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URINARY CALCULUS DISEASE OF SHEEP IN WESTERN AUSTRALIA

By M. R. GARDINER, B.Sc., V.M.D., Chief Veterinary Pathologist

THE formation of concretions in the urinary tract of rams and wethers is one of the most persistent causes of loss of sheep in Western Australia, and has been so for many years.

The disease produced by these stones or "calculi" is widely known by farmers and graziers as "water-belly" from the principal sign exhibited by the affected sheep—the accumulation of fluid in the abdominal cavity.

However, this common name which so aptly describes the disease in typical final form gives little indication of the cause and intermediate stages of the disease. "Urinary calculus" more accurately defines a condition in which "water-belly" is the main clinical sign. It also includes several more subtle conditions characterised by kidney and bladder infections and destruction of kidney tissue. The common factor in all these conditions is stone formation somewhere in the urinary system.

This article deals specifically with disease caused by the production of calculi leading to obstruction, either partial or complete, anywhere from the kidney itself to the tip of the penis.

It also refers, in passing, to forms of "water-belly" which may not be due to obstruction by stone material and which have been recognised with increasing frequency in recent years.

The basis of all these forms of urinary calculus disease is the "coming together" somewhere in the urinary system of one or more constituents of the urine to form discrete particles of various sizes, shapes, and degrees of hardness.

The kidney is the organ which more than any other body tissue is involved in the maintenance of the normal internal environment. It does this in an extremely complicated way but in the simplest terms, one might say that an excess of almost any of the inorganic and organic chemical substances consumed in the food or derived from metabolic processes of the body is removed by way of the kidney.

As the metabolism of the animal's body is fairly constant in a given environment, it follows that the greatest variation in urinary excretion patterns is related to the dietary intake.

This article shows how the different forms of the disease are associated with nutritional patterns in the various districts and amongst the several classes of sheep.

THE BASIC DISEASE

In all forms of urinary calculus disease, stones form from the salts and organic materials filtered out of the blood stream by the kidney tissue.

They may form in the kidney tissue itself as "micro-calculi" and remain there indefinitely or, due to circumstances mentioned below, dislodge and pass down the urinary tract. They may form in the pelvis of the kidney and subsequently fragment and be flushed along the tract. Finally, they may form in the urinary bladder and eventually cause trouble in the same way as the stones formed higher up in the urinary system.

The urinary tract of a normal sheep is illustrated in Figure 1. This shows various anatomical subdivisions of the urinary system at a glance.
The principal features of the disease are summarised by the following points:—

A. Harmless Calculi

It is probable that the vast majority of urinary calculi are so small that they pass harmlessly out in the normal urine flow and one is never aware of any tendency to disease. This appears to be the situation in the great majority of ewes where urethra is so large and short that only the largest concretions are obstructive.

B. Obstruction of Urethra

In wethers and rams, with the long curved urethra as shown in Figure 1, calculi of a certain critical size are able to pass from the bladder into the neck of the urethra and thence downwards but are too large to make the entire passage. These critically-sized stones tend to impact either

(i) at or near the sigmoid flexure, or
(ii) at the tip of the “pizzle.”

In such an event the passage of urine is blocked, partially or completely; the bladder begins to accumulate urine and eventually ruptures. In addition to the mechanical stoppage many of these calculi, especially those with a roughened surface, cause great irritation to the walls of the urethral passage, with swelling and a further narrowing of the passage.

C. Calculi in the Bladder

Some calculi forming in the bladder grow rapidly and, not prone to fragmentation, tend to remain in this organ and may act as “ball valves.” Sheep affected in this way may suffer bladder rupture and yet may survive thereafter for long periods. The reason for this is that the “ball valve” stones will fall out of the ruptured bladder into the body cavity but the urethra, which is not obstructed, will permit a dribbling excretion of urine and thus a continuation of kidney function.
D. Kidney Stones

"Kidney stones" may sometimes obstruct the ureters (the tubes running from the kidneys to the bladder). This leads to back pressure on the kidney tissue and to eventual destruction of the organ if the ureteral obstruction is permanent. In most cases, however, the stone emerges, after a stormy passage, into the bladder. This form of urinary calculus disease is the one so familiar in human medicine and which is responsible for the excruciating pain of "renal colic."

