

The human resource is still being wasted by the ravages of disease, ignorance, and war. We shall not be true conservationists until we recognize these primary causes of human wastage.

### National Survival

The conservation of ourselves and of our physical resources will make a large contribution to our survival as a nation. These physical factors are certainly not the only factors in national survival—a great array of factors not so easily appraised—psychological, political, sociological, religious, and economic—both national and international in scope affect our welfare and hence national survival. It is not the present purpose to discuss these non-physical factors but it is timely to suggest that they be approached in the true spirit of conservation.

## URINARY CALCULI OF LAMBS

by  
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### Description of the Disease

The presence of mineral deposits in the kidneys, ureters, urinary bladders or urethrae is spoken of as urinary calculi or urolithiasis. The uroliths may form as large single, stone-like aggregates, or they may form as multiple smaller gravels or even clay-like deposits. Unless the uroliths interfere with the passage of urine they do not appear to interfere with the health of the animal. If the stones cause stoppage of urine they produce an accumulation of fluid in the tissues or abdominal cavity and the condition is often called "water belly" by sheepmen. We do not have accurate information as to the exact losses caused by uroliths but the number of requests for information regarding this disease is sufficiently high to indicate that losses resulting from urinary calculi are sufficiently high to be of considerable economic importance.

Field reports indicate that losses from urinary calculi are much higher in western North Dakota than they are in the eastern portion of the state. However, there have been reports of losses due to urinary calculi from nearly all of the Red River Valley counties.

Urinary calculi formation appears to be a response to a number of predisposing causes. The causes enumerated by Newsom (1) are as follows: hard water, vitamin A deficiency, mineral imbalance, reaction of urine (pH), hyperparathyroidism and infection. Experimental work directed at producing urinary calculi has followed the general topics listed above, but most investigations have failed to establish any one factor as the primary predisposing agent in the formation of urinary calculi.

### Ten Years' Experiments and Observations in North Dakota

This report summarizes experiments conducted in this laboratory during the past ten years and discusses our observations under the various hypotheses enumerated by Newsom.

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*The First Experiments—1938*

Investigations as to the cause and treatment of urolithiasis in sheep were started here somewhat by accident. The appearance of several clinical cases in the college experimental flock in 1938 allowed a limited experiment with affected animals. Dilute hydrochloric acid is quite commonly used as a prevention and treatment by farmers. For that reason ten affected lambs were given dilute hydrochloric acid in the drinking water with ten untreated controls. The acid-alkaline reactions of the urine were checked to determine changes. There were no appreciable changes in these reactions and no alterations in the course of the condition.

*1939-'40 Experiments*

In 1939-40 similar experiments were conducted using acid sodium phosphate. This was given in large doses on the feed until toxic symptoms were noticed. The alkaline reaction of the urine changed to an acid condition, but the calculi which were present did not dissolve. These calculi were later shown to contain large amounts of magnesium. Analysis of the feed showed no alarming mineral imbalances.

In the fall of 1940 experiments were started to test the effects of low carotene rations and restricted water intake on the production of urinary calculi in wether lambs. Four lots of 10 lambs each were selected and fed the following rations over a 90 day period:

- Pen I—Received the basal ration\* plus 40 cc of carotene\*\* concentrate per day mixed in the feed and water free choice.
- Pen II—Basal ration\*. No carotene—water free choice.
- Pen III—Received carotene supplement 40cc per day plus basal ration\* with limited water supply.
- Pen IV—Basal ration\* and limited water supply.

No clinical cases of urinary calculi were produced in this 90 day period. Post-mortem examination of the lambs at the end of the experiment revealed calculi present in the bladders of 3 lambs. One case was from Pen I, one from Pen II, and one from Pen IV. The bladder of a lamb in Pen IV showed an irritation, possibly the result of decreased urine output following reduced water intake.

It was found that lambs on full feed will cease to eat when their water supply is cut to 50% of the amount which they will consume normally. They eat normally when this amount is increased to 75% of the normal.

