The risk of flax versus straw bedding on ileal impaction in colic horses: Retrospective analysis of 2336 cases (2008-2017)

Vlaslemen versus stro als risicofactor voor ileumobstipaties bij paarden met koliek: Retrospectieve analyse van 2336 gevallen tussen 2008 en 2017

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ABSTRACT

While mature coastal bermudagrass hay is strongly associated with ileal impaction in the Southeastern United States, stabling on flax bedding has anecdotally been associated with this condition in Europe. The aim of this retrospective study was to investigate the association between ileal impaction and the use of flax shives compared to straw as bedding in horses with colic. Medical records of 2336 referral cases evaluated for abdominal pain between January 2008 and May 2017 at the Department of Large Animal Internal Medicine, Ghent University were reviewed. Diagnosis, date of admission, age, breed, gender, body weight and stable bedding were recorded. Conditional logistic regression analysis was used to assess the association between ileal impaction and each individual variable. Odds ratios (OR) and 95% confidence intervals (CI) were determined. Predictors with a value of $P < 0.2$ were included in a multivariable Cox regression model and Wald's test was used to assess parameter estimate significance. Further, the association between survival to discharge and type of bedding or type of treatment (medical versus surgical) was analyzed for horses with ileal impactions. The proportion of colic cases stabled on flax bedding at home was 11.3%. The overall prevalence of ileal impaction was 4.2%. In the flax group, the prevalence of ileal impaction was 9.4% as opposed to 3.6% within the straw group. The OR of 2.8 (95% CI 1.7-4.7; $P < 0.001$) in the multivariable logistic regression model indicated that horses stabled on flax shives were approximately three times more likely to have ileal impactions than horses stabled on straw. There was no significant association found between ileal impaction and the period of admission, age, gender or body weight in a multivariable logistic regression model. The odds for having ileal impaction is approximately six times (OR 6.3; 95% CI 2.4-16.4; $P < 0.001$) higher in draft horses than in warmbloods in the multivariable logistic regression model. No significant association was found between survival to discharge and type of bedding or treatment. These results suggest that horses with colic that were housed on flax bedding are more likely to present ileal impactions than horses housed on straw.

SAMENVATTING

Terwijl ileumobstipatie bij paarden in het zuidoosten van de Verenigde Staten voornamelijk geassocieerd wordt met de sterk lignine-houdende vezels van het mature bermudagrashooi, wordt ileumobstipatie in Europa anekdotisch geassocieerd met het huisvesten van paarden op vlaslemen. Het doel van deze retrospectieve studie was het bestuderen van het verband tussen ileumobstipatie en het gebruik van vlaslemen of stro als stalbodembedekking bij paarden aangeboden voor koliek. De medische dossiers van 2336 paarden aangeboden met koliek op de dienst Inwendige Ziekten van de Grote Huisdieren, Universiteit Gent tussen januari 2008 en mei 2017 werden geanalyseerd. Uit de medische dossiers werd informatie verkregen met focus op diagnose, het moment van aanbieden, ras, geslacht, lichaamsgewicht en stalbedding. Door middel van logistische regressie werd de associatie tussen ileum-