There is thus an important distinction between urinary calculus disease in man, where the ureter is mainly involved, and in sheep, where the urethral passage is usually the site of obstruction.

Effect of Concentrates

All investigators of the ruminant disease agree that the feeding of concentrated rations predisposes to stone formation. This varies with the type of concentrate. Wheat has, in general, only slight activity in contrast to the great potency for calculus development of oats. Other concentrates reported from other parts of the world to favour stone formation are sorghum grain, corn, cotton seed meal, and barley.

There appear to be three main reasons for this property of concentrates.

- The excretion of increased amounts of the so-called urinary "mucroproteins" when the concentrate/roughage ratio rises. The mucroproteins act as cementing substances binding various inorganic materials into calculi.

- The greater quantities of mineral salts such as calcium, phosphorus, magnesium, potassium and so forth in concentrates. The mineral salts affect the process of stone formation in different ways, often favouring the growth of the stone.

- Concentrate feeding is often associated with a reduction of water intake and urine volume, thereby causing an increase in the concentration of the mineral salts and mucroproteins which make up the stone, and encouraging their precipitation from urine solution.

GEOGRAPHICAL DISTRIBUTION OF CALCULUS DISEASE IN WEST AUSTRALIAN SHEEP

Geraldton

In the Geraldton district, the disease appears to be limited mainly to the wheat and sheep zone with a 10 to 15 inch annual rainfall, and has been reported to have a peak incidence in March and April. Siliceous stones predominate in this district.

At least 80 per cent. of the wether flocks here have been affected to some extent, although it is impossible to estimate the number of sheep affected each year on these properties. The condition is so common that owners seldom bother to report it. It is said that as many as 60 per cent. of a flock may be lost in a bad year.

Rams in the Geraldton district are apparently not often affected and when seen have generally been "shed-fed" on concentrates.

Moora

In the Moora district, records of losses due to the disease are rather meagre. Attention has been directed from time to time to exceptionally heavy losses but in the main, the disease appears to have a low incidence on many properties in the rainfall belt bounded on the west by the 18 in. rainfall isohyet.

A property at Barberton has had losses of up to 10 per cent. of its wether flocks for many years although during the last two (when higher than normal winter rainfalls have been recorded) only occasional sheep have died from the disease. Most of the losses have been due to the siliceous type of stone although, where subterranean clover has comprised a large proportion of the grazing, clover stones have been found sporadically. An occasional ram has yielded calcium-type calculi.

* A wave of outbreaks of calculus disease occurred in the Moora and Dandaragan districts in August, 1965 in wethers grazing dominant Dwalganup subclover pastures. The obstructions were very similar to calcium carbonate stones discussed in detail on page 739.
A high loss (150 of 1,500 wethers) experienced on a Dalwallinu property in 1963 was found to be due to the oxalate type of stone.

There are no reports of urinary calculus disease from the higher rainfall (above 20 in.) sandplain country in the Moora district, and in our extensive investigations of lupinosis no signs of the disease have been found in the many hundreds of sheep examined in detail.

**Northam**

In the Northam district, the incidence of the disease again is not accurately known, but the number of farmers reporting losses would not exceed five or six a year. It is thought, however, that many losses are not reported and that wether losses could possibly reach 2 per cent. on some properties.

There is some evidence that losses in the Northam district are higher on newly developed clover country but the type of calculi involved here is not definitely known.

Clover stones and calcium carbonate stones are the types found in the few sheep examined from clover properties in the Northam district.

**Merredin**

The Merredin district has always reported a considerable incidence of urinary calculus disease. In recent years, losses have not often been reported as they are “accepted.” Some properties have been more affected than others and on these it is the usual practice to sell the wether drop in the spring or early summer.

There is little doubt that in this district the incidence of urinary calculus disease is significantly increased with the feeding of oats during the summer months. One farmer who has had a serious calculus problem for some years and who had been a heavy feeder of oats, reports that losses were greatly reduced when he changed from feeding oats to feeding silage. However, occasional losses also occur in the winter.