Further observations on field cases have revealed that most cases of urinary calculi develop during a 120-150 day feeding period.

*New Experiments in 1942*

A similar series of experiments was started in the fall of 1942. Forty feeder lambs were divided into four pens of ten each and placed on feed

*Oats	.75 lbs.	} Plus free choice of equal parts calcium carbonate and salt.
Barley	.75 lbs.	
Linseed meal	.25 lbs.	
Prairie hay	1.00 lbs.	

\*\*Carotene supplement 3300 International units per gram.

for a 150 day period beginning October 1, 1941. This trial was designed to determine whether vitamin A deficiency or an insufficient water supply were factors in the production of urinary calculi.

A basal ration was given with 40cc carotene concentrate added to the ration for pens 1 and 3 and an insufficient water supply in pens 3 and 4. The basal ration was the same as used in the 1940 experiments.

No clinical cases of urinary calculi appeared during the 150 day feeding period nor were any calculi discovered by post-mortem examination at time of slaughter.

The purpose of the 1942 experiment was to determine whether a ration high in phosphorus content and with a deficient water supply would result in the production of urinary calculi. On September 20, 1942, thirty-two lambs were divided into four pens of eight each and placed on an experimental feeding trial until December 20, 1942, a time period of 90 days. To the basal ration which has already been noted was added free choice of calcite and salt in equal parts. The grain ration for Pens 1 and 3 had one per cent disodium phosphate added and the water in Pens 3 and 4 was restricted to half that used by Pens 1 and 2.

No clinical cases of urinary calculi occurred during the 90 day period. There were no calculi found on post-mortem examination at the packing plant nor any evidence of inflammation in the kidneys, ureters or bladders.

During the latter part of 1943 and first six months of 1944 no feeding trials were conducted. Histories were studied of field cases of urolithiasis in sheep and cattle. In most instances it was found that the animals were receiving deep well water. A few calculi were obtained but the number was insufficient to justify a detailed analysis since it was impossible to obtain other factual data regarding the feed and water used by the animals prior to the development of clinical symptoms of urolithiasis.

#### *Another Approach in 1944*

During the fall of 1944 an attempt was made to produce uroliths in two lambs fed a ration composed entirely of beet tops for six weeks. This ration was selected because feeder lambs being fed a similar ration had had a high incidence of urolithiasis with rather heavy death losses. These losses were stopped by discontinuing the feeding of beet tops and using prairie hay. The lambs fed the beet tops at the laboratory failed to develop calculi.

#### *A Large Scale Test At Dickinson—1945*

October 15, 1945, a feeding trial was conducted at the Dickinson Station. The objective of this trial was to determine the practicability of pasturing corn fields as compared to dry lot feeding. Four lots of 30 lambs each were selected and handled as described below.

Lot I lambs were allowed only a 10 acre field of Falconer corn, computed to yield 17.5 bushels per acre. In addition, water, salt and a simple mineral were fed ad libitum as in the other three lots. Two lambs develop-

ed urinary calculi January 11 and February 8, respectively, and were removed from the lot. The lambs increased their average initial body weight by 26.45 pounds during the 103 days.

Lot II lambs were allowed to run in a ten acre field of white corn that was computed to yield 16 bushels per acre. Each lamb consumed in addition to the white corn 22.7 pounds of soybean meal. Six lambs were removed because of urinary calculi on the following dates: November 16, December 28, December 30, and January 19, and two lambs on January 22. The lambs gained an average of 31.4 pounds per head.

The thirty lambs in Lot III consumed an average of 22.65 pounds of soybean meal per lamb in addition to the 10 acres of Falconer corn yielding 12 bushels per acre. On January 31, a ruptured lamb was removed, and February 8 a small lamb was removed with a complicated "water belly" condition. The average increase in body weight was 31.3 pounds per lamb.

