between six and seven hundred thousand small stock. In the Union-dale-Willowmore area *Chrysocoma tenuifolia* Berg causes the loss annually of thousands of kids and lambs from *kaalsiekte*. In addition *Dichapetalum cymosum* Hook (gifblaar) and *Urginea burkei* Baker causes heavy losses yearly in stock in the Transvaal, whilst *Senecio spp.* (dunsiekte) have made the breeding of horses impossible in certain parts of the Union of South Africa and Basutoland. In some years wilted grasses (*geilsiekte*, prussic acid poisoning) cause very high mortaily in small stock in the semi-arid regions of South Africa. Tulip (tulp) and *Cotelydon* poisoning is so common that it need hardly be mentioned. Not only in South Africa, but also in America, New Zealand, Australia, Central Africa and India stock poisoning is very common. In Montana and Colorado over two hundred million dollars damage is done to the stock industry by plant poisoning every year.

XXI. ACTION OF POISONS ON FOETUSES.

It is possible for a poison to exert its harmful effects on the wall directly or indirectly through the nervous system of the pregnant uterus or on the foetus or on both. The expulsion of the foetus may be caused by the poison inducing contraction of the uterus or by bringing about the death of the foetus, which is then expelled by the uterus or in both these ways. It is a well-known fact that drastic purgatives very frequently cause abortion.

XXII. INDIRECT POISONING OF HUMAN BEINGS.

Human beings may become poisoned by A. eating the carcases of animals that have died from poisoning, B. drinking, or using in their diet, the milk of poisoned animals; and C. eating honey prepared from the flowers of poisonous plants.

A. Carcases of Poisoned Animals.

The edibility of the carcase, or a part thereof, of an animal which has died from poisoning depends on the channel by which the poison found entrance into the body. If the animals received the poison per os, the flesh can be safely eaten as has been proved repeatedly by a number of investigators. Fröhner (1919, p. 23) states that according to results obtained by his experiments and those of other investigators the flesh (including heart, liver and kidneys) of sheep, rabbits, geese, ducks, fowls, doves and a bovine poisoned with strychnine, eserine, pilocarpine, veratrine, apomorphine, arsenic, oleandrine and lead can be eaten with impunity. Some authors ate the flesh themselves, others fed dogs or examined the flesh for the presence of the poison. Ostertag (1922) also refers at length to the fact that the flesh of poisoned animals could be consumed with safety. It is advisable, as a rule to discard the organs of excretion as here the poison may be found in dangerous amounts. It is for this reason that the liver, kidneys, udder and milk, stomach and intestines should be discarded. If the poison was introduced subcutaneously and intromuscularly as is the case when animals are killed by poisoned arrows, all the flesh, except that part immediately surrounding the point where the arrow struck the animal, is edible.

It would be advisable to discard the organs of excretion mentioned above. Steyn [1931 (*d*)] fed the internal organs and flesh cut from different parts of the body of a sheep killed by the intrajugular injection of strychnine on the left side to dogs. Only those dogs which had received the left front leg, the kidneys and the lungs and heart died, whilst the remaining ones developed no symptoms of poisoning. Henning (1926) was able to produce poisoning in dogs by feeding them on very large quantities of the meat of goats which had died from *Cotyledon wallichii* Harv. poisoning. This is the first record of flesh of animals poisoned per os causing poisoning when eaten. This is possible when the animal, whose flesh is eaten, is much more resistant to the poison concerned than the animal or human being partaking of that flesh. This would mean that the poisoned animal would have such a high concentration of the poison in its flesh, as to cause poisoning in the much more susceptible human being or animal eating its flesh.

B. Milk.

As the lactating mammary gland is an active excretor of many poisons, the milk of poisoned animal or animals treated with very poisonous drugs should be discarded.

Fröhner (1919, p. 24) refers to the young of animals having become poisoned after they have partaken of the milk of animals which had taken arsenic, tartar emetic, meal contaminated with *Agrostemma Githago* Linn, castor bean cakes, and *colchicum*. A native woman who had partaken of coffee poisoned with arsenic, suckled her child, which died from arsenical poisoning, whilst its mother recovered after having exhibited symptoms of poisoning (Juritz, 1910). Muller, Senior Chemical Analyst, fed a suckling cat with arsenically poisoned food with the result that her four kittens died from arsenical poisoning (Juritz, 1910). It stands to reason that the amount of poison secreted in the milk will depend on the amount of poison taken and the time in which it is taken. Many poisons, if not taken in too large quantities at one time, will be changed by the organs, and body tissues and be excreted in harmless forms. Van Itallie (Fröhner, 1919 p. 24) states that morphine, eserine, pilocarpine, iodine, salicylic acid and oil of turpentine are not excreted by the milk.

C. Honey.

Poisoning with honey prepared from the nectar of the flowers of poisonous plants has been known since the earliest ages. According to Leschke (1932a) the first classic description of cases of honey poisoning is to be found in Xenophons Anabasis (Vol. IV, Chapter 8). The symptoms exhibited by the troops who had partaken of poisonous honey were vomiting, diarrhœa, inability to maintain their balance and unconsciousness. Some of the affected cases ended fatally.

Aristoteles, Strabo, Plinius and Dioscorides also refers to cases of poisoning with honey (Leschke, 1932a). Leschke (1932a) furthermore states that honey poisoning has occurred in New Zealand and North America and that the symptoms are those of gastric and nervous disturbances.

It is obvious that no definite symptoms of honey poisoning can be described as these will depend on the effects caused by the plant or plants from which the bees have gathered the nectar.

Pammel (1911) mentions plants from whose flowers it is said poisonous honey is produced. Many cases of honey poisoning are on record. It is said that the bees themselves are poisoned by honey made from the flowers of poisonous plants. In South Africa poisonous honey may be produced from the flowers of *Nerium oleander* Linn, *Datura stramonium* Linn, *Datura tatula* Linn, and other poisonous plants. Pammel says: " A South African species of *Euphorbia* also produces a poisonous honey which was not noted by Greshof ".

SPECIAL TOXICOLOGY.

The following are examples of special toxicology of plants, some of which were investigated by the writer. A comprehensive consideration of the poisonous plants in the Union of South Africa will appear in the contemplated handbook by the writer.

I. GRAMINAE.

THE PROBLEM OF " GEILSIEKTE ".

Many species of the *Gramineae*, some of which constitute our most valuable pasture grasses, develop dangerous amounts of prussic acid (hydrocyanic acid) under certain climatic and soil conditions. This phenomenon has been the cause of severe losses in stock especially in the more arid areas of South Africa. Brown (1864) was the first to refer to " geilsiekte " and subsequently frequent reference to this disease is made in South African Agricultural Journals. The toxicity of wilted pasture grasses has long been known to South African farmers, who wrote to the *Landbou Journal* about " geilsiekte " as early as 1889 (Editorial, 1889), whilst MacOwan (1877) referred to heavy losses caused by this disease in stock. The actual cause of " geilsiekte " due to the ingestion of wilted grasses was investigated by the author in 1929. The term " geilsiekte ", as used by stockowners, embraces quite a number of diseases in sheep and cattle which are characterised by sudden death. It is, however, a term applied mostly, especially in arid and semi-arid areas, to prussic acid poisoning in sheep caused by the ingestion of certain wilted grasses, and, in other areas by the ingestion of species of *Dimorphotheca* (Steyn, 1929), Henrici (1926) found that certain grasses produced prussic acid very soon after the process of wilting has set in, whilst others do so at later stages of wilting. Those members of the family which have been definitely proved to contain prussic acid under certain conditions will now be discussed.

Anthephora pubescens Nees.

Common names: English—woolgrass; Afrikaans—borseltjiegras, bloubuffelgras.

Distribution: Bechuanaland, Hay, Gordonia, Prieska, Barkly West, Kimberley, Vryburg, Hoopstad, Bloemfontein, Kroonstad, Christiana, Bloemhof, Wolmaransstad, Pretoria, Lydenburg and South West Africa.

Henrici (1926) who used the " vest-pocket test " for prussic acid in her investigations found that when in a wilted state, it contains large amounts of prussic acid. The nature of the cyanogenetic substances present in the wilted grass is unknown. This grass is considered one of the three best pasture grasses in those areas where it occurs (Burtt-Davy, 1912).

Aristida congesta R. & S.

Common name: Afrikaans—steekgras; Suto—*phutha-dikxoba, mahlaswa.*

Distribution: Common all over Union of South Africa.

This grass when wilted contains large amounts of prussic acid, (Henrici, 1926).

Aristida uniplumis Licht.

Common names: English—large Bushman grass, shiny grass; Afrikaans—langbeen t'waa (Toa) gras (southern Bechuanaland).

Distribution: Very common in southern Bechuanaland, extending westward to Namaqualand (Burtt-Davy, 1912), also in Griqualand West, Transvaal, southern Orange Free State, and certain parts of the Karroo (Colesberg).

It yields prussic acid when wilted (Henrici, 1926).

Eustachys paspaloides (Vahl) Lanza & Matti

[=*Chloris petraea Thunb. (non Swartz).*]

Common names: Suto—sebokynyana.

Distribution: Common all over Union of South Africa.

Rosenthaler (Wehmer, 1929) records 0·002 mg. per cent. prussic acid in the leaves while Henrici (1926) found prussic acid in both fresh and wilted specimens.

Raphis montana var. tremula (Stapf.) Phill.

(=*Chrysopogon serrulatus* Trin.=*Andropogon monticola var. Trinii Hook. f.*).

Common names:

Distribution: Pretoria, Waterberg, Bloemhof, Bechuanaland, Hopetown.

When wilted it yields prussic acid (Henrici, 1926).

Cynodon Bradleyi Stent.

Common name: English—Bradley grass.

Distribution: Cultivated as a lawn grass.

Specimens of this grass collected from a lawn at Onderstepoort yielded large amounts of prussic acid when wilted (Steyn, 1929). On one occasion even fresh (unwilted) specimens, collected in the early morning (about 8 a.m.) within two days after a heavy rain, showed

the presence of prussic acid. Subsequent tests performed with fresh specimens failed to reveal the presence of prussic acid. Sundried specimens collected when wilted and tested two days after picking, still contained large amounts of prussic acid.

Cynodon dactylon Pers.

Common names: English—Florida grass, Germiston grass, Bahama grass, Scotch grass, Devil's grass, Bermuda quick grass, Bermuda grass, Dub grass, Doab grass, fine couch grass; Afrikaans—Batawiese kweek, fynkweek, kwaggakweek, Oostindiesekweek, kruisgras, kweek; Suto—*mohlwa, morara;* Xosa—*uQaqaqa.*

Distribution: Occurs practically throughout the Union of South Africa. Common on old lands near homesteads and " kraals ".

Wehmer (1929) refers to this species, but does not mention anything about the presence of prussic acid. Specimens of this plant growing at Onderstepoort were tested by the author and were sometimes found to contain small amounts of prussic acid when in a perfectly fresh (unwilted) state and invariably very large quantities when wilted during periods of hot dry weather.

