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Copper and cobalt deficiency of livestock in Western Australia

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COPPER AND COBALT DEFICIENCY OF LIVESTOCK IN WESTERN AUSTRALIA

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PART 1.—DISTRIBUTION AND EFFECTS

DISEASES of animals due to copper and cobalt deficiencies are well known in this State where much of the original work, on the cause of these conditions, was carried out. These investigations have been recorded elsewhere and described briefly in this Journal by Filmer and Underwood (1936), Bennetts (1935), (1937), (1940), (1941), (1942) and Bennetts et. al. (1939), (1942). During more recent years the distribution of these deficiencies in Western Australia has been surveyed in some detail. This survey has been made by field investigations and by chemical estimations of animal tissues and pastures from many localities throughout the State.

With present knowledge it is now practicable to make standard recommendations for the control of these diseases and to indicate more clearly the regions and types of country where they may be expected to occur.

Animals may suffer from a deficiency of either copper or cobalt, or from a dual deficiency, as in "coast disease." Sheep and cattle are the stock mainly affected. Cobalt deficiency affects the ruminant animal only, but copper deficiency may affect horses and pigs as well as sheep and cattle.

In brief, the main sign of cobalt deficiency is a progressive wasting and weakness suggestive of starvation. The signs of copper deficiency vary with the species of animal affected and with the degree of the deficiency. In cattle the growth of young animals is retarded and they appear unthrifty; there may be fading of hair colour, intermittent scouring and lowered production and fertility. If the deficiency is very severe, cows, particularly those in production, may die suddenly from heart failure ("falling disease"). In sheep the occurrence of "stringy" or "steely" wool is the main characteristic in the adult, and lambs may develop a condition known as ataxia, under conditions of more severe deficiency. Young pigs also may show ataxia. Adult horses appear to thrive on copper deficient pastures, but foals bred on the same deficient areas show abnormalities in the structure and posture of the legs.

Sheep or cattle affected with "coast disease" may die from the effects of cobalt deficiency before they develop definite signs of copper deficiency.

A.—COPPER DEFICIENCY

The animal body requires small amounts of copper for various functions and if adequate amounts are not available the signs of illness, briefly outlined above, may develop. The deficiency may result from an unduly low copper content in the feed available to the animal or, sometimes, from the operation of factors which prevent the animal body from utilizing the adequate, or even high, amounts of copper contained in the diet. The nature and mode of action of these factors causing a "conditioned" copper deficiency are being studied both here and elsewhere.

Fortunately in this State copper deficiency diseases seem to occur, almost exclusively, on pastures which are low in copper content. Their detection and control are, in consequence, relatively simple. The results of surveys reported by Beck (1941), (1951) indicate that where the copper content of pasture is above 6 parts per million stock remain healthy, that with lower values between 3 to 6 p.p.m. signs of copper deficiency may be anticipated, and

that with values below 3 p.p.m. severe manifestations (ataxia and "falling disease") are present. The copper content of pastures on which "falling disease" was common was extremely low, usually below 2 p.p.m.

Regions and Types of Country Where Copper Deficiency Occurs in Animals.

The evidence available indicates that much of the western and southern coastal country is deficient. Evidence of deficiency has been observed from Broome in the north to as far east as Hopetoun, on the southern coast. Knowledge of the copper status of animals and herbage in the northern interior, however, is limited. On the other hand the distribution of the main affected regions in the South-Western Division of the State has been mapped (see map).

The regions where a more or less severe deficiency is almost universally present are:—

(a) Coastal and semi-coastal country. This includes the calcareous windblown sands of the coastal fringe, which are invariably deficient in copper (and in cobalt) and the "light" country of the coastal plain which is deficient to a variable degree. The latter includes the banksia and tuart sands, the peaty swamps and much of the country adjacent to Albany.

(b) The Gingin and Dandarragan districts (cretaceous country).

(c) The Busselton-Margaret River and Northcliffe districts where a widespread and very severe deficiency exists, particularly throughout the jarrah-redgum belt. Similar country west of Mt. Barker is also markedly deficient. In other types of forest country in the lower South-West, notably in the Denmark, Walpole, Manjimup and Pemberton districts, the deficiency is less severe and more patchy in distribution.

In the agricultural areas further inland especially in the Great Southern district and the wheatbelt the occurrences of copper deficiency in animals is still more widely scattered, less severe, and more subject to seasonal variations. In these areas, which have been mapped in conjunction with surveys of woolclips initiated in 1941, the manifestations are restricted to seasonal occurrences of "stringy" wool and occasional cases of ataxia in lambs. In some localities only occasional properties are affected, in others, as in the vicinity of Corrigin, the deficiency is more widespread.

Investigations in the region, referred to, have indicated that the types of country likely to be affected are light sandy (or sandy-gravelly) soils carrying predominantly whitegum, tammar and wodgil; or whitegum, associated with stunted jam and sheoak, although these vegetation associations do not necessarily indicate copper deficiency. It appears quite evident, however, that heavier forest country carrying salmon gum or york gum is generally healthy and that where sheep have adequate access to this, as well as to the lighter types, they are able to obtain sufficient supplies of copper for all bodily needs.

The whitegum, redgum, flooded gum, country of the "clover belt," notably to the west of the Great Southern railway is, almost generally, free from evidence of copper deficiency signs in animals, although some light sandy soil types in this region have been shown to be copper deficient. Here, as elsewhere in the agricultural areas, there may be evidences of copper deficiency if sheep are maintained on areas which are dominantly of the "light" sandy copper-deficient type (e.g. casuarina sands).

Seasonal Variation.

In the more severely deficient regions animals show evidence of copper deficiency every year, although even here the signs are more apparent during the green feed period than the dry, and in seasons favouring the growth of lush green feed than in drier years.

In the marginally deficient areas signs of deficiency may be slight or absent in some years and definite in others depending on the seasonal influences referred to.

Symptoms of Copper Deficiency in Cattle.

1. *Non-fatal Copper Deficiency.*

Calves may show signs of deficiency at an early age. Growth is retarded and there

is marked unthriftiness. The limbs show abnormalities—pasterns are straight and calves tend to stand up on the toes. Joints, particularly those of the hind legs, are "knobby" as a result of bony prominences. These clear up as the animal reaches the age of 1½-2 years. Diarrhoea and signs of anaemia are commonly noted. With increasing age the animals grow slowly and have a very stunted, undeveloped and unthrifty appearance. On some holdings they cannot be reared into profitable animals and are destroyed. Maximum size is not attained in adults on the worst-affected properties and each successive generation tends to be smaller in frame.

In adult cattle, manifestations are particularly marked during the period from August to October when, despite abundance of green feed, there is some loss of condition and the coat is very rough and "starey." A severe anaemia, due to copper deficiency, is commonly present during this period; recovery from this is rapid and spontaneous during the summer months.

Depraved appetite is common; cattle eat soil around the roots and butts of upturned trees. Scouring is frequently present. Temporary infertility with suppression of heat is an associated condition; many cows served during the autumn and winter months, although failing to get in calf, do not return to the bull generally until November or December when they are readily stocked. It should be borne in mind however, that temporary infertility may be due to a number of causes other than mineral deficiency. At the same time there is no doubt that the use of copper supplements did facilitate the stocking of dairy and beef cattle in the regions where copper was very deficient.

