Clinical, biochemical, and hygiene assessment of stabled horses provided continuous or intermittent access to drinking water

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Objective—To compare health, hydration status, and management of stabled pregnant mares provided drinking water continuously or via 1 of 3 intermittent delivery systems.

Animals—22 Quarter Horse (QH) or QH-crossbred mares and 18 Belgian or Belgian-crossbred mares (study 1); 24 QH or QH-crossbred mares and 18 Belgian or Belgian-crossbred mares (study 2).

Procedure—Stabled horses were provided water continuously or via 1 of 3 intermittent water delivery systems in 2 study periods during a 2-year period. Body temperature, attitude, appetite, water intake, and urine output were recorded daily. Hygiene of each horse and the stable were assessed weekly. Clinical and biochemical measures of hydration were determined 3 times during each study. Clinical measures of hydration included skin turgor, gum moisture, capillary refill time, and fecal consistency. Biochemical measures of hydration included PCV, plasma total protein concentration, serum osmolality, plasma vasopressin concentration, urine specific gravity, and urine osmolality.

Results—All horses remained healthy. Stable hygiene was worse when horses had continuous access to water. Clinical and biochemical measures of hydration did not differ among water delivery systems.

Conclusions and Clinical Relevance—Various continuous and intermittent water delivery systems provided adequate amounts of water to stabled horses to maintain health and hydration status. Providing intermittent access to water may be preferable on the basis of stable hygiene. (*Am J Vet Res* 1999;60:1445–1450)

Methods of providing water to horses vary. Recommendations for horses in barns include providing water in buckets, by means of automatic water bowls, or through various automatic water delivery devices.[1,2] Provision of water in buckets is labor intensive and does not necessarily provide a continuous supply of water. Automatic water bowls provide horses with a continuous supply of water but have potential problems, including overflow when the float fails, water deprivation when the device is plugged, or safety concerns associated with placement.[2,3] Stalls may also become undesirably soiled or wet when horses use continuous water delivery systems.[4] It may not be prudent to provide continuous access to water for horses that have clinical problems such as psychogenic polydipsia.

Although horses on pasture have been observed to drink water only once or twice daily,[5,6,a,b] there is a lack of data on voluntary water intake, optimal methods for water delivery, or health and hydration of stabled horses provided water by various water delivery systems and in accordance with various schedules. The objective assessment of animal management systems and associated effects on animal health and welfare has become increasingly timely and important because of public debate about animal welfare issues and the definition of animal well-being. Therefore, we investigated the well-being of stabled horses provided water by continuous or any of 3 intermittent delivery systems.

Our laboratory group concurrently investigated the psychologic well-being of the horses reported here, comparing detailed quantitative measures and clinical assessments of behavior.[7] The various water delivery systems provided adequately to maintain the psychologic well-being of the horses. The objective of the studies reported here was to concurrently investigate the physiologic well-being of the horses by comparing measures of health, clinical and biochemical indicators of hydration status, and hygiene among stabled horses provided water continuously or intermittently.

Materials and Methods

Animals and general husbandry—Two studies were conducted during November through March of 1995-1996 (study 1) and 1996-1997 (study 2) on a **pregnant mare urine (PMU)** ranch in Manitoba, Canada,[c] which provided an appropriately managed population of stabled horses readily accessible for serial data collection. In study 1, 11 **Quarter Horse (QH)** or QH-crossbred mares and 9 Belgian or Belgian-crossbred mares were assigned to each of 2 groups. In study 2, 8 QH or QH-crossbred mares and 6 Belgian or Belgian-crossbred mares were assigned to each of 3 groups. Mares were 2 to 4 months in gestation when moved to the tie-stall barn in October prior to the start of each study. Horses were randomly assigned to groups after stratification on the basis of body weight, parity, and age.

