Association of Enterolith Formation Relative to Water Source pH Consumed by Wild Equids under Captive Conditions

M. Gaffney[1], R.E. Bray[1], and M.S. Edwards[2]

Equine Research Center and Animal & Veterinary Sciences - California State Polytechnic University[1], Pomona[1] and Zoological Society of San Diego[2]

Intestinal disorders associated with enteroliths in domestic and wild equids have perpetuated folklore feeding practices in the western U.S. Enteroliths are stones formed in the large intestine, consisting primarily of magnesium ammonium phosphate [$Mg(NH_4)(PO_4) \bullet 6H_20$]. The frequency of enteroliths reported in clinical cases and necropsy reports among captive equids at the Zoological Society of San Diego appears to be similar to those for domestic horses. Dietary influences, primarily the feeding of alfalfa hay, have been associated with the formation of intestinal stones. Long-stem and processed alfalfa hays were historically major dietary components fed to several equid species. Przewalski's horse, Grevy's zebra and eastern kiang were among those requiring surgical removal of stones. Among the factors identified in enterolith formation include an alkaline pH of the hindgut. Alfalfa forages contribute to an alkaline pH of the hindgut. Studies have also suggested that feeding vinegar will reduce the hindgut pH, thereby reducing the incident of enterolith formation. Recent fieldwork suggests that water pH (7.6-8.2) may also be a contributing factor to an alkaline pH of the hindgut. Duplicate water samples were taken from 16 sources at the San Diego Wild Animal Park during two different time periods (spring and summer) and analyzed for pH using a Corning Model 240 digital pH meter. Water pH ranged from 6.7 to 8.3. Average pH for the spring samples was 7.55 compared to 7.94 for the summer samples. The highest mean pH values were observed in the Grevy's zebra (8.00) and Somali Wild Ass (8.13) enclosures. Dietary changes have been implemented to minimize the contribution of alfalfa to the total diet, although the influence of water pH requires further evaluation.

Key Words: zoo, equine, *Equus* spp., intestinal stones

INTRODUCTION

Enteroliths are stones that can form in the large intestine of equids and consist primarily of magnesium, ammonium and phosphates. Their shapes can vary but the two more common forms are spherical and tetrahedral (Lloyd et al, 1987). Equids in the western states appear more likely to develop enteroliths than horses in other regions (Lloyd et al, 1987; Bray, 1995). Equine enteroliths have been ranked as one the most common causes of surgical colic at the UC Davis Veterinary College (Hassel et al, 1999). Their enterolith ten-year caseload has included over 900 horses with approximately 30% of the horses euthanized due to gastrointestinal rupture or for financial considerations.

Intestinal stones may exist in the large colon for extended periods without causing clinical signs of illness. They can be eliminated via feces, but if they become large enough, they can obstruct the bowel and cause colic symptoms. Five factors have been reported as important in the formation of enteroliths (Lloyd et al, 1987): 1) nidi (matrix for formation); 2) alkaline pH in the hindgut; 3) reduced rate of digesta passage; 4) excess dietary N; 5) excess dietary Mg.

Although phosphorus is a necessary component of enteroliths, there is no evidence that excess dietary P levels are required for enterolith formation.

Alfalfa diets have been implicated as a major contributor to the formation of enterolith. Important considerations relative to alfalfa forages include high concentrations of N; high concentrations of Ca; contributes to the hindgut's higher alkaline pH; very digestible and subsequently does not encourage the same degree of gut contraction as other forage types, i.e., reduced rate of passage. Magnesium concentrations in California alfalfa have also been a focus; Mg levels in predominately alfalfa diets have been reported to be as high as 5 (Bray, 1995) to 7 times (Lloyd et al, 1987) above maintenance requirements for domestic horses.

The pH concentrations in the large intestine of horses that had stones surgically removed has also been reported as significantly higher than a control group of colic patients (Hassel et al, 1998). The literature suggest that alfalfa based diets contribute to the increase alkalinity but there has been no studies relative to the influence of drinking water that has a high pH. Fieldwork (Bray, 1999) has suggested that drinking water pH may also be a contributing factor in increasing alkalinity of the hindgut.

At the Zoological Society of San Diego (ZSSD), several cases of enteroliths in captive wild equids have been documented. Historically the diets of these equids have consisted primarily of alfalfa forages as long-stem hay or processed hay (pellets). To further evaluate the dietary factors involved in the formation of intestinal stones, the pH levels of drinking water sources of ZSSD equids were determined.