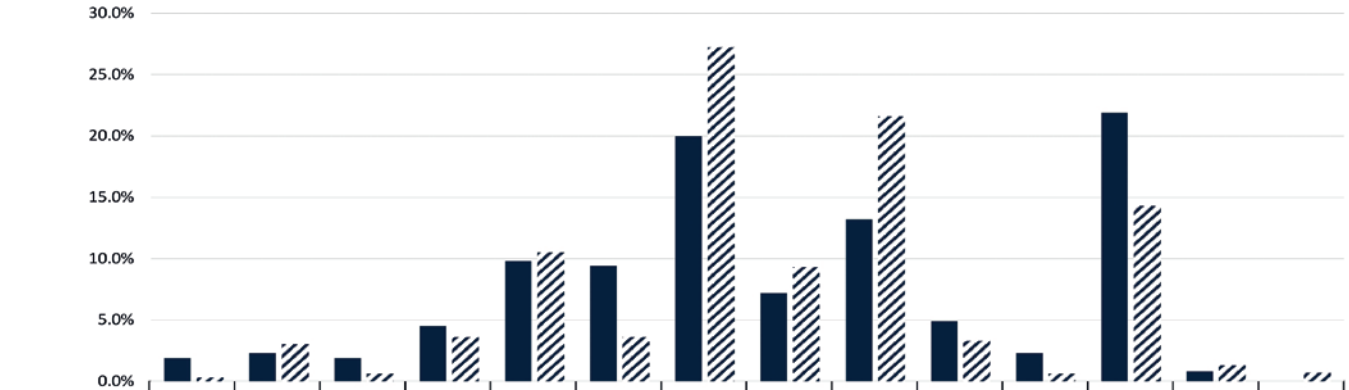
obstipatie en elke individuele variabele bepaald. Variabelen met P < 0,2 werden opgenomen in een multivariabel cox-regressiemodel en door middel van de Wald's test werd de significantie van de parameters bepaald. Verder werd voor de paarden met ileumobstipatie het verband tussen het overlevingspercentage en de bodembedekking of de behandelwijze (medisch of chirurgisch) bepaald. Van de met koliek aangeboden paarden werd 11,3% op vlaslemen gehuisvest. De totale prevalentie van ileumobstipatie in de bestudeerde populatie was 4,2%. In de vlasgroep was de prevalentie van ileumobstipatie 9,4%, terwijl deze in de strogroep 3,6% bedroeg. De odds-ratio voor het ontstaan van ileumobstipatie bij paarden gehuisvest op vlaslemen ten opzichte van op stro gehuisveste paarden bedroeg 2,8 (95% CI 1,7-4,7; P < 0,001) in het multivariabel regressiemodel. Er kon geen significant verband aangetoond worden tussen ileumobstipatie en het moment van aanbieden, leeftijd, geslacht of lichaamsgewicht. Trekpaarden hadden een zes keer hoger risico (OR 6,3; 95% CI 2,4-16,4; P < 0,001) op het ontstaan van ileumobstipatie dan warmbloeden in het multivariabel regressiemodel. Er kon geen significant verband worden aangetoond tussen het overlevingspercentage en de stalbodembedekking of de behandelwijze. De resultaten van deze retrospectieve studie suggereren dat op vlaslemen gehuisveste paarden met koliek een hoger risico hebben op het ontstaan van ileumobstipatie dan paarden gehuisvest op stro.

INTRODUCTION

Ileal impaction is the most frequently reported cause of small intestinal nonstrangulating obstruction in adult horses, with a prevalence ranging between 0.5 to 10.8% (Blikslager, 2009; Fleming and Mueller, 2011; Hanson et al., 1995; Hanson et al., 1998; Plummer, 2009). The prevalence as well as the etiology of ileal impactions varys with geographical location. While ileal impactions are strongly associated with the ingestion of high lignin containing fibres in mature coastal bermudagrass hay in the Southeastern United States; in Europe, ileal impactions have been associated with vascular thrombotic disease. Risk factors for ileal impaction include sudden changes in feed, a diet consisting of high amounts of acid detergent fibre (ADF), ascarid and tapeworm (*Anaplocephala perfoliata*) infestation, ileal hypertrophy, mesenteric vascular thrombotic disease, foreign body ingestion, decreased water intake or weather changes (Blikslager, 2009; Blikslager, 2010; Hanson et al., 1995; Hanson et al., 1998; Little and Blikslager, 2002; Plummer, 2009).

Ileal impactions arise from accumulation of ingesta within the ileum, leading to intraluminal obstruction (Blikslager, 2009; Blikslager, 2010; Hanson et al., 1995; Hanson et al., 1998; Fleming and Mueller, 2011; Little and Blikslager, 2002; Plummer, 2009). Spasmodic peristaltic waves around the obstructing fibres extrude water from the ingesta and exacerbate the impaction (Gonçalves et al., 2002; Hanson et al., 1995; Fleming and Mueller, 2011). The resulting colic is characterized by biphasic signs of abdominal pain; initially due to spasms and small intestinal distension, in a further state due to progressive or persistent intestinal and gastric distension (Hanson et al., 1998).