Horses were housed in a tie-stall barn that was ventilated to maintain a temperature range of 5 to 10 C. Stalls varied from 1.22 to 1.52-m wide on the basis of size and weight of each horse. Stalls were 2.44-m long, including the manger, and were separated from adjacent stalls by metal rails that extended the entire length of the stall. Floors were concrete, which was covered with stall mats and bedded with straw. Tethers were individually fitted to allow each horse to lie down and move back 0.61 to 1.22 m into the alley behind the stall.

Horses were fed grass hay 4 times daily (8 AM and 1, 4, and 8 PM) and approximately 1.2 kg of oats twice daily (morning and late afternoon). A fortified mineral-vitamin mixture containing 25% salt, formulated to balance or marginally exceed mineral and vitamin requirements of the horses, was provided once daily.

Experiment design—The study was conducted, using a repeated-measures, randomized block design, with horses blocked on the basis of breed. In study 1, horses (n = 20/group) were provided continuous access to water (group C) or intermittent access to water, using a flip-lid (group I-lid). The water bowl consisted of a rectangular box (43.5 X 19.7 X 17.8-cm deep) with a hinged lid. The water bowl was attached to the far left or far right side of a manger that spanned the entire width at the front of a stall. The top of the water bowl was even with the top of the manger (1 m above the floor). For horses in group C, the lid of the water bowl remained open, and the water was maintained at a depth of 2.5 to 5 cm by a float control mechanism. For horses in group I-lid, the lid of the water bowl remained closed except when it was manually opened for a period of 5 minutes 3 times daily (7:30 AM and 1:30 and 7:30 PM). For group I-lid, water was maintained by a similar float control mechanism at a depth of 5 to 10 cm.

In study 2, horses (n = 14/group) were provided continuous access to water (group C), intermittent access to water by use of a timer system (group I-timer), or intermittent access to water by use of a timer system with a float (group I-timer-float). All groups used a rectangular curved-bottom water bowl (25.4 X 23.3 X 19.7-cm deep) positioned above the top of the manger such that the top of the water bowl was approximately 124 cm above the floor. The water delivery system for horses in group C automatically maintained a continuous supply of approximately 2 L of water (5 to 10-cm deep). The watering system for group I-timer delivered a fixed volume of water at 90-minute intervals from 6:00 AM to midnight. Each water delivery lasted 110 to 120 seconds, and the volume was adjusted for each horse so that the bowl did not overflow and some water should remain in the bowl after delivery. The water delivery system for group I-timer-float delivered water for a period of 5 minutes 5 times daily (6 and 8:30 AM and 1:30, 5, and 10 PM). This variation was designed to deliver the volume of water consumed during each 5-minute period as well as to provide approximately 2 liters of residual water (5 to 10-cm deep) at the end of each delivery period. The I-timer-float variation was designed to provide semicontinuous access to water while minimizing spillage and overflow.

A CBC and serum biochemical analysis were obtained for each horse at the start and end of each study. Health, hydration status, and hygiene of the horses and stable were determined in each study. Rectal temperature, attitude, appetite, water intake, and urine output were recorded daily. Horse hygiene, stable hygiene, and associated barn management factors were evaluated weekly. At 3 regular intervals during each study, clinical and biochemical measures of hydration status, serum cortisol concentration, and fecal water content were determined.

Samples for discrete data were collected on 1 or 2 pairs (study 1) or triplets (study 2) of horses on 3 separate days in January, February, and March (study 1) and November, January, and March (study 2). The horse pairs or triplets were randomly assigned to a data collection day, and the same sequence of horses was repeated on subsequent sample collection days.

Hydration status—Daily amount of water delivered was measured for each horse, using an in-line turbine water meter[d] or manual recording from graduated gravity-flow tanks supplied for each horse. Daily urine output was measured for each horse, using a noninvasive PMU collection apparatus suspended near the perineum.

