Recent advances in lupinosis research

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ANIMAL DISEASES

RECENT ADVANCES IN LUPINOSIS RESEARCH
— a progress report

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BECAUSE of the important role which lupins play in light land development, flock losses from the effects of lupinosis must inevitably continue to be a matter of serious concern. However, research carried out during the last four years has considerably advanced our knowledge of the fundamental nature of this disease and of the way in which it may be prevented or controlled.

This article outlines the general findings from 15 pen trials and 35 field trials. The possible associations between the disease and factors such as copper and cobalt status and worm burdens are also considered. Summary reports on our efforts to find the basic cause of lupinosis and our present tentative conclusions arrived at from the work done, are also included.

The Background of the Problem

A few years ago officers of the Moora District Office of the Department of Agriculture conducted a survey on the incidence of lupinosis of sheep. The yardstick used as a measure of lupinosis was the occurrence of deaths in flocks grazing dry lupin paddocks during the summer, although it was realised that the disease was more widespread than indicated by actual mortalities. The survey indicated that total losses amounted to 0.7 per cent. of all sheep carried during the decade 1950-1959, of which about half occurred during one of those years—1958-1959. In that year, lupinosis caused over 3,700 deaths, representing 3.5 per cent. of sheep carried on affected properties.

A more rigorous criterion—the production of typical liver damage—has been used since then in assessing the incidence of lupinosis in almost 500 sheep from 33 field trials. Only a very small proportion of these sheep was completely free of signs of lupinosis, suggesting that the majority of sheep running in lupin paddocks for several months during the summer may suffer some degree of liver damage. In spite of this high incidence of disease, the mortality rate in our summer trials has been relatively low:

- 5 of 80 sheep in 1961 trials (6.25 per cent.).
- 2 of 88 sheep in 1962 trials (2.27 per cent.).
- 24 of 170 sheep in 1963 trials (14.1 per cent.).
- None of 30 sheep in 1964 trials (0 per cent.).

It will be noticed that the 1963 losses were exceptionally high; the reasons for this will be discussed later.

Field Observations

Accumulated field experience of lupinosis indicated that the clinical disease—

(1) Regularly followed periods of summer rain and high humidity.
(2) Is more serious and apt to be followed by higher mortality rates, when liver copper levels are high.
(3) Is likely to be aggravated by cobalt deficiency, by parasitism and by poor, unpalatable feed.

Pen trials have helped to confirm these field observations.
Lupins play an important role in light land development in many districts and the study of lupinosis has been a major research project. An important finding is that outbreaks regularly follow periods of summer rain and high humidity; sheep should be removed from lupin paddocks under such weather conditions.

The onset of clinical lupinosis is invariably associated with loss of body weight. As long as body weight is at least maintained during the summer, significant liver damage is unlikely to occur.

The course of lupinosis may be acute or chronic. In its acute form the condition occurs within a week or less of introducing sheep to lupin grazing and jaundice or "yellows" is the clinical sign which is most closely associated with the development of severe lupinosis. In its chronic form depressed appetite, dullness, severe loss of condition and death are seen at varying times following access to lupins. The acute condition is relatively uncommon and the type of disease found after three or more weeks of lupin grazing appears to be much more important as a source of economic loss.

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Unusually widespread and serious outbreaks of lupinosis were recorded in the summer of 1963. Most were reported a week or two after 70-173 points of rain which fell over a three to four day period towards the end of January, and again after 105-162 points which fell over a five day period from February 16 to 20. These outbreaks also coincided with the losses in our own field trials that year and support the conclusion that 1963 was one of the worst years on record for lupinosis losses and the summer was one of the wettest for the last few years in these districts.

In the experimental groups, the first signs of liver damage that summer were seen two or three days after the end of the first rainy period.

In contrast to 1963, the summer of 1964 was considerably drier than usual. There was only one period of significant rainfall in most of the lupin country—towards the end of February—and the return to hot dry conditions was fairly rapid. No outbreaks of lupinosis were reported before the rainy spell and experimental sheep running on lupin paddocks were free of liver damage when examined in January and February. A few mild outbreaks of lupinosis were recognised for a couple of weeks in March and experimental sheep also became mildly affected at this time.
Nutritional Aspects

The nutritional aspects of lupinosis have been studied many times and there is clearly an association between this disease and poor feed, involving both a reduction of total consumption and the consumption of feed of declining quality.

