Stone Cold Killers:

The Devastating Effects of Urinary Calculi in Goats

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Abstract

The topic of urinary calculi in goats has begun trending in research studies and conversations of owners and veterinarians alike. While the disease may have been an existing problem in goats, increased use of wethered goats and first-time goat owners has led to many owners being unaware of the disease until the damage has been done. The purpose of this paper is to bring awareness of urinary calculi, the signs and treatment, and outline a specific approach to prevention in animals' respective environments.

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The increased use of wethered goats for packing has brought a much-needed awareness of urinary calculi as previously, wethers were not typically kept for longer than a year as that was all that was necessary for meat production. The younger wethers had lower incidence of urinary calculi. The cause of urinary calculi has become a heavily debated topic between goat producers and veterinarians alike but bringing awareness of signs and preventative measures is necessary to help decrease and ideally prevent the occurrence of urinary calculi complications. This paper will discuss the disease, urinary calculi; it's economic and emotional impact on producers; and how to identify, treat and prevent the disease.

Introduction

Urinary calculi, or urolithiasis, is when uroliths; crystallized formations of organic materials such as sugars, protein, and cells, and minerals, including calcium, magnesium, and phosphate; become lodged in the urinary tract. (Jones, 2021). While does are prone to develop uroliths at the same frequency as wethers and bucks, the shorter length of the urethra and absence of the sigmoid flexure decreases the chance of uroliths blocking the urinary tract. Uroliths have a greater chance of causing obstruction of urine in the s-shaped curve of the sigmoid flexure in the urethra and at the urethral process, commonly called the pizzle, where the urethra ends and folds over the penis. (Makhdoomi, D.M. and Gazi M.A., 2013)

Producers are not as familiar with urinary calculi as in years past it was not common to keep wethers longer than a year as they were used for meat production. The last 20 years have seen an increased retention of wethers for use as pack animals as alternatives to horses, mules

and llamas. Contrary to the consistent feeding regime horses, cattle and sheep can withstand, not all producers are aware of the diverse feeds that goats need to maintain their nutritional balance. A review by Morand-Fehr of the research on goat nutrition concluded that although nutritional requirements of goats specifically has improved in recent years, the quality and consistency of research is not matched to that in cattle or sheep. (Morand-Fehr, 2005) Goats are ruminants and are able to eat similar feed as cows and sheep, but since they are browsers, they can, and actually need, to consume high fibrous materials that they would naturally consume if they were in the wild. Urolithiasis is not as common in wild or range goats due to their ability to browse for grasses and shrubs that have balanced amounts of calcium, phosphorus, and silica, all of which contribute to urolithiasis.

The incidence of obstructive urolithiasis is considered to be the most common urinary tract disease of small ruminants. (Pugh et al., 2021) While the current incidence in goats alone is unknown, a 2001 USDA-NAHMS survey of 1,101 sheep operations with greater than 20 head of sheep found that 20% had at least one case of urolithiasis in the last three years. (USDA, 2003) Many cases of urolithiasis are only found after an animal is brought to a clinic for bloat or anorexia, rather than for suspected urolithiasis. (Van Metre, n.d.). In a survey of 40 packgoat owners conducted through North American Packgoat Association (NAPgA) members for this paper, 13 respondents (32.5%) have had at least one case of urinary calculi in their herd, 26 (65%) have never had any incidences, and one has had more than 6 cases. Only one owner has never heard of the disease. It is worth noting that seven respondents (18%) have owned wethers for one to two years while the majority (41%) have owned wethers for three to five years (see Appendix C for full survey responses).

Mortality

If left untreated, blockage of the urinary tract can lead to rupture of the bladder or urethra with unexpelled urine then beginning to fill the body cavity resulting in drastically increased chances of death. (Ranjith et al., 2019) Uroliths may not completely obstruct urine flow and manifest as an incomplete or even intermittent obstruction. Initial incomplete obstruction often becomes complete obstruction with time due to inflammation of damaged urethral mucosa. (Pugh et al., 2021) Complete blockage may take between 12-24 hours to cause a rupture. If the bladder rupture is not corrected by draining the cavity of urine within 24-72 hours, shock and infection will occur, leading to death of the animal.

