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Prevalence of Ulcers of the Squamous Gastric Mucosa in Standardbred Horses

Marie-Andrée Roy, André Vrins, Guy Beauchamp, and Michèle Y. Doucet

This study was performed to determine the prevalence of ulcers in the gastric squamous mucosa in Standardbred racehorses. Observations were performed at monthly intervals between the beginning of their training season and their 1st qualifying race. This study also identified risk factors at different levels of race training. Forty-eight Standardbred racehorses from 3 training stables in Quebec, Canada, were studied. Baseline historical information and gastroscopic findings were recorded at the beginning of the trial, and once a month thereafter, between December 2001 and June 2002, until the horse's 1st qualifying race or the end of the training. Intensity of training ranged from jogging to intensive training just before the 1st race and was assigned an ordinal score. Location of squamous ulcers and their appearance were observed on gastroscopy, and an ordinal score was assigned. Prevalence of squamous ulcers from the 2nd through the 4th month (72–88%) of training remained at a significantly higher level ($P = .002$ to .04) than at the onset of the study (38%) and was also higher in intensely trained horses than in joggers (93% versus 56%). Moderate or more intensive training increased the odds (odds ratio [OR], 3.39; confidence interval [CI], 1.34–8.56; and OR, 11.4; CI, 3.21–40.5, respectively) of detecting ulcers with higher scores. These odds were also higher in trotters (OR, 2.17; CI, 1.07–4.43) than in pacers and generally increased with the duration of training. Duration of training, training level, and gait type also influenced the number of sites with ulcers in the same way. Ulcers had higher scores along the lesser curvature (LC) and the *margo plicatus* (MP) areas of the stomach. It was concluded that squamous ulcers appeared early in the training of Standardbred racehorses, that the number of sites affected and the ulcer score are related to the intensity of training, and that trotters are more prone to squamous ulcers than pacers.

Key words: Epidemiology; Equine; Exercise; Therapy.

Gastric ulceration has been reported in the majority of young horses under intensive training.[1–5] In mature horses, gastric ulcers are more frequently observed in the squamous mucosa of the stomach, and the margo plicatus (MP) is the most common site.[3,5–15] The pathophysiology of this disease is not well defined, but many studies support the hypothesis that the development of gastric ulcers of the squamous mucosa results from excessive exposure to gastric acid.[1,3,11,16–19] The clinical relevance of squamous ulcers in horses is unclear,[20] although many risk factors, including training, have been identified for the development of these lesions in mature horses.[1–4,6,8,10,16,20–22] The prevalence in Standardbred horses at rest was 15.9%, the prevalence in training was 28.3%, and the prevalence in racing was 63.3% in one study performed in Canada.[15] In the United States, the prevalence is similar, with values ranging from 87 to 89%, including horses in training and in racing.[a,23] Standardbred horses in training and racing were 2.18 and 9.3 times, respectively, more likely to develop squamous ulceration than were those at rest, and gait and body condition in Standardbred horses in training are significant risk factors for squamous ulcers.[15] Trotters also seem more likely to have squamous ulcers than pacers.[15] Despite the very high prevalence of this condition, specific risk factors associated with the development of squamous ulcers over time are not known. Consequently, cost-effective therapeutic and preventive strategies are difficult to validate because little is known about the evolution of squamous ulcers in horses. To better determine effective treatment strategies for squamous ulcers, the objectives of this study were to determine the prevalence of this disease by means of repeated examinations and its associated risk factors during progressive high-intensity training in Standardbred racehorses.

Materials and Methods

Study Design

A prevalence-over-time study was conducted at 3 training stables in Quebec, Canada (stables A, B, and C). The study population was determined on the basis of the trainer's willingness to keep their horses in training but not racing and to make their horses available for monthly gastroscopic examinations between December 2001 and June 2002. The end point of the study was each horse's 1st qualifying race or end of the training. Horses were aged 18 months or older and had last participated in a race at least 3 months before enrollment. Horses that received treatment for gastric ulcers in the 3 months before December 2001, or at anytime during the study, were excluded. A total of 48 young horses in training among the possible 89 horses present (54%) at the 3 stables were thus included in the study.