Cynodon incompletus Nees.

Common names: English—quick grass; Afrikaans—regte kweek, Transvaal kweekgras.

Distribution: Albany, Uitenhage, Queenstown, Humansdorp, Hanover, Port Elizabeth, Griqualand West.

Wehmer (1929) states it contains prussic acid, but not constantly.

Cynodon transvaalensis Burtt-Davy.

Common names: English—quick grass; Afrikaans—kweekgras, kweek.

Distribution: Ermelo, Vereeniging, Witwatersrand, Kroonstad and Bloemfontein.

At Onderstepoort the author found that wilted specimens contain large amounts of prussic acid.

Digitaria eriantha Steud.

Common names: Suto—*mmoyane.*

Distribution: Bechuanaland, Eastern Cape Province, Griqualand West, Prieska, Tembuland, Natal.

Henrici (1926) found prussic acid in wilted specimens.

Pogonarthria squarrosa (Licht) Pilger

(=*Pogonarthria falcata* Rendle).

Common names: Suto—*mongoyane.*

Distribution: Bechuanaland, Natal, Basutoland, Orange Free State, Griqualand West, Transvaal.

Wilted specimens contain prussic acid (Henrici, 1926).

Sorghum verticilliflorum Stapf.

[=*Andropogon halepensis* Brot. var. *effusus* Stapf].

[=*Sorghum halepense* Nees (non Pers)].

Common name: English—Johnson grass.

Distribution: Cultivated as a fodder crop.

According to Wehmer (1929) and Cough (1932) *Sorghum halepense* (Johnson grass) may develop dangerous amounts of prussic acid. Mathews (1932) reports seven cases of poisoning with "*Sorghum halepense*" in cattle. Periods of drought varying from days to weeks preceded every outbreak. At the time of the outbreaks the grass was wilted and showed sunburnt tips. The symptoms described markedly resemble those in prussic acid poisoning. Burtt-Davy (1903-1904) states that "Johnson grass or Evergreen Millet (*Andropogon halepensis* var. *effusus* Stapf) is one of the most pernicious weeds ever introduced by human agency". According to him Johnson grass has found its way into the Transvaal, and is now a weed at the Potchefstroom Agricultural College.

Sorghum saccharatum Pers.

Common names: English—Sorghum; Afrikaans—Soetriet; "Imphee".

Distribution: Cultivated.

When wilted it contains dangerous amounts of prussic acid, which is liberated from a cyanogenetic glucoside (Wehmer, 1929).

Sorghum Sudanense Stapf.

Common names: English—Sudan Grass; Afrikaans—Sudangras.

Distribution: Cultivated as a fodder crop.

It is well known that Sudan grass may under certain climatic and soil conditions develop fatal amounts of prussic acid. The following is the summary of a publication by Swanson (1921), who investigated the toxicity of Sudan grass:

"(1) Hydrocyanic acid was found in large amounts in Sudan grass used for pasture and no harm resulted to cattle.

(2) Liberation of hydrocyanic acid from Sudan grass is apparently associated with enzyme action. Digesting in water at room temperature for several hours and then distilling gave larger amounts of hydrocyanic acid than if sulfuric acid was added at once. Hot water and dry heat diminished the amount of hydrocyanic acid obtained. Slow drying caused the hydrocyanic acid to disappear. Tests made on wilted samples or those several days old may be worthless.

(3) Making Sudan grass into silage did not diminish the amount of hydrocyanic acid.

(4) Tests made immediately on frosted Sudan grass gave very large amounts of hydrocyanic acid, but it disappeared rapidly as soon as the plant began to wilt; when dry the hydrocyanic acid had disappeared.

(5) While Sudan grass giving a strong test for hydrocyanic acid was not harmful to cattle under other conditions it was harmful. Immunity was not due to habituation ".

According to Horwath (1931) sheep grazing on Sudan grass developed symptoms of photosensitization. Photosensitization due to the ingestion of this grass has not as yet been noticed in South Africa, where conditions appear to be most favourable for the development of this malady.

Sorghum vulgare Pers.

Common names: English—kaffir-corn; " Dhurra "; guinea-corn; Indian millet; great millet; Juár of India, Durrha Shirshabi of Egypt. Afrikaans—kafferkoring. Zulu—*ama Bele.*

Distribution: Widely cultivated in South Africa, especially by the natives, as a food grain. Its toxic properties have been known for a long time.

Dunston and Henry (1902) isolated a cyanogenetic glucoside (dhurrin) from kaffir-corn. The interaction of dhurrin and an enzyme, which is present in the plant and apparently is identical with the emulsin of bitter almonds, liberates prussic acid, dextrose and para-hydroxybenzaldehyde. Dilute acids have the same action as this enzyme on dhurrin. Dhurrin is resolved into dhurrinic acid and ammonia when heated with alkalis. Dunston and Henry showed that only the young plant, and not the mature plant and " seeds ", contain dhurrin or prussic acid. Robinson (1930) also refers to the toxicity of immature kaffircorn plants. The disappearance of dhurrin and prussic acid from the cut plant apparently occurs very slowly as cattle died from eating the plant three days after it had been cut.

Sporobolus fimbriatus Nees.

Common names: Suto—*matulo-a-maholo.*

Distribution: Southern Bechuanaland, South Eastern Cape Province, Basutoland, Orange Free State, Transvaal.

Henrici (1926) demonstrated the presence of prussic acid in the wilted plant.

Themeda triandra Forsk.

Common names:

Distribution: Throughout Union of South Africa.

According to Henrici (1929) it contains prussic acid when wilted.

Henrici (1926) failed to demonstrate under any circumstances the presence of prussic acid in the following grasses: *Eragrostis superba* Peyr., *Eragrostis lehmaniana* Nees, " *Cymbopogo plurinodis* ", and

"*Fingerhuthia africana*". Fresh specimens of *Pennisetum claudestinum* Chiov (kikuyu grass) and specimens in all stages of wilting up to complete withering were examined at Onderstepoort by the author for the presence of prussic acid with negative results.

Zea mays L.

Common names: English—maize, mealie, Indian corn ; Afrikaans—mielie; Sesuto—*poone*.

Distribution: Extensively cultivated as a foodstuff for man and animal.

Walsh (1909) states that the male inflorescence contain a variable amount of prussic acid. Burtt-Davy (1912) (pp. 189-190) writing about the American cornstalk disease refers to a letter received from a correspondent. The latter states that during an exceptionally dry year thousands of head of cattle were lost in the cornfield of Western Nebraska. Upon investigation it was found that the mealie stalks contained a large percentage of prussic acid. The correspondent however adds: I am not positive if I am correct in the poison". Quite a number of publications on cornstalk disease are mentioned by Burtt-Davy. Price and Craig (Burtt-Davy, 1912) consider it possible that cornstalks may at times contain prussic acid. According to a verbal report made to the author a number of donkeys, which had been driven on to a land of wilted mealies in Natal, died within a few hours.

Experiments conducted by the author at Onderstepoort have shown that under certain soil and climatic conditions green mealies may develop prussic acid. The results were however by no means constant. A large number of tests were conducted on wilted mealies growing on black clay soil and sandy soil and only in a few instances was prussic acid detectable and then only in the specimens growing on red sandy soil.

Toxicity of the Cyanogenetic Gramineae.

The toxicity of the above-mentioned cyanogenetic Gramineae obviously depends on their cyanogenetic glucoside or prussic acid content, which varies considerably according to climatic and soil conditions, and upon the rate at which such plants are ingested. Furthermore, the toxicity of plants containing cyanogenetic glucosides depends to a considerable extent on the amount of enzyme, which is capable of splitting up these glucosides, present in the plant. The fact that such enzymes may be contained in other plants eaten by stock should not be lost sight of. Seddon and King (1930) state that fresh plants containing 0·02 per cent. of prussic acid and dry plants containing 0·05 per cent. of prussic acid must be considered dangerous, assuming that a sheep eats an average of 500 grams of the fresh plant.

The following conditions may give rise to the formation of fatal amounts of cyanogenetic glucosides (or prussic acid) in the above-mentioned plants: wilting and withering, especially during spells of hot dry weather; disease (Willaman and West, 1916); frost; bruising; trampling; soils of different composition (plants grown on good

soil contain more prussic acid than those grown on poor soil and fertilizing with nitrates stimulates the production of prussic acid (Burtt-Davy, 1912; Cough, 1932). The younger and the more succulent the plants are the more likely they are to produce lethal amounts of prussic acid. During the process of desiccation most, if not all, of the prussic acid disappears from the plants. Well cured plants, which contained dangerous amounts of prussic acid at the time of cutting, can as a rule be fed to stock without any danger of poisoning. The rate of drying of plants, which contain prussic acid or cyanogenetic glucosides, is of great importance. Swanson (1921), who investigated the amount of prussic acid present in Sudan grass from the time of cutting up to complete dryness states: " The portion tested at once gave large amounts, that dried in the oven somewhat less, that dried in the sun still less, and that dried slowly in the shade none or only a trace ". Rosenthaler (1929) found that a decrease in the intensity of light is accompanied by a decrease in the prussic acid content of leaves of " *Prunus laurocerasus* ". Before feeding hay prepared from mealie stalks and sorghums it would be advisable to collect specimens from various parts, and especially from the centre, of the stacks (or silos) and submit these to prussic acid tests.

The possibility of a plant containing a cyanogenetic glucoside but not the necessary enzyme to split it should be mentioned here. This enzyme might, however, be present in some other plant. This was found to be the case in Australia with *Eremophila maculata* Fr. and *Acacia Georgina* Bailey (Finnemore, 1931).

The Physiological Significance of Cyanogenesis.

Prussic acid was discovered by a Swedish chemist in 1782. The production of this acid by a plant was first recorded by Böhm in bitter almons in 1802 (Heffter, 1923).

In considering cyanogenesis in plants we have to distinguish between those plants (*Dimorphotheca spp.*) which normally contain prussic acid (or cyanogenetic glucosides) and those (wilted grasses) which develop prussic acid under certain conditions only.

There is no consensus of opinion with regard to the physiological significance of cyanogenesis in plants and what has been said under " VII. The Toxic Principles of Plants and their Physiological Significance " also applies to cyanogenesis in plants.

Dunston and Henry (1906), Gresshof (1906), Willaman and West (1916), Czapek (1921), Henrici (1926) and Robinson (1930) refer to the physiological significance of cyanogenesis in plants.