In Europe, anecdotally, ileal impaction has been associated with the use of flax shives as bedding (Figure 3). However, to the authors' knowledge, there are no data available to support this. The purpose of this study was to investigate the association between ileal impaction and the use of flax shives opposed to



	Gastric dilation	Gastric ulcers	Proximal enteritis	SI dilation	SI strangulation	Ileal impaction	LI impaction	LI meteorism	LI displacement	LI strangulation	Typhlocolitis	Spasmodic colic	SC impaction	Other
Flax group % (n)	1.9 % (5)	2.3 % (6)	1.9 % (5)	4.5 % (12)	9.8 % (26)	9.4 % (25)	20.0 % (53)	7.2 % (19)	13.2 % (35)	4.9 % (13)	2.3 % (6)	21.9 % (58)	0.8 % (2)	0.0 % (0)
Straw group % (n)	0.3 % (6)	3.0 % (63)	0.6 % (12)	3.6 % (74)	10.5 % (217)	3.6 % (74)	27.2 % (564)	9.3 % (192)	21.6 % (447)	3.3 % (69)	0.6 % (13)	14.3 % (296)	1.3 % (27)	0.8 % (17)
Overall % (n)	0.5 % (11)	3.0 % (69)	0.7 % (17)	3.7 % (86)	10.4 % (243)	4.2 % (99)	26.4 % (617)	9.0 % (211)	20.6 % (482)	3.5 % (82)	0.8 % (19)	15.2 % (354)	1.2 % (29)	0.4 % (17)

Figure 1. Prevalences of types of colic within flax, straw and overall population.

straw as bedding in horses referred for colic to the Department of Large Animal Internal Medicine, Ghent University.

MATERIALS AND METHODS

Medical records (January 2008 - May 2017) of horses diagnosed with colic due to a gastro-intestinal disorder and admitted to the Large Animal Internal Medicine Department, Ghent University, were reviewed retrospectively. Horses stabled on flax shives or straw at home were included in this study; horses housed on wood shavings or solely living on pasture were excluded. Information obtained from the medical records included diagnosis, stable bedding, date of admission, age, breed, gender and body weight. Based upon the diagnosis recorded in the medical file, the colic cases were classified within a few major diagnostic categories: gastric dilation, gastric ulceration, proximal enteritis, small intestinal dilation, small intestinal strangulation, small intestinal impaction, large intestinal impaction, large intestinal meteorism, large intestinal displacement, large intestinal strangulation, typhlocolitis, spasmodic colic, small colon impaction and other types of colic. The category of gastric dilation included gaseous gastric distension as well as gastric impaction. The group of gastric ulceration included all horses admitted for a suspicion of gastric ulceration due to recurrent colic, as well as all horses admitted for colic without any abnormality on transabdominal ultrasound or rectal palpation where ulceration was confirmed by gastroscopy. Proximal enteritis was characterized by fever in presence of proximal small intestinal dilation, gastric distension with hemorrhagic reflux or increased white blood cell count and total protein concentration in peritoneal fluid tap. The diagnosis of small intestinal dilation was made in case of detectable dilated small intestines on ultrasonography or rectal palpation, without any clear indication of small intestinal obstruction or strangulation. Large intestinal impaction included cecal as well as colonic impaction. Large intestinal meteorism included gaseous distension of the colon or cecum without indications for displacement. The group of large intestinal displacement included all large intestinal displacements with or without impaction or gaseous distension. Indication for inflammation of the colonic or cecal wall on ultrasonography in presence or absence of diarrhea was defined as typhlocolitis. Spasmodic colic was defined as mild colic without any significant ultrasonographic or rectal palpation abnormalities. The group of other types of colic included all horses which were not suitable for categorization within one of the other groups and included tumoral masses, adhesions or gastrointestinal rupture cases. With regard to the general clinic population, the study population was categorized into four groups based on breed: warmbloods, draft horses, ponies and other breeds, which included Appaloosas, Arabians, Fjords, Friesians, Haflingers, Irish Cobs, Lusitanos, Paints, Pura Raza Espanolas, Quarter horses, Trakehners, Trotters and crossbreeds. For period of admission, four groups were made (January until March, April until June, July until September and October until December). Body weight was categorized into three groups: horses with a body weight less than 445 kg, between 445 – 540 kg and higher than 540 kg.