Baseline information, including age, sex, body condition, treatment history, feeding management, and gait (trotter or pacer), was recorded. Once a month, from December to June, a gastroscopy was performed on all horses that remained in training. The intensity of training was recorded by an ordinal scoring system ranging from 1 to 4 as follows: 1, jogging; 2, light training; 3, moderate-to-intensive training; and 4, intensive training just before the 1st race. All horsetrainers (1 per stable) defined their own criteria to describe the level of training corresponding to each score. It was assumed that slight differences in training methods among stables would not be reflected by this semi-objective scoring system.

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Endoscopic Examination

Water was provided ad libitum, and food was withheld for 12–18 hours before endoscopy. Horses were physically restrained with a nose twitch, and 0.5 mg/kg IV per body weight of xylazine hydrochloride[b] was administered as needed for sedation. A 1-m polyethylene nasogastric tube was passed via the left or right nostril, and a 2.5-m flexible video endoscope[c] was passed through the tube to the stomach. The stomach was distended with air. Feed material adherent to the surface of the stomach was flushed by a jet of water passed via the endoscope biopsy port with a pressure pump.[d] For each gastroscopy, the stomach was observed systematically to visualize the entire squamous mucosa, as previously described by Vatistas et al.[24] The endoscopist was not aware of the previous race history of the horse and was masked to the results of previous examinations.

Classification of Ulcers

Squamous lesion score and location were recorded. A distinction was made between the MP and the greater curvature (GC) or the lesser curvature (LC), in that the latter 2 locations were recorded for lesions that did not appear close to the MP. Lesions were never observed along the MP in the LC. Gastric locations in the nonglandular mucosa included the area along the MP of the GC, the GC and the LC, the cardia (C), and the saccus caecus (SC). For each horse, the appearance of nonglandular ulcers was rated by a previously reported scoring system.[6] An overall score, based on the worst squamous ulcer lesion present, was assigned to each horse. The lesion scores were described as follows: 0, intact epithelium; 1, intact mucosa with areas of reddening or hyperkeratosis (squamous); 2, small, single, or multifocal lesions; 3, large, single, or multifocal lesions or extensive superficial lesions; and 4, extensive lesions with areas of apparent deep ulceration.

Statistical Analysis

Statistical analysis was performed by SAS version 8.02.[e] A logistic regression model, by the method of generalized estimating equations with time treated as a repeated factor, was used to compare the monthly prevalence of squamous ulcers from December 2001 to June 2002. The outcome variable was the presence of squamous ulcers, and independent categorical factors included were as follows: stable, month, sex, previous training experience (age group), gait type, and training level. The same analysis of prevalence was performed subsequently for each specific site in the stomach. The covariance structure was modeled with the exchangeable correlation matrix, and the logit link with binomial distribution was used.

Changes through time in the number of sites with ulcers and in ulcer scores were examined with a proportional odds model, by the method of generalized estimating equations with time treated as a repeated factor. The independent variables described above were also included in the model.

The effect of ulcer location on ulcer scores was evaluated. At each stomach site and for each horse, the highest score assigned to an ulcer during the entire study period was selected as the outcome variable. The proportional odds model was used to examine the effect of the above independent variables, with the exception of training level, where the maximum level during the entire training period was used. For the proportional odds model, the covariance structure was modeled with an independent working correlation matrix, and a cumulative logit link with a multinomial distribution was used.

In all of the above models, the decision to retain each variable in the final models was evaluated by fitting the 2 models. One model included the variable, and the other omitted the variable. The difference in the log-likelihood ratios obtained from each model was calculated and used to test for the level of significance of the variable left out. The significance of the difference was tested with a chi-square statistic with 1 *df*. The final model was found when the omission of any remaining variable caused a significant increase in the difference. The ''stable'' variable was retained in all models to control for potential differences among stables in the rate of squamous ulcers. A priori contrasts for all of the categorical variables associated with the outcome were used to test for differences between significant independent variables. Odds ratios for each contrast were obtained by the exponentiating parameters obtained from each model. *P* values for these odds ratios, along with 95% confidence intervals, are provided in ''Results.'' Note that in a proportional odds model, the odds of being in a higher rather than in a lower category of the ordinal outcome variable are calculated. A significance level of $P \leq .05$ was used for all analyses.

