Equine vet. J. (2005) **37** (4) 351-355

Risk factors for faecal sand excretion in Icelandic horses

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Keywords: horse; sand sedimentation; faecal sand; sand colic; sandy soils; pasture quality; risk factor

Summary

***Reasons for performing study*: Sandy soil is often mentioned as a risk factor in the development of sand-related gastrointestinal disease (SGID) in the horse. There are other variables, but few studies confirm any of these.**

***Objective*: To investigate soil type, pasture quality, feeding practice in the paddock, age, sex and body condition score as risk factors for sand intake in the horse.**

***Methods*: Faeces were collected from 211 Icelandic horses on 19 different studs in Denmark together with soil samples and other potential risk factors. Sand content in faeces determined by a sand sedimentation test was interpreted as evidence of sand intake. Soil types were identified by soil analysis and significance of the data was tested using logistic analysis.**

***Results*: Of horses included in the study, 56.4% showed sand in the faeces and 5.7% had more than 5 mm sand as quantified by the rectal sleeve sedimentation test. Soil type had no significant effect when tested as main effect, but there was interaction between soil type and pasture quality. Significant interactions were also found between paddock feeding practice and pasture quality.**

***Conclusion*: To evaluate the risk of sand intake it is important to consider 3 variables: soil type, pasture quality and feeding practice. Pasture quality was identified as a risk factor of both short and long grass in combination with sandy soil, while clay soil had the lowest risk in these combinations. Feeding practice in the paddock revealed feeding directly on the ground to be a risk factor when there was short (1–5 cm) or no grass. Also, no feeding outdoors increased the risk on pastures with short grass, while this had no effect in paddocks with no grass. More than 50% of all horses investigated in this study had sand in the faeces.**

***Potential relevance*: The identification of risk factors is an important step towards prevention of SGID. Further research is necessary to determine why some horses exhibit more than 5 mm sand in the sedimentation test and whether this is correlated with geophagic behaviour.**

Introduction

Sand-related gastrointestinal disease (SGID), such as colic caused by colonic impaction and diarrhoea, seems to be more prevalent in certain areas such as Florida and California, USA. Sandy soils are frequently mentioned as a potential risk factor for these conditions (Colahan 1987; Ott 1987; Ragle and Meagher 1987; Sullins 1990; Lieb 1997; Edwards 1999; Hanson 2002). Although SGID is well known to European equine clinicians, there are few reports of this condition from Europe, those existing having been conducted primarily by Finnish researchers (Rouhoniemi *et al*. 2001; Korolainen and Ruohoniemi 2002). Other potential risk factors such as season, quality of pasture (Colahan 1987; Ott 1987; Specht and Colahan 1988), feeding aspects (Ramey and Reinertson 1984; Ott 1987; Sullins 1990; Lieb 1997), geophagic behaviour (Specht and Colahan 1988; McGreevy *et al.* 2001) and physiopathological subjects have been mentioned (Bertone *et al.* 1988).

The main objective of this study was to investigate the influence of soil type on the risk of ingestion of sand. The demonstration of sand in the faeces by faecal sand sedimentation was used as a marker for sand intake. Other factors included individual characteristics, quality of pasture and feeding practice in the paddock. This study included only Icelandic horses, as this breed is kept at pasture throughout most of the year in Denmark and is therefore considered suitable for investigation of pasture-related risk factors.

Materials and methods

Epidemiological design

Faecal samples were collected during October and November 2003 in this retrospective cohort study. The total number of faecal samples was based on simulations using logistic analysis based on expected prevalences of horses demonstrating faecal sand on the different soil types. Farm, paddock number, pasture quality, feeding practice in the paddock, sex, age and body condition score were also included as biologically relevant variables. A total test population of a minimum of 200 animals from a minimum of 15 farms was determined as a sufficient sample size. Soil type was regarded as the primary variable of the study.

