | | |
| Weaning (179d) | [1]261 | [1]2 | 5.22 | - | |
| Yearling (360d) | [1]377 | [2,7]2 | 7.54 | - | |
| Mature horse, Broodmare, pregnant | [3,4]560 | [5]2 | 11.2 | - | 11.2 (100) |
| Broodmare, lactating | [4]560 | [4]2.5 | 14 | - | 14 (100) |
| Mixed | | | | | |
| Weaning (179d) | [1]261 | [1]2 | 5.22 | [8]2.9 | [D]2.6 (50) |
| Yearling (360d) | [1]377 | [2,7]2 | 7.54 | [B]4.5 | [D]3 (40) |
| Sport horse model | | | | | |
| Mixed | | | | | |
| Eventing | [9]524 | [5]2 | 10.48 | [C,9]4.8 | [D]5.68 (54) |
| Show jumping | [9]531 | | 10.62 | [C,9]5.8 | [D]4.82 (45) |
| Dressage | [9]550 | | 11 | [C,9]7.1 | [D]3.9 (35) |
| Racehorse model | [10,11]500 | [12]2 | 10 | [C,12]7.88 | [D]1.12 (11) |

[1]Grace et al. (2003), [2]Grace et al. (2002a), [3]Pagan et al. (2009), [4]Grace et al. (2002b),[5]NRC (2007), [6]Oftedal et al. (1983), [7]Bishop (2013), [8]Rogers et al. (2007), [9]Verhaar et al. (2014),[10]Southwood et al. (1993), [11]Suagee et al. (2008),[12]Williamson et al. (2007)

[A] Calculated by percentage of body weight.

[B] Calculated by assuming concentrates provide 75% of energy requirements of yearlings (Rogers et al. 2017).

[C] Total DMI from concentrates, and other conserved forages.

[D] Calculated by difference (daily dry matter intake – dry matter intake of other supplements).

DMI=dry matter intake

values in () are percentage of pasture in the diet.

model, the crude protein digested is calculated based on apparent digestibility and assumed to be bioavailable. Assuming microbial protein is not available to the horse (Santos et al. 2011) and non-protein N absorbed from hindgut is utilised less efficiently than dietary protein (Reitnour & Salsbury 1972), then the N available (protein digested) thus the modelled N balance (N excreted in urine) can be overestimated. However, there are few reports on pre-caecal and caecal-colon digestion of different equine feedstuffs. The extent of non-protein N utilisation is currently unclear due to lack of understanding of nitrogen metabolism in horses (Santos et al. 2011). Hence, these factors cannot be included for modelling until the nitrogen metabolism in the equine is fully elucidated.

There are few reports on N excretion in horses. N excretion in horses is reported by different sources to be 0.12 kg N/day (Bouwman et al. 1997) and 0.095 (Smil 1999) (values calculated from annual N excretion values). Values reported by Bouwman et al. (1997) were calculated by difference (N intake – N requirements, maintenance requirements are proportionate to metabolic BWT) and assumed nitrogen excretion of horses is similar to that of buffalo. The data presented by Smil (1999) only accounted for faecal N and the values were estimated for a 400-kg horse using amount of faeces produced per day and assumed faeces contained 3% nitrogen. The estimation by Smil (1999) agrees with the faecal N loss modelled for mature horse in this study. Whereas, Bouwman et al. (1997) reported a lower total N excretion rate than the modelled results, possibly due to differences in protein requirements per unit metabolic BWT, protein intake and digestive system difference (mono-gastric vs ruminant) between buffalo and horses (Illius & Gordon 1992; Kurar & Mudgal 1981).

In this model, the crude protein percentage of pasture (22%) is higher than that of supplement feeds (13%). Hence, reduction in the percentage of pasture offered in the diet reduced N percentage of the diet, and the daily N intake. The faecal N losses decreased with level of pasture in the diet because crude protein digestibility of pasture (76%) was lower than that in the supplement feeds (80%). Therefore, in the mixed diets modelled, the urinary losses decreased with lower N intake along with greater amount of crude protein digested. In a study that measured N excretion in Standardbred geldings through urine collections, increase in proportion of hay which had lower crude protein content (6.5%) compared to oats (13%) led to lower daily N intake and urinary N loss (Karlsson et al. 2000). The lower urinary N loss observed, however, did not occur with increased digestibility in the diet as the crude protein digestibility of diets decreased with forage content. In contrast, increased crude protein digestibility reduced the urinary N loss (39.5 g/day vs 52.7 g/day) in ponies even when N intake increased (59.6 g/day vs 71.4

**Table 4** The daily nitrogen intake (kg/day), the total, urinary and faecal nitrogen excretion (kg/day) and nitrogen utilisation (%) by different classes of horses (Thoroughbred weanlings and yearlings, pregnant and lactating Thoroughbred broodmares, sport horses and racing Thoroughbreds) modelled under different management systems.