Results

The study population was composed of 48 Standardbred horses, including 28 aged between 18 and 24 months and 20 older than 24 months at the start of the study. There were 25 females, 15 geldings, and 8 sexually intact males. A total of 32 horses were pacers, and 16 were trotters. A total of 13 horses came from stable A, 17 came from stable B, and 18 came from stable C. Only 20 horses had previous training experience, and these were aged 3 and 4 years. A total of 45 horses were examined in December (3 were not available), 47 in January (1 had residual feed material), 46 in February (1 was unavailable, and 1 had residual feed material), 42 in March (2 were unavailable, 1 had with residual feed material, 1 received treatment for gastric ulcers, 1 was sold, and 1 had raced), 44 in April, 38 in May (1 died, and 5 had raced), and finally 19 (6 were no longer in training, and 13 had raced).

The prevalence of squamous ulcers ranged from 38% in December to 84% in June and peaked in March at 88%. The odds of squamous ulceration were similar among stables and were not associated with sex and age group (Table 1). The odds of squamous ulceration varied with duration of training (month) and training level (Table 1). With respect to the onset of the study, the odds of squamous ulceration were significantly higher from the 2nd through the 4th month of training but were no longer significant, compared to the onset of the study, during the 5th and 6th months, despite remaining high. High training intensity before a race increased the odds of squamous ulceration in horses with respect to jogging.

The odds of squamous ulceration in the MP area varied significantly with training duration ($P = .001$) and gait type ($P = .003$). Trotting increased the odds of ulcers with respect to pacing at this site. The odds of squamous ulceration along the LC varied with training duration ($P < .001$). The odds of squamous ulceration at the SC varied with training level ($P < .001$) and gait type ($P = .038$). The odds generally increased with training intensity and were higher in trotters than in pacers. The odds of squamous ulceration at the C were associated only with training level ($P = .003$) and again generally increased with training intensity.

The odds of having a high number of ulcerated sites varied with duration of training, training level (Fig 1), and gait type (Table 2). The odds that a higher number of specific anatomic sites (SA sites) with ulcers incurred increased generally with the duration of training (Table 2). Moderate or more intensive training increased these odds with respect to jogging, and we observed that trotters showed higher odds than pacers.

Table 1. Effects of several factors on the odds ratios of the presence of squamous ulcers.

Factor	OR (95% CI)	*P* Value
Stable:		
B versus C	0.69 (0.075–6.41)	.75
A versus C	0.65 (0.17–2.48)	.53
Sex:		
Female versus male	1.05 (0.40–2.74)	.92
Gelding versus male	0.74 (0.26–2.15)	.58
Gait:		
Pacer versus trotter	0.58 (0.25–1.32)	.19
Age group:		
3–4 years versus 24 months and younger	1.17 (0.17–8.19)	.88
Duration of training:		
1 month (January) versus onset	3.78 (1.65–8.68)	.002
2 months (February) versus onset	4.93 (1.81–13.4)	.002
3 months (March) versus onset	6.17 (2.00–19.00)	.002
4 months (April) versus onset	3.68 (1.10–12.3)	.04
5 months (May) versus onset	3.47 (0.93–13.0)	.06
6 months (June) versus onset	1.85 (0.40–8.57)	.43
Training level:		
Level 2 versus level 1	2.13 (0.91–5.01)	.08
Level 3 versus level 1	2.55 (0.69–9.45)	.16
Level 4 versus level 1	6.71 (1.46–30.8)	.01

OR, odds ratio; CI, confidence interval.

The odds of a horse being assigned a higher squamous ulcer score were similar across stables and were not associated with sex, previous training experience, or body condition (Table 3). Changes in the odds occurred as a function of training duration (Fig 2), training level (Fig 3), and gait type (Table 3). With respect to the onset of the study, the odds of a horse being assigned a higher squamous ulcer score increased after the 1st month of training through the end of the study (Table 3). A peak in squamous ulcer scores occurred in the 3rd month of training, and the odds of a horse being assigned a higher squamous ulcer score were significantly higher during the peak than during each of the 2 earlier months. Moderate or more intensive training increased the odds of a horse being assigned a higher squamous ulcer score with respect to jogging (Table 3). Trotting also increased the odds with respect to pacing (Table 3).

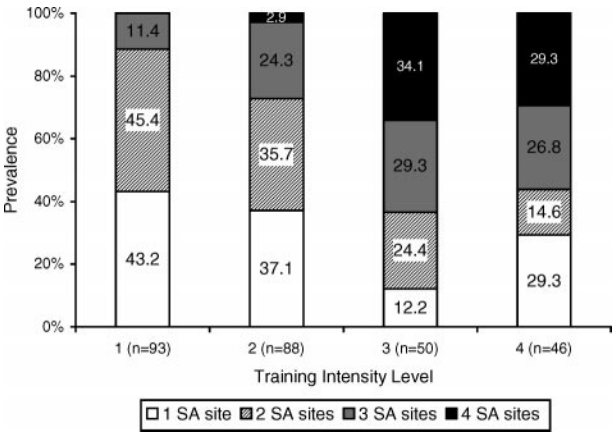

Fig 1. Proportion of horses with squamous ulcers with different numbers of specific anatomic sites (SA sites) presenting squamous ulcer lesions as a function of the training intensity level.