Bach (Dunston and Henry, 1906) " supposed that from the small amount of nitrate present in cell-sap, nitric acid was liberated in minute amount by the considerable quantities of oxalic and carbonic acids usually present, and that this free nitric acid was continuously reduced by formaldehyde, producing hydroxylamine, which immediately combined with formaldehyde, forming formaldoxime. The latter might undergo transformation in two ways. It might be converted into the isomenic formamide, which by simple

dehydration would give prussic acid and water, and in this way account for the frequent occurrence of this acid in plants, or the formamide might be hydrolysed, yielding ammonium formate, so supplying ammonia and formic acid ". This view of Bach seems to offer quite a feasible theory of cyanogenesis in wilted grasses, as in this condition natural dehydration occurs, thus causing the formation of prussic acid from a large proportion of the formamide present in the wilted plant. Gautier (Dunston and Henry, 1906) holds: " that the free nitric acid of cell-sap reacts with formaldehyde, forming free prussic acid, carbon dioxide, and water ".

Willaman and West (1916) consider the large amount of prussic acid in " *Sorghum* ", when the water supply is inadequate, a result of the lack of glucoside stimulation. The increased amount of prussic acid in " unhealthy Sorghum plants " is thought by Willaman and West (1916) to be produced for the purpose of stimulating hormones.

The view most widely held at present is that prussic acid is an intermediate product of proteid synthesis, hence plants will contain most of this acid when protein metabolism is most active. Treub (Robinson, 1930) regards the following facts as a support of this view: —

(*a*) The occurrence of cyanide in phloem and pavicycle (Pangium edule); (*b*) the absence of protein from your " special cells ", the basilar hair cells and the oxalate-containing cells (" Pangium edule "); and (*c*) the disapperance of cyanide from leaves during senescence, or when the plant is kept in the dark. The accumulation of cyanide in the basilar hair cells and the oxalate containing cells was an indication to Treub that its formation was normally related to photosynthetic processes.

Fearon (1926) discusses the possibility of cyanic acid being an intermediate in the urea-urease system.

Absorption, Mode of Action, and Elimination of Prussic Acid.

Prussic acid is absorbed by the blood vessels and not by lymph vessels; tendons aponeurosis and nerves absorb prussic acid very slowly (Heffter, 1923). The action of prussic acid is most pronounced when inhaled or when injected intracheally, death occurring within a few seconds. Blake (Heffter, 1923) found that prussic acid is not absorbed from the stomach when the vena portal is ligatured. Symptoms of poisoning, however, set in within a minute after removal of the ligature. Bonanni and Marino (Heffter, 1923) maintain that prussic acid is absorbed by the oesophagus. It is quite conceivable that prussic acid being a gas will diffuse not only through all mucous membranes but also through the skin. Theben and Coullon (Heffter, 1923) found that prussic acid is less poisonous when given per os than when administered rectally. The conjunctiva is a very active absorber of prussic acid.

When administered per os the largest percentage of prussic acid will be present in the blood and intestines, whilst when injected intraveneously the largest proportions are found in the heart and brain (Heffter, 1923).

A certain percentage of the prussic acid taken is converted into the relatively non-toxic sulphocyanate and excreted as such in the urine, whilst some is eliminated as such by the lungs. It is held that the sulphur necessary for the formation of sulphocyanate is derived from protein. The bright red colour of the venous blood is due to the fact that prussic acid paralysis the oxidative enzymes, which are responsible for the transference of oxygen from the red blood corpuscles to the tissue constituents (internal asphyxia). If the affected subject survives the effects of prussic acid poisoning for a time the blood turns cyanotic owing to inhibition of respiration and the consequent small intake of oxygen. In cold blooded animals the reddish colour of the blood persists from half-an-hour to twenty-four hours after death. Prussic acid is an active poison of the nervous system causing first stimulation and later on paralysis of the centres in the medulla oblongata, namely, the centre of respiration and the vasomotor centre, and also the motor centres in the brain. According to Voigt (1932) the origin of the spasms caused by prussic acid in the ventral horns of the spinal cord. The disturbances in the blood circulation are due to actions on the sinus nodes.

Toxicity of Prussic Acid.

When inhaled the toxicity of any gas depends on the time of inhalation and on the concentration of the gas in the inhaled air. The toxicity of gases may be expressed by concentration-time curves as was the general practice in the Great War. When taken per os the concentration (amount of prussic acid or cyanogenetic glucosides) in the materials ingested and the time taken to ingest such materials are as is usually the case with toxic substances, the factors which determine the toxic and lethal doses of cyanogenetic substances. The following table is taken from Barcroft's publication (1931) with regard to the toxicity of prussic acid when inhaled :—

Animals in Order of Sensitiveness to Prussic Acid.

Animal.	Lethal time of exposure to a concentration of 1·0 mg/litre (minutes).	Animal.	Highest approximate concentration which can be breathed indefinitely mg/litre.
Dog.....	0·8	Dog.....	0·10
Mouse.....	1·0	Rat.....	0·10
Cat.....	1·0	Mouse.....	1·14
Rabbit....	1·0	Rabbit....	0·18
Rat.....	2·0	Monkey...	0·18
Guinea-pig.	2·0	Cat.....	0·18
Goat.....	3·0	Goat.....	0·24
Monkey...	3·5	Guinea-pig	0·40

With regard to the susceptibility of man to prussic acid Barcroft (1931) states that man is not very susceptible in comparison with the dog. He also states that canaries and pigeons are extremely susceptible to prussic acid poisoning, a concentration of 1:10,000 killing the former within two minutes, whilst pigeons vomit at 1:10,000 and die in 1:5,000. Schütze (Petri, 1930), in the course of experiments upon animals and human beings, found that highly concentrated prussic acid is absorbed by the intact skin.

The following are the lethal doses of prussic acid and its salts administered in one dose to animals, as computed from the results of experiments conducted by the author at Onderstepoort and from the publications of Fröhner (1919), Lander (1926), Hindmarsh (1930), Leschke (1932), and Voigt (1932): Horses 0·5-1·0 gm. HCN per os; 4·0-8·0 gm. KCN per os (approximately 0·009 gm. per Kg. body-weight); cattle: 2·2 mg. HCN per Kg. body-weight intraperitoneally; sheep: 2·2 mg. HCN per Kg. body-weight per os; 6·0 mg. KCN per Kg. body-weight per os; dogs: approximately 2·0 mg. KCN per Kg. body-weight; small animals (birds, guinea-pigs): approximately 0·1 mg. HCN per animal; rabbits: 12·0-15·0 mg. KCN per Kg. body-weight; frogs: 0·5 mg. NaCN per gm. body-weight (injected into lymph sack); white mice: 0·25 mg. NaCN per mg. body-weight injected subcutaneously).

According to Kobert (1902) 0·15 gm. chemically pure KCN and seventeen drops of oil of bitter almons taken per os are sufficient to cause death in adult human beings, whilst Leschke (1932) states that 0·1-0·2 gm. KCN causes death in human beings within twenty to forty minutes. The amount of acid in the stomach naturally plays an important rôle in the determination of the toxicity of potassium cyanide.

Prussic acid being a diffusible gas is very rapidly absorbed from the gastro-intestinal tract and is also eliminated at a very rapid rate by the lungs and skin. Animals poisoned with just sublethal amounts of prussic acid will be found to show symptoms of dyspnoea only within a very short time after having been at the point of death.

Blake (Glaister, 1931) " has demonstrated that if prussic acid be introduced into the stomach of an animal by a fistulous opening, after ligature of the portal vessels, no poisonous results will ensure; but that immediately after removal of the ligatures, the poison begins to act ".

Symptoms of Prussic Acid Poisoning.

(*a*) *Acute poisoning.*—The symptoms vary according to the size of the dose of prussic acid and mode of application. It is a poison which acts extremely rapidly, large amounts causing death almost instantaneously with spasms and respiratory paralysis. Smaller doses of prussic acid cause accelerated and deepened respiration, accelerated, irregular and weak pulse, bright-red mucous membranes, which later turn purplish in colour on increased salivation and frothing at the lips, muscular twitchings, shivering, staggering, as if intoxicated and dropping down, staring and anxious look in the eyes, dilatation of the pupils, clonic spasms of the neck and legs, especially front legs, pronounced bloating, distress, epileptiform convulsions at varying intervals, opisthotonus, orthotorus, trismus, coma and death due to respiratory paralysis. The heart usually continues to beat for some time after respiration has stopped.

(*b*) *Chronic poisoning.*—According to Kobert (1902) the following symptoms and lesions may be encountered in chronic prussic acid poisoning in human beings: Dyspnoea, lassitude, degeneration of the muscles of the extremities, headaches, gastro-intestinal

disturbances, uncertain gait and difficulty in moving the jaws; when the gas is inhaled hyperaemia of the pharynx mucosa, severe irritation in the throat, pronounced salivation, retching, vomiting, headache, bradycardia, lassitude and albuminuria may be experienced.

There is no concensus of opinion with regard to chronic prussic acid poisoning. The author was unable to produce chronic poisoning in sheep and rabbits by drenching these animals at twenty-four hourly intervals with toxic but not lethal amounts of potassium cyanide for periods up to one month. Heffter (1923) however states that repeated administration of prussic acid causes chronic poisoning but not always with characteristic symptoms. He states that frequently the symptoms resemble those of a cumulative action. According to Koelsch and Seligmann (Petri 1930) continuous action of prussic acid on human beings causes oedematous swellings of external genital organs, urticaria-like eruptions on the skin, eczemata, and itching nodules and vesicles. Haemorrhages are rare. According to Koelsch chronic prussic acid poisoning causes the development of "Acna rosacea", an angioneurotic inflammation. The amount of prussic acid given and the interval at which it is administered will naturally determine whether repeated administration will have any effect on the system.

Post-mortem Appearances.

In peracute cases of prussic acid poisoning the blood is bright-red owing to the formation of cyan-haemoglobin. The bright-red colour of the venous blood is due partly to the ineffective deoxidisation of the arterial blood in the tissues. On opening up the body cavities and stomach (rumen) a smell of bitter almonds is perceived provided the post-mortem is performed soon after death.

The venous system is distended and if animals are skinned soon after death cyanotic blood, the coagulation of which is retarded, escapes freely from the subcutaneous tissues. As a rule the right ventricle of the heart is markedly distended. The stomach (rumen) shows pronounced distension with gas and there is marked hyperaemia and sometimes oedema of the lungs and liver. There may be haemorrhages in the serous membranes.

Staemmler (1932) conducted an autopsy on a human being four days after death had occurred from poisoning with potassium cyanide. In spite of very hot weather there were hardly any signs of decomposition. A distinct smell of oil of bitter almond was emitted from the mouth, and the stomach contents smelled of ammonia and of oil of bitter almond. The mucosa of the stomach and of the anterior portion of the small intestine was swollen, reddish in colour and covered with a mucous substance. The consistence of the affected mucosa was peculiarly firm. Histologically no changes, apart from slight dilation of the bloodvessels, could be detected. A remarkable finding was that practically no post-mortem changes were noticeable in the affected mucosa. This was borne out by the fact that the cell nuclei stained perfectly well. Staemmler ascribes the preservative effect of prussic acid to the fact that it is a specific poison for oxidising ferments.