2. *Fatal Cases of Copper Deficiency—"Falling Disease."*

As reported previously "falling disease" occurs only in areas which are severely deficient in copper. Cattle only are affected, not horses, sheep or pigs.

Cows die, generally, when from four to seven years of age but not uncommonly when older. "Falling disease" is uncommon in younger animals and it not known to affect cattle under 15 months old. Male animals are rarely affected. Reports indicate that death occurs most frequently just before or within a week or two after calving. It is most frequently observed

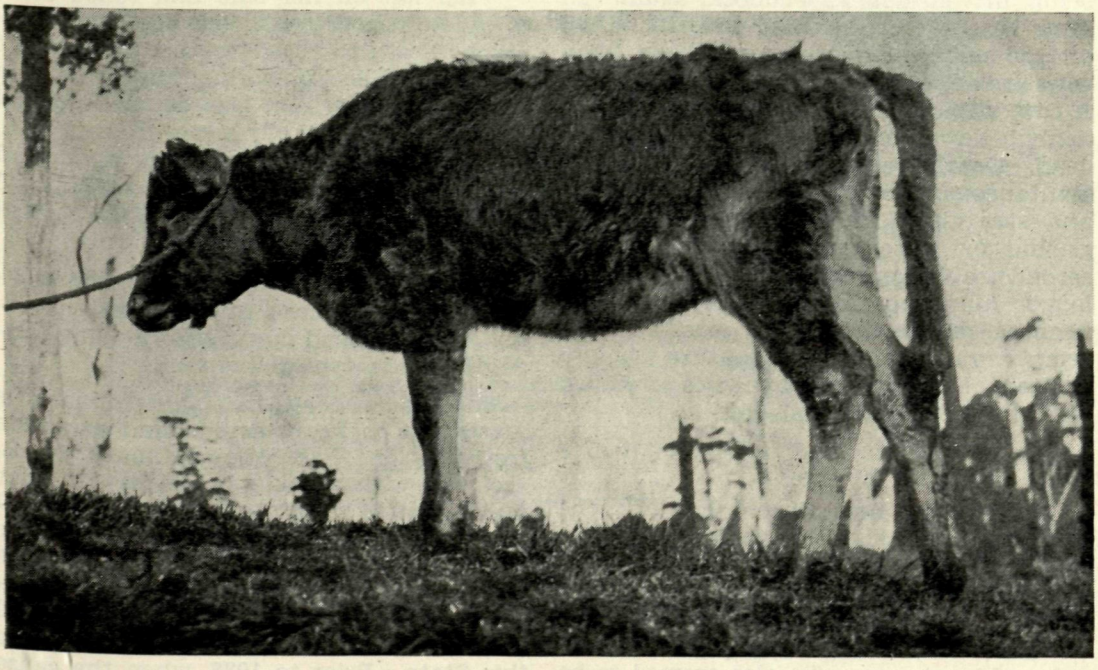

Fig. 2.—A heifer suffering from cobalt deficiency.

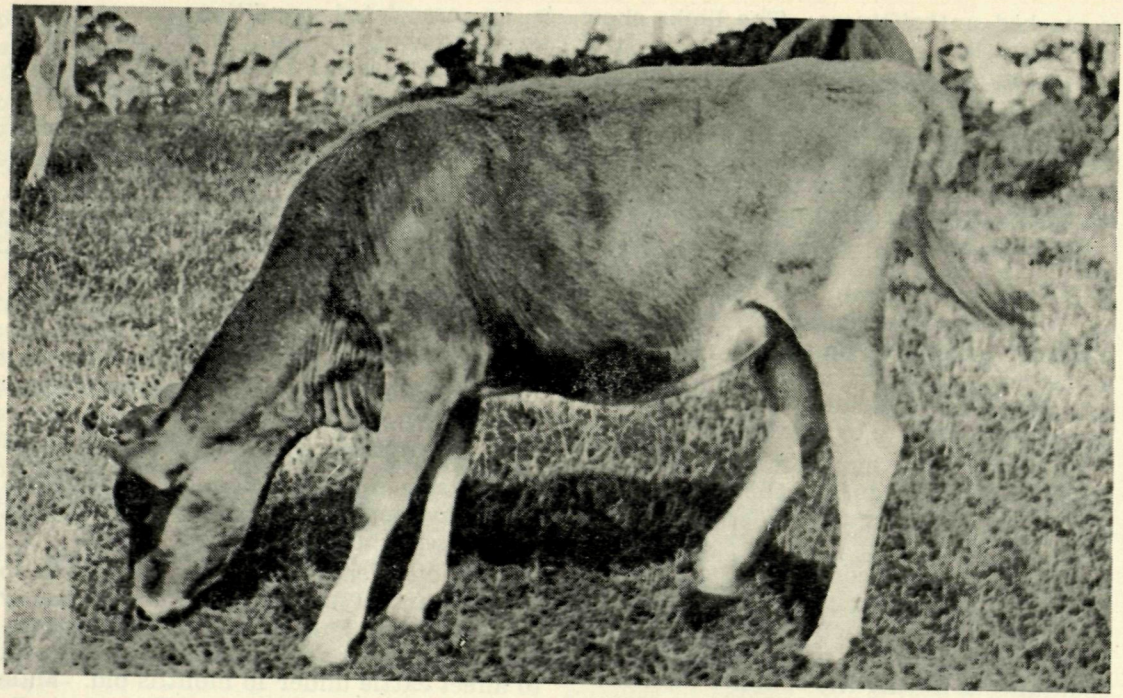

Fig. 3.—The same heifer showing the improvement in condition following upon cobalt supplementation.

when cows are being brought into be milked, are standing in the bail, or are being driven out to paddock again. In some cases the cows have actually fallen on the milker. Deaths also occur when cows are at pasture but are rarely observed. A cow, apparently normal in health, suddenly bellows, throws up its head and falls dead. Death frequently appears to be instantaneous. Sometimes the animal falls and struggles feebly on its side on the ground for a period varying from a few seconds to five minutes. In these cases of longer duration intermittent bellowing, running movement of the legs, and attempts to regain an erect posture are also noticed. Finally the animal lies stretched out with head back and dies.

The following is a settler's account of a death witnessed by him:—

> "When I first started bringing the cows home she was perfectly normal and grazing with the rest. I had got them about halfway home when she stopped and started swaying on her feet; she seemed to be paralysed and could not move, she also seemed to be forcing water from herself. She then started to stagger with her head down, as if she was drunk, after that she fell flat on her side and rolled completely over with her back downhill, her legs and neck stretched out straight and her legs quivering. She gave a few groans, her back legs doubled up and she turned partly over on her back, her legs then went straight again and she was dead. She died within one minute and a half of when she started to sway."

Rarely an animal may show symptoms for 24 hours or more, intermittently pivoting with the head down, before dying suddenly in the typical manner.