Ulcer location within the stomach had a significant effect on the odds that a squamous ulcer would be assigned a higher score at a given SA site (Table 4). Odds varied significantly between every combination of sites, with the lowest scores occurring in the SC and C sites and the highest scores occurring in the LC and MP areas (Table 4).

Discussion

The horse population examined in the current study was representative of the majority of Standardbred horses at the beginning of their training in Quebec, Canada. In Quebec, young horses usually begin their training program in December, and by the summer, they are ready to race. This training period may differ in other regions where seasons have a lesser impact on training approaches and where different age groups can be found to be in training at any given time. Seasonality may also have been a factor in the current study, because horses did not have access to pasture from December to April, and free access to pasture has been reported to decrease the prevalence of squamous ulcers in horses.[11,17,25–27]

The overall prevalence of squamous ulcers in Standardbred horses undergoing intensive training (90%, including levels 3 and 4) in this study was as high as the prevalence reported in Thoroughbred horses in training and racing,[17,28] but there was a marked difference when compared to the previously reported prevalence in training as well as in racing Standardbred horses in Quebec.[15] In the latter study, the prevalence of squamous ulcers in Standardbred horses in

Table 2. Effects of several factors on the odds of high numbers of sites in the squamous gastric mucosa with ulcers (see also Fig 1).

Factor	OR (95% CI)	*P* Value
Stable:		
B versus C	1.62 (0.32–8.19)	.56
A versus C	0.70 (0.26–1.89)	.48
Sex:		
Female versus male	0.98 (0.42–2.29)	.97
Gelding versus male	1.39 (0.59–3.26)	.45
Gait:		.025
Trotter versus pacer	2.38 (1.20–4.74)	.013
Age group:		
3–4 years versus 24 months and younger	0.45 (0.12–1.69)	.24
Duration of training:		
1 month (January) versus onset	3.42 (1.56–7.48)	.002
2 months (February) versus onset	6.59 (2.83–25.9)	<.001
3 months (March) versus onset	10.87 (4.10–28.8)	<.001
4 months (April) versus onset	5.50 (1.71–27.6)	.004
5 months (May) versus onset	6.47 (1.70–24.6)	.006
6 months (June) versus onset	4.74 (1.05–21.4)	.043
3 months (March) versus 1 month	3.18 (1.56–6.50)	.002
3 months (March) versus 2 months	1.65 (1.01–2.70)	.046
Training level:		.013
Level 2 versus level 1	1.51 (0.75–3.06)	.25
Level 3 versus level 1	5.29 (1.93–24.5)	.001
Level 4 versus level 1	5.85 (1.71–20.0)	.005

OR, odds ratio; CI, confidence interval.

Table 3. Effects of factors on the odds ratios of a high squamous ulcer score.

Factor	OR (95% CI)	*P* Value
Stable:		
B versus C	1.38 (0.18–10.3)	.75
A versus C	0.96 (0.36–2.58)	.93
Sex:		
Female versus male	1.02 (0.43–2.40)	.97
Gelding versus male	1.05 (0.41–2.70)	.92
Gait:		.048
Trotter versus pacer	2.17 (1.07–4.43)	.033
Age group:		
3–4 years versus 24 months and younger	0.62 (0.11–3.47)	.59
Duration of training:		.005
1 month (January) versus onset	3.70 (1.75–7.81)	.001
2 months (February) versus onset	5.13 (2.04–12.9)	.001
3 months (March) versus onset	11.01 (4.07–29.8)	<.001
4 months (April) versus onset	4.04 (1.28–12.8)	.017
5 months (May) versus onset	6.61 (1.68–26.0)	.007
6 months (June) versus onset	5.29 (1.40–19.9)	.014
3 months (March) versus 1 month	2.98 (1.37–6.46)	.006
3 months (March) versus 2 months	2.15 (1.22–3.77)	.008
Training level:		.003
Level 2 versus level 1	1.50 (0.69–3.24)	.31
Level 3 versus level 1	3.39 (1.34–8.56)	.009
Level 4 versus level 1	11.40 (3.21–40.5)	.001

OR, odds ratio; CI, confidence interval.