Farms and horses

From a map defining the soil types of Denmark, potential areas of sandy and clay soils were determined (Smed 1981). Stud owners of Icelandic horses in these areas were contacted. The criteria of selection were a minimum of 10 horses at the stud, a paddock turn-out time of minimum 8 h daily and no change of paddock within the last 3 weeks. No anthelminetic administratiion was

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[Paper received for publication 21.03.05; Accepted 24.05.05]

TABLE 1: Categories of the 'standardised sand sedimentation test': 200 g faeces dissolved in 1 l water in a rectal sleeve, hung up and evaluated after 20 mins of sedimentation

Sand test category	Subjective evaluation
0	No sand (visually and palpably)
1	0.5–5 mm (minimum recognisable layer of sand)
2	5–10 mm (minimum of one finger)
3	10–20 mm (minimum of one finger)
4	>20 mm (minimum of one finger)

allowed in the 3 weeks prior to the sampling. Feeding practice in the paddock (no feeding, feeding directly on the ground or in a crib [feeding trough] outside) were noted during the visit. An equal distribution of horses of different sex and age was intended when selecting the individuals. Each animal's condition was scored at the visit (Henneke *et al.*1983).

Sand sedimentation test

As a pilot project, the sand sedimentation test intended for faecal testing was standardised and validated. The test procedure used a rectal sleeve containing the suspension of 200 g faeces in one litre of water. The test was read after leaving the sleeve vertically, allowing the sand to sediment, for 20 mins. Validation of this test was conducted by comparing the test results of 100 faecal samples to the results of retrieving sand from the same individual faecal sample by decantation (gold standard). Decantation was evaluated as a gold standard by applying 0, 5 and 10 ml sand to 3 portions of the same faecal sample. Recovery of at least 95–97% of the sand applied to the samples using decantation in 3 rounds confirmed its use as a gold standard test. A comparision of the 2 methods showed highly significant correlation.

Faecal samples

A minimum of 200 g faeces were collected either rectally or from freshly deposited manure from an identified horse or foal noted with Farm ID number, Horse ID and paddock number. Within 24 h, the standardised sand sedimentation test was performed with the sand quantity expressed as a category (Table 1).

Soil samples

A soil sample, composed of 4 or 5 spade cuts to a depth of approximately 15 cm, was collected from each paddock. After airdrying, the fine-earth fraction (<2 mm) was collected by sieving. The contents of clay, silt, fine sand and coarse sand were determined using the combined sieving and hydrometer method (Borggaard *et al.* 2003). The organic fraction was quantified by carbon analyser (ELTRA CS 500)[1]. Samples were categorised according to their texture and organic carbon content (Table 2). The categories used were based on 'The Danish Soil Classification' which expresses the content of clay, silt, fine sand, total sand and organic carbon content (Breuning-Madsen *et al.* 1992).

Pasture quality

Length of the grass was measured at 10 different sites in the paddock (on 2 diagonals). On each diagonal, samples were taken every 10–20 m. The average grass length was used to categorise the paddock into one of 3 groups: *type 1* = no grass (dirt paddock); *type 2* = sparse grass (average length 1–5 cm); and *type 3* = long grass (>5 cm).

Statistical analyses

The null hypothesis of no association between sand detected in faeces and every independable variable was examined initially using a univariable logistic analysis (proc logist) and the likelihood ratio χ^2 test procedure (SAS version 8.2)[2]. A positive sand detection was classified as sedimentation category >0. Single independent variables which demonstrated P values <0.25 were included in the multivariable start model. Excluded variables were re-investigated for any confounding effect by single introductions into the preliminary start model before final exclusion (Hosmer and Lemeshow 2000). The final model was found by introducing the significant variables and their possible interaction combinations, followed by a manual reduction of the most insignificant items. The best fitted model that describe the association with the fewest significant variables (P<0.05) was:

$$\text{Logit } (P(X)) = Y = \alpha + A_i + B_j + \ldots + F_k$$

where P (X) = estimated probability for sand category >0; α = intercept (general level) and A_i, B_j … F_k = estimates for F significant variables (at n = i, j … k levels).