It has been repeatedly found at the Animal Health Laboratory that the severity of liver damage is, paradoxically, less if more lupins are eaten. It is considered that the consumption of 600 to 700 grams of dry feed, such as wheaten chaff or good quality hay, will provide adequate nourishment for average sheep under normal pen conditions. Assuming an average from 9 to 10 per cent. crude protein in such feed, the sheep’s protein requirement of 50 to 70 grams a day is met by this amount of feed.

However, sheep in pen trials have seldom consumed more than 400 grams of lupin feed a head a day; usually they eat much less than this. The average daily feed intake over 30 days in the last six pen trials conducted at the laboratory, employing a total of 69 sheep, was 218 grams of lupin roughage a head a day.

The crude protein content of lupin leaf is usually fairly good (10 to 15 per cent.) and that of lupin seed exceptionally high (30 to 40 per cent.) but lupin stalk and pod seldom contain more than 7 per cent. of crude protein. The protein requirement (the limiting nutritional factor on these paddocks) of the sheep would be assured by adequate consumption of lupin leaf or seed or from alternative good quality feed, if available.

A few of the better lupin paddocks may contain subterranean clover or capeweed, either of which may provide adequate alternative protein, but more commonly the non-lupin feeds comprise spear grass, silver grass, barley grass, veldt grass, and so on. The feeding value of these grasses may be barely adequate early in the summer, but as they deteriorate after summer rains and when their seeds are shed, their protein contents may decline to as low as 2 to 3 per cent., making them almost useless as sheep feed.

The liver damage of lupinosis is therefore promoted by lowered intakes of feed of declining quality and palatability.

It is probable that the growth of fungi on the lupin roughage after summer rains not only gives rise to substances which may exert toxic effects on the liver, but also contributes to a lowering of its palatability.

Lupin Seed

It is not yet known how much lupin seed is actually eaten by sheep grazing lupin paddocks. There is no doubt that some seed is picked up, but in most sheep from our trial paddocks the amount found in the rumen has been small.

The only positively identified toxin yet found lupins is the alkaloid lupinine. This is concentrated in the seed and is responsible for the nervous symptoms (convulsions) occasionally seen in sheep running on lupins. This disease is uncommon in Western Australia probably because of low consumption of these seeds, which are bitter and unpalatable.

Trace Minerals

Lupins have considerable ability to grow on poor, mineral-deficient soils and copper deficiency diseases of plants and animals are common on soils on which lupins thrive.

Numerous analyses of lupin plants during the last four or five years indicate that lupin seed and leaf may contain adequate levels of copper for animal health (4.5 to 6 parts per million) and that other lupin roughage usually contains less than 3 p.p.m. and therefore is markedly deficient. Even copper topdressing appears to do little to increase these levels. There is therefore no doubt that most country in which lupinosis is a serious problem is also copper-deficient country.

However, lupinosis was unknown in Western Australia until 1948, several years after copper topdressing and other copper treatments to stock became prevalent in this copper-deficient country.

It was thought that lupinosis could, in fact, be a kind of copper poisoning. We, therefore, investigated whether lupinosis could arise on non-topdressed severely copper-deficient country.

Some virgin ground on such country was cleared and sown to lupins. Sheep were run on this land the following year (1963) and all developed lupinosis. The copper contents of these lupins and other feeds from the paddock were exceedingly low. However, some of the sheep were killed soon after the period of active disease
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(following the summer rains, as described above) and were found to have high normal copper levels, of greater than 300 p.p.m. Obviously these sheep were not picking up copper from the deficient pasture but had gone onto the experiment with high liver stores of this metal. No sheep died in this paddock but all developed liver damage of lupinosis.

An identical adjacent paddock was also cleared and sown to lupins but at the same time received a heavy copper topdressing. During the summer, all the sheep on this paddock developed severe liver damage of lupinosis, and 40 per cent. of them died from the disease.