Almost all the urinary calculus disease in the Merredin district is due to the siliceous type of stone. The exception is where rams are hand-fed concentrates, where calcium stones and stones containing oxalates have been identified.

**Narrogin**

The Narrogin district has more often reported urinary calculus disease than any other agricultural district in Western Australia. It is highly probable that every property in this district with annual rainfall of 20 in. or less would have summer losses, especially in the late summer.

Most of the affected flocks are fed grain supplements, mainly unstripped oat stubbles.

Where investigated, the deaths have been due to the siliceous type of stone.

In the last several years, in the higher rainfall part of the district where subterranean clover often dominates pastures, losses from urinary calculus disease have been significant in the spring. Although it has not been possible to confirm the type of stone involved in losses of this kind in the Narrogin district, the history of these outbreaks has been identical to others on sub. clover properties in the South-West Division in the spring and found to be due to calcium carbonate stones.

In addition to classical siliceous stones, and calcium carbonate stones, occasional losses have been associated with “clovers stones” in sheep grazing sub. clover during several seasons.

**Katanning**

Urinary calculus disease in the Katanning district (including the country around Wagin, Dumbleyung and Gnowangerup), has occasionally been reported but is probably much more common than indicated by the reports, since here also sheep losses which are clearly identified as “water-belly” are not likely to be mentioned unless they are exceptionally large.

Both siliceous and calcium carbonate stones have been reported from this general area. Sometimes combinations of these two substances with or without oxalates are formed in calculi causing deaths.

**Mt. Barker**

In the Mt. Barker district, urinary calculus disease is not recognised as a common condition. About six or eight properties report losses each year, and these have almost always been among wethers introduced from the eastern wheatbelt, carrying siliceous type calculi. “Clover stones” are occasionally seen in sheep killed for rations.
Recently, the calcium carbonate type of stone, described below, has been found as a cause of mortalities of wethers grazing dominant stands of some strains of subterranean clover during the spring.

South-West

Reports on urinary calculus disease have been received from various parts of the South-West Division. The disease has not been of much significance in the Manjimup-Bridgetown-Upper Blackwood districts although during the last year or so, the calcium carbonate type of stone in the spring has assumed importance. In these districts up to 10 per cent. of wethers in some flocks have died seven to 10 days after being introduced onto dominant Dinninup or Yarloop clover pastures in September and October.

Similar outbreaks have also been reported in flocks grazing dominant stands of these strains in the Kojonup, Boyup Brook and Dinninup districts. Siliceous type calculi have not often been found in these higher rainfall areas, except in sheep introduced from districts where they are common.

VARIETIES OF URINARY CALCULUS DISEASE

Siliceous Stones

In Western Australia, the majority of urinary calculi have silica as the predominant mineral element. This type of calculus is the one which is so widespread in the drier wheatbelt, especially in wethers during the summer.

Almost all the research on urinary calculus disease in Western Australian sheep has been on the siliceous type. Work of this kind has been undertaken at the Animal Health Laboratory for at least 15 years and considerable progress has been made in our understanding of the way in which these calculi form. They are composed of a mixture of silica (silicon dioxide) and organic matter, are usually small, irregularly shaped, slightly roughened and brittle. They have a greyish-white to yellowish tan appearance, often with reddish-brown mottlings. (Figure 2.)

It is thought that siliceous calculi often begin to form in the urinary tract as early as January, but their formation is apparently stimulated by environmental factors more likely to occur in March and April, the months with the highest incidence of siliceous calculus disease.

There appears to be a direct correlation between the prevalence of this form of disease and the feeding of oat grain or unstripped oaten stubbles. Barley feeding is also associated with a high incidence of the disease but feeding on wheat stubbles appears to be fairly safe.