On the assigned data collection day (monthly for study 1; bimonthly for study 2), body weight was recorded on a large-animal scale.[e] Body condition scores were recorded concurrently, using a 9-point scoring system.[8] Hydration status for each horse was evaluated by subjective measurements of skin turgor, gum moisture, capillary refill time, and fecal consistency.[9] Total fluid intake (water delivery and feed intake) and total fluid output (urine and feces) were measured during the 24-hour period. Water delivery and urine output were measured as described. All hay and grain fed to the horses as well as any feed remaining at the end of the 24-hour data collection period were weighed. Nutrient and moisture analyses of grain and hay samples, obtained by use of a core sampler, were submitted to a commercial feed testing laboratory.[f] Total water intake was calculated, using daily amount of water delivered and moisture content of feed consumed. All feces produced during the 24-hour data collection period were collected and placed in a plastic bag to prevent evaporation. At the end of the 24-hour collection period, total wet weight of feces was recorded, and a subsample of approximately 400 to 600 g of wet feces was placed in an aluminum pan and dried at 55 C in a forced-air oven. Fecal moisture content was calculated, using the difference between weights of the wet and dried fecal sample.

On the assigned data collection day (monthly for study 1; bimonthly for study 2), blood samples were collected at 7 AM and 1:30 PM on the day after the 24-hour urine collection period. Samples (20 ml) of blood were collected in evacuated tubes that did not contain anticoagulant[g] or that contained potassium EDTA.[h] Packed cell volume was determined by a microhematocrit technique,[i] and plasma **total protein (TP)** concentration was determined, using a refractometer.[j] Blood samples were centrifuged[k] at 2,000 X g for 30 minutes at 4 C. Serum and plasma were harvested into sterile 12 X 75-mm polypropylene or polystyrene culture tubes. Serum osmolality of both samples (AM and PM) were measured on unfrozen samples by use of a freezing-point depression technique.[l] Blood for plasma vasopressin analysis was collected into evacuated tubes containing potassium EDTA that were chilled on ice prior to collection and remained on ice or were refrigerated throughout plasma harvest. Stored serum and plasma were frozen at –70 C until analyses were performed. Plasma vasopressin concentrations were determined at a university laboratory,[m] using the method of Brownfield et al.[10] Serum obtained in the AM sample was submitted to an agricultural veterinary services laboratory[n] for standard biochemical analyses.

Urine produced during the 24-hour period prior to collection of blood samples was collected in the PMU device. Urine specific gravity was determined on an aliquot, using a refractometer,[j] and urine osmolality was measured by use of a freezing-point depression technique.[l]

Serum cortisol concentration—Serum obtained in the AM sample was also submitted to the agricultural veterinary services laboratory[n] for measurement of serum cortisol concentrations. Serum cortisol concentrations were determined by use of a fluorescent polarization immunoassay.[o]

Hygiene of horses and the stable—Cleanliness of water bowls, feed mangers, stalls, and horses was assessed weekly.

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A descriptive evaluation form and numbered scale (**Appendix**) were used by the investigators.

Statistical analyses—For each study, statistical analyses of repeated-measures data were conducted, using statistical computer programs.[11] Discrete data were analyzed as a split-plot analysis in which main effect of water delivery system was tested by use of the interaction error term (breed by water delivery system).[12] Differences between means were compared, using the probability difference. For all tests, a value of $P \leq 0.05$ was considered significant.

Results

General health of horses and clinical assessments—All horses remained healthy during both studies, as determined on the basis of daily rectal temperatures and clinical examinations. Initial and final mean body condition scores were between 6 and 7 for all horses. Mean body weights did not differ significantly between groups of horses in either study (**Tables 1 and 2**). In study 1, 3 horses in group C had mild colic. One mare in group I-lid aborted as a result of infection with equine herpesvirus-1; another mare aborted prior to group assignment, but a cause could not be determined. None of the horses in group I-lid were judged to have abnormal feces, whereas 2 horses in group C produced feces that had a consistency typical of the feces of dairy cattle. In study 2, 2 horses in group C and 4 horses in group I-timer-float had mild spasmodic or flatulent colic. Feces were judged to be normal with the exception of 5 horses in group C, 4 horses in group I-timer-float, and 1 horse in group I-timer; these horses produced feces that had a consistency typical of the feces of dairy cattle. Skin turgor, capillary refill time, and gum moisture consistently were considered to be normal.