The significance of every variable tested in the final model was examined using the procedure 'genmod' in SAS[2], in which the use of 'least square means' provides estimates for each level.

Results

Descriptive analysis

Nineteen Icelandic horse stud farms in Denmark participated in this study. Of 225 individual faecal samples, 211 were included; 14 were excluded due to insufficient sample material. In faeces

TABLE 2: Categorisation of soil types (particle size in parentheses); weight percentage relates to the distribution of soil particles

Soil category	Weight percentage: Clay content (<2 µm)	Silt (2–20 µm)	Fine sand (20–200 µm)	Total sand (20–2000 µm)	Humus (58.7% C)
Coarse sand	0–5	0–30	0–50	75–100	≤10
	5–15		0–40	55–95	
Fine sand	0–5	0–30	50–100	75–100	≤10
	5–15		40–95	55–95	
Clay and silt	>15	0–100	-	40–85	≤10
Organic soil					>10

Modification after 'The Danish Soil Classification' (Breuning-Madsen *et al.* 1992).

TABLE 3: Descriptive analysis of variables regarded as biologically potential risk factors of sand detection in 211 faecal samples

Variable	Total no. observations	Sand detected (n)	Prevalence (%)	No sand detected (n)	Prevalence (%)
Sex					
Mare	107	61	57.0	46	43.0
Stallion	21	9	42.9	12	57.1
Gelding	83	49	59.0	34	41.0
Age (years)					
0–3	32	16	50.0	16	50.0
4–7	77	44	57.1	33	42.9
8–11	54	30	55.6	24	44.4
12–16	32	19	59.4	13	40.6
>16	16	10	62.5	6	37.5
Condition score					
4	7	5	71.4	2	28.6
5	91	48	52.7	43	47.3
6	84	49	58.3	35	41.7
7	24	14	58.3	10	41.7
8	5	3	60.0	2	40.0
Soil type*					
Coarse sand	84	54	64.3	30	35.7
Fine sand	85	51	60.0	34	40.0
Clay/silt/organic	42	14	33.3	28	66.7
Pasture quality*					
No grass	58	37	63.8	21	36.2
Sparse grass	95	45	47.4	50	52.6
Long grass	58	37	63.7	21	36.2
Feeding practice in paddock*					
No feeding	71	39	54.9	32	45.1
On ground	71	50	70.4	21	29.6
Outdoor crib	69	30	43.5	39	56.5

*P<0.25 in univariable logistic analysis, included in multivariable start model.
n = No. of horses.

from 119/211 (56.4%) horses, sand was detected using the sand sedimentation test. In 5.7% of all horses, more than 5 mm sand (category 2–4) was found.

The prevalence of sand detected in the faecal samples for the independent variables is shown in Table 3. Age of horses was 3 months–31 years (average 8.4 years). Texture analyses categorised the 51 paddocks as 17 coarse sand, 20 fine sand and 13 clay/silt. Only one paddock was classified as organic soil and it is included in the clay/silt category as a reference group for the sandy soil types.

Logistic analysis

Only the estimates for the variables soil type, pasture quality and feeding practice in the paddock showed P values <0.25 in the univariable analysis (Table 3) and were included in the multivariable start model. No horse individual variables were found to be significant in the study. The final and reduced model included 2 significant interactions between pasture quality and soil type (P = 0.0071) and pasture quality and feeding practice (P = 0.0051). The 19 stud farms and 51 paddocks could not be analysed as individual variables, due to the low number of observations in each level.

The procedure 'genmod' (SAS)[2] revealed the estimates of the 3 levels of each variable. The estimated probabilities for being sand-positive were calculated from P (X) = 1/1 + exp(- estimate) and are shown in Figures 1 and 2. In view of the complicated model, pasture quality was used for definition of the groups, as this variable was found in both the significant interactions.