It is interesting to note that at the time the autopsy was conducted prussic acid was still detectable in the gastric contents.

Histology.

Petri (1930) discussed the histology of prussic acid poisoning. If the gas is inhaled the erythrocytes assume the form of the fruit of *Datura stramonium* Linn. (*Stechapfelformen*) and are ultimately completely destroyed. In chronic poisoning there is high haemoglobin content owing to an increase in the number of erythrocytes, lymphocytosis, an increase in the immature and mature basophiles.

There is oedema and pronounced venous congestion of the central nervous system with haemorrhages in the subdural tissues and in the pia mater. Incipient "inflammation" in the pallidum, spinal cord and medulla oblongata, acute affection of the ganglian cells and small vessels occluded by hyalin thrombi are also mentioned.

In chronic poisoning, animals which die with symptoms of atrophic paralysis show chromatolysis, vacuole formation, shrinking, and dissolution of the protoplasm of the cells of the ventral horns of the spinal cord. In rabbits there is "degeneration" of the peripheral nerves. The small brain vessels show fatty changes and calcification, and the lungs may show haemorrhages in the parenchym. Extensive haemorrhage into the fatty tissues of the pancreas is also described.

Diagnosis of Prussic Acid Poisoning.

The symptoms and post-mortem appearances must be considered in the diagnosis of prussic acid poisoning, as the presence of small amounts of prussic acid in the gastro-intestinal contents does not justify a definite diagnosis of poisoning by this acid. The amount of prussic acid present in the gastro-intestinal contents, blood and organs depends on (*a*) whether free prussic acid or its combinations are concerned, (*b*) the method of administration, (*c*) the course the poisoning has taken, and (*d*) the time that has elapsed since death has occurred.

Prussic acid disappears from the carcase more rapidly than its salts and cyanogenetic glucosides. Seni and Revello (1929) who conducted experiments upon dogs with gaseous prussic acid and aequeous solutions of prussic acid and potassium cyanide, found that if the minimum lethal dose of prussic acid is given this poison cannot be recognised either by chemical or spectroscopic means. When three times the minimum lethal dose is given the prussian blue reaction is positive, whilst the spectroscopic examination is still uncertain. When large doses of prussic acid are given, this poison disappears from the organism within twenty days. In the case of poisoning with gaseous prussic acid the tests for this acid are invariably negative. With regard to the detection of prussic acid in carcases of rabbits poisoned with *Dimorphotheca spectabilis* Schltr, which contains a cyanogenetic glucoside, Steyn (1931A) found that when the minimum lethal dose of this plant was given no prussic acid was detectable in the gastro-intestinal contents forty-eight hours after death, whilst the test for prussic acid was positive when large

amounts of the plant were given. A rabbit drenched with a sublethal quantity of *Dimorphotheca spectabilis* Schltr., which had developed symptoms of poisoning, showed no prussic acid in the stomach and intestinal contents within five hours after dosage. The stomach contents of a rabbit, that had died from poisoning by this plant, was kept in a well stoppered bottle and up to four months after collection prussic acid was still detectable. No more material was left for further tests. In the above experiments the " vest-pocket test ", described below, was used for the detection of prussic acid.

From the above experiment it appears that gastro-intestinal contents containing hydrocyanic acid can be kept for long periods without any risk of the hydrocyanic acid escaping, provided the vessel in which such contents are placed is air-tight. Furthermore in the light of the foregoing experiments, it is proposed to adopt the following procedure in attempting to diagnose cases of prussic acid poisoning: About 4 ounces of the stomach contents of the animals suspected to have died from " geilsiekte " should be collected as soon as possible after death. These must be placed immediately in a container (preferably a fruit jar fitted with an unperished rubber ring) which should be firmly closed so as to prevent the escape of gases. The specimen should then be packed carefully so as to avoid breakage, and be sent to a laboratory for a chemical test. In each case the time which has elapsed between the death of the animal and the taking of the specimen should be stated. In this way it will be possible to ascertain whether a disease thought by the farmer to be " geilsiekte " is hydrocyanic acid poisoning or some other disease of unknown aetiology.

Vest-pocket Test for Cyanogenesis.

This test is eminently suitable for work conducted under field conditions. The following description of the test is taken from a publication of Henrici (1926, pp. 495-496):—

" Picrate solution and papers, 5 gm. sodium carbonate and 0·5 gm. picric acid in 100 c.c. water. Wet ordinary filter paper with this, hang up to dry until only just ' perceptibly moist ', and cut into convenient strips, about 1 cm. by 4 cm. Papers should be made up fresh every week as sensitiveness decreases with time. The solution keeps well for months in a stoppered bottle.

" Test—into a stout glass tube, about 1½ cm. of 7 cm. or other convenient vest-pocket size, push a few grammes of the moist shredded plant (or moist pulverised seed). Add two or three drops of chloroform to hasten autolysis, insert a slip of ' perceptibly moist ' picrate paper at the top, and cork tightly. Incubate in a vest-pocket, examining at intervals. Liberation of HCN is indicated by reddening of the yellow picrate paper—within a few minutes if the amount is large, after twenty-four hours if only traces are present. If the paper remains lemon-yellow it either means that a cyanogenetic glucoside is absent or that a hydrolytic enzyme is not intimately associated with it. In the latter case chemical analysis may still show hydrocyanic acid, but with the majority of plants analysis will not show much if the simple test fails. It may be added that the test

is so delicate that cyanogenesis is revealed in a large number of common non-toxic edible plants, an easily comprehensible fact in view of the significance of cyanogen in normal plant anabolism."

Further tests for the presence of prussic acid in the gastro-intestinal contents, blood and organs, and in plants are described by Koert (1902), Furlong (1914), Fröhner (1919), Swanson (1921), Lander (1926), Glaister (1931) and Leschke (1932).

Differential Diagnosis.

The presence of prussic acid in the carcase will assist to a considerable extent in the diagnosis of prussic acid poisoning. In cases which simulate prussic acid poisoning but which yield negative results for the specific reaction, the circumstantial evidence, symptoms, post-mortem appearances, and chemical tests may be of value in diagnosing the cause of death.

Treatment.

Prussic acid is a rapid acting and deadly poison and unless treatment applied before serious symptoms of poisoning have developed, it will be of very little or no avail. Treatment may be administered on the following lines. In human beings and those animals that are capable of vomiting, emetics will be of value when unabsorbed prussic acid or its combinations are still present in the stomach. In such cases stomach lavage with the chemical antidote mentioned below will materially retard or prevent further absorption of the poison. Bleeding and blood transfusions, undoubtedly will be of value in the treatment of prussic acid poisoning.

As pharmacological antidotes (symptomatic treatment), the following drugs may be given: Ether subcutaneously, camphor, caffeine, veratrin, strychnine, alcohol (brandy) per rectum, lobeline subcutaneously and sodium nitrite intravenously. Lobeline is a valuable stimulant of the respiratory centre, and is preferable to atropine. It is held that nitrates react with urea in the body producing carbon dioxide, which stimulates respiration. The intravenous dose of sodium nitrite for a human being is 10-20 c.c. of a 1 per cent. solution (Barcroft, 1931). Brooks (1932) suggests that methylene blue injections could be used advantageously in prussic acid and carbon monoxide poisoning, as it activates the oxygen supply of the body. Geiger (1932) reports favourably on the use of methylene blue (methylthionine chloride, U.S.P.) in prussic acid poisoning in a human being. The patient had received 50 c.c. of a 1 per cent. sterile aequeous solution of this preparation intravenously with the result that complete recovery occurred within fifteen minutes. Artificial respiration, oxygen inhalations, cold affusions and electrical stimulation of the phrenic nerves and chest are of great value. Adrenalin will retard absorption from the gastro-intestinal tract. The following may be administered as chemical antidotes: Sodium thiosulphate, colloidal sulphur, ferrous sulphate followed by a solution of potassium carbonate, glucose, dioxyacetone, glycerinaldehyde, potassium permanganate, hydrogen peroxide and ammonia. Prussic acid and its salts form sulphocyanic (thiocyanic) and sulphocyanides (thiocyanides) with sodium thiosulphate ($NaCN + Na_2S_2O_3 + O - NaCNS + Na_2SO_4$). In the blood, which is alkaline, liberation of

sulphur from sodium thiosulphate is slower than in acid medium, on the other hand alkalinity favours the formation of sulphocyanic acid and sulphocyanides. Sodium thiosulphate is therefore of greater value as a preventive than as a curative of prussic acid poisoning. It can be administered in the following doses: Human beings—0·1-0·2 gm. intravenously; 0·65-2·0 gm. per os; animals—0·003 gm. per Kg. body-weight intravenously and about five times this dose per os (Kobert, 1902; Lander, 1926; Forst, 1928; Milanesis, 1929; and Leschke, 1932). Chistoni and Foresti (1932) found that tetrathionate of sodium ($Na_2S_4O_6$) has a marked antidotal action on prussic acid, causing formation of the harmless alkaline sulphocyanate. This action of tetrathionate of sodium is also exerted on prussic acid present in the tissues, hence this sodium compound is of great value in the treatment of cases of prussic acid poisoning already showing symptoms of poisoning. Sulphides will have effects similar to those described above on prussic acid poisoning.

The sulphur (sulphide) of protein also combines with prussic acid, the combination is however very slow. With regard to sulphur metabolism in prussic acid poisoning Kahn and Goodridge (1926, p. 373) write: " Loewy, in 1907, demonstrated that hydrocyanic acid not only increased the protein catabolism, but also influenced the metabolism qualitatively. Wallace and Richards studied the effect of potassium cyanide upon metabolism, and they observed that the total S-output was increased on the day of poisoning, but, unlike the total nitrogen, it fell on the following day. The neutral sulphur fraction was increased, whereas the sulphate sulphur was diminished, showing that the oxidative processes in the body were lessened.

Loewy, Wolf and Osterberg concluded from their experiments on dogs that even in slight cases of poisoning with hydrocyanic acid there was an appreciable increase in the neutral sulphur in the urine and with marked poisoning the neutral sulphur fraction was greater than the sulphate sulphur fraction. It is therefore clear that hydrocyanic acid lessens the exidative processes in the body ".

According to Kahn and Postmonteir (Denis and Reed, 1926-7) the non-protein sulphur in the blood exists in three forms, namely, inorganic, ethereal and neutral. There are also sulphur-containing lipoids in animal tissues (Denis and Reed, 1926-7).

When a certain percentage of cyanide is administered to dogs the neutral sulphur of the urine is increased absolutely and relatively (Smith and Malcolm, 1930).

Prussic acid forms innocuous ferrocyanides with ferrous salts in concentrated alkaline solutions. It is therefore advisable to administer freshly-prepared ferrous hydrate *ad lib.* This antidote is only of value as far as the prevention of absorption of prussic acid or cyanides from the gastro-intestinal tract is concerned (Kobert, 1902; Fröhner, 1919; Lander, 1926; Couch, 1932).