Research Findings

Mr. M. Nottle, of the Animal Health Laboratory, has been carrying out research on this form of urinary calculus disease since 1953. Some of Mr. Nottle's important findings are:

(1) Silica excretion is usually high on the grazing available to West Australian sheep. Highest concentrations occur in urine samples collected in summer and autumn whilst the lowest are found in winter and spring. The increased urinary concentrations of silica in the drier months appear to be due mainly to the much smaller volumes of urine excreted at this time.

(2) The total urinary excretion of silica by sheep on green feed is approximately double that of sheep on dry feed. This suggests that green-feed silica is much more available and absorbed much more easily than dry-feed silica.

(This important finding may explain the frequent occurrence of sudden outbreaks of siliceous calculus disease following summer rains when green feed appears in the oaten stubble pastures.)

(3) The concentration of urinary silica is about 10 times greater in sheep fed oat grain than in those fed wheat grain.
(4) The total daily excretion of silica on hay and oat grain diets is, on the average, sufficient to cause the formation each day of a dozen obstructive urinary stones. That stones do not form in the great majority of cases with these very high excretions of silica is strong testimony to the belief that special conditions are required for the amalgamation of urinary silica into particles large enough to cause obstruction in the urethra.

(5) The water intake and urine volume are greater on diets containing wheat grain than on comparable oat grain diets.

(6) The average silica excretion each day of a large number of sheep consuming oat-grain or oat hay rations conducive to siliceous stone formation is not significantly greater than the daily silica excretion of sheep receiving grass on which urinary calculus disease never occurs.

These findings strongly suggest that the silica content of oats, although significant in the cause of the disease, is less important than another factor in the oats, probably concerned with the excretion of the "matrix" material essential for the actual formation of the stone. (See earlier discussion on urinary mucoproteins).

A field trial carried out by the Animal Health Laboratory on a Doolakine property during the summer of 1962-63 gave further confirmation of the above findings. In this trial there was a complete...
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absence of developing urinary calculus disease during the first half of the summer while the flock grazed a stripped oaten stubble paddock. Later in the summer, sheep were brought to the Laboratory and received oat grain and oat hay from the paddock without developing any signs of disease. However, when laboratory chaff was substituted for the oat-hay calculi began to form. We cannot explain this result at present but it indicates the importance of dietary changes in the causation of this disease, although the high silica (and presumably the high mucoprotein) excretions associated with the oat grain feeding were essential factors.

Silica in chemical solution condenses most readily when conditions are acid. This may also be true in urine solution within the urinary tract and the acidification of the kidney excretion which often accompanies summer nutritional stress may be important in the formation of silica stones. It, however, still requires confirmation.

Limited trials in this State have given some encouragement to overseas reports that salt (sodium chloride) may help to prevent the formation of siliceous calculi. Salt may be beneficial by causing increased water intake and urinary volume and lowering the concentration of the substances that condense into calculi.

**Calcium Carbonate Stones**

Calcium carbonate stones are usually small, spherical and hard, have a smooth surface, and range in colour from an off-white to grey-black, depending on the amount of organic material contained in them. Some calcium carbonate stones are gold-tinted (Figure 2).

As in siliceous stones organic material seems to be important in the binding of the calcium salt.

Most calcium carbonate stones form in the bladder, subsequently descending into the urethra where the blockage occurs.

The main predisposing factor in the formation of this kind of calculus is a high excretion of calcium in the urine, while an important associated factor is an alkaline urine, in which calcium carbonate is rather insoluble. There is thus a major difference in the conditions favouring the formation of carbonate stones and those involved in siliceous calculus disease, in that the calcium carbonate stones can form in alkaline urine while the siliceous stones are unlikely to form unless the urine is acid.

Another common situation in which carbonate stones form is inflammation of the bladder (cystitis) from any cause. Cystitis is usually infectious in origin and leads to degeneration of the cells lining the bladder, which in turn provides a nucleus around which the calcium salt may grow.

Although calcium carbonate calculi may occasionally be found in the drier wheatbelt districts where siliceous stones predominate, particularly in rams hand-fed a concentrated ration high in calcium, a special predisposition has been found in the last two years wherever Dwalganup, Yarloop or Dinninup strains of sub. clover dominate the sward. Most outbreaks of this type of calculus disease have been seen in September and October, often within a few days of introducing wethers to the clover pastures. It is often difficult to find these stones on post-mortem examination and a greyish-white sludge or paste filling the urethral canal may be the only evidence of an earlier urethral obstruction.