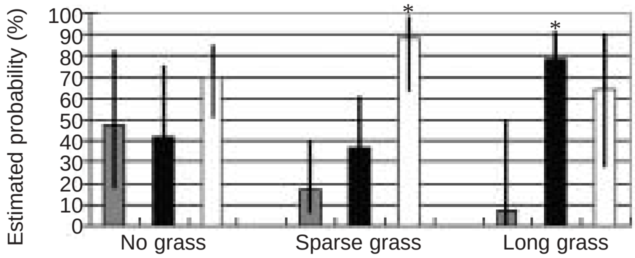

*Fig 1: Estimated probabilities (%) for being sand-positive with variable pasture quality and soil type; clay/silt/organic (■), fine sand (■) and coarse sand (□). Bars show 95% confidence intervals. *Significantly higher probability for sand ingestion (P<0.05) within the given pasture quality level.*

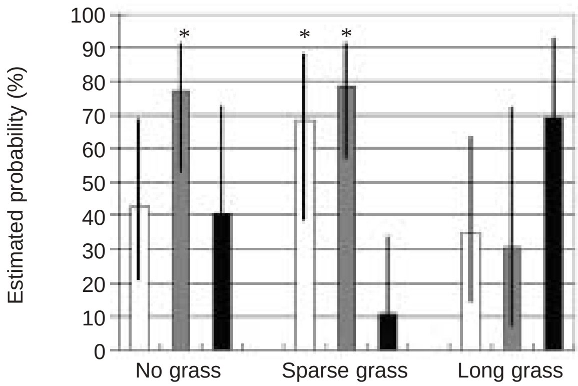

*Fig 2: Estimated probabilities (%) for being sand-positive with variable pasture quality and feeding practice; no feeding (□), fed on ground (■) and fed from outdoor crib (■). Bars show 95% confidence intervals. *Significantly higher probability for sand ingestion (P<0.05) within the given pasture quality level.*

Discussion

Identification of risk factors for the detection of sand in the faeces of clinically healthy horses is important if these factors correlate with an increased risk of developing SGID. Clinically healthy horses given an experimental sand intake excrete as much as 78% of the given amount in the faeces over a period of 5–11 days (Lieb 1997; Hammock *et al.* 1998). The remaining 20% has the potential to accumulate in the gastrointestinal system, and hence could increase the risk of SGID. Consequently, the detection of sand in the faeces may be regarded as a marker of sand intake and, in turn, a risk factor for the development of SGID.

The sand sedimentation test relies on the concept that ingested sand is measurable and detectable in the faeces within a certain period. Lieb (1997) demonstrated that housing of horses was followed by a decrease in detectable sand in faeces, whereas administration of sand by nasogastric tube caused an increase after 2 days. Hammock *et al.* (1998) stated that if exposure to sand ceases, the healthy large intestine should be able to eliminate 100% of the sand without clinical signs. The sand sedimentation test was regarded as a reliable test in this study, as demonstrated by recovery rates of 95–97% in initial experiments.

The interaction of pasture quality and soil type shown in the present study implies that soil type alone cannot be viewed as a risk factor, but it was noticeable that only the sandy soil types showed higher estimated probabilities for sand, even though it was seen on different pasture qualities. The clay/silt soil group was used as reference, as this demonstrated the lowest or equal prevalences for sand in faeces in each pasture quality group. No apparent explanation for the significantly enhanced risk (RR = 10) for long grass on fine sandy soil was found, but the roots of long grass might be less anchored in sandy than clay soils and horses might ingest more sand when involuntarily picking up these roots. This does not, however, explain why no increased risk on fine sandy soil could be shown for pastures with sparse grass.