MATERIALS AND METHODS

Duplicate water samples were taken from 16 different drinking sources of equids at the San Diego Wild Animal Park (SDWAP) during two different time periods (mid-spring and mid-summer). Samples were collected in sterile vials and then analyzed for pH using a Corning Model 240 digital pH meter. Collection sites included exhibits of six species of captive (zoo) equids: Somali wild ass (*Equus africanus somalicus*), Persian onager (*Equus hemionus onager),* eastern kiang (*Equus kiang holdereri*), Grevy's zebra (*Equus grevyi*), Przewalski's horse (*Equus przewalskii*), and Hartmann's zebra (*Equus zebra hartmannae*). Current and historical medical and nutritional records were reviewed for potential influences in the formation of intestinal stones.

RESULTS

Water pH for all exhibits ranged from 6.7 to 8.3 (Table 1). Average pH for the spring samples was 7.55 compared to 7.94 for the summer samples. The highest mean pH values were observed in the Grevy's zebra (8.0) and Somali Wild Ass (8.13) enclosures. In the past 10 years, there have been five colic cases involving surgical removal of intestinal stones. Two of the colic surgeries involved the Przewalski's horse, in which the highest mean pH of drinking water was 7.89. Three adult male eastern kiangs have also required surgery to remove intestinal stones; their exhibit's water pH ranged from 7.2–7.97.

The forages fed to the SDWAP equids have varied over the past 15-20 years. In the earlier years alfalfa hay was the primary forage with oat hay and more recently bermudagrass hay being incorporated. A high-fiber herbivore pellet has also been a primary dietary component that consists mostly of processed alfalfa.

Table 1. Water pH means and ranges of drinking water sources for captive (zoo) equids

Equid Exhibit	Number of Collection Sites	Mean pH (Spring Samples)	pH Range (Spring) Samples)	Mean pH (Summer Samples)	pH Range (Summer) Samples)
Hartmann's Mountain zebra	3	7.13	6.70 – 7.30	NA	NA
Przewalski's horse	3	7.65	7.37 – 7.70	7.89	7.84 – 7.95
Eastern Kiang	2	7.60	7.52 – 7.70	7.95	7.92 – 7.97
Grevy's Zebra	4	7.53	7.45 – 7.67	8.00	7.79 – 8.18
Somali Wild Ass	2	7.66	7.61 – 7.71	8.13	8.00 – 8.30
Persian Onager	2	7.71	7.67 – 7.76	7.72	7.70 – 7.75
All 6 Equid Exhibits	16	7.55	6.70 – 7.76	7.94	7.70 – 8.30

NA: Exhibit was not available on day of water sampling

DISCUSSION

The alkalinity of the drinking water sources is evident. These values are similar to values (7.6–8.2) in which there was a high incident of enterolith colic cases in two different geographical areas of California. There is data suggesting that feeding vinegar (apple cider vinegar) will reduce the pH of the hindgut (Hintz et al., 1989). Industry practices with feeding vinegar include feeding ¼ cup daily to ½ - 1 cup per day for five consecutive days monthly. Although feeding vinegar will reduce the hindgut pH, there is no evidence that it will reduce the size of intestinal stones, or prevent the formation of stones. As already noted, supplementing a diet with apple cider vinegar that is predominately alfalfa hay is perhaps a contradiction (Bray, 1995). If small portions of apple cider vinegar can influence the hindgut's alkalinity, then it would be arguable that 20–40 l of alkaline water consumed/day could also influence the pH of the equid's hindgut.

In order for the nitrogen, magnesium and phosphates to crystallize on the nidus (matrix), an alkaline condition is required. An important but unknown factor is the alkalinity threshold of the hindgut necessary for intestinal stone formation. Further understanding how the pH of the hindgut is influenced would permit opportunities to improve nutritional management practices relative to intestinal stones.

The SDWAP purchases water from the local municipality, but the municipalities sources are not currently known. Most municipalities purchase water from more than one source, which may explain the water pH being higher in the mid-summer samples vs. the mid-spring samples.

The intakes of the equids were difficult to quantify since the amounts of hay and pellets fed daily varied over the years with management differences of animal care personnel. Actual determination of N, Ca and Mg intakes were also not possible but based on California forage

composition data of Bray (1997), the N, Ca and Mg levels appear high and similar to those already reported (Lloyd et al, 1987; Bray, 1995).

The influence of pH in drinking water is suggestive; but further studies are needed to identify the potential influence of drinking water pH in the formation of enteroliths.

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