Ileal impaction was defined as small intestinal obstruction in the right dorsocaudal abdomen near to the ileo-cecal junction with secondary distention of small intestines cranial to the obstruction diagnosed by ultrasonographic and rectal examination of the patient, without indication of a strangulating disorder on peritoneal fluid tap. Horses with ileal impaction were treated medically or by exploratory celiotomy for resolution of the impaction. Surgery was followed by a postsurgical treatment including intravenous fluids, prokinetics, broad-spectrum antimicrobials, analgesic drugs, laminitis prevention and evacuation of gastric reflux every four hours. Medical therapy included intravenous balanced polyionic fluids, prokinetics, analgesic drugs and, in the absence of gastric reflux, administration of paraffin oil by nasogastric intubation. Survival was defined as survival to discharge from the hospital. Long-term follow-up information was not available.

STATISTICAL ANALYSIS

Data are reported as median (range) for non-normally distributed data. Normality was assessed by visual inspection of the raw data plots and by using the Shapiro-Wilk test of linearity and Kolmogorov-Smirnov test (SPSS statistics version 25.0, SPSS Inc, Chicago, IL). Initially, Pearson χ^2 tests were used to assess the association between ileal impaction and each individual variable (stable bedding, date of admission, age, breed, gender, body weight and outcome) and odds ratios (OR) and 95% confidence intervals (CI) were determined by performing logistic regression (univariable logistic regression model). Those predictors with $P < 0.2$ were included in a multivariable Cox regression model, built by stepwise backward selection, gradually excluding nonsignificant variables. Wald's test was used to assess parameter estimate significance. Within the group of horses admitted with ileal impaction, the association between stable bedding or treatment (medical versus surgical) and outcome was analyzed by Pearson χ^2 tests. Statistical significance was defined as $P < 0.05$.

RESULTS

In total, 2336 colic patients stabled on flax shives or straw were included in the study. A detailed over-

view of the prevalence of different types of colic within the flax and the straw group is presented in Figure 1. Spasmodic colic (21.9%/14.3%), large intestinal impaction (20.0%/27.2%) and large intestinal displacement (13.2%/21.6%) were the most prominent types of colic within the flax and straw group, respectively. Approximately 11.3% (265/2336) of all horses were stabled on flax shives at home, compared to 88.7% (2071/2336) on straw bedding. The median age of the horses was 9 years with a range between 2 weeks and 36 years. Data concerning period of admission, age, breed, gender and body weight are resumed in Table 1.

All horses with ileal impaction had a history of abdominal pain, clinical signs consistent with a nonstrangulating small intestinal obstruction and presence of small intestinal distension based on abdominal ultrasonography or transrectal palpation. Peritoneal fluid taps confirmed a nonstrangulating disorder. The final diagnosis of ileal impaction was made by rectal palpation of the impaction at admission or was confirmed either by surgery or postmortem examination. All small intestinal impactions were located in the region of the ileum.

Factors associated with ileal impaction

Ileal impaction had an overall prevalence of 4.2% (99/2336). Within the flax group, ileal impaction had a prevalence of 9.4% (25/265), opposed to a prevalence of 3.6% (74/2071) within the straw group (Figure 1). Ileal impaction was diagnosed in 4 stallions, 42 geldings and 52 mares. For one horse, no information about the gender was available. Fifty-three warmbloods suffering from ileal impaction were included in the study, as well as 6 draft horses, 8 ponies and 23 other breeds. There was no information concerning the breed available for 9 horses. The age of the horses ranged between 6 months and 31 years, with a median of 10 years. Twenty-seven horses were admitted between January and March, 15 horses between April and June, 27 horses between July and September and 30 horses between October and December; which represented 4.4%, 2.8%, 5.2% and 4.4% of all colic cases within this period, respectively. Seventeen horses had a bodyweight less than 445 kg, 38 horses weighed between 445-540 kg, 42 horses had a bodyweight higher than 540 kg and in 2 cases no information regarding bodyweight was available.