The lambs in Lot IV consumed an average per lamb of 105 pounds of barley, 51.5 pounds of oats, 22.65 pounds of soybean meal, and an unknown quantity of poor quality crested wheatgrass hay. A lamb was removed December 20 with an infected jaw. These lambs averaged 23.95 pounds gain during the 103 days.

Several calculi were found upon examination of the lambs developing "water belly".

#### *The Most Recent Experiments—1947*

The high incidence of urolithiasis in the lambs fattened at Dickinson suggested the possibility that the well water may have been of primary importance in the production of the calculi.

A sample of well water was analyzed as shown in Table 1. An attempt was then made to alter the composition of the water in such a way that it would be more like the water found in those areas where urolithiasis is rare.

**Table 1—Analysis of Well Water at Livestock Unit, Dickinson Station**

	ppm*	pH-7.45		E.p.m.**
K	9.04		K	.2311
Ca	75.40		Ca	3.7620
Na	92.27		Na	4.0100
Fe	.1-.15		Fe	.0067
			Total cations	8.0098
SO <sub>4</sub>	165.4		SO <sub>4</sub>	3.4420
HCO <sub>3</sub>	237.8		HCO <sub>3</sub>	4.4876
Cl	5.3		Cl	.1495
			Total anions	8.0791
Total solids 676.0 ppm				
Total fixed solids 132.0 ppm				
Total dissolved solids 654.0 ppm				

\*Parts per million.

\*\*Equivalent per million.

A method of removing most of the sulfate and bicarbonate ions was developed and the following trial conducted.

The one hundred wether lambs used in the study were grown 15 miles south of Belfield, North Dakota, and were a healthy, uniform lot of 68 pound feeder lambs. On October 8 the lambs were ear tagged, graded, weighed and divided by random selection into two lots. Both lots received corn silage as a roughage; and oats, barley and soybean meal were fed three times daily. As the feeding period progressed, the barley portion of the ration was increased in both lots according to good husbandry practices. Salt was fed ad libitum to both lots.

The controls, Lot II, received water as it came from the well, and Lot I received water treated according to the following procedure:

1. Dilute one (1) part commercial HCl (Sp. Gr. 1.19) with six parts distilled water. This acid solution is now 2 N.
2. To each 1000 mls. of the 2 N HCl solution, dissolve 100.3 grams of BaCl<sub>2</sub> · 2 H<sub>2</sub>O (usual commercial form). Heating is necessary to effect solution readily.
3. The BaCl<sub>2</sub> acid solution is now ready for use. Use 13.5 mls. for each gallon of water and mix vigorously.

Individual body weights were taken at the end of the first month, but there was not a significant difference in the mean weights of the two lots.

It was observed after the first 45 days of the feeding period that the Lot I lambs did not eat as readily as did the Lot II lambs. Both lots appeared to be craving something in their ration as they chewed considerable wood and other material in the lots.

#### Results:

Lot I losses: No. 1993, December 31, apparently urinary calculi  
 No. 1973, January 2, digestive trouble  
 No. 1921, January 8, digestive trouble  
 Lot II losses: No. 1998, January 15, digestive trouble

Body Weight	Lot I Ave.	Lot II Ave.
October 8	66.96 lbs.	68.94 lbs.
November 7	80.62 "	81.00 "
January 14	92.65 "	94.73 "

The urinary systems of all lambs were examined when they were slaughtered. In Lot I, nine lambs were found with kidney uroliths and five with bladder calculi. In Lot II, the controls, seven lambs were found with kidney and four with bladder uroliths. From the above data it would seem the water treatment had little effect on the formation or prevention of urinary calculi in lambs and did not significantly affect weight gains during the 103 day feeding period.

At the same time that the 1947 feeding trial was in progress at Dickinson a trial was conducted at Fargo to determine the effect of calcium and vitamin D in the role of urolith formation.

Two lots of 11 wether lambs were placed in stalls with concrete floors. The rations fed are given in Table 2. One lamb in the calcium deficient lot died as a result of an intercurrent infection.