The interaction between pasture quality and feeding practice demonstrated an increased risk when feeding directly on the ground in paddocks with no or sparse grass, but feeding practice had no effect when grass was long. The ingestion of sand particles is likely to occur when horses are searching for the last bits of feed on the ground (Udenberg 1979). Owners are advised to avoid feeding directly off the ground to prevent development of SGID (Ragle *et al.*1989a; White and Lessard 1990), advice supported by this study. Horses that were not additionally fed during the outdoor period were often fed indoors, and were only offered the grass in the paddock while turned out. This practice should be avoided if the grass is sparse, since this increased the risk 6-fold compared to horses fed in outdoor cribs. Since horses spend long periods seeking food while turned out (Davidson and Harris 2002), it will be expected that they will continue to graze until the grass is very short. This behaviour could result in intake of a lot of sand particles. Paddocks with no grass (dirt paddocks) showed enhanced probabilities for sand ingestion if feeding was from the ground, but this risk was lowered when no feeding or feeding in outdoor cribs was used. The factor of feeding practice in the paddock is an attractive prevention method, as it is relatively easy to change. Prevention and reduction of sand intake should be based on crib feeding outside, especially when the quality of pasture declines.

Due to the seasonal nature of pasture quality, the observed prevalence of sand in faeces could vary, increasing during winter and early spring and decreasing with improved pasture quality during the summer. This would be in agreement with observations of a seasonal pattern of SGID (Ragle and Meagher 1987; Specht and Colahan 1988; Korolainen and Ruohoniemi 2002).

The findings of this study relate to Icelandic horses, but these risk factors should be important in prevention of SGID in all pastured horses. No individual parameter was found to have statistical significance, which corresponds to the fact that SGID has been diagnosed in horses of all ages and sex (Specht and Colahan 1988; Ragle *et al.* 1989a; Korolainen and Ruohoniemi 2002).

A body condition score was included since it has been stated that underfeeding could be a potential risk factor for SGID (Ott 1987; Ragle *et al.* 1989b; Davidson and Harris 2002) and weight loss has been mentioned as sign of sand accumulation (Bertone *et al.* 1988). This study showed a tendency for larger quantities of sand to be detected among horses with condition scores below average (condition score <5), but this group consisted of only 7 horses and the association was not statistically significant. Insufficient intake of energy and protein showed no associated increase sand intake (Weise and Lieb 2001), but other studies have shown increased intake associated with insufficient supply of roughage (Sullins 1990; White and Lessard 1990; Hanson 2002).

Twelve out of 211 horses without clinical signs of gastrointestinal disease had more than 5 mm of sand detected using the sand sedimentation test, which in our hospital is the limit suggesting SGID in sick horses. These 12 horses were from different studs, and this is in accordance with the observation that cases of SGID are often single cases (Bertone *et al.* 1988). Geophagic behaviour could explain these individual differences. Information regarding this was not recorded systematically, but when asked, 37% of the stud owners revealed that this behaviour had occurred in single individuals. No soil type was preferred, since all 3 types were represented. It is unknown why some horses demonstrate this geophagic behaviour, which is often related to specific areas. In one study, these areas were found to contain significantly higher amounts of iron and copper (McGreevy *et al.* 2001) than in the rest of the pasture. Some authors state that foals are particularly prone to geophagic behaviour (Specht and Colahan 1988). We found that the faeces sample containing the largest amount of sand (30 mm) was from a foal age 3 months. We also noticed a tendency for greater quantities of sand to be found in the group of young horses; 25% (4/16) had more than 5 mm of sand in the test. Whether these horses were showing geophagic behaviour was not recorded, but this could explain the fact that within the same paddocks we found both horses with no sand and horses with >5 mm sand in the faeces.

Neither soil type nor feeding practice in the paddock could be identified as a single risk factor for detection of sand in the faeces of clinically healthy horses, but both can be regarded as contributing to the risk when combined with pasture quality. Increased risk was found when horses were grazing paddocks with sparse grass on coarse sandy soils and when grazing long grass on fine sandy soils. Feeding directly on the ground increased the risk in paddocks with no or sparse grass. No feeding in paddocks with sparse grass also increased the risk significantly. In conclusion, the effects of the variables are complicated and must be evaluated collectively on each farm.

Manufacturers' addresses

[1]ELTRA GmbH, Neuss, Germany.
[2]SAS Institute Inc., Cary, North Carolina, USA.

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