Table 1. Risk factors and variables associated with colic within the general study population of 2336 horses admitted for colic.

	Flax group (n=265; 11.3%)		Straw group (n=2071; 88.7%)		Overall (n=2336; 100%)	
Risk factor Variable	**No. of cases**	**% within Flax group**	**No. of cases**	**% within Straw group**	**No. of cases**	**% Overall**
Period of admission						
January-March	59	22.2%	549	26.5%	608	26.0%
April-June	68	25.7%	463	22.4%	531	22.7%
July-September	61	23.0%	455	22.0%	516	22.1%
October-December	77	29.1%	604	29.2%	681	29.2%
Age						
<4 years	29	10.9%	226	10.9%	255	10.9%
4-15 years	167	63.0%	1342	64.8%	1509	64.6%
>15 years	67	25.3%	490	23.7%	557	23.8%
No information	2	0.0%	13	0.6%	15	0.0%
Breed						
Warmblood	136	51.3%	1222	59.0%	1358	58.0%
Draft horses	5	1.9%	23	1.1%	28	1.2%
Ponies	43	16.2%	229	11.1%	272	11.6%
Other breeds	60	22.6%	425	20.5%	485	21%
No information	21	7.9%	172	8.3%	193	8.3%
Gender						
Stallions	21	7.9%	160	7.7%	181	7.7%
Geldings	112	42.3%	961	46.4%	1073	45.9%
Mares	132	49.8%	947	45.7%	1079	46.2%
No information	0	0.0%	3	0.1%	3	0.1%
Body weight						
< 445 kg	68	25.7%	472	22.8%	540	23.1%
445-540 kg	93	35.1%	698	33.7%	791	33.9%
>540 kg	79	29.8%	685	33.1%	764	32.7%
No information	25	9.4%	216	10.4%	241	10.3%

Table 2. Results of univariable and multivariable conditional logistic regression regarding information on stable bedding, period of admission, age, breed, gender and bodyweight for 99 horses with ileal impaction and 2237 reference horses with other types of colic. Percentages were calculated on effective available data. Parameters with P < 0.2 were retained within the multivariable model (§). Parameters with P < 0.05 were considered significant (*). All parameters with P > 0.2 were not considered within the multivariable model.

Risk factor Variable	Horses with ileal impaction No. (%)	Horses with other colic No. (%)	Univariable logistic regression			Multivariable logistic regression		
			Odds ratio	95% CI	P value	Odds ratio	95% CI	P value
Bedding								
Straw	74 (74.7)	1997 (89.3)	Ref.			Ref.		
Flax	25 (25.3)	240 (10.7)	**2.8**	1.7-4.5	**<0.001***	**2.8**	1.7-4.7	**<0.001***
Period of admission								
January - March	27 (27.3)	581 (26.0)	Ref.					
April - June	15 (15.2)	516 (23.1)	0.6	0.3-1.2	0.152§			
July - September	27 (27.3)	489 (21.8)	1.2	0.7-2.1	0.537			
October - December	30 (30.2)	651 (29.1)	1.0	0.6-1.7	0.975			
Age								
4-15 years	65 (65.7)	1444 (65.0)	Ref.					
<4 years	8 (8.0)	247 (11.1)	0.7	0.3-1.5	0.388			
>15 years	26 (26.3)	531 (23.9)	1.1	0.7-1.7	0.723			
Breed								
Warmblood	53 (58.9)	1305 (63.5)	Ref.			Ref.		
Draft horse	6 (6.7)	22 (1.1)	**6.7**	2.6-17.3	**<0.001***	**6.3**	2.4-16.4	**<0.001***
Ponies	8 (8.8)	264 (12.9)	0.7	0.4-1.6	0.447	0.7	0.3-1.5	0.328
Other	23 (25.6)	462 (22.5)	1.2	0.7-2.0	0.426	1.2	0.7-2.0	0.506
Gender								
Mare	52 (53.1)	1027 (46.0)	Ref.					
Stallion	4 (4.0)	177 (7.9)	0.4	0.2-1.2	0.125§			
Gelding	42 (42.9)	1031 (46.1)	0.8	0.5-1.2	0.305			
Body weight								
445-540 kg	38 (39.2)	753 (37.7)	Ref.					
< 445 kg	17 (17.5)	523 (26.2)	0.6	0.4-1.2	0.139§			
>540 kg	42 (43.3)	722 (36.1)	1.2	0.7-1.8	0.536			