The reason for the high incidence of calcium carbonate stones in sheep grazing these strains of subterranean clover is not known, although there are indications based on chemical analyses of sub. clover from several severe outbreaks that they may be caused by an increased calcium intake. It has been ascertained that increasing the amount of calcium in the diet often results in an increased absorption from the intestine and, presumably, an increased excretion through the kidney.

It is fairly certain, however, that calcium stone formation is not another manifestation of sub. clover oestrogen intake ("clover disease") as outbreaks have usually occurred very quickly after sheep have been introduced to the pastures. Nevertheless, one cannot rule out the possibility that plant oestrogens may be playing an indirect role of some kind.

As mentioned above, these stones form only in alkaline urine and, conversely, are dissolved in acid urine. Therefore, if sheep begin to show signs of calculus disease on
a Dinninup or Yarloop sub. clover pasture in the spring, they should be removed to a bare paddock or yard, or onto scrub. The acid urine resulting from the change to a suboptimal diet will dissolve the carbonate stone or sludge and losses will soon cease.

**Calcium Phosphate Stones**

Calculi in which calcium and/or magnesium phosphate salts constitute the major part are rather uncommon in Western Australia in a pure form, although phosphate may make up a small fraction of other calculus types.

The conditions under which they form are very similar to those described for calcium carbonate stones with the exception that a high urinary excretion of phosphate is necessary. This is unlikely under natural grazing conditions in this State but may occur when concentrates hand-fed to rams contain added phosphates.

Acidifying the urine will help dissolve phosphate stones in the same way as with carbonate stones. In this connection, it may be mentioned that in America, phosphate stones are very common under feed-lot conditions where concentrated rations are often fed to fat lambs. Recent work in that country has shown that the incorporation of ammonium chloride in concentrated feeds containing added calcium or phosphorus will acidify the urine and thus help prevent the formation of stones of these types.

Ammonium chloride will do nothing to prevent siliceous stones and may in fact, favour their formation.

**Calcium Oxalate Stones**

Calcium oxalate is a not-uncommon constituent of many calculi primarily composed of one of the substances described in the preceding sections. Sometimes, however, oxalate makes up the major portion of the mineral fraction of the stone.

These stones, formed in the pelvis of the kidney or in the bladder, in an acid urine, are rounded or irregular, hard and crystalline. They are often fairly large and tend to remain in the area where they are formed. Thus in the bladder, oxalate stones may partially occlude the opening into the urethra ("ball-valve stones") and lead to rupture of the bladder.

An extensive outbreak of oxalate calculus disease of this kind was investigated in the Dalwallinu district in the summer of 1963. Many sheep with typical "water-belly" survived for weeks because urethral obstruction did not occur, thus allowing the passage of urine even though the bladders were ruptured.

Oxalate calculi are almost always associated with the consumption of plants which contain a high proportion of oxalic acid, of which there are many in Western Australia. The commonest of these in the agricultural districts are sourso, soureee (young succulent stage), dock and sorrel. In pastoral country, the chief offender is paraakeelya although portulaca, prickly saltwort, mulia-mulla and some of the salt-bushes may contain toxic levels.
severe kidney damage which they also
cause, may be found in Department of
Agriculture Bulletin 3098.

Although plants like doublegee and
soursob may often be early germinators
on wheatbelt properties where siliceous
stones are the chief cause of calculus
disease, there is still no real evidence that
they predispose to silica calculi even
though kidney damage is frequently
severe in sheep grazing them. Oxalate
may, however, form part of siliceous
stones.

**Clover Stones**

Sheep grazing pastures in which sub­
terranean clovers are present in large
amounts often develop large “stag horn”
concretions in the pelvis of the kidney,
composed almost entirely of organic
matter derived from the sub. clover.
These are sulphur-coloured, fairly soft
and easily fragmented, since they do not
contain mineral salts. (Fig. 2).