All these deaths occurred within three weeks of heavy showers of rain. The first death, a few days after rain, had a high toxic level of copper of 1,200 p.p.m. while thereafter, the levels of liver copper fell steadily to deficiency levels.

Many other trials have been conducted on the copper aspects of lupinosis and will be reported when a pattern has been more clearly defined.

At present the facts which have been fairly well established on the rainfall-fungus-copper relationships of lupinosis may be summarised as follows:

1. Lupinosis occurs on mineral-deficient country able to support good stands of lupins. These lupins may be extremely deficient in trace elements, but may still produce various degrees, often severe, of liver damage.

2. Lupinosis did not become a problem, and indeed was not recognised until 1948, several years after copper topdressing became standard practice.

3. The disease does not occur to any extent until after summer rains when lupin paddocks acquire a toxic quality.

4. Following summer rains, the disease may appear in any sheep, regardless of mineral status (and in fact causes liver damage in the great majority of sheep at risk). Under these conditions fungus development is likely to be at its greatest. This liver damage appears to be more severe at higher liver copper levels.

5. As the copper contents of lupins and other available feeds are usually low to deficient, it is unlikely that sheep with high liver coppers acquire this status by grazing lupins in the early part of the summer (this conclusion is still tentative and it may be that under certain conditions, sheep may gain significant loads of copper from recently copper top-dressed paddocks).

6. It is considered that sheep going onto summer lupin paddocks and carrying high levels of copper in their livers, are much more likely to be affected and far more likely to die from lupinosis than those with a low copper status.

7. It is probable that fungi growing on lupins under appropriate environmental conditions reduce palatability of feed and perhaps elaborate toxic substances, which damage the liver and affect copper metabolism.

Alternative Grazing

Although lupinosis has been seen in severe forms in paddocks containing less than 15 per cent. of lupins and, conversely, has at times been apparently absent or only mild in paddocks containing little else but lupins, there is little doubt that the presence of alternative feed, especially if it is palatable, helps to lessen the severity of the disease in flocks. Liver damage may not be prevented, but the mortality rate is usually lowered.

Hay, cereal grain, or sheep cubes have been provided for the sheep in some of our field trials and the severity of the disease definitely diminished, but we do not yet know if alternative feed standing in the paddock and therefore subjected to the same climatic conditions as the lupins, is beneficial. The evidence to date suggests that such standing feed is not likely to help much unless it retains its palatability.

Another mineral which has often been found only in extremely small quantities in lupins and other feeds in these districts is cobalt. If sheep are marginal or near-deficient in cobalt when they go onto lupin paddocks, they may become clinically deficient later on; a serious complicating factor may thus be added to the problem.
Fungus Studies

The possibility that a toxic fungus on lupins might be the main cause of lupinosis was suggested many years ago but no progress was made in studies that followed. This aspect of the lupin problem has again been critically studied during the past year, although progress has been slow. More than 20 different fungal species have been isolated, in different combinations, from lupins in our various field trials but there is no single quick way of evaluating their toxic properties, either alone or together. It seems possible, however, that one or more of these fungi may be toxic under certain conditions.

Lupins collected from “toxic” paddocks have been stored for several years in our laboratory and have retained their toxic properties throughout this time. It is therefore interesting to find that sheep on “toxic” paddocks following a definite outbreak of lupinosis invariably recover. Definite signs of liver regeneration have been repeatedly seen in sheep killed two or three weeks after a return to hot, dry sunny weather.

If a fungal toxin is produced on these lupins, either it must be relatively unstable under field conditions or sheep learn to avoid fungus-infested herbage.

Fungi are rather exacting in their growth requirements, many making significant growth only at temperatures ranging from 70° to 80° F. and at relative humidities above 90 per cent.

The amount of rain and/or the duration of the subsequent period of high humidity necessary for the precipitation of outbreaks of lupinosis are not known with certainty at the present time.

While there is no definite knowledge of the cause of the lupin toxicity following rain the most likely reason appears to be the growth of a fungus on the dead plant.

