Soil by Grazing Sport Horses

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Soil ingestion has been well documented for the majority of outside reared animals but not in horses. As soil can be a vector of environmental pollutants, such studies generally aim at controlling exposure to pollutant uptake in food producing animals.

Keywords: soil ingestion ; equids ; herbage offer ; health ; pasture ; welfare

1. Introduction

In general, soil ingestion has no nutritional purpose except counterbalancing significant mineral deficits described as geophagia [1]. Nevertheless, it has some negative consequences. Firstly, global digestibility of the feed decreases as soil is very poor in organic matter, and its presence in the digestive tract disturbs the digestive flora. However, the main risk is that soil may be a vector of environmental pollutants, which can accumulate over a very long time in soil and is therefore one of the principal exposure pathways to food producing animals [2]. Hence, the evaluation of soil ingestion is a central point in risk assessment approaches. It has been studied in numerous food producing animals such as dairy cows [3][4], beef cattle [5][6], sheep [7][8], free-range pigs [9], free-range hens [10] and chicken [11]. Nevertheless, no such data are available in horses. In this species, the frame of food safety evaluation would not really match since consumption of horsemeat is—except in Central Asia (e.g., China, Kyrgyzstan, and Kazakhstan)—very low. Even if this reduced issue of food safety can explain the lower interest of the scientific community to study soil ingestion in horses, there are pathologic concerns justifying investigations. Indeed, superficial soil can carry an important amount of microorganisms in the stomach. Its relatively high pH would not very efficiently limit microbial growth. In addition, a deposit of ingested soil may sensitively reduce the relatively small volume of the horse's stomach. Moreover, Kilcoyne et al. [12] and also Niinstro et al. [13], both describe pathologic consequences such as sand colic or eroded intestinal mucosal lining without quantifying the responsible amount of ingested sand. Siwinska et al. [14] reported proportions of sand in stool but did not evaluate the corresponding level of ingestion. Thus, the ingestions of soil and sand by horses and its pathologic consequences has been clearly shown but no available data allows more accurate evaluation in horses.

Animals of comparable size, such as adult cattle, may ingest 30 to 100 g of dry soil per 100 kg of BW daily [3][6] under classical pasture conditions, and even up to 150 g per 100 kg of BW under poorer conditions [4][15], but the grass prehension differs notably between both species. Indeed, the height of the available grass is objectively measured with a herbometer and expressed as sward height (SH). It has been shown in ruminants that sward height (SH), especially post-grazing, is a good predictor of the level of soil ingestion [4][6]. Indeed, the shorter the grass sward, the closer to ground surface do animals graze and can consequentially ingest more soil along grass prehension. The anatomy of the equine mouth (i.e., movable lips and presence of maxillary) allows them to graze closer to the ground surface in comparison to cattle. This raises the following questions: Would the ingestion of soil by horses also increase when grass offered decreases, or would the difference of grass prehension between both species not (or less) expose horses to an increased risk of soil ingestion?

2. Grazing Parameters and Body Weight

The pre-grazing sward height was 11.9 cm without any difference between the three treatments (**Table 1**). Contrarily, after grazing, the sward height at the lowest DHA was 3.1 cm and was significantly lower than the 4.4 cm at the highest DHA. The post-grazing SH at the intermediate DHA (i.e., 3% of the BW) of 4.1 cm did not significantly differ from the other treatments (**Table 1**). Nevertheless, the post-grazing SH tended to be lower between the lowest and the two higher DHAs (3.1 cm for 2% vs. 4.1 cm for 3% and 4.4 cm for 4%, $p < 0.10$).

Table 1. Ingestion of grass and soil depending on the Daily Herbage Allowance (DHA, % of the body weight), period and DHA × period interaction.

Variable	DHA Level			Residual Variation [1]		*p*-Value		
	2%	3%	4%	RSD	RSE	DHA	Period	DHA × Period
Grazing								
Pre-grazing sward height (cm)	12.0	12.2	11.5	-	0.9	NS	-	-
Post-grazing sward height (cm)	3.1 ^{bB}	4.1 ^{abA}	4.4 ^{aA}	-	0.7	*	-	-
Grass AIA [2] content (g/kg DM [3])	17.2	18.9	19.2	-	4.2	NS	-	-
Grass intake (kg DM/d)	14.0	15.2	14.4	1.0	-	NS	NS	NS
Body weight (kg)	610 ^{b}	630 ^{a}	628 ^{a}	7.3	-	**	NS	NS
Faeces								
Faecal output (kg DM/d)	7.5	8.0	7.7	0.2	-	NS	NS	NS
DM digestibility of ingested grass	0.466	0.476	0.470	0.01	-	NS	*	NS
DM digestibility of total diet	0.470	0.480	0.473	0.01	-	NS	*	NS
Faecal AIA content (g/kg DM)	60.3 ^{a}	55.3 ^{ab}	51.1 ^{b}	4.5	-	*	**	NS
Soil AIA content (g/kg dry soil)	697 ^{A}	678 ^{B}	697 ^{A}	-	13.9	*	-	-
Daily Soil Ingestion								
SIR [4] (% of total DM ingested)	4.5 ^{a}	4.1 ^{ab}	3.7 ^{b}	0.4	-	*	**	NS
Absolute QIS [5] (g/horse)	648 ^{a}	624 ^{a}	543 ^{b}	54.3	-	*	***	NS
Relative QIS (g/100 kg BW)	107 ^{a}	99 ^{ab}	89 ^{b}	9.5	-	*	***	NS
Relative QIS (g/kg metabolic BW)	5.3 ^{aA}	5.0 ^{abA}	4.4 ^{bB}	0.5	-	*	***	NS