Signs/Symptoms

Signs of urolithiasis are similar to many other gastrointestinal diseases. The animal may begin to show signs of depression, malaise, separation from the herd, and eventually go off feed. As the disease progresses, the animal may have difficulty urinating and show signs of straining, slow urination, stomping of the feet and kicking at the area of the penis. (Pugh, 2020) Vocalization due to pain and discomfort is a common sign. Goats may also stand with the front and back legs extended and the back bowed downwards to help alleviate the pressure of the bladder. (VanMetre, n.d.) Constant tail flagging may also be seen. Some calculi may be present on the hairs surrounding the sheath, but absence should not indicate an unobstructed urethra. Prolonged disease is defined as showing signs of blockage for longer than 24 hours. With inability to urinate, the bladder becomes overly distended with urine. Deep abdominal palpations in the flank area of the goat may confirm a firm, spherical mass when there is an obstruction and the bladder is still intact. (Van Metre, n.d.) In cases where the bladder has

already ruptured, the goat may no longer display signs of pain and the bladder will no longer be felt with palpation as urine begins to fill the body cavity. Swelling in the belly or abdominal wall will be visible, showing signs of what is commonly called "waterbelly." (Pugh, 2020) Depression and anorexia will continue as sepsis sets in and death will occur between two to seven days, with potential to last up to two weeks before death. (Shahrom and Zamri-Saad, 2011)

Treatment

Treatment of urolithiasis is dependent on the stage of the disease. If caught before complete obstruction occurs, treatment can include altering the urine pH by changing the diet depending on the cause of the uroliths with the most common cause of urolith formation from a phosphorus imbalance, typically due to higher phosphorus than calcium when feeding high-grain concentrate diets. When the calcium to phosphorus ratio is lower than 2:1, phosphatic uroliths may form. When the calcium to phosphorus ratio is too high, or greater than 4:1, calcium carbonate uroliths may form (see Appendix A for visuals of phosphatic and calcium carbonate uroliths). This may be caused by high mineral content in water or by feeding a heavy legume diet, such as feeding strictly alfalfa hay. (Jones, 2021) Both phosphatic and calcium carbonate uroliths will cause the urine to become more alkaline and therefore Ammonium chloride can be administered orally to help dissolve the alkaline uroliths. (Ranjith et al, 2019) In contrast calcium oxalate uroliths may form due to grazing on high oxalate plants such as Russian thistle, cultivated rhubarb, sugar beet leaves, dock sorrel and purslane. Silicate uroliths form from ingesting excessive amounts of silica, typically from grazing in high silica pastures or drinking water high in silica. Calcium oxalate and silicate uroliths may not alter the pH of the urine and

therefore cannot be treated by altering the urine pH. (Pugh, 2020) (See Appendix B for visuals of calcium oxalate and silicate uroliths.)

All four urolith types have distinctive shapes when visually observed. After determining the type of urolith, the diet should be adjusted accordingly. Costs associated with treatment may include separation from the herd for feeding of a specialized diet, purchase of higher roughage feed if the goat was previously fed a high-grain concentrate, need for a water filtration system if a high mineral or silica content is found, and increased labor needed to observe the affected animal.

Obstructive urolithiasis requires medical attention as the condition will not resolve itself. Once the obstruction occurs, location of the obstruction may be identified through ultrasound or radiographic imaging, with or without contrast imaging. The most common place of obstruction occurs at the end of the urethra and can be relieved by removing the urethral process, a procedure that can be completed with local or general anesthesia and requires minimal recovery time. The cost for such a procedure can range from $200 for the removal of the urethral process to upwards of $600 depending on the facility, emergency after-hours fees, boarding for medical team observation, and pain and antibiotic medications. The procedure can be performed as a preventative measure if history of urinary calculi is present in a herd. While the urethral process is designed to assist in breeding, removal of the process has not shown decreased fertility in breeding rams or bucks.

Ultrasounds or imaging showing obstruction in the urethra that are not able to be cleared through flushing or removal of the urethral process prompt the need for surgical treatment. Cystotomy involves inserting a tube through the urethra and another directly into the bladder to

manually flush the calculi from the urethra. This procedure may take many hours. Tube cystostomy is similar, however a tube is inserted into the bladder and stitched to the outer abdomen to allow dissolution of the calculi with dietary management and infusions of an acidic solution. (Ranjith et al, 2019) The tube will remain on the goat until urine can naturally pass through the urethra. Once urine is observed being passed, the tube will be clamped for five to seven days, depending on the passage of urine through the urethra. Upon monitoring successful and continuous natural urination for a minimum of a week, the tube is removed. Depending on the success of the tube cystostomy, treatment may cost upwards of $3,000 due to the extensive monitoring and flushing of the urethra.