The sudden death in "falling disease" is attributed to heart failure and extensive investigations have shown that it is associated with marked changes in that organ; cattle maintained on **severely copper deficient** pastures show a progressive destruction (atrophy and fibrosis) of heart muscle. This manifestation does not appear to occur in any other species of animal and has rarely been reported from outside this State. Prior to 1938, when the cause was determined, "falling disease" was a

source of serious economic loss in the Busselton-Margaret River region and at Northcliffe—similar mortalities were also reported from some coastal areas. Following the widespread use of copper fertilisers and supplements, however, the disease has ceased to occur and "falling disease" is now only of historic and scientific interest.

Symptoms of Copper Deficiency in Sheep.

In the adult sheep the main sign of copper deficiency is "stringy wool." Anaemia and scouring may also occur under some conditions.

"straight steely" wool, are loss of crimp and straight, glassy or silky appearance; the fleece lacks "bulkiness." The defect is much more noticeable in Merino than British breed types.

Banding of the fleece in black sheep, so that the staple shows alternate bands of pigmented and unpigmented wool, is also an early and characteristic sign.

The anaemia and excessive scouring, associated with a fairly severe degree of copper deficiency, occur particularly in the breeding ewes and are noted, generally, only during the winter months. Obviously both anaemia and scouring may be

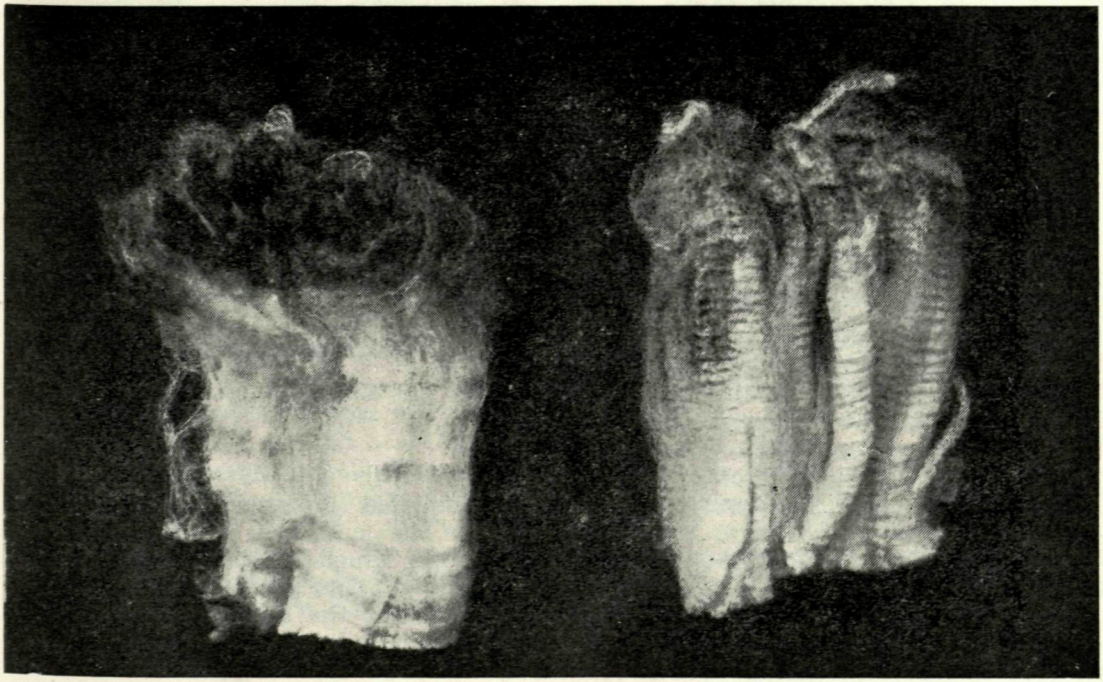

Fig. 4.—"Stringy wool" from West Mt. Barker is shown on the left. On the right is normal wool from a copper top-dressed location at Dandarragan.

"Stringy wool" occurs even when pastures are deficient to such a mild degree that all other signs are indefinite or absent. In fact the absence of this wool defect in a clip, predominantly of the Merino type, can be taken as reliable evidence that stock are receiving adequate copper from the pastures provided, of course, that copper is not being supplied through bluestone worm drenches, etc.

The characteristics of "stringy wool," sometimes referred to also as "slippery" or

due to many other causes; the occurrence of these manifestations therefore has no diagnostic significance.

Lambs, born of mothers maintained on copper deficient locations, may show a disease, named ataxia. This name refers to the characteristic manifestation, an incoordination of gait.

This disease, resulting from a low copper status, affects lambs from birth to when about four months old. Typically there is some check in growth followed by a loss

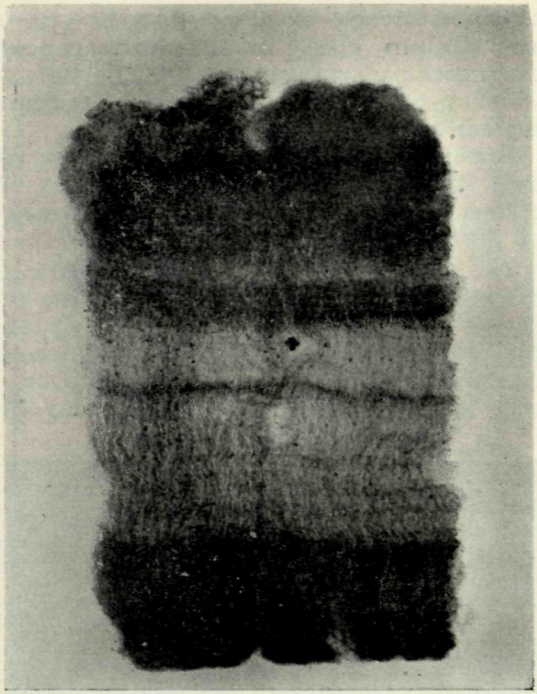

Fig. 5.—Banded black wool from South Australia. Photo by courtesy of Prof. E. J. Underwood.

of control of the hind legs. This, at first, is noted during driving, when movement becomes progressively more difficult. Finally the hind quarters sway ("sway back") and the affected lamb falls over and is only able to proceed again after resting. The condition gets progressively worse until in the course of days or weeks the lamb can travel only short distances or not at all.

The characteristic incoordinated gait (ataxia) results from degeneration of the nervous system and should not be confused with the stiffness and lameness seen in arthritis, an infectious disease.

More rarely copper deficient lambs are born dead, or are affected at birth or when a few days old with a rapidly fatal disease in which there are signs of brain involvement. In general the earlier the lamb is affected the more rapid and fatal is the course of the disease. Usually, under Western Australian conditions, lambs do not show signs until about four to eight weeks old; these may survive for weeks and, although the majority may die, others may grow to maturity. Some abnormality of gait, however, almost always persists.

The numbers of lambs affected and the course taken by the disease is related to the degree of copper deficiency and may vary considerably from year to year, particularly in areas not severely deficient. It has been shown quite definitely that a degree of deficiency insufficient to cause ataxia may, however, retard the growth and development of lambs to quite a marked extent.