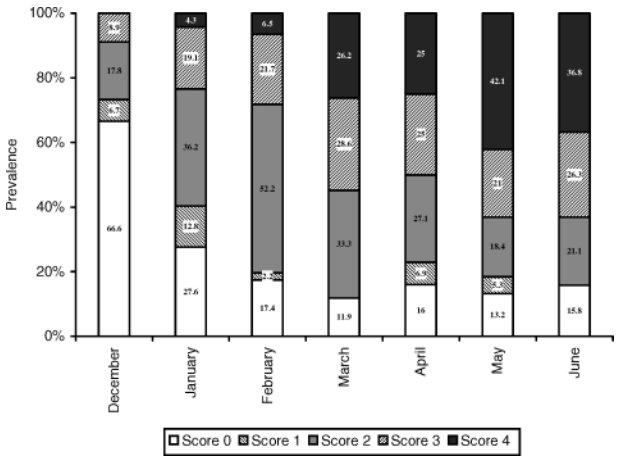

Fig 2. Distribution of squamous ulcer scores in the nonglandular portion of the stomach as a function of training duration.

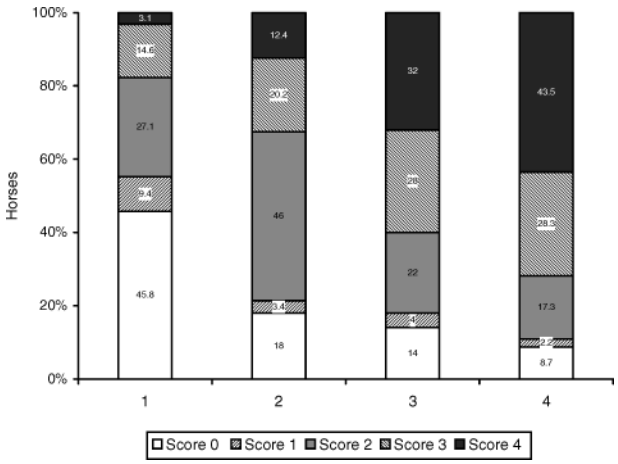

Fig 3. Proportion of horses with different squamous ulcer scores as a function of training level.

training was 38%. The difference in prevalence in this study could be partially because, in the latter study, horses were grouped differently, with no distinction of the level of training intensity (horses that were only jogging were mixed with horses at training levels 3 or 4). The time of year was also different between these 2 studies, resulting in an older population of horses that was already racing in December, compared to a majority of horses only jogging in the present study. Finally, the prevalence may have been underestimated in the previous study, because a different gastric ulcer scoring system was used. In a recent study performed on a similar population (81% horses aged 3 years), the prevalence of squamous ulcers in Standardbred horses in training and racing was 94%,[7] which is closer to the prevalence reported in the present study.

The marked increase, over time, in the prevalence of squamous ulcers within the 1st 3 months of training and the high prevalence of squamous lesions in jogging horses were interesting findings of this study. That squamous ulcers appear rapidly in horses in training was noted by Murray et al (unpublished data), who observed that 90% of young Thoroughbred horses in training developed gastric lesions after 2 or 3 months of intense training.[20] In another study, 30 horses were exercised 6 times a week on a treadmill, and 100% of them developed gastric ulcers within only 2 weeks after the start of the trial.[6] In the present study, because 38% of the horses already had ulcers at the onset of the trial, despite being at the beginning of training, risk factors other than training were probably involved, such as feeding schedules, ration, and housing. These factors should not be ignored, but they may have a lesser impact as training duration and intensity progress.