Glucose (dextrose) and its decomposition product dioxyacetone proved to be of great value as antidotes in the treatment of prussic acid or cyanide poisoning (Forst, 1928; Casser, 1930; Barcroft, 1931; Wiegand, 1931; Couch, 1932; Forst, 1932; Leschke, 1932). These

and other carbohydrates form innocuous cyanhydrin with prussic acid. According to Forst (1932) cyanhydrin is then slowly decomposed in the system again liberating prussic acid. The liberation of prussic acid from the carbohydrate cyanhydrin depends to a certain extent on the rate of oxidation of the carbohydrate. The most effective treatment of cases of prussic acid or cyanide poisoning apears to be combined intravenous injections of dioxyacetone and colloidal sulphur (Forst, 1928). Glucose may be administered orally, intramuscularly intravenously, intraperitoneally, subcutaneously or rectally. For intravenous administration glucose is dissolved in distilled or physiological salt solution and sterilised before injection. The intravenous dose of a 50 per cent. solution of glucose for man and animal is about 1·0 c.c. per Kg. body-weight. Rabbits may receive about 2-4 c.c. per Kg. body-weight. For subcutaneous injection a 10 per cent. and for intraperitoneal injection a 5 per cent. solution is recommended (Milks, 1930). Dioxyacetone in a 20 per cent. solution in physiological salt solution [Oxantin (Hoechst)] could be administered intravenously in half the doses prescribed for glucose. Glycerinaldehyde also converts prussic acid into the comparatively non-toxic glycerinaldehyde cyanhydrin.

Potassium permanganate administered in solutions up to 0·5 per cent. in strength destroys by oxidation the prussic acid still present in the gastro-intestinal tract (Kobert, 1902; Fröhner, 1919; Couch, 1932; Leschke, 1932). Hydrogen peroxide causes the formation of comparatively harmless oxamide $\frac{(H_2O_2 + 2\ HCN - CONH_2)}{CONH_2}$. The subcutaneous injection of hydrogen peroxide in a 3 per cent. solution is recommended and also a stomach lavage (Kobert, 1902; Fröhner, 1919; Couch, 1932; Leschke, 1932).

Ammonia inhalations are recommended as ammonia has a strong stimulating action and has a tendency to convert prussic acid into less dangerous substances (Couch, 1932).

Prevention of Prussic Acid Poisoning.

Keeser (1930) found that rabbits fed with green feed and ferrous chloride showed a greater resistance to cyanide poisoning than those rabbits fed on milk rice or green feed only. Keeser concludes that this increased resistance in the animals which received ferrous chloride, is due to the increased iron content of the tissues.

Feeds rich in carbohydrate (molasses, mealies) give a certain protection against prussic acid. It is also said that lucerne hay and linseed cake retard the production of prussic acid and in this way may prevent poisoning (Couch, 1932).

Investigations made by Steyn (1931A) have shown that sulphur is an excellent preventive of "geilsiekte" (prussic acid poisoning due to the ingestion of certain wilted grasses) in sheep.

Farmers are advised to combat the disease by mixing sulphur with their sheep licks. On farms deficient in minerals, i.e. where the animals eat bones, rags, etc., the lick should not contain more than 5 per cent. sulphur; and on farms where the mineral shortage

is not so pronounced, the lick may contain 7½ per cent. sulphur (1 part sulphur to 13 parts of any lick which does not already contain sulphur). Copper sulphate (blue stone), Cooper's Dip and the Government wireworm remedy were also tested, but the best results were obtained by using sulphur.

When climatic conditions are favourable for "geilsiekte", that is, light rains after prolonged droughts, with spells of sunny weather, or, during an actual outbreak of "geilsiekte", every sheep or goat above the age of six months may be given a well-filled teaspoon of sulphur (= ±5·0 gm.) every fourth day, while the animals should at the same time have free access to the sulphur lick. Sheep and goats under the age of six months should be given half a teaspoon of sulphur. Calves not receiving sulphur licks may receive the same dose of sulphur as full-grown sheep and full-grown bovines up to two tablespoons of sulphur (=30 gm.) daily over unlimited periods (Onderstepoort experiments conducted by the author). The animals should not be dosed continuously for longer than one month in addition to having access to sulphur licks.

II. ALOPECIA (KAALSIEKTE) IN KIDS AND LAMBS CAUSED BY PLANT POISONING.

(*Chrysocoma tenuifolia* Berg.)
(O.P. No. AW; 1929. N.H. No. 14407.)

Introduction.

Kaalsiekte (*alopecia*), which literally means "naked-disease", is the term applied to a disease in lambs of cross-breeds of sheep and in kids, the most outstanding symptom of which is partial or complete loss of the coat. Hence the appropriate name assigned by farmers to this disease.

Fig. 1.—*Chrysocoma tenuifolia* Berg. (Plant used in feeding experiments.)

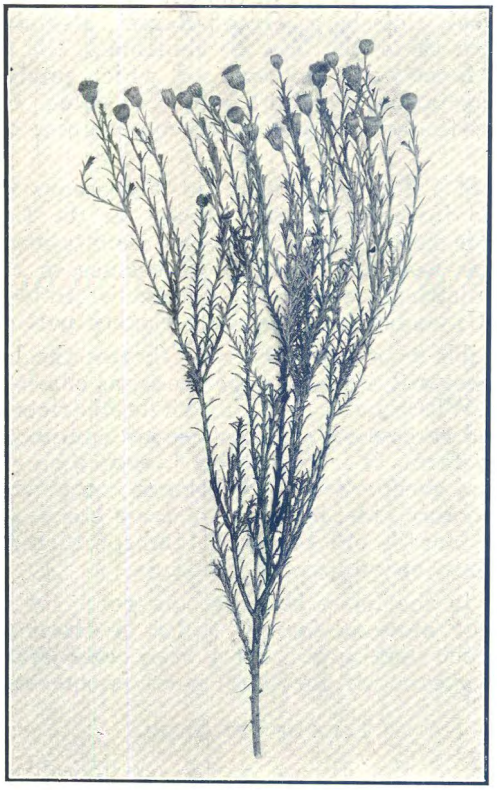

Fig. 2.—*Chrysocoma tenuifolia* Berg. (Plant used in feeding experiments.)

Alopecia, although it had existed in the Willowmore Uniondale and other neighbouring districts for the last seventy or eighty years, according to reliable information supplied by elderly and experienced farmers, was for the first time investigated and reported upon by Van Rensburg (1925), the then lecturer in veterinary science at the Grootfontein School of Agriculture, Middelburg, Cape Province. Specimens of the skin and thyroid glands of affected kids were forwarded to Onderstepoort for histological examination. The skin showed a crystaceous eczema and the thyroids revealed no specific changes.

As the affected area in the Willowmore and Uniondale districts alone carries approximately two hundred and fifty thousand Angora and mixed breed of goats, it was decided to have this disease investigated.

Incidence and Statistics.

The disease is said to be limited to "sour veld". A sheep inspector who has had many years' of experience as sheep inspector in the areas where alopecia is prevalent, has informed the author

that he has also seen the disease in the Cradock, Hofmeyr, Tarkastad, Middelburg (Cape), Colesberg, Graaff-Reinet, Pearston and Jansenville districts. In these districts, he continued, the disease invariably appears on farms with deficient soil which produces very little, if any, edible vegetation of a high nutritive value. In the course of his investigations the author had ample opportunity of verifying the latter statement.

Mr. O. T. de Villiers, Government Veterinary Officer, Middelburg, Cape, who investigated the disease in the Cradock district, reported that it is most prevalent in the mountainous parts of that district. This has been the author's experience in the Willowmore and Uniondale districts, where the disease is limted to the north-western part of Uniondale and the south-eastern part of Willowmore.

It is impossible to express in exact figures the losses caused by this disease. These are, however, enormous, as can be gauged by the fact that in the Willowmore and Uniondale districts alone over two hundred thousand susceptible small stock are running in the affected areas. On many farms it is impossible to rear a single kid, or lamb of mixed breeds of sheep. On such farms it is a general practice not to attempt to rear any kids, or lambs of cross-breeds of sheep, but to buy three to six months old kids and lambs, which then mature on these farms without any apparent ill-effects.

In addition to the losses amongst the young of the small stock the owner of an "alopecia farm" suffers a direct heavy financial loss due to the fact that such a farm loses considerably in value as far as the grazing capacity for small stock is concerned.

Time of the Year.

The severity of the disease varies considerably from year to year. In years when late winter or early summer rains fall the disease is much more prevalent than in dry years, during which the disease either does not appear or occurs in a very mild form, even on the most notorious alopecia farms. The disease is most prevalent during the period August to October, although severe outbreaks have been known to occur during May, June and July. The writer has seen the disease in June, 1930, in the Willowmore district.

Species of Animals Affected.

Cases have appeared in the lambs of cross-breeds of all sheep, in Angora kids and in the kids of cross-breeds of goats. The disease exhibits itself in from four to fourteen days old lambs and kids and rarely makes its appearance in these animals after the age of two weeks. During the worst outbreaks cases have been reported to occur in kids up to one month old. The affected areas carry the above breeds of small stock but no Merino sheep. None of the many farmers interviewed could supply the author with any information regarding the occurrence of the disease in Merino lambs.* Donkeys, horses and cattle also run in the alopecia areas, but no cases of this disease have ever been known to appear in the young of these animals.

* Van Rensburg (1925), however, mentions that some farmers reported that they have seen alopecia in Merino lambs.

Morbidity and Mortality.

The morbidity depends to a considerable extent on the rainfall. It is highest after late winter or early summer rains, when the morbidity might be as high as 100 per cent. We must bear in mind the fact that the kidding season in the affected areas extends usually from the beginning of August to the end of October.

The mortality depends largely on the care given to the affected animals. In cases of negligence the mortality may be as high as 90 per cent., whereas it could be reduced to 50 per cent. or less with proper treatment. This point will be discussed under " Treatment ".

Symptomatology.

The symptoms can best be divided into primary and secondary.

Primary Symptoms.—These are the shedding of the coat and diarrhœa. The former symptom appears in about 95 per cent. of the cases and frequently is associated with diarrhœa. It rarely happens that the affected kids and lambs develop a pronounced diarrhœa and die before loss of hair occurs.