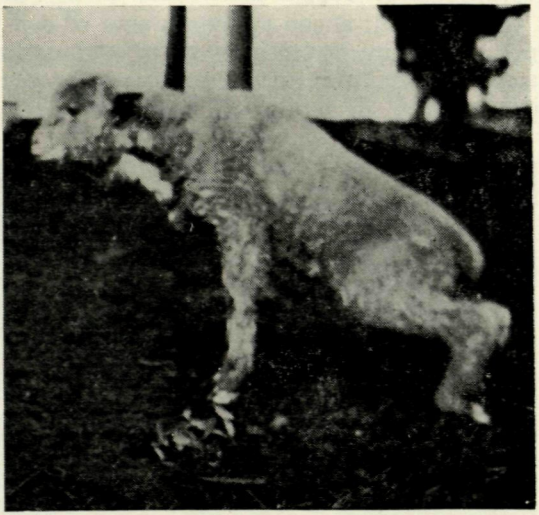

Fig. 6.—A lamb suffering from ataxia, resulting from a low copper status (Mt. Barker).

Copper Deficiency in Horses and Pigs.

No detailed investigations have been made of the conditions affecting foals and young pigs, which are attributed to copper deficiency. There seems to be no doubt, however, that the abnormalities referred to do result from this deficiency and are prevented by copper supplementation.

Foals.—The so-called "rickets" which was formerly commonly seen, particularly in thoroughbreds, in the Gingin and Dandaragan districts, was characterised by unthriftiness, depressed growth rate and in the more severe cases, by pronounced stiffness of the limbs which were commonly held in various abnormal positions due to bending at the joints. The bones themselves did not bend as in true rickets (rachitis), but the development of bony enlargements, ("apple joints") was a not uncommon sequel. Affected animals tended to stand up on their toes. This condition was sometimes apparent at birth, or be-

came manifest during the succeeding six months. It did not develop after weaning, although animals tended to grow slowly until about two years old.

The disease was sometimes fatal, but stockowners found that its progress could be arrested by stable feeding mother and foal with **dry feed,** grown locally.

Young pigs, bred in the severely copper deficient area of the lower South West, commonly showed a condition of ataxia similar to that described for lambs—this condition is now rarely seen.

Post Mortem Appearances.

The carcases of animals affected with copper deficiency do not show any striking or characteristic appearance on post mortem examination. In lambs, however, the skeleton may be rather poorly developed—the shafts of long bones are thin and brittle and there may be spontaneous fractures of the ribs.

The microscopic examination of tissues however, may reveal marked changes, notably degeneration of the nervous system (demyelination) in lambs and pigs; this degeneration accounts for the characteristic incoordination of gait. No such changes have been seen in cattle, which do not show ataxia. Cattle, as we have indicated, may show marked heart abnormalities with loss of muscle and its replacement by scar tissue (atrophy and fibrosis). Some evidence of fibrosis may be obvious to the naked eye but generally microscopic examination is necessary to detect changes which, however, may be profound.

Control.

As a deficiency of cobalt, not uncommonly, occurs concurrently with that of copper it is convenient to consider the control of both together in a separate section at the end of this article.

B.—COBALT DEFICIENCY

Investigations carried out in this State, in South Australia, and more recently in other parts of the world, have demonstrated that minute amounts of the element cobalt are necessary for the growth and health of the ruminant animal. If the diet contains less than the exceedingly small minimal requirement, sheep and cattle will not thrive and may waste and die. Horses and other non-ruminant animals, however, do well on cobalt deficient pastures which will not maintain sheep and cattle.

As cobalt is not needed by plants we may have the anomalous spectacle of these animals dying, apparently from starvation, although grazed on luxuriant pastures. This was the case at Denmark until Filmer and Underwood *(loc. cit.)* determined the cause of "Denmark wasting disease."

Recent investigations indicate that the ruminant animal needs cobalt because this element is used by the microscopic organisms (rumen flora) which live in the paunch, and there build up certain nutrients (notably Vitamin B12) which are vital to the welfare of these animals. For this purpose the animal must **eat** regular supplies of cobalt. Any reserves which are stored in the liver are valueless for the purpose; injected cobalt is ineffective. As reported by Lee (1951) sheep receiving by the mouth 7 milligrams of cobalt once a week remained in excellent health; sheep receiving 21 mg. once every three weeks were not so thrifty, whereas others receiving 35 mg. once every four weeks developed typical signs of deficiency and some died.

Cobalt deficiency was responsible for serious mortalities of dairy cattle in the Denmark district, particularly following the establishment of group settlements in that area after World War I; it has also been responsible for the death of large numbers of sheep and cattle from "coast disease" which has been known since the earliest days of settlement of the State.

It is now recognised, however, that the distribution of cobalt-deficient areas is more extensive and that there are regions where the degree of deficiency is less severe and frequently does not lead to death, but merely to suboptimal growth and production. The occurrence of this marginal deficiency is not always easy to confirm. The estimation of the cobalt content of the liver does give some indication of the amounts available in the diet, but the test has limitations. In cases of marginal deficiency it must be interpreted in conjunction with other criteria, notably the symptoms shown, the region and type of country, or the demonstration of the animals' re-

sponse to cobalt supplementation; this is extraordinarily dramatic where a significant deficiency exists.

Survey work in relation to these considerations has been carried out in the South Western districts, since 1938, and has given a reasonably sound basis for general recommen...tions for the use of cobalt supplements in the South West Division of the State.

The Signs of Cobalt Deficiency in Animals.

The signs of cobalt deficiency exhibited by sheep and cattle are essentially similar. Young growing animals are more susceptible than adults. Where the degree of deficiency is only slight, that is in "marginal" areas, the signs may be rather indefinite, these being restricted to sub-optimal growth and development in young animals. This may be more apparent in some seasons than others.

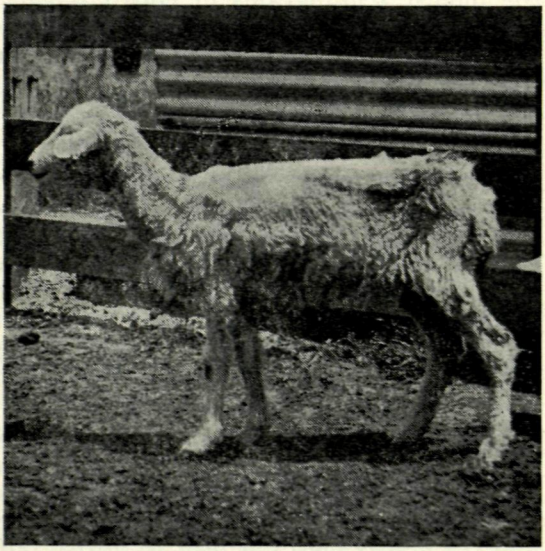

Fig. 7.—A sheep showing typical cobalt deficiency symptoms (Mt. Manypeaks).