Training intensity rather than training alone increased the odds of observing a squamous ulcer and of assigning it a higher score in this study. The intensity of training has been suspected to have an effect on the development of equine gastric ulcer syndrome.[f,2,3,5,7,11,15,17,22] A decrease in the intraluminal pH of the proximal portion of the stomach occurs in horses when activity progresses from walking to trotting or galloping.[29] This is possibly because, during intensive exercise, contraction of the abdominal muscles compresses the stomach, which results in a longer period of acid exposure to the proximal portion of the stomach.[27] This would explain why the prevalence, score, and number of sites affected increase as training duration and intensity increase. However, that the prevalence remained constant after March, even though the intensity of training was still increasing, was unexpected. The stomach of horses undergoing intense training for a given period may become accustomed to this internal physical mechanism, and this could also explain why spontaneous healing of gastric ulcers can occur in horses in training[30] and why an unchanging prevalence over time was observed in the current study after March. Alternatively, it should also be considered that when the prevalence reaches close to 90%, the squamous ulcer scores are above 3, and the number of sites affected is greater than 3, then there is less possibility for an increase in either of these variables; hence, a plateau is reached and is maintained during the following months. Finally, this study appears to indicate that moderate-to-intense training levels (levels 3 and 4) are required to significantly increase the odds of developing squamous ulcers and to assign them higher scores than low-intensity training or jogging (levels 1 and 2).

After 3 months in training, horses presented more lesions located at the LC and the MP areas in this study. These

Table 4. Specific anatomic sites significantly associated with an elevated squamous ulcer score and their odds ratios.

Specific Anatomic Site	OR (95% CI)	*P* Value
Site affected		<.001
Saccus caecus:	Reference	
Margo plicatus	21.5 (9.60–48.1)	<.001
Lesser curvature	12.35 (5.87–26.0)	<.001
Cardia:	Reference	
Margo plicatus	7.60 (3.93–14.7)	<.001
Lesser curvature	4.37 (2.53–7.53)	<.001
Saccus caecus	0.35 (0.18–0.68)	.002
Margo plicatus:	Reference	
Lesser curvature	0.58 (0.36–0.93)	.02

OR, odds ratio; CI, confidence interval.

sites are reported to be the most commonly affected sites for squamous ulcers in horses in general.[3,5,6,8–15] Horses were also more at risk of developing higher squamous ulcers scores over time. Exercise on a treadmill decreases the pH of acidic content in the proximal area of the stomach, a possible explanation for why the LC and MP areas are more prone to develop squamous ulcerous lesions.[29] The severity of gastric ulcers in horses in training increases with the intensity of training,[2,22] but, to our knowledge, this is the 1st study in which lesions located at SA sites were followed over time and associated with training intensity.

The number of SA sites affected with squamous ulcers was significantly associated with the intensity of training and duration (month). This result could be expected, because intensity and duration of training have been associated with lesion scores, which were previously reported to be associated with the number of SA sites presenting squamous ulcers in Standardbred horses in training.[15] There is no known study concerning the intensity of training in relationship with the number of sites affected by squamous ulcers or the true effect of having more than 1 site affected on a clinical basis in horses. Therefore, finding a link between the number of sites and lesions with a higher score could bring relevant new insights into deciding when to treat for squamous ulcers in horses.

Gait has been previously suggested to represent a significant risk factor for squamous ulcers in Standardbred horses in training.[15] In the latter study, trotters were reported to have a higher prevalence of squamous ulcers than pacers, but this observation could not be explained. In the current study, gait (trotter) was again associated with a high score and a higher number of SA sites affected by squamous ulcers, confirming these previous findings. These differences could not be explained by a difference in training level with respect to gait. During high-speed exercise, the contraction of abdominal muscles reduces the gastric size, which decreases the pH of the proximal portion of the stomach.[29] The occurrence of this internal physical mechanism during training or racing in trotters may perhaps be more important than it is in pacers. To our knowledge, there is no published study on correlating the effect that such physical mechanisms have on gait. Other risk factors such as feeding behavior, gastric emptying, or genetic differences might be involved, but it was not possible to investigate those factors in this study.

Footnotes

[a] Rabuffo TS, Orsini JA. Incidence of gastric ulcers in Standardbred racehorses. Proc Am Coll Vet Surg 11th Annual Symp 2001, Chicago, IL (abstract).

[b] Xylazine hydrochloride, Bayer Inc, Agriculture Division, Animal Health, Etobicoke, Ontario, Canada

[c] Pentax Videoendoscope model VSB-2900, Pentax Corp, Englewood, CO

[d] Pentax Endo irrigator pump model El-400C, Pentax Corp, Englewood, CO

[e] SAS version 8.02, Statistical Analysis Systems Institute, Cary, NC

[f] Orsini JS, Pipers FS. Endoscopic evaluation of the relationship between training, racing, and gastric ulcers. Proc Am Coll Vet Surg 6th Equine Colic Res Symp 1998;424 (abstract).

Acknowledgments

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