CI = Confidence interval; Ref. = Reference category; (§) P-value < 0.2 retained within multivariable model; (*) P-value < 0.05 considered significant

In the univariable logistic regression model, no significant association between period of admission, age, gender or body weight and ileal impaction could be found. Stable bedding and breed were retained in the multivariable regression model. Flax bedding (OR 2.8, 95% CI 1.7-4.7, P<0.001) and draft horse breed as opposed to warmblood (OR 6.3, 95% CI 2.4-16.4, P<0.001) were significantly associated with ileal impaction in this multivariable model (Table 2).

Ileal impaction: treatment and outcome

Horses with ileal impaction were treated medically in 58.6% (58/99) of the cases, compared to 41.4% (41/99) receiving surgical treatment. The overall survival percentage was 74.7% (74/99) for the entire ileum impaction population; 69.0% (40/58) within the medically and 82.9% (34/41) within the surgically treated group. There was no significant association between type of treatment and survival to discharge (P = 0.115). Survival within the flax group was 68.0% (17/25) and 77.0% (57/74) within the straw group. There was no significant association between stable bedding and survival (P = 0.369) (Table 3).

DISCUSSION

This retrospective study shows that flax shives as stable bedding are a risk factor for the incidence of ileal impaction in horses with colic. The risk factors associated with the development of colic in horses differ according to the type of colic (Hudson et al., 2001). Geographical differences may occur as well due to differences in feeding regime. In the Southeastern United States, colic and especially ileal impactions are associated with mature coastal bermudagrass hay, which is frequently used as a source of roughage in this region (Fleming and Mueller, 2011; Hanson et al., 1998; Little and Blikslager, 2002). Mature bermuda-

Table 3. Results of univariable logistic regression used to determine associations between stable bedding, medical or surgical treatment and survival to discharge. Parameters with P < 0.2 were retained but did not reache statistical significance within the multivariable model. All parameters with P > 0.2 were not considered within the multivariable model.

Risk factor variable	Survival within group No. (%)	Univariable logistic regression Odds ratio	95% CI	P value
Bedding				
Straw	57 (77.0%)	Ref.		
Flax	17 (68.0%)	0.9	0.7-1.2	0.369
Treatment				
Surgical	34 (82.9%)	Ref.		
Medical	40 (69.0%)	0.8	0.7-1.0	0.115

CI = Confidence interval; Ref. = Reference category

grass hay is a stemmy, fine hay with an increased acid detergent fibre (ADF) content (Blikslager, 2009; Blikslager, 2010; Hanson et al., 1995; Hanson et al., 1998; Plummer, 2009). The feeding of hays containing higher percentages of ADF may predispose to ileal impaction (Little and Blikslager, 2002).

In contrast to reports from the United States; ileal impactions in Europe have not been associated with a high amount of acid detergent fibre within the roughage (Hanson et al., 1995), and bermuda grass hay is not cultured within this areas. Within the population of admitted colic cases of this study, 4.2% of the horses were diagnosed with an ileal impaction (Figure 1). This value is in line with the previously reported prevalence of ileal impactions in referral populations, which ranges between 0.5 and 10.8% (Hanson et al., 1998). To the authors' knowledge, no studies refer to flax shives as causative agent for ileal impaction at this moment.