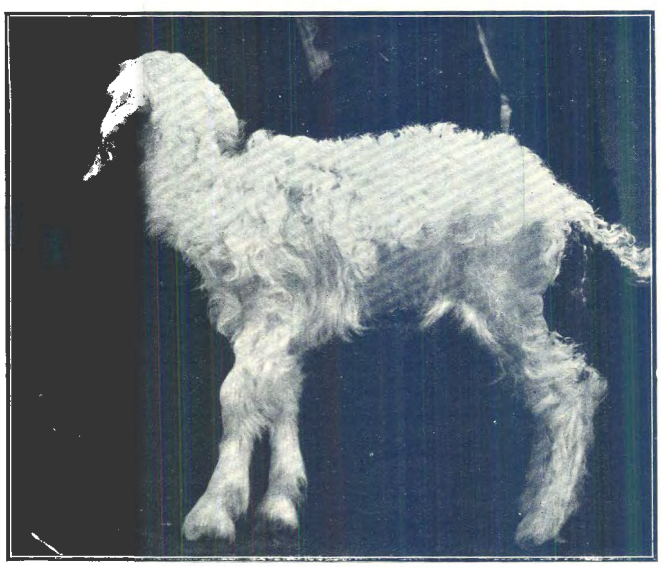

Fig. 3.—Alopecia. Note loss of hair on side of body. Experimental case.

On careful observation the first discernible symptom is itching and the affected animals can be seen scratching and biting their sides. At this early stage the hair, especially over the sides, can be easily removed by hand. Macroscopically the skin on the affected parts of the body appears normal. In bad cases such animals lose practically the whole coat overnight and it continually seeks shelter. In mild cases the coat is shed over a period of a few days provided the affected animal survives the diarrhœa.

Invariably the first bald patches are to be seen over the shoulder blades and the upper half of the hind legs (see Fig. III). By pulling the hair on these parts an affected case can be detected in its earliest stages. Many cases in the initial stages can be picked out by the peculiar ruffled appearance of the hair over these parts.

As soon as diarrhœa sets in the animals show inappetence, listlessness and, frequently, fever. In cases of severe diarrhœa the animals die in one to three days without loss of hair.

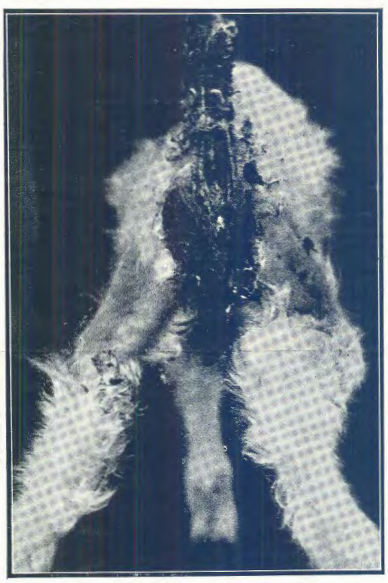

Fig. 4.—Alopecia. Kid showing profuse diarrhœa and hairless patches on hind legs. Experimental case.

In the course of a few hours to a few days, depending on the severity of the case, the affected kids and lambs become completely bald (see Fig. II), with a little hair left on the lower parts of the legs, the tips of the ears and tail, and on the head. These animals present a most peculiar appearance. In this state the animals show symptoms of a marked general disturbance, e.g. fever, diarrhœa, inappetence, marked depression, staggering gait and, ultimately, inability to rise.

The hair on the coloured patches of the skin (in mixed breeds of sheep and goats) is much more resistant to the effects of the toxin than that on the unpigmented parts, with the result that the coloured patches are still covered by hair, while the unpigmented parts of the skin are completely bald. Likewise, black and brown animals are more resistant to alopecia. However, in bad cases these animals also lose their hair, provided they do not die within a short time from diarrhœa.

In addition, the affected kids develop an acute conjunctivitis, keratitis and rhinitis (see Fig. IV). Permanent loss of eyesight is, however, very rare.

Fig. 5.—Alopecia. Condition more advanced. Diarrhœa and acute purulent conjunctivitis and rhinitis present. Experimental case.

Fig. 6.—Alopecia. Dermatitis setting in. Note the bad condition of the animal. Experimental case.

Fig. 7.—Natural case of alopecia.

Fig. 8.—Natural case of alopecia showing almost complete hairlessness. The skin appears quite normal.

Fig. 9.—Natural case of alopecia. Acute crustaceous dermatitis.

Fig. 10.—A kid recovering from alopecia. A new coat is appearing. Natural case.

Secondary Symptoms.—These are an acute dermatitis, pronounced diarrhœa, obstruction of the gastro-intestinal tract by hairballs, and acute catarrhal pneumonia.

The acute dermatitis is caused most probably by the action of sunlight on the unprotected skin (see Fig. VII). It commences on the hairless patches with an intense reddening, swelling, painfulness and, later on, exudation. In the course, of time, hard crusts are formed on the skin. It is evident from Fig. IV that such animals experience severe pain when walking or standing with straightened legs and back, as this causes stretching of the skin.

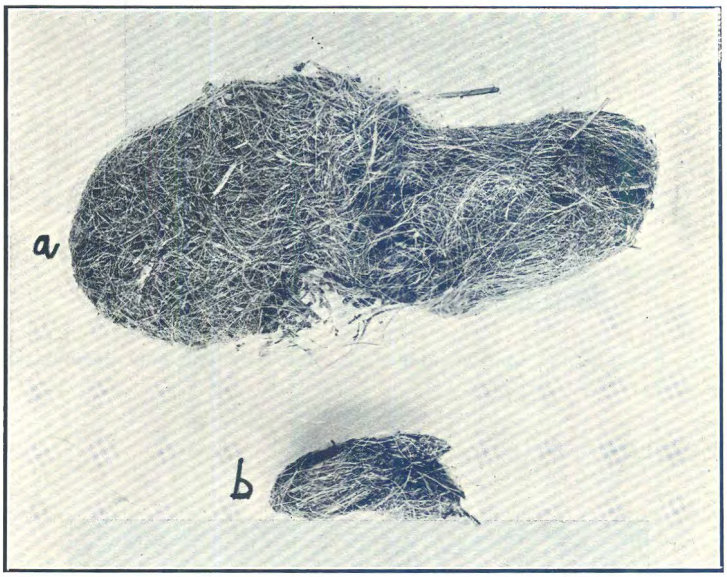

Fig. 11.—(*a*) Ruminal and (*b*) abomasal hairballs collected from a kid which had died from alopecia.

Diarrhœa almost invariably accompanies the process of shedding of the hair. Diarrhœa in alopecia in kids and lambs may be caused either primarily by the toxin, as it is present in cases where no loss of hair occurs, or secondarily, by the irritation produced by the ingestion of large amounts of hair, or by both these factors. Affected kids can be seen pulling out mouthfuls of hair from the itching skin, and chewing and swallowing them.

It rarely happens that kids shed the coat and die within a comparatively short time without developing a diarrhoea. In these cases autopsy reveals one or more hairballs completely obstructing the pyloric portion of the abomasum (see Fig. IX). The abomasum is distended by intense malodorous gases and its contents are in a state of advanced decomposition. Many farmers have informed the author that they have lost kids from the effects of hairballs up to three months after these animals had recovered from alopecia.

In cold weather a large percentage of the hairless kids develop a fatal acute catarrhal pneumonia if the necessary provisions for shelter are not made.

Post-mortem Appearances.

As far as the external lesions are concerned these coincide with those described under Primary and Secondary Symptoms. An acute catarrhal gastro-enteritis is present in cases which have exhibited a diarrhoea. In all cases where alopecia is present autopsy reveals an enormous amount of hair mixed with the gastro-intestinal contents, and hairballs varying in size. As has been described before, the latter might cause death before the gastro-intestinal irritation has been produced.

An acute catarrhal pneumonia frequently is the cause of death in hairless kids and lambs and may be complicated by one or more of the other secondary conditions.

Nature and Cause of the Disease.

This aspect of the disease will be discussed under " Experiments to determine the Cause of Alopecia in Kids and Lambs ".

Treatment.

The careful nursing of the affected animals is of much greater importance than the treatment which is not of much use. Treatment can be carried out on general principles.

Mild oily laxatives, for example, raw linseed oil, are indicated to remove the hair and hairballs from the gastro-intestinal tract. This treatment must be commenced as soon as the kids are noticed to bite and scratch, as in the course of a day or two the hairballs reach such dimensions as will render their escape from the abomasum into the small intestine impossible.

In diarrhoea small quantities of raw linseed oil and limewater prove beneficial.

In pneumonia treatment generally is of no avail, it could be carried out on general principles.

The dermatitis can be treated with liniments to prevent the skin from hardening and to allay the irritation, and farmers have reported very favourably on the effects of lanolin on the bald and burnt skin.

Prevention.

Prevention as far as the primary symptoms are concerned will be discussed in the second part of this paper.

Many farmers although experiencing a high percentage of alopecia amongst their animals, have reduced their losses to a minimum by erecting a small shed at the kraal where the kids and lambs are kept. These sheds afford the necessary shelter against cold and the burning rays of the sun, with the result that pneumonia and dermatitis rarely develop.

Experiments to Determine the Cause of Alopecia in Kids and Lambs.

A.—EXPERIMENTS ON THE FARM SKILPADBEEN, WILLOWMORE.

Preliminary Investigations.

The author investigated the disease on a number of farms in those parts of the Uniondale and Willowmore districts where the disease is most prevalent. In addition, alopecia-free farms were visited for purposes of comparison.

First of all the nature of the disease had to be settled. Was it a deficiency disease or infectious disease or a plant intoxication?

The following facts gathered in the course of the investigation pointed strongly to plant poisoning:—

(*a*) The disease does not appear when the pregnant goats and cross-breeds of sheep are turned on to green barley or oat-lands fourteen days before kidding and lambing commence and kept there until fourteen days after kidding and lambing. The same applies when the pregnant goats and sheep are allowed to graze high up in the mountains for the above period. The disease is also known to be more severe on certain parts of one and the same farm than on other parts.

(*b*) The disease is most prevalent in years when the rainfall is at its highest. At such times there is a luxuriant growth of herbage and we must consider that certain plants may be eaten only when in the flowering stage. In addition, in good years the milk yield is much higher than in years of drought. Farmers have informed the author that in years of drought the morbidity may be 1 per cent., or even less, whereas on the same farm the morbidity might be as high as 100 per cent. during years with a high rainfall.

(*c*) The disease can be controlled to a certain extent by partially emptying the mother's udder before the young ones suck. This method of preventing the disease is practised by many farmers with a fair amount of success. The less milk the kids get, the less " poison " they ingest.

(*d*) Twins and triplets are much less susceptible to the disease than in cases where only one kid or lamb sucks the mother. This again is a case of the young receiving less milk and consequently less " poison ".

(*e*) No new outbreaks are experienced as soon as the kids and lambs are weaned.

(*f*) Kids and lambs are never born bald, the earliest cases of alopecia appearing in three days old kids and lambs. It is most prevalent in kids and lambs from four to fourteen days old, less prevalent in three weeks old kids and lambs, and is rarely seen after these animals have passed the age of three weeks.

(*g*) It is common experience that kids or lambs sucking a mother-goat or sheep, whose young have died from the effects of alopecia, will also contract the disease.

It has been suggested that alopecia is due to a deficiency of iodine. The above-mentioned points, as well as the fact that the kids and lambs are born in a state of perfect health with a perfectly normal coat, speak against this theory. In the face of the above facts it is unnecessary to elaborate on the symptoms of iodine deficiency.