**Table 2—Rations Fed Experimental Sheep**

Pen I—Ration	Pen II—Ration
Soybean meal 100 lbs.	Soybean meal 100 lbs.
Wheat bran 100 lbs.	Wheat bran 100 lbs.
Gr. limestone 3 lbs.	Common salt 2 lbs.
Common salt 2 lbs.	

The average initial weight of the lambs in Pen I was 47.7 lbs. and of those in Pen II, 47.8 lbs.

All lambs except 2 in each group received 65,000 Vitamin A units and 13,000 Vitamin D units per week plus prairie hay, distilled water, and grain mix ad libitum.

Two lambs in each group received 75,000 Vitamin A units per week with no Vitamin D.

Cobalt was added to water once a week. Approximately 1 mg. Cobalt per lamb.

In January 15,000 pounds of corn was added to the mixture and the salt and limestone increased to keep the percentages constant.

The average initial weights of Lot I and II were 47.7 and 48.3 pounds respectively. After 158 days the weights were 92.3 and 87.8 respectively. The kidneys, bladders and urethrae were examined at time of slaughter. One small kidney calculus was found in a lamb from Lot II.

Chemical analyses made on the blood and blood serum of the lambs are summarized in Table 3.

**Table 3—Composition of Blood and of Blood Serum From Sheep Used in 1947 Experiments**

	Oxyhemo- globin in blood	COMPOSITION OF BLOOD SERUM						
		Total protein	Albu- min	Globu- lin	Ratio of albumin to globulin	Cal- cium	Phos- phorus	Mag- nesium
		grams per 100 milliliters	%	%	%	mg per 100 ml.	mg per 100 ml.	mg per 100 ml.
Lot I Ave.	8.94	6.03	3.024	3.004	1.048	8.5	9.272	1.353
Lot II Ave.	10.25	6.25	3.113	3.137	1.003	7.15	10.27	1.313

The two lambs in Lot I that had received no vitamin D during the feeding period had serum calcium and inorganic phosphorus within the range of the group. The two lambs in Lot II that did not receive vitamin D had serum calcium of 6.5 and 4.7 mg. per 100 milliliters of serum while the serum inorganic phosphorus values were 9.2 and 10.0 mg. per 100 ml. of serum, both the phosphorus and calcium for the two lambs were below the group average.

In both lots the calcium values are lower, while the phosphorus values are higher than the average for the age.

It was noticeable that the non-calcium supplemented lambs frequently scoured during the feeding period (Figures 1 and 2).

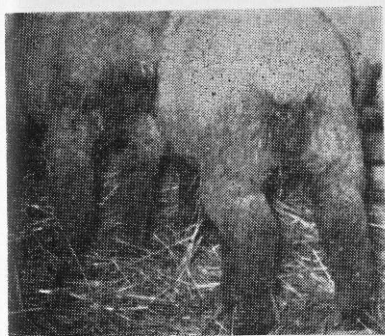


Figure 1—Note soiled wool of calcium deficient lambs

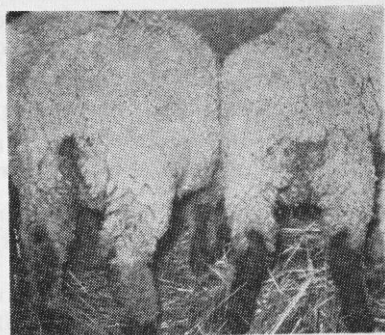


Figure 2—Note dry clean wool of calcium supplemented lambs

### Discussion

The data presented here clearly show that the cause of urolithiasis, if it is a single entity, has not been determined. There is, however, considerable evidence to indicate multiple causes of urolithiasis and a detailed study of the experiments and field cases show certain things in common.

First losses from urinary calculi, as reported to this laboratory, are usually found in flocks watered from a well with "hard" water. A case of interest has been reported where steers were found to have developed numerous uroliths. The present owner of the farm reported that the previous owner had died as a result of kidney stones. Another factor which suggests the possible role of the water is the recurrence of the disease on the same farms year after year.