Flax (*Linum usitatissimum*) is one of the most important fibre crops in Europe (González-García et al., 2009) (Figure 2). Flax shives, also known as core flax fibres, are the woody and lignified inner tissues of the stem. Flax shives are generally composed of about 53% cellulose, 21% hemicellulose, 24% lignin and 2% ash (Czemplik et al., 2017; Ross and Mazza, 2010). Flax shives have a diameter of maximum 2 mm and a length of less than 25 mm. Due to their porous structure, flax shives have highly absorbent characteristics and are therefore used in stable bedding, especially for horses (González-García et al., 2009) (Figure 3). Unfortunately, there are no data available concerning the number of horses stabled on flax shives within Belgium or the surrounding countries. This study revealed that 11.3% of the referred colic cases were stabled at home on flax shives. Unfortunately, the data do not allow to determine whether the use of flax shives reduces or increases the overall risk for colic in horses. The prospective study of Tinker et al. (1997) and the case-control study of Cohen et al. (1995) did not reveal a significant association between colic and the type of bedding (no bedding, shavings, sawdust, dirt and clay, sand, straw, shavings and dirt or shavings and sand); however, flax shives were not included.

Spasmodic colic was the most prevalent type of colic within the horses stabled on flax shives (21.9%) (Figure 1). Proudman et al. (1998) demonstrated a strong association between spasmodic colic, *Anoplocephala perfoliata* infection and ileal impaction. An increased intestinal motility around the ingesta dehydrates the intestinal content by increasing the absorption of water (Embertson et al, 1985; Gonçalves et al., 2002; Hanson et al., 1995; Hanson et. al., 1998). As a high percentage of acid detergent fibre has been suggested to favor small intestinal impaction by stimulating intestinal motility (Gonçalves et al., 2002), flax fibres may contribute to intestinal spasticity as well and may subsequently lead to ileal impaction. Some spasmodic colic cases may even have been mild ileal impactions that resolved either spontaneously or with medical treatment (Proudman, 1998; Little and Blikslager, 2002). As impactions are typically located at sites where the intestinal diameter decreases or at sites where sphincters are located, the ileocecal orifice stays a predisposed site (Plummer, 2009).

About 58% of the ileal impactions were admitted to the clinic of Veterinary Medicine (Ghent University) between October and March, while 42% were admitted between April and September. Although previous studies revealed an increase in ileal impactions during the fall (September-November) (Hanson et al., 1998; Plummer, 2009), no significant association between the prevalence of ileal impactions and period of admission could be found in our study. Increasing time spent in stable (Hudson et al., 2001), the fact that pastures become sparse and the higher incidence of tapeworm infections during the fall have been suggested to be causative factors for the increased prevalence of ileal impactions during these months (Hanson et al., 1998). In the present study, a non-significant decrease in ileal impactions was observed between April and June compared to January until March, which might be associated with an increased time spent out on pasture with access to fresh grass (Table 2). This has been shown to reduce the risk for impaction colic in horses

Figure 2. Flax plant.

(Cohen et al., 1999; Gonçalves et al., 2002; Hillyer et al., 2002).

Similar to previous studies, which reported that ileal impactions can develop at any age and are not only restricted to older horses with mastication problems (Hanson et al., 1998), no significant association between age and ileal impaction was found in this study. Parks et al. (1989) reported an increased prevalence of ileal impactions in mares (56.0%), but this was not confirmed in the present study (52% mares, P = 0.125 and 0.305 versus stallions and geldings, respectively).

Breed distribution showed that draft horses had an odds ratio of 6 for ileal impaction, compared to warmbloods. A higher percentage of draft horses stabled at home on flax shives (17% versus 11% within the general study population) may contribute to this finding. Parks et al. (1989) reported an increased prevalence of Arabian horses (20.0%) with ileal impactions compared to their general hospital population (10.0%); however, these findings depend strongly on geographical location, general hospital population or criteria for categorization.