It is most unusual for clover stones to
cause typical urinary calculus disease but
they tend to grow in size in the kidney
pelvis and mechanically, by pressure, pro­
gressively destroy the kidney. A well
advanced clover stone in a sheep’s kidney
is shown in Figure 3.

Recently, there have been suggestions
that at times the clover stone material may
form yellow sludges in the bladder and
urethra and may thus contribute to
urinary obstruction and possible rupture
of the bladder.

Earlier in this article, reference was
made to the occurrence of “water-belly”
without the prior formation of a calculus.
Although we know very little about this
matter, there is evidence that some of
these cases may be associated with the
grazing of oestrogenic subterranean
clovers. Cystic degeneration of the bulbo­
urethral glands, lying over the urethra
near its junction with the bladder, often
results in the formation of “false-bladder”
(see Department of Agriculture Bulletin
3345) in wethers. Pressure from these en­
larged glands may narrow the urethral
canal while necrotic cell debris from them
may form part of a complex material
obstructing the free passage of urine.

**PREVENTION OF URINARY CALCULUS DISEASE**

**Siliceous Calculi**

Siliceous calculi may be prevented to a
great extent by restricting the feeding of
oat grain or unstripped oaten stubbles to
wheatbelt sheep during the summer,
especially the later part of the summer.
Stripped oaten stubble, or wheat stubble,
appears to be relatively safe. If precau­
tions are taken to introduce wheat
gradually during supplementary feeding
in the summer it can replace oat grain
and should markedly decrease the in­
cidence of urinary calculus disease.

Avoidance of conditions favouring the
excretion of acid urine (nutritional stress
and weight loss in late summer, chronic
parasitism, or rations high in acid-form­
ing minerals such as phosphates or
sulphates) will help, as siliceous calculus
formation is favoured in acid urine. Also
the provision of common salt has given
encouraging results in some flocks, al­
though it cannot be regarded as a cure-all.

If oxalic acid plants appear significantly
on summer paddocks, sheep should be
removed if possible, or if this is not prac­
tical, limestone should be added to the
salt mixture. Since green grass or sub.
clover appearing after summer rains may
increase the incidence of siliceous stones,
it is advisable to provide a limestone-salt
mixture at this time. Finally, as sheep
from drier wheatbelt properties may be
carrying incipient siliceous stones, buyers
of such sheep would be wise to ascertain,
if possible, the history of the flock before
purchase.

**Calcium Carbonate Calculi**

Calcium carbonate calculi may be pre­
vented by avoiding unbalanced rations,
especially high calcium—containing con­
centrates, in high rainfall districts where
pastures often have an alkalinizing effect
on the urine.
Where calcium stones appear in a flock, acidifying agents such as ammonium chloride or phosphoric acid, may be useful.

Often, the simple removal of sheep to a scrub paddock or yarding for a few days may abort an attack. This has proved to be a valuable measure where this type of stone formation is due to the grazing of pastures dominated by Dinninup, Dawlganup or Yarloop sub. clovers.

**Phosphatic Stones**

Phosphatic stones, restricted almost entirely to rams on special concentrated rations, may be avoided by balancing the ration with calcium and urinary acidifiers, and by providing ample roughage.

**Oxalate Stones**

Oxalate stones are prevented largely by avoiding the grazing of oxalic acid plants. If feasible, limestone should be given as a supplement since it neutralises oxalic acid, forming insoluble salts in the gastrointestinal tract.

**Clover Stones**

Clover stones cannot be prevented by any known therapeutic measure but the recommendations currently advocated for the control of clover disease* should also be effective in this complication. Obviously, the avoidance of subclover dominance in pastures is the most logical preventive of clover calculi.

It almost goes without saying that sheep should have easy access at all times to *palatable* drinking water. Highly saline waters, despite the probably beneficial effects of salt as described above, are always unpalatable and thus strongly predispose to urinary calculus disease of all kinds.

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* *Journal of Agriculture, July, 1965; Department of Agriculture Bulletin 3345*

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