Where a marked deficiency occurs there is a more or less rapid loss of condition and weakness, resulting from decreasing appetite. The animals literally starve themselves to death. In cattle there is a depraved appetite for rubbish such as bark, sticks, bones, earth, etc. and the coat becomes long and rough. In young calves, scouring is often noted. In cows, lactation is suppressed, abortion may occur, and stocking may be difficult. Wasting in cows is often particularly rapid immediately after calving or abortion.

In affected animals anaemia is pronounced in later stages of the disease. In sheep "weepy" eyes are notable and wool growth is depressed; in the later stages there is a definite break in the staple and the wool pulls out easily. Both cattle and sheep become weaker, and if not treated may die within two or three months or so after symptoms are first noted. The disease runs a much more rapid course in sheep and calves than in older cattle. It may occur at any time of the year, but is more common during the spring and early summer when green feed is abundant.

Many diseases, for example starvation, worm infestation, tuberculosis, etc., may cause similar signs to these outlined above. The following may be of assistance in determining whether a disease characterised by loss of condition and weakness is due to cobalt deficiency:—

1. The deficiency disease occurs in the presence of ample feed of apparently good quality, and is most common when the herbage is green.
2. Horses are never affected, whereas sheep and cattle are.
3. Young cattle, especially those between six and eighteen months are more susceptible than adults.
4. Sheep, and lambs especially, are even more susceptible than young cattle.
5. The response to cobalt supplementation or to a change to "sound" country is dramatic—affected animals regain their appetites almost immediately and within a day or two become obviously "brighter" and stronger.

The Distribution of Cobalt Deficiency.

On the evidence available it appears that cobalt deficiency is almost entirely restricted to the more coastal areas.

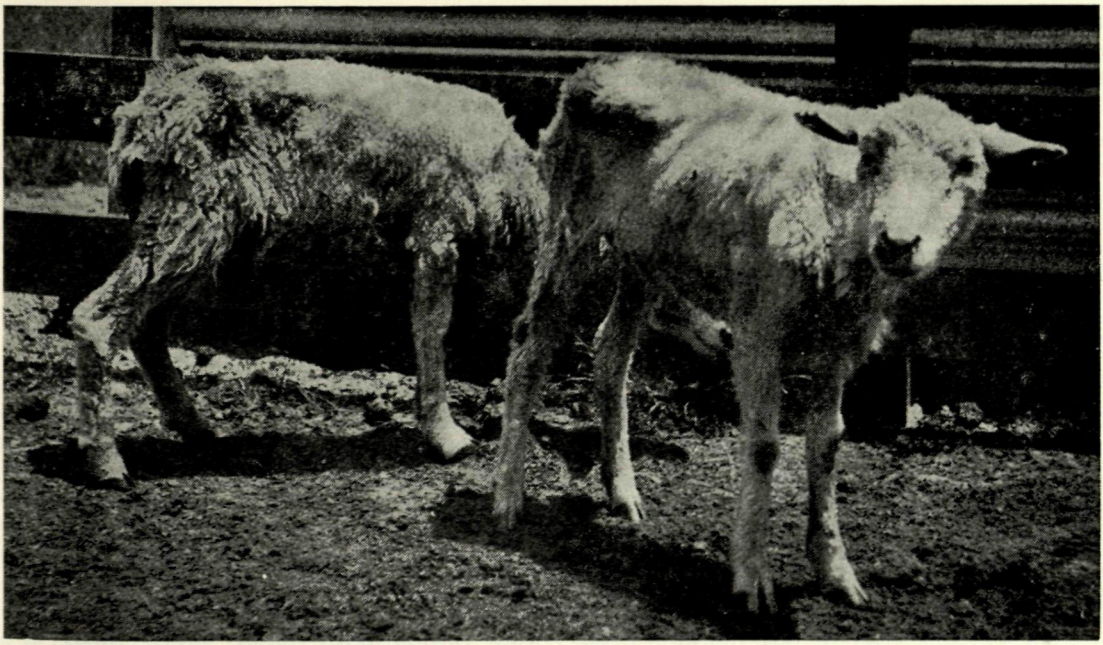

Fig. 8.—Cobalt deficient sheep at Mt. Manypeaks.

1. The severely affected areas, where it is, in general, impossible to maintain stock without the use of cobalt supplements are the following:—

(a) The Denmark region—the karri soils of the South-West, despite their rich appearance and loamy texture, are notably deficient.

(b) The "calcareous littoral"—the fine calcareous sands and limestone of the coastal fringe, throughout, are constantly deficient in cobalt (as in copper *q.v.*).

2. Cobalt deficiency is more patchy in distribution and more variable in degree in the following areas and types of country:—

(a) The banksia, tuart and jarrah sands appear to be fairly generally deficient and stock maintained on these types of country commonly show marked signs of deficiency e.g. at Muchea, in the vicinity of Perth, at West Murray and around Bunbury (copper deficiency is also present).

(b) Plain country adjacent to the South coast notably in the vicinity of Albany may be more or less severely deficient.

(c) The jarrah-redgum sands and gravels. Varying degrees of cobalt deficiency, from indefinite to fatal, have been found to occur on this type of country from in the vicinity of Busselton to Karridale, but the distribution appears to be patchy. (This is the region which is so severely deficient in copper—"the falling disease region").

It seems evident that jarrah-redgum country within 15 miles or so of the coast should be regarded with suspicion; similar country further inland, however, has only rarely been found to be cobalt deficient.

It is most probable that intrusions of alluvial soils, as for example at Capel, would prevent the occurrence of cobalt deficiency on properties consisting otherwise of the above types of country.

Cobalt supplementation is essential for sheep and cattle which are maintained on types 1 (a) and (b); is a fairly general necessity on types 2 (a) and (b); its use

may be advantageous on many locations on type 2 (c) where a marginal degree of cobalt deficiency appears to be widespread.

The methods of supplementation will be discussed in a separate section at the end of this article.

C.—"COAST DISEASE" A DUAL DEFICIENCY OF COPPER AND COBALT

From the earliest days of settlement it has been known that sheep and cattle could not be run continuously on much of the coastal country; generally within a few months they developed coast disease. It has been a common practice to graze large coast runs during the autumn and early winter months with stock, particularly cattle, which have been depastured further inland on "sound" country during the rest of the year. Sheep and cattle did very well for a short period on the natural herbage on the coast, but if left too long droving was frequently difficult on account of a "tail" which became too weak to travel. If left still longer animals died from coast disease. It was noted, however, that even badly affected stock recovered rapidly when they reached the "clay" country further inland.

Investigations carried out in South Australia by Marston *et. al.* (1938) demonstrated that coast disease was a manifestation of a dual deficiency of cobalt and copper. It was subsequently confirmed that coast disease in this State was an identical condition due to the same cause.

The manifestations of coast disease in sheep and cattle, generally, are essentially those of cobalt deficiency, namely progressive wasting and weakness associated with loss of appetite. If the animals live long enough and the liver stores of copper are depleted, sheep show "stringy wool" and ewes may give birth to ataxic lambs; in rare instances sudden deaths in cattle, simulating "falling disease" have been reported from coast runs. These deaths presumably resulted from the effects of severe copper deficiency but there has been no opportunity of confirming this. These mortalities have been reported only in cattle changed to the coast from the severely copper-deficient country at Gingin and Dandaragan—such losses have not occurred since the use of copper supplementation has been general there, and since cattle have been fed both copper and cobalt on coast runs.