| Management systems/ horse classes | Daily nitrogen intake (kg/day) | Total daily nitrogen excretion (kg/ day) | Urinary nitrogen loss (kg/day) | Fecal nitrogen loss (kg/day) | Total nitrogen excretion (g/kg BWT) | N utilisation (%) |
|---|---|---|---|---|---|---|
| Thoroughbred stud farm model, young horses | | | | | | |
| 100% pasture ($P_{100Y}$) | 0.185(2.2) | 0.098(53) | 0.05(29) | 0.044(24) | 0.38 | 47 |
| Weanling | 0.268(2.2) | 0.161(60) | 0.097(36) | 0.064(24) | 0.43 | 40 |
| Yearling | 0.23 | 0.13(57) | 0.07(33) | 0.05(24) | 0.40 | 43 |
| Average | | | | | | |
| 50% pasture ($P_{50Y}$) | 0.143(1.8) | 0.055(38) | 0.024(16) | 0.032(22) | 0.21 | 62 |
| Weanling | 0.157(1.7) | 0.05(31) | 0.018(11) | 0.031(20) | 0.13 | 69 |
| Yearling | 0.15 | 0.05(34) | 0.02(14) | 0.03(21) | 0.17 | 66 |
| Average | | | | | | |
| Thoroughbred stud-farm model, 100 % pasture ($P_{100m}$) | | | | | | |
| Mature horse/empty mare | 0.398(2.2) | 0.285(71) | 0.189(47) | 0.095(24) | 0.51 | 29 |
| Broodmare, pregnant | 0.398(2.2) | 0.224(75) | 0.128(43) | 0.095(32) | 0.40 | 25 |
| Broodmare, lactating | 0.497(2.2) | 0.303(61) | 0.184(37) | 0.119(24) | 0.54 | 39 |
| Average | 0.40 | 0.27(69) | 0.17(43) | 0.1(25) | 0.48 | 31 |
| Sport horse model, 50% pasture($P_{50S}$) | | | | | | |
| Show jumping | 0.290(1.8) | 0.149(51) | 0.084(29) | 0.065(22) | 0.28 | 49 |
| Dressage | 0.267(1.7) | 0.121(45) | 0.062(23) | 0.059(22) | 0.22 | 55 |
| Eventing | 0.312(1.6) | 0.173(55) | 0.103(33) | 0.07(22) | 0.33 | 45 |
| Average | 0.29 | 0.147(50) | 0.08(28) | 0.06(22) | 0.28 | 50 |
| Racehorse model, 11% pasture ($P_{11}$) | 0.224(1.3) | 0.092(41) | 0.046(21) | 0.046(20) | 0.18 | 59 |

Values in () represents % of nitrogen in diet and nitrogen loss in % of daily intake
BWT=body weight

g/day) (Gibbs et al. 1988). Modelling results from this study, and those reported by other studies, show that the feeding management influences the dietary variables (N intake and digestibility) and will affect the N balance based on N requirement of different horse classes. Protein turnover varied greatly among studies due to differences in diet composition, protein quality, age and activity levels (Freeman et al. 1988; Gibbs et al. 1988; Glade & Biesik 1986; Karlsson et al. 2000). Therefore, the modelled results can only be applied to the specific equine stock classes and feeding systems referred to in this study.

Based on a report from the Ministry of Primary Industry for nitrous oxide inventory development (Luo & Kelliher 2014), the total N excreted in dairy cattle, beef cattle, and sheep were 0.31, 0.202, and 0.04 kg N/animal/day, respectively. Assuming an average BWT of adult dairy cattle, beef cattle, and sheep are 600 kg, 500 kg, and 65 kg respectively, the N excreted would be 0.52 g/kg BWT, 0.40 g/kg BWT and 0.62 g/ kg BWT, compared to 0.18, 0.28, and 0.48 g N/kg BWT in racehorse, sport horse and Thoroughbred mares respectively. The N excreted per kg BWT for growing-finishing beef cattle (calculated with finishing weight), growing dairy cattle, and lambs were around 0.33, 0.43, 0.50 g N/kg BWT (Grenet 1983; Guo & Zoccarato 2005; Phillips et al. 1995; Zanton & Heinrichs 2009), compared to 0.17 g N/kg BWT in young Thoroughbred horses (fed mixture of concentrate and pasture) ($P_{50Y}$). The modelled N excretion per unit BWT in Thoroughbred mares was similar to values in beef cattle and dairy cattle and was lower than those of sheep. The N excretion per unit weight from racehorses, sport horses and young Thoroughbred horses were substantially lower than that for ruminants. Therefore, horse-specific values should be used when estimating N excretion.

The lower N excretion/kg body weight can be due to higher N utilisation in horses. The percentage of N intake excreted were reported to be 73.2% (dairy cattle), 65.9% (beef cattle and sheep), 76% (growing cattle), 86% (growing sheep) hence translating to N utilisation of 26.8% (dairy cattle), 34.1% (beef cattle, sheep), 24% (growing cattle), 14% (growing sheep) (Grenet 1983; Luo & Kelliher 2014; Zanton & Heinrichs 2009). These values are much lower than the N utilisation estimated by this model in Thoroughbred mares, sport horses, racehorses, and young Thoroughbred horses (31%, 50%, 59%, 43%($P_{100Y}$), 66% ($P_{50Y}$), respectively). This higher utilisation in horses was due to lower urinary N loss and a similar faecal N loss compared to ruminants. The supplementation of pasture in the diet with conserved forage and concentrates increased the disparity between the ruminant data and the horse data.

## Conclusion

Based on the comparison between the modelled results and ruminant values, the N utilisation in horses were generally higher than that of ruminants. Our model showed that the different feeding systems alter the quantity and proportion of pasture and other feedstuffs (concentrates and conserved forages) which in turn affect the nitrogen content and digestibility of the diet. The different stock classes varied in physiological demands for nitrogen. Together, they influenced N utilisation in the horses. Therefore, modelling N excretion of horses needs to correspond to the feeding management and stock class. This model estimates N output at animal level and does not reflect farm-level N output and leaching potential. To estimate the farm-level N leaching, information on stocking density, pasture, grazing and manure management on equine farms is required. At present, there are limited reports on these farm variables for equine properties and no studies have been done to investigate their impact on N leaching in soil.

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