It is of interest to mention the views expressed by the farmers as to the cause of the disease. These can be summed up as follows:—

(*a*) A number of farmers ascribed the disease to the mother-goats and sheep eating the so-called " opslag " after the rains. The term " opslag ", as used by the farmer, may include any plant whose growth is dependent on the late winter or early summer rains.

(*b*) The following plants have been incriminated: The geelbos (*Lopholaena Randtii*); the beesbossie, also known as the bitterkarroo, brandbossie; bitterbossie (*Chrysocoma tenuifolia*); Euphorbia species; and a number of other plants. Some farmers maintained that the mothers had to ingest more than one plant at the same time in order to cause the development of alopecia in their young.

(*c*) Many believed the water to be the source of the trouble.

(*d*) Others again were baffled by the disease and could express no opinion as to its possible cause.

(*e*) Many farmers regarded Alopecia as a deficiency disease and claimed good results by supplying the mothers with licks containing iron sulphate and bonemeal.

(*f*) Some farmers maintain that they combat the disease very successfully by feeding a salt-bonemeal lick to the breeding stock.

The results of investigations made by the author pointed to alopecia in kids and lambs being due to plant poisoning, the pathogenesis of which is as follows: The mother of the affected kids or lambs ingests a plant, which apparently causes no harmful effects on the full-grown animals, but whose active principle is secreted in the milk and in this way produces the so-called alopecia in the kids and lambs.

The water as a possible source of the trouble could be eliminated, as the disease could be prevented by allowing the mothers to graze on green oats or barley lands, while the water supply remained the same.

A careful botanical survey of a number of affected and unaffected farms was then made. The unaffected farms and the " alopecia-free " and " alopecia " portions of the affected farms were carefully

examined with the result that the number of suspicious plants were reduced to two, namely, the beesbossie *(Chrysocoma tenuifolia)* and the Bothablom *(Polygala teretifolia)*.

It was then decided to conduct experiments with these plants.

Arrangements were accordingly made with Mr. M. J. Ferreira, Skildpadbeen, Willowmore, to conduct the experiments on his farm, which in the past has been so bad with the disease that the owner had practically stopped breeding kids and lambs, and resorted to the method of buying three to six months' old kids and lambs for purposes of speculation.

Field Experiments in the Willowmore District.

The undermentioned experiments with highly pregnant Angora goats were commenced on 12th August, 1930, approximately two weeks before kidding was due.

Experiment I.

To determine whether *Chrysocoma tenuifolia* Berg. is the cause of alopecia in kids.

Common names of plants: Bitterkarroo, beeskarroo, bitterbossie, brandbossie.

Fifteen goats were fed as follows:—

(*a*) Bitterkarroo only: 5 goats.

(*b*) Bitterkarroo + 0·1 gram potassium iodide per head daily: 5 goats.

(*c*) Bitterkarroo + two tablespoons of salt-bonemeal lick (1 : 2) daily: 5 goats.

These animals were placed in a specially constructed wire-netting kraal twenty-six by sixteen yards, from which all the vegetation, except the bitterkarroo, was removed. The animals immediately commenced eating the bush and completely cleared the kraal in six hours. From 13.8.30 the animals received approximately sixty pounds of the freshly cut bush per day. The flowering plant only was utilized in the feeding experiments and was collected by cutting off the upper four inches of the bush. The material, which was scattered in a shady place, in order to prevent rapid wilting, was very eagerly eaten by the goats.

All the experimental goats received their drinking water from the same source as the flock in order to ascertain whether the drinking water played any part in the causation of the disease.

The five goats in group (*b*) were dosed daily with 0·1 gram potassium iodide in order to exclude an iodide deficiency. The potassium iodide was dissolved in ordinary spring water and dosed by means of a syringe.

Each of the five goats in group (*c*) received daily two tablespoonfuls of a mixture of one part of salt and two parts of bonemeal, in order to determine whether these substances had any direct effect on the disease, preventively or curatively. It should be mentioned that many farmers in the "krimpsiekte" areas of the Uniondale and Willowmore districts, where this disease

is caused by *Cotyledon ventricosa* and *Cotyledon wallichii* informed the author that they have reduced their losses from "krimpsiekte" to a negligible number by allowing their stock free access to a salt-bonemeal lick.

It was the intention to include an additional experiment by daily force-feeding twenty pregnant goats with the salt-bonemeal lick and allowing them to run with the flock, which had to serve as controls. This experiment was abandoned, as Mr. Ferreira allows all his animals free access to a salt-bonemeal lick.

On the fourth day after the commencement of the experiment, that is, after each animal had ingested approximately sixteen pounds of the flowering tops of the frshly cut plant, all the animals showed a marked diarrhœa, which in the course of a few days became very acute. The animals exhibited pronounced straining, evacuating varying quantities of a very fluid greenish material mixed with large amounts of mucus which from a few animals was mixed with blood. There was extremely rapid loss in condition, and the animals drank enormous amounts of water. The eyes were sunken and the nostrils showed a dirty mucous discharge.

The visible mucous membranes were extremely pale and there was complete absence of appetite. Furthermore, the animals exhibited a general weakness, which progressed until they were unable to rise. The respiration was very rapid, costo-abdominal and shallow. The pulse was accelerated and in the course of time became very irregular and ultimately imperceptible. In the last stage of the disease the animals lay on their sides utterly exhausted and helpless until death intervened.

Four of the fifteen animals aborted in the course of the disease, and it is of interest to note that three of these animals were receiving 0·1 gram potassium iodide daily.

Three animals died and one was killed *in extremis* sixteen days after commencement of the experiment.

Post-mortem Appearances.

Anaemia, cachexia, hyperaemia of the lungs and liver; heart extremely flabby and both ventricles markedly distended with coagulated blood; acute catarrhal gastro-enteritis. The four animals showed advanced pregnancy.

All the affected animals were treated with a mixture of limewater and raw linseed oil with very unsatisfactory results. As mentioned above, four died and the rest recovered extremely slowly.

Only seven pregnant animals were left, and of these one had to be discharged on account of its bad condition. Another nine available pregnant Angora goats were placed in the experiment in order to bring the number up to fifteen and the experiment continued from 1.9.30.

During field observations it was noticed that both sheep and goats fed extensively on the flowering bitterkarroo without any ill-effects. It was thought that symptoms of bitterkarroo poisoning could be prevented when additional food was given to the experimental animals. Accordingly from 1.9.30 the fifteen experimental animals received approximately sixty pounds of the freshly cut flowering bitterkarroo in the morning, and as soon as this had been ingested they were offered twenty pounds of lucerne-hay and forty pounds of green barley. Of the lucerne-hay and barley they took variable quantities, whereas of the bitterkarroo each animal daily took approximately four pounds of the freshly collected flowering plant. In spite of the fact that the animals were daily fed as above from 1.9.30 to 27.9.30, they developed no symptoms of ill-health.

Eleven out of thirteen kids born from the above goats developed typical symptoms of alopecia as it occurs under natural conditions. Of the affected kids eight died and one was killed *in extremis*.

The results of this experiment are summarized in the following table:—

TABLE I.

Chrysocoma tenuifolia fed to Pregnant Goats.

No. of pregnant goats.	Material received.	Date of birth of kids.	Date on which symptoms of alopecia appeared in kids.	Interval between date of birth and date of appearance of symptoms.	Remarks.
1	Bitterkarroo only	—	—	—	Died on 27/8/30 from effects of bitterkarroo.
2		—	—	—	Died on 26/8/30, from effects of bitterkarroo.
3		Aborted on 27/8/30	—	—	Discharged.
4		—	—	—	Killed *in extremis* on 28/8/30. Condition due to ingestion of bitterkarroo.
5		9/9/30	18/9/30	9 days	Alopecia diarrhœa. Died on 1/10/30.
6		11/9/30	14/9/30	3 days	Slight alopecia. No diarrhœa. Died on 14/9/30
7		16/9/30	23/9/30	7 days	Alopecia and diarrhœa. Died on 1/10/30.
8		16/9/30	27/9/30	11 days	Alopecia and diarrhœa. Died on 29/9/30.
9		19/9/30	24/9/30	5 days	Alopecia and diarrhœa. Died on 30/9/30.
1	Bitterkarroo + potassium iodide	Aborted on 19/8/30	—	—	Discharged.
2		Aborted on 20/8/30	—	—	Discharged.
3		Aborted on 23/8/30	—	—	Discharged.
4		7/9/30	—	—	No alopecia developed.
5		9/9/30	—	—	Mother had no milk, hence discharged.
6		16/9/30	22/9/30	6 days	Alopecia + diarrhœa. Died on 26/9/30.
7		Aborted on 16/9/30	—	—	Discharged.
8		Aborted on 16/9/30	—	—	Discharged.
1	Bitterkarroo + salt-bone-meal lick	18/8/30	—	—	Kid died on 22/8/30. Cause of death unknown Mother discharged.
2		—	—	—	Died on 27/8/30 from effects of bitterkarroo.
3		8/9/30	18/9/30	10 days	Alopecia + diarrhœa. Died on 30/9/30.
4		12/9/30	19/9/30	7 days	Alopecia. Died on 26/9/30.
5		16/9/30	27/9/30	11 days	One kid developed alopecia and recovered, whereas other one remained healthy.
6		19/9/30	23/9/30	4 days	Alopecia and diarrhœa. Killed *in extremis* on 27/9/30.
7		19/9/30	27/9/30	8 days	Alopecia + diarrhœa. Recovered.

Discussion.

From the above table it is evident that—

(*a*) five goats of the potassium iodide group aborted, and one of the bitterkarroo group;

(*b*) eleven out of thirteen experimental kids developed typical symptoms of alopecia, and of these eight died and one was killed *in extremis;*

(*c*) only one of the twin kids developed alopecia;

(*d*) the earliest case of alopecia appeared three days and the latest one eleven days after birth;

(*e*) death occurred two to twelve days after the appearance of symptoms; one kid died on the day alopecia was noticed;

(*f*) three pregnant goats died from the effects of the bitterkarroo and one was killed *in extremis.*

The appearance, course, symptoms and post-mortem appearances of alopecia, as it was noticed in the experimental kids, coincided completely with those encountered in the natural cases of the disease.

The mother goats, although well-fed, were much worse in condition and consumed much larger quantities of water than the fifteen animals in Experiment II, which, in addition to the " Bothablombos ", received the same amount of lucerne-hay and green barley as the goats in Experiment I.

EXPERIMENT II.

Polygala teretifolia, Thunb.

Common name: Bothablombos.

Fifteen pregnant Angora goats were placed in a pen erected about fifty yards away from that of Experiment I and received daily sixty pounds of the fresh flowering tops of the " Bothablombos " from 12.8.30 to 27.9.30. The animals picked off all the flowers and took very little of the leaves of the plant, with the result that they ingested only about thirty of the sixty pounds of plant offered them. As the animals steadily lost in condition they received twenty pounds of lucerne-hay and forty pounds of green barley in the afternoon.