Many producers do not recognize the signs of urinary calculi until they have lost a goat to the disease. Packgoat owners, in particular, suffer great heartache due to the increased one-on-one time required to raise and train goats for the purpose of packing. Many packgoat owners dedicate three to four years of training before they are even able to use their goats to their fullest potential. The stress of urinary calculi on the goat is difficult for owners to watch as the owners consider them companion animals as opposed to a production animal. As one owner described his experience with urinary calculi, it was difficult for him to watch an informational video of a goat in distress due to urinary calculi because he had watched his own personal goat suffer with the disease. His goat spent over two weeks at the veterinary hospital, a month with a cystotomy tube, and had amassed close to $3,000 in treatment. (WSU, 2021) Since then, he has drastically changed his feeding program, installed a water softener to eliminate the hard minerals in the goats drinking water, and closely monitors the urine pH of all of his goats. Although these measures may sound too intensive for a larger commercial producer, the extraordinary care and

dedication to management is not uncommon for packgoat owners. Many packgoats will be used for the duration of their life, in what is hoped to be upwards of ten to twelve years.

Prevention

Increased awareness of urinary calculi has caused considerable confusion for owners over recommendations for the "best" prevention of the disease with many suggested blanket preventative measures potentially causing more harm than good especially if used in the incorrect cases. Prevention of urolithiasis should be focused on the four potential causes of calculi development: high phosphorus or low calcium intake, high calcium or low phosphorus intake, increased oxalate consumption and high silica intake. While the structure of the urethra in its length and inclusion of the sigmoid flexure cannot be altered, the diameter of the urethra may be allowed to reach its largest size if castration is delayed until four to eight months of age. In a 2007 published study of 20 lambs, castration was completed at two weeks, three months and five months of age, while the control group was not castrated. Upon slaughter at seven months of age, each groups' urethra was measured at three separate sections of the urinary tract. The diameter and length of the penis was measured at the proximal sigmoid flexure, distal sigmoid flexure, and glans penis using a digital micrometer caliper (Bani Ismail et al., 2007), all three areas where obstructive urolithiasis occurs. The study concluded a significant size increase from three months to five months of age in all three areas measured, concluding early castration's effect on an increased occurrence of urolithiasis. (Bani Ismail et al., 2007) While maturation of breeds and individual animals may occur at varying ages, delaying castration may decrease an animal's predisposition to urolithiasis. More in-depth studies of specific breeds of goats may be beneficial. A prophylactic approach of removing the urethral process has seen success as well,

but will not prevent calculi build-up in the upper urethra. (Makhdoomi, D.M. and Gazi M.A., 2013)

In cases of animals grazing in a range setting, knowledge of plant species and soil makeup may prevent oxalate and silicate uroliths through managed grazing. If specific plants are not easily identifiable due to the large areas animals graze, USDA and local university extensions offices may be able to provide the general forages grown in a given area. Web Soil Survey services online may help determine the soil makeup of a grazing pasture to identify soils with high silica content. It is less likely for goats to develop calcium and phosphorus imbalances when grazing free-choice due to the high fiber content consumed. Vegetative forages also meet the daily vitamin A requirements, which is approximately 105 IU per kilogram of body weight per day where deficiencies can lead to shedding of the urinary bladder lining, increasing chances for stones to form around the cells. (Pugh et al., 2021). Goats in late gestation or lactating require 150 to 175 IU per kilogram of body weight per day, although risk of urolithiasis is not as high as in wethers or bucks. (Pugh et al, 2021) Diets containing at least 30% of green forage should be sufficient in beta-carotene, fulfilling the daily Vitamin A requirements. (Pugh and Belknap, 2002)

Goats fed controlled daily rations are more susceptible to imbalanced calcium and phosphorus levels as concentrated feed typically contains a higher amount of phosphorus than the 2:1 or 3:1 ratios recommended. Grain diets with equal amounts of calcium, potassium, magnesium and phosphorus are thought to be a potential cause of phosphatic calculi. (Shahrom and Zamri-Saad, 2011) Although pre-mixed grains may indicate proper calcium to phosphorus ratios, high grain diets decrease the saliva production, reducing saliva recycling of phosphorus

and causing the rumen to expel phosphorus through the urine instead of the feces. Phosphorus deficiency can have just as detrimental effects as phosphorus surplus. A study of phosphorus-deficient diets concluded a decrease in reproductive efficiency and feed intake in breeding does. (Haenlien and Anke, 2010) Alfalfa hay or legumes cause the formation of calcium carbonate uroliths due to the high amount of calcium in the hay. (Pugh and Belknap, 2002)

Water intake of any animal should be monitored closely, as lack of water can influence urinary calculi occurrence. Clean, palatable water should be available at all times and temperature moderated in both cold and hot weather. Too hot of water in the summer months and too cold of water in winter months can cause a decrease in water intake. Automatic waterers, while convenient, do not allow for measurement of water intake and the floats have a tendency to stop working without notice. If automatic waterers must be used, frequent verification of proper flow will limit the chance of animals without adequate access to water. Multiple animals using the same water source may also cause difficulty in measuring water intake per each individual animal, so evaluation of the herd should be used to determine proper water intake.