Hydration status—Measures of hydration status were determined (Tables 1 and 2). For each study, significant differences were not detected for amount of water delivered, urine output, or biochemical measures of hydration among horses provided water by continuous or intermittent delivery systems. In study 2, fecal water content, urine specific gravity, and urine osmolality differed significantly ($P < 0.05$) among horses provided water by continuous, I-timer, or I-timer-float systems. However, all absolute values for these criteria were within expected ranges, and differences were sufficiently small such that we did not consider them to be clinically relevant. Analyses of the data from both studies indicated normal hydration status and water balance in all horses.

Mean urine specific gravity was > 1.040 for all groups of horses (Tables 1 and 2). These values are at the high end of the reference range (ie, 1.020 to 1.050) for clinically normal horses, but were considered normal on the basis of typical water intake and serum osmolality values for all groups of horses.

Table 1—Results (mean ± SEM) of measurements during study 1 to determine hydration status for stabled pregnant mares (n = 20 horses/group) provided continuous access to water or intermittent access via a water delivery device with a manually operated lid (I-lid)

	Group	
	Continuous*	**I-lid†**
Water balance		
Body weight (kg)	644.7 ± 13.2	646.8 ± 15.0
Water delivery (L/d)	32.2 ± 1.2	29.6 ± 1.2
Water from feed (L/d)	2.2 ± 0.1	2.2 ± 0.1
Total water intake (L/d)	34.4 ± 1.2	31.8 ± 1.2
Total water intake (ml/kg of BW/d)	53.2 ± 1.4	48.8 ± 1.2
Urine production (L/d)	4.9 ± 0.3	4.4 ± 0.2
Fecal water output (L/d)	21.6 ± 0.8	20.1 ± 0.7
Total water output (L/d)	26.5 ± 1.0	24.5 ± 0.8
Total water output (ml/kg of BW/d)	40.9 ± 1.2	37.7 ± 0.8
Biochemical analyses		
PCV (%)		
AM	37.6 ± 0.6	8.2 ± 0.4
PM	39.6 ± 0.6	40.4 ± 0.5
Plasma total protein (g/L)		
AM	70.1 ± 0.0	71.2 ± 0.0
PM	74.6 ± 0.0	74.2 ± 0.0
Serum osmolality (mOsm/kg)		
AM	282.6 ± 0.4	286.2 ± 0.4
PM	286.0 ± 0.4	280.7 ± 0.5
Urine osmolality (mOsm/kg)	1,263 ± 33	1,343 ± 19
Urine specific gravity	1.051 ± 0.001	1.054 ± 0.001
Plasma vasopressin (pg/ml)		
AM	0.89 ± 0.05	0.94 ± 0.05
PM	1.01 ± 0.06	0.92 ± 0.05

*Continuous access to water, using a float system. †Each water delivery device was covered with a hinged lid that was manually opened for 5 min 3 times daily.

BW = Body weight. AM = Samples collected during the morning. PM = Samples collected during the afternoon.

Table 2— Results (mean ± SEM) of measurements during study 2 to determine hydration status for stabled pregnant mares (n = 14 horses/group) provided continuous access to water or intermittent access via an interval-timer or an interval-timer-float water delivery system