A possible factor in formation of the calculi or "stones" that has not been considered by investigators is the role of protein in preventing urolithiasis. In a trial here four wether lambs fed a ration of prairie hay, wheat bran and distilled water all developed calculi. In the 1948 trial 21 lambs fed a ration of wheat bran, soybean meal and prairie hay and distilled water only one developed a calculus or "stone". A field case furnishes some evidence in support of this theory. A farmer submitted an 11 week old kid for diagnosis. The bladder outlet was found to be closed by a mass of calculi. The owner reported that the kid's dam had died when the kid was 8 weeks old and that the kid had had only grain, hay and water to eat since the death of the dam.

Schmidt (2) found that many of his cattle, sheep and goats on carotene-low rations developed uroliths. Experiments to be reported later from this laboratory fail to confirm Schmidt's observations. A fairly large series of ewes and lambs have been allowed to die as a result of vitamin A deficiency and in none of them was it possible to demonstrate uroliths.

Rupture of some portion of the urinary tract as a result of its being filled with tissue debris and the subsequent urinary pressure causing the rupture has been observed in several instances. It is quite conceivable that if the tissue debris were to lodge in any portion of the urinary tract and still allow passage of urine that the dead tissue would eventually become calcified. This type of occlusion of the urinary tract would be

associated with a type of infection or other disease process in which there is a necrosis of the lining of the urinary tract.

In further considering the cause of urolithiasis in regard to the possibilities enumerated by Newsom (1) a review of the literature disclosed some reports that further substantiate a theory of multiple factors being the cause of mineral deposits in the urinary tract.

"Hard water" as a factor in the production of uroliths seems most likely since in most field outbreaks of this disease this is the type of drinking water. However, the feeding of rations high in calcium and magnesium have not been universally successful in the production of calculi, Beeson, Pence, and Holm (3); Johnson, Palmer and Nelson (4). Vitamin A deficiency appeared to be very conducive to kidney stone formation (Schmidt (2)) but our own experiments and those of Beeson, Pence and Holm (3) indicate that a vitamin A deficiency alone is not the cause of urolith formation.

Mineral imbalances appear to be a contributing cause to urinary calculi formation, but experimentally wide ranges of mineral content of the rations do not cause formation of stones.

Reaction of the urine, pH, the experiments reported here and by Johnson, Palmer and Nelson (4) do not support this theory.

Hyperparathyroidism does not appear to be common in animals.

Infection of the urinary tract causing a necrosis of tissue has been found to cause rupture of portions of the urinary tract and it is conceivable that such tissue shreds could act as nuclei for the formation of stones.

Newsom, Tobiska and Osland (5) are inclined to the theory of a combination of factors as the cause of urinary calculi in sheep.

Harbaugh (6) found that many calculi encountered in Texas were composed of tricalcium phosphate. This material  $\text{Ca}_3(\text{PO}_4)_2$  is much less soluble than  $\text{CaHPO}_4$  so he suggested the use of ammonium chloride in the treatment of clinical cases. The use of hydrochloric acid was not shown to be of any benefit in treating the cases encountered here in 1938. These stones however were of magnesium salts.

One point which has not been considered in experimental urolithiasis studies is the possible presence of small stones in the urinary tract prior to the experimental procedure. In those cases where clinical urolithiasis develops there is no doubt but that the stones have increased in size or new ones have formed.

In the use of small groups of lambs for experimental purposes it is suggested that the lambs be examined by means of a fluoroscope before the feeding period.

#### Summary

The results of numerous feeding trials and the study of field cases of urolithiasis in sheep have failed to identify any one single factor as to the cause of this disease.



The evidence indicates that urinary calculi are found in feed cases when the ration is low in vitamin A and where there is a high mineral content of the drinking water. Experimental rations of this type have failed to produce calculi when fed to sheep.

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