As we have indicated the dual deficiency of copper and cobalt is not restricted to the calcareous sands of the coastal fringes but "coast disease" may occur somewhat further inland.

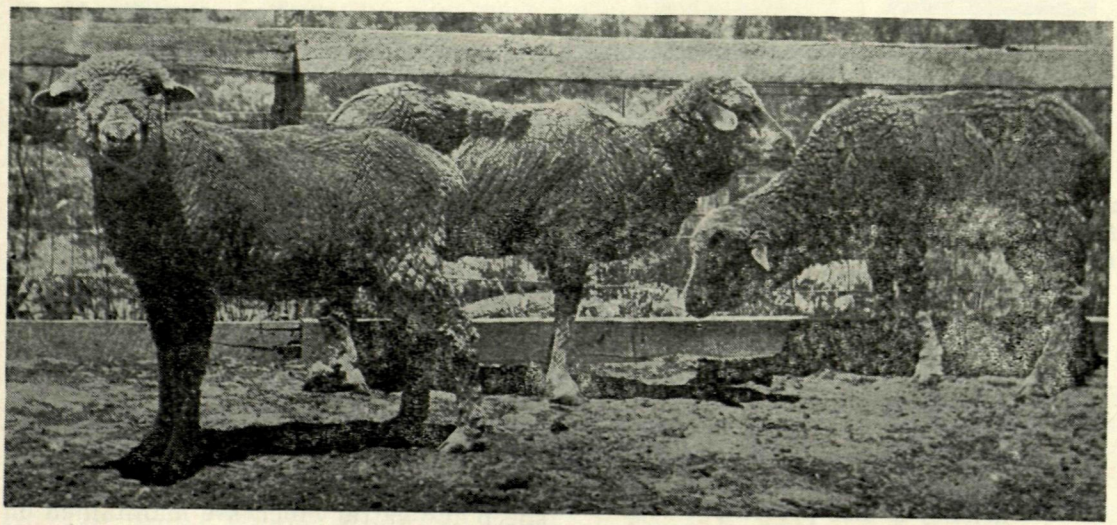

Fig. 9.—These sheep are suffering from "coast disease." The animal in the foreground is showing improvement after being treated with copper and cobalt.

PART 2.—THE CONTROL OF COPPER AND COBALT DEFICIENCIES IN ANIMALS

The manifestations of copper and cobalt deficiency can be prevented by the administration of appropriate mineral supplements given singly, or together where a dual deficiency exists.

The choice of the means of supplementation to be adopted will depend upon environment, methods of stock management, and upon economic considerations.

It must be borne in mind also that cobalt is needed by sheep and cattle at frequent intervals, preferably daily. Large doses may result in increased liver storage but such stored cobalt is of no value to the animal. On the other hand copper which has been stored in the liver is available to the animals so that they may still thrive even when this element is given at more infrequent intervals. A regular intake of both copper and cobalt, however, will give the best results.

The copper and cobalt content of pastures, grown in deficient areas, can be raised to normal levels by topdressing with appropriate compounds incorporated with the superphosphate fertilizer. This is certainly the method of choice if practical and economic considerations warrant its adoption; all grazing animals are then assured an adequate and regular intake of their mineral requirement.

Under many circumstances, however, it is necessary or desirable to use other methods of supplementation:—

(a) By the use of licks.
(b) By the addition of solutions or mixtures of minerals to the food.
(c) By drenching with solutions.
(d) By administration in the drinking water.

THE AMOUNTS OF COPPER AND COBALT REQUIRED BY ANIMALS

1. COPPER.

Sheep require a total daily intake of about 10 milligrams of copper. As the amount consumed, each day, from deficient pastures will be of the order 2-5 mg. it is recommended that a daily supplement of 8 mg. be given. This amount is equivalent, approximately, to only one forty thousandth of an ounce. **Eight ounces of copper sulphate will provide the requirement for 1,000 sheep for one week.**

Cattle need about 10 times the sheep dose so that 8 ounces of copper sulphate will provide an adequate supplement for 100 head for one week.

Pigs and Horses. There is no definite information of the requirements of these animals, but we have recommended that pigs receive the same amounts as sheep. If brood mares and foals are maintained on topdressed pastures the latter do not, in our experience, show the signs attributed to copper deficiency.

Copper is a poison and must be used with caution. Sheep, in particular, are susceptible to copper poisoning; they may accumulate dangerous amounts in the liver if given an intake higher than that recommended, or if copper storage by the animal is facilitated by other factors which cannot be considered here.

In a number of instances, in this State, serious mortalities have been experienced where sheep were run on copper topdressed country and were at the same time given free access to salts containing copper. **Only one method of supplementation should be used at the one time for sheep.**

2. COBALT.

The daily requirement of cobalt, for sheep and cattle, is very much lower than the copper requirement. The minimum requirement of sheep is exceedingly minute, approximately one-tenth of a milligram (equivalent to approximately one three hundred thousandth of an ounce).

It is recommended, however, that when pastures are deficient, sheep should receive a supplement of 1 mg. daily and cattle 10 mg. daily. On that basis **one ounce of cobalt sulphate or cobalt chloride will provide an adequate supplement for at least 1,000 sheep, or for 100 cattle for one week.**

Cobalt, unlike copper, is not very poisonous and the doses recommended, although on the generous side, are very considerably below the toxic level.

SUPPLEMENTATION WITH COPPER AND COBALT

1. TOPDRESSING OF PASTURES.

Copper.—Topdressing with copper compounds, to raise the copper content of pasture to normal levels, is certainly the ideal method in the more severely deficient

areas, and where improved pastures or crops are grown. Under these circumstances the resultant increases in cereal yields and the increased bulk and impovement in pasture quality amply justify the expenditure involved.

In the very severely deficient areas of the South West improved pastures, notably subterranean clover, cannot be maintained without the use of copper fertilizers. Topdressing with copper, during recent years, has become almost universal in that region, and also in the Gingin, Dandarragan and some other districts.

Animals maintained on treated pastures remain healthy although some care must be excercised in maintaining the copper status of the pasture at a sufficiently high level to prevent the occurrence of "stringy wool."

In most affected areas it has been found that a dressing of 5 lb. bluestone per acre or an equivalent amount of copper ore applied with superphosphate is adequate for 2-3 years both for pasture and animal requirements, although it is often necessary to recommend more frequent dressings for the growth of cereal crops.

Information from South Australia and elsewhere, however, indicates that much heavier topdressings are required on the calcareous sands of the coast, and that it may be ineffective as well as unprofitable to topdress areas of unimproved country carrying native herbage. Again it may not be economic to topdress large areas of developed country where only a "marginal" deficiency of copper exists.

In these cases other methods of copper supplementation must be considered.

Cobalt.—Topdressing with cobalt to supply the cobalt requirement of the animal through the pasture would appear to be the most effective and certain method of control and has much to commend it on locations where the degree of deficiency is severe and where pastures are highly improved and productive.