	Group		
	Continuous*	**Interval-timer†**	**Interval-timer-float‡**
Water balance			
Body weight (kg)	655.4 ± 21.7	653.5 ± 21.9	661.5 ± 21.1
Water delivery (L/d)	31.4 ± 1.4	27.7 ± 1.5	36.7 ± 1.9
Water from feed (L/d)	2.0 ± 0.1	2.1 ± 0.1	2.2 ± 0.1
Total water intake (L/d)	33.5 ± 1.4	29.8 ± 1.6	38.9 ± 1.9
Total water intake (ml/kg of BW/d)	51.6 ± 1.8	45.3 ± 1.5	58.6 ± 1.9
Urine production (L/d)	3.9 ± 0.2	4.0 ± 0.3	4.4 ± 0.3
Fecal water output (L/d)	20.9 ± 1.0	18.5 ± 0.7	21.6 ± 1.0
Total water output (L/d)	24.8 ± 1.2	22.4 ± 0.9	26.0 ± 1.2
Total water output (ml/kg of BW/d)	37.7 ± 1.1	34.3 ± 0.7	39.2 ± 1.1
Biochemical analyses			
PCV (%)			
AM	37.7 ± 1.0	37.8 ± 0.8	35.8 ± 0.7
PM	39.2 ± 0.9	38.6 ± 0.7	36.9 ± 0.7
Plasma total protein (g/L)			
AM	73.8 ± 0.1	71.8 ± 0.1	73.6 ± 0.1
PM	77.1 ± 0.1	75.1 ± 0.1	77.4 ± 0.1
Serum osmolality (mOsm/kg)			
AM	282.7 ± 0.5	282.8 ± 0.5	280.8 ± 0.6
PM	285.5 ± 0.5	285.2 ± 0.4	284.4 ± 0.6
Urine osmolality (mOsm/kg)	1,329 ± 36^a	1,469 ± 29^b	1,324 ± 33^a
Urine specific gravity	1.048 ± 0.001^a	1.051 ± 0.001^b	1.048 ± 0.001^a
Plasma vasopressin (pg/ml)			
AM	0.70 ± 0.07	0.75 ± 0.07	0.87 ± 0.10
PM	0.95 ± 0.1	1.45 ± 0.5	2.00 ± 0.7

*Continuous access to water, using a float system. †Each water delivery device provided a set volume of water which a timer delivered at 90-min intervals between 6 AM and midnight. ‡Each water delivery device had a float system, and a timer delivered water for 5 min 5 times daily.

a,bWithin a row, values with different superscript letters differ significantly ($P < 0.05$).

See Table 1 for key.

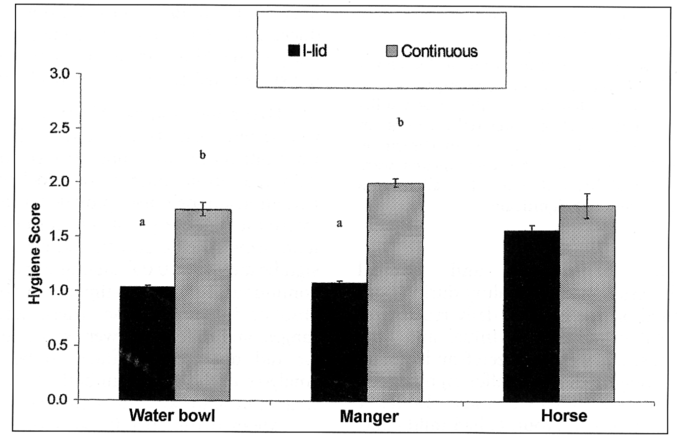

Figure 1—Scores (mean ± SEM) for hygiene of horses and the stable during study 1 in horses (n = 20 pregnant mares/group) provided continuous access to water or intermittent access via a device with a manually operated lid (I-lid). a,bValues with different superscript letters differ significantly ($P < 0.05$). Hygiene scores were determined as follows: 1 = Normal, dry and clean. 2 = Passable, moderate soiling. 3 = Unacceptable, extremely soiled or wet.

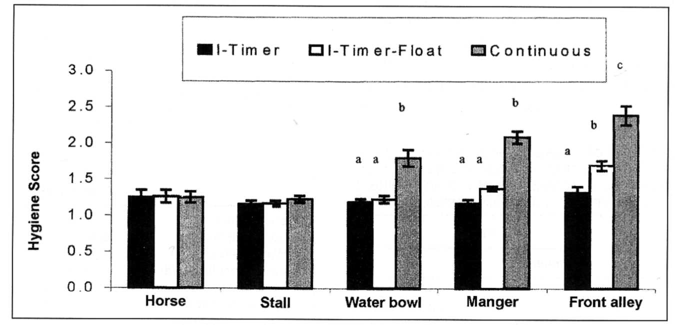

Figure 2—Scores (mean ± SEM) for hygiene of horses and the stable during study 2 in horses (n = 14 pregnant mares/group) provided continuous access to water or intermittent access via an interval-timer (I-timer) or via an interval-timer-float (I-timer-float) water delivery system. a,b,cValues with different superscript letters differ significantly ($P < 0.05$). *See* Figure 1 for key.