Parasitism

There is considerable experimental evidence showing that worm infestation markedly increases the severity of lupinosis and that levels of parasitism which would ordinarily have little noticeable effect on well-nourished sheep may precipitate severe clinical disease in sheep grazing toxic lupin paddocks.

Parasites not only debilitate the sheep and interfere directly with nutrition, but also act to depress appetite and aggravate cobalt deficiency problems. In our 1963 field trials, there were no deaths among 20 sheep rendered worm-free before being placed on six different lupin paddocks, while there were 11 deaths among 50 (about 24 per cent.) wormy sheep placed on the same paddocks. Although other factors were involved these results strongly support field observations relating parasitism to increased mortality of sheep grazing summer lupins.

Phenothiazine and copper-based worm drenches may be attended by considerable risk in sheep grazing lupins. Both of these anthelmintics are likely to be extremely toxic to these sheep and only anthelmintics known to be free of toxic effects should be used.

Geraldton Observations

The Government Veterinary Officer at Geraldton (Mr. A. Williams, B.V.Sc.) has been closely associated with investigations on field outbreaks of lupinosis for the past 10 years and has emphasised the following points which he believes are important:—

1. Lupinosis is caused only by the dead plant. Where green lupins appear to cause trouble, the previous season's trash on the ground is responsible.

2. Rainfall in excess of about 30 points accompanied by two or three days of cloudy weather and high humidity may be followed in a week or 10 days by signs of the disease and by mortalities.

3. The greater the availability of lupin seed to the grazing animal, the less marked the typical damage to the liver. Seed production is lowered by mowing lupins in the green stage or by a check in growth by frost or hormonal sprays; seed can, however, cause occasional cases of alka-loidal poisoning (lupin madness).

Mr. Williams' observations are supported, in general, by the experimental work reported in this article. We have conducted trials with green lupins for as long as 30 days in sheep without producing the slightest liver damage and we are quite satisfied that they do not cause damage. We have also conducted trials on lupin seed and have found that although sheep do not readily eat the seed, presumably because of its bitter taste, it is very nutritious and certainly harmless when consumed.
RECOMMENDATIONS

Accumulated evidence to date gives strong support for the following conclusions and recommendations:—

1. As lupinosis is regularly precipitated by periods of rain and high humidity on paddocks containing lupins, careful attention to weather conditions will result in great protection from this disease. Rainfall of 50 to 100 points, especially if followed by humid weather, should be taken as a warning of an impending outbreak of disease. Owners are emphatically urged to remove sheep from lupin paddocks immediately when these conditions occur and to provide good non-lupin feed.

2. There is now considerable evidence that lupin paddocks affected in this way begin to lose their toxic characteristics in two to three weeks on a return to hot, dry weather conditions. Grazing may therefore be safely resumed on such paddocks.

3. Although no recommendations can be made regarding a change in copper top-dressing practices on lupin paddocks, it should be remembered that high copper status in the sheep grazing them contributes appreciably to lupinosis damage during periods of climatic risk. However, as copper is needed for upgrading much of this country and therefore must be used, some attention should be given to top-dressing at times of the year least likely to contribute to excessive availability to sheep, such as late autumn or early winter when rain might be expected to remove copper traces from the top feed.

4. It is definitely dangerous to provide sheep grazing lupins with any form of copper supplementation (licks, concentrated feeds, etc.). Furthermore, sheep should not be given copper in any form for two or three months before going onto lupins, as animals going into these paddocks with high liver copper levels run a much greater risk of serious lupinosis than those with low or normal levels.

5. Any loss of body weight or condition in a flock grazing lupins should be regarded as a warning that an outbreak of lupinosis may occur.

6. It would be helpful in most lupin country based on sandplain to provide a cobalt supplement, as the decline in appetite associated with cobalt deficiency is likely to aggravate an existing lupinosis.

7. All sheep should be drenched with an efficient worm drench known to be effective against immature as well as mature worms before they are placed on summer lupin grazing.

8. Alternative feeds, if palatable and consumed by sheep, will lower mortality and lessen liver damage, but cannot be relied upon to affect markedly the condition of sheep in the presence of toxic lupins.
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