Due to the relationship of packgoats and their owners, urine sampling may be easier to complete on a more frequent basis than with goats used for meat, milk or fiber products. In addition to testing the acidity or alkalinity of water sources, owners can use pool test strips to determine higher alkalinity in the urine and then adjust feed accordingly. Urine pH higher than 8 should prompt the owner to administer ammonium chloride orally until the urine returns to the range of 7.2 - 8. Caution is advised when using ammonium chloride as extended use has been shown to be less effective over time due to the goat's ability to adjust absorption. Ammonium

chloride should only be used until the pH returns to the normal range and then used in pulse administration one week per month if used as a preventative measure.

Conclusion

In conclusion, it is not only important to know the signs of urolithiasis, but knowing the base cause of the urolith formation is required to properly address the issue. Extensive management of feed, mineral content, vitamin absorption, water intake and time of castration all adds to the decreased incidence of urolithiasis. Routine sampling of feed inputs and water sources establish an overall expectation of animal health. The multitude of causes of urolithiasis add to the importance of management of each individual animal in its respective environment. Studies on goats specifically, various ages of development, breeds and feeding practices would be beneficial for goat owners intending to retain wethered goats for the duration of their natural life as such studies are limited or nonexistent.

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Appendix A:

Phosphatic uroliths, goat

2/3
Phosphatic uroliths from a goat.

Courtesy of Dr. Meredyth Jones.

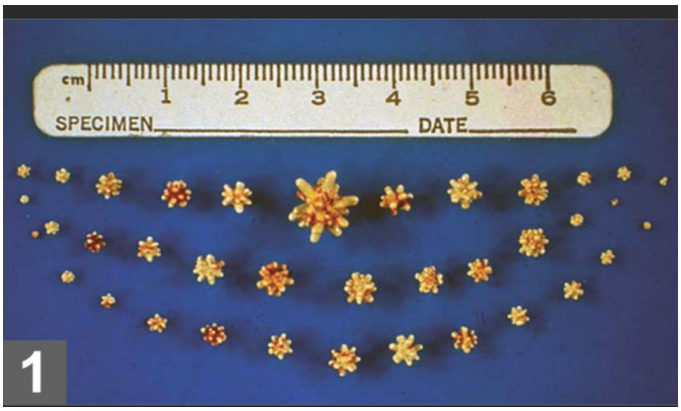
Calcium carbonate uroliths, goat

3/3
Calcium carbonate uroliths from a goat.

Courtesy of Dr. Meredyth Jones.

Appendix B:

Silicate Uroliths



Appendix C:

Urinary Calculi (UC) Survey: Conducted by Andrea Prise, 05/08/2021

How familiar are you with urinary calculi (UC)?

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ANSWER CHOICES	RESPONSES
Extremely familiar	50.00% 20
Somewhat familiar	47.50% 19
Not so familiar	2.50% 1
Never heard of it	0.00% 0
TOTAL	40

What is the size of your goat herd?

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ANSWER CHOICES	RESPONSES
0-2	7.50% 3
3-10	45.00% 18

11-19	12.50% 5
20+	35.00% 14
TOTAL	40

In the past year, how many goats have you had with urinary calculi?
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ANSWER CHOICES	RESPONSES
None	87.50% 35
1-2	12.50% 5
3-5	0.00% 0
6+	0.00% 0
TOTAL	40

How many cases of urinary calculi have you had in your lifetime?

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ANSWER CHOICES	RESPONSES
None	65.00% 26
1-2	32.50% 13
3-5	0.00% 0
6+	2.50% 1
TOTAL	40

What is your primary use of goats?

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ANSWER CHOICES	RESPONSES
Dairy production	30.00% 12
Meat Production	10.00% 4
Packing	45.00% 18
Backyard friend	15.00% 6

TOTAL	40

How many wethers are in your herd?

ANSWER CHOICES	RESPONSES
None	5.00% 2
1-2	30.00% 12
3-5	30.00% 12
6-10	22.50% 9
11-19	5.00% 2
20+	7.50% 3
TOTAL	40

How long have you had wethers in your herd?

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ANSWER CHOICES	RESPONSES
1-2 years	17.95% 7
3-5 years	41.03% 16
6-10 years	20.51% 8
11-19 years	10.26% 4
20+ years	10.26% 4
TOTAL	39