Although ileal impactions have been treated successfully by both medical and surgical treatment, decision making can be difficult (Fleming and Mueller, 2011). Survival rates for medically treated ileal impactions range between 10% to 100% (Fleming and Mueller, 2011; Hanson et al., 1996). Horses can be treated successfully with medical support if an accurate diagnosis is made early on. Essential in conservative treatment is a good cardiovascular status, a good response to analgesic drugs and no significant changes in peritoneal fluid (Blikslager, 2009; Fleming and Mueller, 2011; Hanson et al., 1995; Hanson et al., 1998; Plummer, 2009). Medical treatment should target a reduction in intestinal spasm around the impaction and rehydrate the luminal ingesta to allow passage and restore normal intestinal function (Hanson et al, 1998). Previously reported survival rates for surgically treated cases ranged between 61.0% to 96.0% (Parks et al., 1989; Embertson et al., 1986; Fleming and Mueller, 2011; Hanson et al.,1998 and Little and Blikslager, 2002). The higher survival rates within previous studies of surgically treated horses might indicate that early surgical intervention is beneficial for outcome and survival (Little and Blikslager, 2002; Parks et al.,1998; Plummer, 2009). However, in this study no statistical difference was found (P = 0.115). Surgical intervention is strongly indicated if rectal palpation reveals persistent impaction and distension of small intestines in combination with poor response to analgesic drugs (Hanson et al., 1995). Delay to surgical intervention can decrease survival rates by deterioration of the circulatory function and progressive or persistent small intestinal dilation (Hanson et al., 1995).

In the present study, the survival rates between the flax group (68.0%) and the straw group (77.0%) were not significantly different (P= 0.369) (Table 3). These results may suggest that flax shives did not lead to a lower survival rate due to a more severe ileal impaction.

Limitations

The limitations of this study include the retrospective character of this study and the fact that not all data were available. Model fit during the multivariable logistic regression was assessed using -2 Log likelihood and the Hosmer and Lemeshow test, which indicated that the model estimates fit the data at an acceptable level. However, Cox & Snell R Square and Nagelkerke R Square indicated that only a minor percentage of the variation was explained by the logistic model (1-4%), which might be explained by the low number of ileal impactions in the population as well as the presence of other influencing factors such as feed or parasite infestation, which were not included in the analysis. Confounding factors, such as type, amount and quality of forage, access to pasture, amount and nutritional composition of concentrates or other nutritional supplements, access to sand, dental disorders,

Figure 3. Flax shives.

deworming state and/or other variables could have played a role but were not available. However, these factors were likely to be equally distributed in both populations. As feces was not routinely examined for tapeworm ova and no ELISA tests were performed on blood or saliva (Blikslager, 2009), it was not possible to correlate tapeworm infections with the prevalence of ileal impaction in this study. A further limitation of the study concerns the group of medically treated ileal impactions. Ileal impaction was diagnosed by rectal palpation, explorative laparotomy or postmortem exam. In all horses, in which medical therapy was attempted but failed, diagnosis of ileal impaction was confirmed at postmortem examination. In all horses, in which medical therapy was successfully attempted, diagnosis was based on rectal palpation while a gold standard confirming the diagnosis was lacking. Other lesions than ileal impaction may have contributed to colic. Another limitation of this study was that some horses, suffering from small intestinal dilation, which were treated successfully with medication, could have had ileal impaction, while this could not be confirmed by rectal palpation or surgery. Furthermore, gastroscopy was not performed routinely in all horses with spasmodic colic. Therefore, gastric ulceration might have been present but undiagnosed in certain colic horses. As the total number of horses housed on flax is not known, this study does not allow to determine whether housing on flax shives has an impact on the overall occurrence of colic in horses.

CONCLUSION

This is the first report describing the association between ileal impaction in horses and the use of flax shives as bedding. The results of this retrospective study show that a horse that presents colic and that was housed on flax bedding is approximately three times more likely to have an ileal impaction than horses that were housed on straw.

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