Where the deficiency is less severe, perhaps only seasonal in occurrence, and where the production per acre is not high it cannot be justified because of economic considerations. As we have already pointed out cobalt is not a plant food, so topdressing does not in any way benefit the pasture and the costs are of course very much higher than those involved in supplying the minute amounts of cobalt needed when given directly to the animal. Topdressing with cobalt is used extensively in New Zealand and in other parts of the world to control cobalt deficiency in sheep and cattle but it has, as yet, been used only to a limited extent in this State, even at Denmark where the deficiency is severe and where pastures are highly productive.

On the information available it seems that a topdressing of four ounces of cobalt chloride or cobalt sulphate per acre should be effective for two years on most soil types. Topdressing of the calcareous coastal sands, however, cannot be recommended; this would be of doubtful efficiency and would in any event be uneconomic.

2. THE ADMINISTRATION OF COPPER AND COBALT TO THE ANIMALS

Under conditions occurring in this State, **with the exception of the coastal runs which present special practical problems,** to be considered later, it has been found generally appropriate to control copper deficiency in sheep and cattle by means of topdressing. The use of licks for sheep, however, may be preferred under some circumstances. Cobalt deficiency in dairy cattle has been controlled largely by the provision of supplements given in the feed, or by licks; relatively few sheep are, as yet, carried in the more severely cobalt deficient regions but licks should provide reasonably effective control, where required.

It must be borne in mind that young stock are more susceptible to cobalt deficiency that older animals. It is therefore, very important that they receive a regular supplement.

In preparing solutions of copper and cobalt non-metal containers, of glassware, enamel, or earthenware, must be used.

Licks

Copper.—The licks recommended for sheep in the past have been (a) Bluestone (copper sulphate) $\frac{1}{4}$-$\frac{1}{2}$ lb.; Salt, 100 lb.

The bluestone is dissolved in rainwater, the solution sprayed on the salt and thoroughly mixed to incorporate the bluestone throughout. **In view of the real danger of copper poisoning from an excessive**

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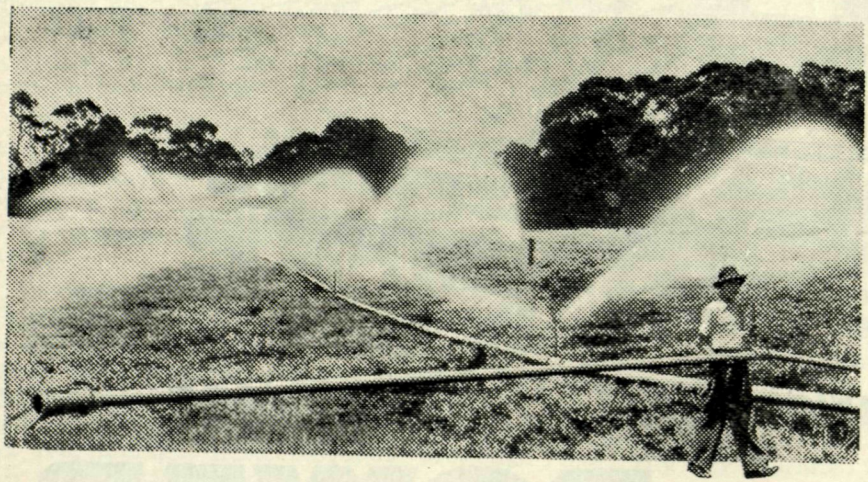

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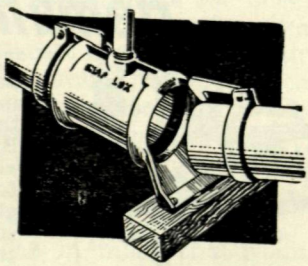

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intake it is now recommended that the concentration or intake of the lick be adjusted so that sheep do not eat more than the amount recommended, that is not more than eight ounces of bluestone per 1,000 sheep per week.

(b)—Denmark Lick, which contains 0.6 per cent. of bluestone, has been sometimes used for the same purpose. The concentration of copper in this lick is such that 80 lb. of lick will provide a copper supplementation for 1,000 sheep for 1 week.

Denmark lick has also been used to prevent ataxia in young **pigs,*** fed at the rate of ½ to 1 oz. per week.

Cattle could be fed either of the above licks at a dose rate of 10 times that recommended for sheep as set out below.

Cobalt.

(a) Denmark Lick.—Since the investigations of Filmer and Underwood *(loc. cit.)* a lick containing limonite, a selected ore containing cobalt (500 p.p.m.), has been widely used for the control of cobalt deficiency in cattle, either mixed in graded doses with feed in the bail, or offered freely in the paddock. This lick consists of two thirds limonite and one third salt, with 0.6 per cent. bluestone added. It has been used also for sheep.

The dose rate recommended is:—

Cattle—1-2 oz. per day.
Sheep—1 oz. per week.

It will be noted that this lick supplies both cobalt and copper requirements.

(b) Cobalt-Salt Lick.—A simple lick containing cobalt and salt may be compounded by the stock owner using—

Cobalt chloride or cobalt sulphate	2 oz.
Salt	100 lb.

This will contain an amount of cobalt approximately equivalent to the Denmark lick, so that the consumption by cattle of 1-2 oz. daily, according to age, or by sheep of 1 oz. per week will be effective in preventing cobalt deficiency.

The control of mineral deficiencies by giving stock free access to appropriate licks is open to a number of objections. The consumption of licks by animals may be variable, some animals not taking enough to correct the dietetic deficiency whereas others may take excessive quantities. The palatability of salt licks, containing mineral supplements, may vary considerably with locality—in some regions salt is eaten avidly by stock, in others, as near the coast, animals may be entirely disinterested. Too frequently also no measures are taken to shelter lick troughs from weathering with the result that the effectiveness of the lick may be lowered because of the leaching out of active constituents. Licks, in general, seem to be taken more readily by sheep than by cattle.

The Use of Solutions

The drenching of animals to control mineral deficiencies has only a limited application but it may be convenient to make use of solutions administered on feed particularly in the control of cobalt deficiency in dairy cattle; this is obviously a very effective method of control where applicable.

The amounts to be used can be based, again, on the fact that 1 oz. of cobalt sulphate or cobalt chloride contains enough cobalt for 100 cattle for one week.

Copper Solutions.—It may be advantageous occasionally to drench sheep with a copper solution which will be stored in the liver and so be effective for some weeks, as for example in the case of lambs which are showing early signs of copper deficiency, or of ewes forward in lamb to prevent the possible occurrence of ataxia in the progeny—this in cases where other methods of supplementation, for some reason, have not been adopted.

To prepare a suitable solution for the purposes indicated dissolve 8 oz. of copper sulphate in 1 gallon of rain water. Give sheep **one** drench of the following amounts:—

Lambing ewes—20 c.c.
Lambs over 4 months—5-10 c.c.
under 4 months—5 c.c.