Significance of *p*-Values for tested effects was <0.05 for *, <0.01 for **, <0.001 for *** and >0.05 for NS (non-significant); ^{a,b} Values within a row with different superscripts (lowercase letters) differ significantly at $p < 0.05$; ^{A,B} Values within a row with different superscripts (capital letters) differ significantly at $p < 0.1$; [1] Mixed models on individual data gave a residual standard deviation (RSD) but simple models on plot data (two animals grazing together) resulted in residual standard error (RSE); [2] AIA: acid insoluble ash; [3] DM: dry matter; [4] SIR: soil ingestion rate; [5] QIS: quantity of ingested soil.

The horses had a lower body weight on the smallest DHA in comparison to the two higher DHAs, 610 and 629 kg, respectively ($p < 0.05$).

The AIA content of the allowed grass of 18 g/kg DM on average did not significantly differ between treatments. In soil, there was a slightly lower content of AIA in the plots pastured for the intermediate treatment (678 vs. 697 g/kg dry soil) but this very small difference did not reach the significance threshold ($p = 0.07$). Thus, the marker fraction AIA was 40 times more concentrated in soil than in the pastured grass (**Table 1**) allowing us to efficiently mark the soil.

3. Grass Intake and Faecal Output

The grass intake of the animals of 14.5 kg DM/d did not differ significantly between the treatments (**Table 1**) even if the raw mean between the lowest treatments differed by 1.2 kg/d (14.0 and 15.2 kg/d respectively for the DHAs of 2 and 3%, $p > 0.10$). The digestibility of the ingested grass did not differ between the three treatments with 0.47 on average (**Table 1**), but varied slightly between the second and the third period of the experiment (0.46 and 0.48 respectively, $p < 0.05$). In addition, the faecal output of 7.7 kg DM/d on average did not differ between treatments (**Table 1**). The AIA content in the faeces decreased significantly from the lowest to the highest DHA (from 60.3 to 51.1 g/kg DM respectively, $p < 0.05$) with an intermediate concentration of 55.3 g/kg DM (NS) for the DHA of 3% (**Table 1**). It is worth mentioning that horses during the first experimental period had significantly lower AIA contents in their faeces than during the periods 2 and 3 (respectively 47.9 and 59.4 g/kg DM, $p < 0.01$) but without any significant interaction with the treatment (**Table 1**).

4. Ingestion of Soil

The soil ingestion rate (SIR) increased significantly when the DHA decreased, from 3.7% at the highest DHA to 4.5% at the DHA of 2% ($p < 0.05$, **Table 1**). The horses had an intermediate SIR of 4.1% at a DHA of 3%, which did not significantly differ to the other treatments. In addition, the SIR was significantly ($p < 0.05$) lower during the first experimental period (3.3%) compared to the other two periods (4.5%) without any interaction to the treatment (**Table 1**).

The quantity of ingested soil (QIS) increased significantly ($p < 0.05$) from 543 g/d at the highest DHA to 636 g/d at the two more restrictive DHAs (**Table 1**). The slight numeric difference between the DHA treatments of 2 or 3% did not reach the significance threshold ($p > 0.10$). The relative soil ingestion per 100 kg of BW followed the same hierarchic order between the treatments (**Table 1**): highest for the lowest DHA at 107 g/100 kg BW and was significantly ($p < 0.05$) higher than for the highest DHA at only 89 g/100 kg BW. Horses had an intermediate relative QIS at the intermediate DHA at 99 g/100 kg BW, which did not differ significantly from the two other treatments.

Absolute and relative QIS are significantly affected by the experimental period ($p < 0.001$) but every time without any interaction with the treatment (**Table 1**). In both cases, QIS in the first experimental period was significantly lower (484 g/d and 79 g/100 kg BW respectively for absolute and relative QIS) than during the periods 2 and 3 (666 g/d and 108 g/100 kg BW respectively for the absolute and relative QIS).

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