Serum cortisol—Serum cortisol concentrations were within the reference range (ie, 11 to 182 nmol/L) reported for the commercial laboratory and did not differ among groups. In study 1, mean serum cortisol concentrations were 125.2 ± 6 nmol/L for horses in group C, which did not differ significantly ($P = 0.25$) from that for horses in group I-lid (109.6 ± 5 nmol/L). In study 2, mean serum cortisol concentrations did not differ significantly ($P = 0.68$) among horses in groups C (153 ± 6 nmol/L), I-timer (148 ± 8 nmol/L), and I-timer-float (160 ± 11 nmol/L).

Hygiene of horses and stable—Feed contamination of water bowls and water spillage resulted in hygiene scores that were significantly ($P < 0.05$) higher for water bowl and manger in study 1 (**Fig 1**) and for water bowl, manger, and front alley in study 2 (**Fig 2**) when horses were provided continuous access to water, compared with all methods for intermittent water delivery. Subjectively, it appeared that these Belgian or Belgian-crossbred horses (ie, draft breeds) spilled more water than these QH or QH-crossbred horses (ie, light breeds).

Discussion

Analysis of results of these studies indicated that providing stabled horses intermittent access to water maintained hydration and water balance as effectively as providing continuous access to water. Furthermore, for stabled horses, hygiene and barn management were better with intermittent than with continuous water delivery systems.

Opinions vary regarding the appropriate frequency for provision of water. Although some specialists in equine management propose that continuous delivery of water (ie, available ad libitum) should be the standard, there are numerous situations in which this is not possible or in which it may not be the best for welfare of the horses. In such instances, analysis of our data indicates that daily intermittent access to water is adequate for maintaining hydration.

Water intake reportedly varies among horses.[13] Multiple factors may influence frequency of drinking and volume of water intake, including ambient temperature, feeding regimen, composition of diet, and variation among horses. For horses, drinking tends to coincide with eating,[14,15] and, therefore, provision of water around feeding time is an appropriate management practice. Ingestion of feed causes increases in plasma osmolality and plasma TP concentration.[16] Thirst threshold for horses is estimated to be attributable to an increase in plasma osmolality (8 mOsm/kg of body weight or a 3% increase in plasma osmolality).[15] Diet affects water intake, urine output, and the percentage of water excreted in feces, compared with the percentage excreted in urine.[17,18] Fecal water excretion increases when horses are fed grass hay, and urinary water excretion increases when horses are fed a legume diet. In the studies reported here, absolute water intake, as measured by amount of water delivered, also varied among the horses. Diet and environment were controlled and should not have contributed to variations in water intake or urine output observed among horses. In summary, defining the absolute water requirement for horses is difficult, and a single prescribed water volume is not appropriate for every horse in a population.

A loss of fluid equivalent to approximately 5% of body weight is the minimum degree of dehydration that can be detected during clinical examination. Thus, it is difficult to identify specific horses that are not drinking an adequate volume of water. Biochemical assessment of hydration status is more sensitive but not practical in a farm setting. Changes in serum osmolality and plasma TP, sodium, and vasopressin concentrations have been documented after varied periods of water deprivation.[15,19-21] These biochemical alterations were corrected within minutes of when horses in those studies were provided water. For example, horses deprived of water and food for 72 hours lost, on average, 51.6 kg (10.7% of body weight).[21] Those horses replaced 62% of the weight loss (32.1 kg; 7% of body weight) by 1 hour after gaining access to water. In that study, other variables such as PCV and serum potassium, calcium, magnesium, and phosphate concentrations were not influenced by dehydration.