Cobalt Solutions.—To prepare a suitable cobalt solution dissolve 1 oz. of cobalt sulphate in 1 gallon of rain water. This

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* For pigs the use of a salt and copper mixture added to the feed has been advocated by Departmental officers for use in the copper deficient areas of the South-West. It is reported as being safe and effective.

A mixture containing 8 oz. bluestone to 100 lb. salt is prepared as directed above.

For use ½ lb. of this mixture is added to each 100 lb. of feed. (The mixed feed so prepared will contain approximately 5 parts per million added copper.)

solution may be given as a drench or given with concentrates, or in the case of calves added to the milk.

The required doses are:—

Cattle—

Adults—30 c.c. (1 fluid oz.) daily.
Calves—15 c.c. ($\frac{1}{2}$ fluid oz.) daily.

(**Sheep**—If it is desired to treat sheep with cobalt solutions this may be conveniently carried out by the use of methods detailed under coast disease, **omitting the bluestone** from the solutions recommended in that section.)

THE CONTROL OF "COAST DISEASE"

The control of the dual deficiency of copper and cobalt on the coast runs in this State presents a number of practical problems for which there is as yet not really a satisfactory solution. Under most conditions topdressing, as we have indicated, would be of doubtful efficiency and is impracticable; licks are not readily taken, particularly by cattle; drenching with solutions needs to be carried out preferably once a fortnight or not more infrequently than once a month in order to prevent losses from cobalt deficiency; the provision of supplements in the drinking water, which has been the most favoured method of control, also has many limitations.

The choice of the method or methods adopted to control "coast disease" must depend on the system of management adopted and upon practical possibilities. We will consider two methods:—

1. Drenching.
2. Supplementation in Drinking Water.

1. Drenching with Copper and Cobalt Solutions.

Lee *(loc. cit.)* for somewhat similar conditions has suggested the following solutions:—

A convenient *stock* solution of copper and cobalt may be prepared by dissolving 1 oz. cobalt sulphate and 8 oz. copper sulphate in one gallon of rain water.

Earthenware, enamelled, or glass containers must be used exclusively, as these solutions destroy iron or galvanized surfaces.

A *dilute* solution, suitable for frequent drenching, is prepared by mixing the stock solution with an equal volume of rainwater. The *dilute* solution will contain approximately 8 mg. cobalt, and 60 mg. copper in each 10 c.c.

These may be used as follows:—

Sheep, of all ages, may be drenched:—

(i) *Dilute solution*—10 c.c. once a week. This will give the maximum response.

(ii) *Stock solution*—20 c.c. once a fortnight. This will be effective.
—20 c.c. once a month. This may prevent losses from coast disease but cannot be expected to maintain stock in good condition.

Cattle, of all ages, can be treated similarly giving 10 times the above doses, that is *stock* solution—50 c.c. or $1\frac{2}{3}$ fluid ounces once a week. 200 c.c or 7 fluid ounces once a fortnight (or once a month).

2. The Addition of Copper and Cobalt Salts to the Drinking Water.

It is difficult or impossible to give regular and accurate quantities of these minerals to cattle and sheep through the drinking water. Nevertheless a rather surprising degree of success in the control of "coast disease" in cattle, carried on the coast during the dry period of the year, has been achieved by rather crude means which will be referred to later. A degree of success has also been obtained on some of the northern coast runs where sheep are maintained for long periods on deficient country.

It has been found, however, that stock waters in many deficient areas contain carbonates in solution; these react with both copper and cobalt salts to form insoluble compounds which are precipitated. The supplements are in consequences not taken in by stock when drinking. Another disadvantage is that sheep drink little water in the winter and spring months when green feed is available.

So far no really satisfactory and economic method has been devised to ensure that the drinking water will contain constant and controllable amounts of the copper and cobalt salts, added as a supplement. The crude method referred to above, which has given a measure of success in the hands of some stock owners, is to wrap in hessian a week's supply of bluestone and cobalt sulphate and immerse it in the water trough just below the ball tap; the salts then dissolve slowly in

the drinking water. Obviously, however, the dose rate received by cattle varies considerably from day to day.

In some instances two holding tanks are used with each trough the required amounts of supplements being added to the tank which is at that time being used to supply the trough. In that way drinking water containing a definite concentration of minerals may be supplied.

The quantities of copper sulphate and cobalt sulphate or chloride to be added to the drinking water are based on the assumption that sheep drink 1 gallon and cattle 10 gallons of water per day.

The required concentration will therefore be:—

Cobalt sulphate or chloride	1 oz.
Copper sulphate	8 oz.
Water	7,000 gallons.

This will provide the needs for 1,000 sheep or 100 cattle for one week.

It should be noted that only cement lined or bitumen painted troughs and tanks must be used because copper solutions corrode metal reservoirs and fittings.

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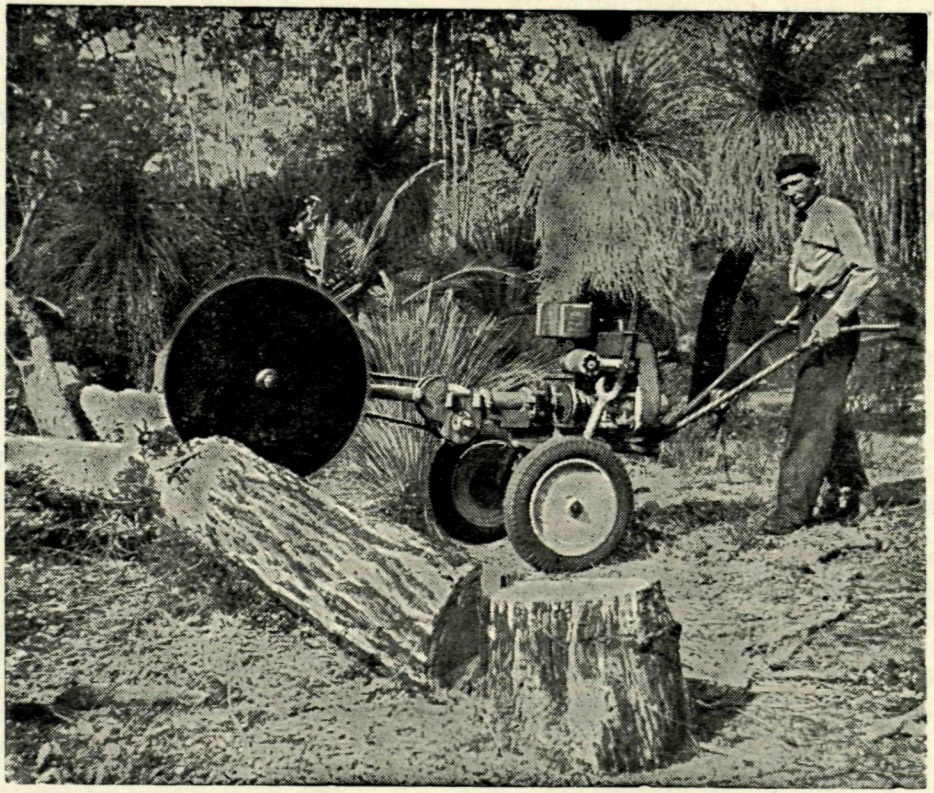

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