Serum osmolality and vasopressin concentrations documented here are similar to those of other reports. In our studies, mean serum osmolality did not differ among horses provided continuous or intermittent access to water. As would be expected, serum osmolality was higher in the morning for horses provided intermittent access to water during study 1. It was higher in the afternoon for horses with continuous access to water. Horses provided with continuous access to water attained the same serum osmolality during the day that horses with intermittent access had after 12 hours without water. Therefore, it seems unlikely that these fluctuations in serum osmolality have clinical relevance for thirst or hydration status. In study 2, differences were not detected in serum osmolality among the horses provided water by automatic intermittent water delivery systems and those provided continuous access to water.

Increased plasma osmolality causes release of vasopressin and ACTH in horses.[22] Increased vasopressin and ACTH concentrations are associated with stress and increased osmolality in horses,[23] and distress was documented in ponies during water deprivation when they saw or smelled water.[19] Therefore, serum cortisol concentrations likely would have identified differences in stress response among groups of horses provided water by the various water delivery systems in our studies. However, on the basis of serum cortisol concentrations, a stress response was not observed. This was supported by assessments of time budgets and behavior patterns that were made by use of 24-hour videotape monitoring in the concurrent studies.[7]

In the studies reported here, the method of water delivery or interval for access did not affect health measures. However, malfunction of a float device or interruption of the water supply can result in water deprivation, regardless of the type of water delivery system. Monitoring fecal consistency and feed intake are recommended routine management practices, because impaction of the large colon reportedly develops secondary to dehydrating ingesta.[24] All colics in the horses of these studies were mild spasmodic or flatulent colics that required minimal or no medical intervention.

Although we did not detect clinically relevant effects of water delivery method on health and hydration status of the horses, important husbandry differences were observed. Hygiene was more likely to be a problem with continuous delivery of water, resulting in increased labor and management requirements to maintain acceptable stable conditions. Therefore, potential secondary effects on health of the horses associated with hygiene and a wet stable environment or on labor and management costs are considerations when selecting a water delivery method for stabled horses.

Many animal industries evaluate housing, management practices, and animal use in regard to welfare and well-being of the animals, including that of horses. In addition to providing the basic physiologic needs for an animal, behavioral and psychologic well-being should be considered. The studies described here did not identify clinical health concerns when several water delivery systems and access intervals were used for stabled horses.

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[f]NorWest Laboratory, Winnipeg, MB, Canada.
[g]No. 6442, Becton-Dickinson Corp, Franklin Lakes, NJ.
[h]EDTA (No. 6457), Becton-Dickinson Corp, Franklin Lakes, NJ.
[i]IEC Micro-MB centrifuge, International Equipment Co, Needham Heights, Mass.

[j]Reichert-Jung Model 10436 veterinary total solids refractometer, Leica Inc, Buffalo, NY.
[k]Beckman GS-6R, Beckman Instruments Inc, Palo Alto, Calif.
[l]Osmette A Model 5002, Precision Systems, Natick, Mass.
[m]Radionuclide Laboratory, School of Veterinary Medicine, University of Wisconsin, Madison, Wis.
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Appendix

Scoring system used to assess hygiene of pregnant mares and the stable

	Score		
Category	**1**	**2**	**3**
Appearance of horse	Dry and clean	Abdomen or hindquarters slightly soiled or wet	Abdomen or hindquarters extremely soiled or wet
Water bowl	Clean with little feed in bowl	< 50% feed in bowl	Bowl soiled; blocked with feed
Manger	Minimal amount of wet feed; manger dry	Feed and manger damp	Feed and manger saturated; filled with water
Front alley*	Dry	Wet only in area below water bowl	Wet across front of manger
Stall*	> 10% of stall wet or soiled	> 25% of stall wet or soiled	> 50% of stall wet or soiled

*Category only evaluated and included in study 2.