The following experiments were conducted:—

(*a*) Bothablombos only: 5 goats.

(*b*) Bothablombos + 0·1 gram potassium iodide per head daily: 5 goats.

(*c*) Bothablombos + two tablespoonfuls of salt-bonemeal lick (1 : 2) per head daily: 5 goats.

Up to 1.9.30 two goats in (*b*), one in (*c*), and one in (*a*) aborted. These four animals were replaced by four pregnant goats on 1.9.30. On 5.9.30 another potassium iodide goat aborted. The rest of the goats gave birth to normal kids. At the time the experiment was discontinued there were ten kids ranging in age from two to five weeks. Both the kids and their mothers were in good condition and perfect health.

Discussion.

The fresh " Bothablombos " in the quantities fed had no deleterious effects on the experimental animals. Three potassium iodide goats, one salt-bonemeal goat, and one " Bothablombos " goat aborted.

EXPERIMENT III.

Twenty pregnant Angora goats, which daily received 0·1 gram potassium iodide from 12.8.30, were allowed to run with the flock. As a high percentage of abortions occurred in the animals receiving the potassium iodide, the quantity was reduced to 0·05 gram daily from 1.9.30. From this date onwards all the experimental animals in the potassium iodide groups received 0·05 grams per head.

Up to 14.9.30 five of the twenty goats aborted. At the time the experiment was discontinued, the fifteen remaining goats had kids ranging in age from eleven days to six weeks. Amongst these kids only one very light case of alopecia occurred.

EXPERIMENT IV.

Twenty pregnant Angora goats, each of which received daily 5 grams of sulphur, were allowed to run with the remainder of the flock.

On 27.9.30, when the experiment was discontinued, the kids ranged in age from twelve days to six weeks. Only one case of alopecia appeared amongst these kids. It is of interest to note that no abortions occurred in this group of animals.

Controls.

The rest of the flock of pregnant goats, numbering about three hundred, which had free access to a salt-bonemeal lick (1 : 2), was kept as controls.

As the owner was advised to keep the pregnant animals away from the "bitterkarroo" veld, the flock of pregnant goats were allowed to graze high up in the mountains during daytime, and only had the opportunity of feeding on the bitterkarroo, in the evening when they were brought home, and early in the morning when they were driven out.

This accounts for the extremely low percentage, namely, 2·4 per cent., of alopecia which occurred in the flock, of which two hundred and fifty had already kidded at the time the experiment was discontinued. Of these animals six had aborted, and amongst the kids only six cases of alopecia appeared.

The owner stated that in good years, such as 1930, up to 90 per cent., of his kids developed alopecia.

Cotyledon wallichii and *Cotyledon ventricosa* must be considered as a possible cause of the abortions in the control flock, as these two plants, especially the latter, grow luxuriantly on the mountain slopes. The author witnessed a number of cases of "krimpsiekte" in the control flock, and one goat had actually aborted twins during an attack of "krimpsiekte".

EXPERIMENTS CONDUCTED AT ONDERSTEPOORT.

Since it was established that *Chrysocoma tenuifolia* (bitterkarroo) is the cause of alopecia, which occurs so extensively in kids and lambs of mixed breeds in the Willowmore and neighbouring districts, it was decided to continue the investigations at Onderstepoort. The first point that had to be settled was whether the plant in the dry state was capable of producing the disease. This naturally was of the utmost importance, as it was the most important factor to determine whether or not it would be possible to conduct experiments at Ondersteporto. As will be seen in the course of the undermentioned experiments, the dried plant was found to produce the disease, and it was proposed to investigate the following points in connection with alopecia: :—

(*a*) The susceptibility of Merino lambs to alopecia.

(*b*) The age factor. This is a point of enormous practical and economical importance. How long before kidding must the pregnant goats and sheep be removed from the "bitterkarroo" veld in order to prevent alopecia? Experienced farmers maintain that no cases of alopecia will appear if the pregnant animals are removed from "alopecia veld" fourteen days before kidding and kept away from such veld until the kids are fourteen days old. This "time limit" could be easily determined by experiment. It will be realized that this "time limit" is of the utmost importance, as the feeding of thousands of pregnant animals involves large sums of money and frequently is impossible. It is, therefore, in the interest of the farmers concerned to know exactly how long to keep their animals away from "alopecia veld".

(*c*) Is the alopecia-toxin prepared in the system or is it contained as such in the plant?

(*d*) Does the "bitterkarroo" from "alopecia-free" areas also produce the disease? It is an interesting fact that alopecia only occurs in certain parts of the affected districts. In the Willowmore and Uniondale districts the disease is very prevalent in the mountainous parts, whereas it is of extreme rare occurrence on the even veld. The grazing on the "alopecia farms" is very poor, with the result that the animals have to rely to a large extent on the "bitterkarroo" for their food, whereas the veld of the "alopecia-free" farms is of a much superior quality. Is the quality of the veld or a difference in the toxicity of the responsible plant in different localities the determining factor in the occurrence of alopecia?

PRELIMINARY EXPERIMENTS.

Experiment I.

To ascertain whether the plant in the dry state will still produce alopecia.

Pregnant Angora goats obtained from the Willowmore districts were employed in these experiments. The "bitterkarroo" bush was collected in the flowering stage on the farm Skildpadbeen, and sun-dried and forwarded to Onderstepoort.

Goats 29207 and 29214 were starved for twenty-four hours and then offered the dried "bitterkarroo". As nothing was ingested during the following twenty-four hours, the dried bush was cut up coarsely and mixed with lucerne-hay. During the following three days the animals did not ouch the mixture. As a good milk-yield is essential for the production of alopecia, it was thought inadvisable to discontinue starvation, and drenching was resorted to in all the following experiments.

The above animals received daily (except Sundays) 400 grams of the dry plant from 27.10.30. On 8.11.30 No. 22907 aborted and was discharged. As the abortion was most probably caused by the "bitterkarroo", this was an indication that the animals were receiving too large quantities of the plant. Consequently goat 29215, together with goats 2906 and 29203, the latter two having been added to the experiment on 10.11.30, received daily (except Sundays), 200 grams of the plant until the date of lambing, when the dose was increased to 400 and 800 grams on alternate days.

Result.

Goat 29203.—This animal kidded on 30.11.30 (kid 29371). On 16.12.30 it accidently inspired some of the drenching material with fatal results. Up to the time of death this animal had received 12·4 kilograms of the dried plant in the course of five weeks without any deleterious effects.

Kid 29371 (born on 30.11.30).—9.12.30: Diarrhœa. 10.12.30: Diarrhœa with straining. At 2 p.m. the animal was noticed stamping with the hindlegs, swishing the tail, running about and biting at its sides and hindlegs. It was seen chewing and swallowing the hair which had been pulled out during the biting. On closer examination it was found that the hair over the shoulder-blade, the sides and the lateral aspects of the hindlegs could be removed very easily (see Fig. I). Temperature: 103·4° F. The animals keenly sought shade. Macroscopically the skin appeared perfectly normal.

11.12.30.—Diarrhœa. Sides almost completely hairless; hair on neck and back easily removable. Temperature: 103·8° F. Pronounced acute catarrhal conjunctivitis. Losing in condition. Pulse: 120, strong. Inappetence.

12.12.30.—Diarrhœa pronounced. Hairless areas on the skin on the sides are red, warm, painful, and swollen. Temperature: 103·6° F. Pulse: 124, strong. Inappetence.

13.12.30.—Diarrhœa pronounced. Losing in condition. Shedding of the coat continued. Acute catarrhal conjunctivitis. The hairless portion of the skin shows an acute dermatiis. Animal walking with stiff legs, as movement causes stretching of the inflamed skin with consequent pain. Temperature: 104·4° F. Animal shows symptoms of severe irritation of the skin. Pulse: 118, strong. Inappetence.

14.12.30, 15.12.30, 16.12.30.—Condition as on 13.12.30. As the mother goat 29203 died, on 16.12.30, the kid was handreared from this date onwards on cow's milk. Inappetence.

17.12.30.—Diarrhœa pronounced. Losing in condition and very apathetic. Moist dermatitis. Still shedding coat. A bilateral purulent conjunctivitis with the lids of the eyes glued together. An increased discharged from the nostrils. Temperature: 103·6° F. The inflamed skin over the lateral aspect of the thigh shows a dry crustaceous dermatitis with deep blood-stained cracks (see Fig. III). Pulse: 132, strong. Inappetence.

18.12.30.—Diarrhœa pronounced. Condition bad. Hairless portion of skin swollen, reddened, painful, and hard. Animal appears hidebound, stands with back arched and moves with difficulty. Temperature: 103·4 F. Pulse: 128, strong. Inappetence.

19.12.30, 20.12.30.—Condition as on 18.12.30. Animal almost hairless. Little hair left on the legs, back, and head. Diffuse crustaceous dermatitis. Inappetence.

21.12.30.—As on 20.12.30.

22.12.30.—New hair appearing on the first hairless patches. Diarrhœa pronounced, acute purulent conjunctivitis and rhinitis. Diffuse crustaceous dermatitis, with bleeding cracks. Temperature: 102·8° F. Not feeding. Condition very bad. Pulse: 124, strong.

The above-described skin lesions and symptoms culminated in death during the night of 26.12.30.

Post-mortem Appearances.—Almost complete hairlessness with new coat appearing on some parts of the skin; cachexia, anaemia; acute purulent conjunctivitis and rhinitis; acute crustaceous dermatitis, hyperaemia of the lungs and liver; marked atrophy of the spleen; hairballs in rumen [see Fig. IX (*a*)] and abomasum [see Fig. IX (*b*)], the latter completely obstructing the pyloric portion of the abomasum; acute catarrhall duodenitis, jejunitis and colitis; entire gastro-intestinal tract completely devoid of ingesta.

Goat 29214.—This animal gave birth to a normal kid (No. 29373) on 5.12.30. From 27.10.30 to 5.13.30 goat 29214 received 23·2 kilograms of the dry plant without developing any symptoms of ill-health.

Kid 29373 (born 5.12.30). 11.12.30.—Stamping with hind feet, swishing the tail, running about, and biting at external surface of hind legs. On closer examination the hair on the sides and external surfaces of the legs and to a slighter extent on the back can be easily removed. Temperature: 103·8° F. Pulse and respiration normal. No diarrhœa.

12.12.30.—Hairless patches on the sides and back. Temperature: 103·9° F. Animal exhibits symptoms of marked irritation of the skin. Biting at the sides, chewing and swallowing the extracted hair.

13.12.30.—As on 12.12.30.

14.12.30.—Sides and lateral aspect of the thighs completely hairless. The hairless portions of the skin show signs of inflammation.

15.12.30.—Diarrhœa. Shedding of coat progressing. Temperature: 103·4° F. Slight catarrhal conjunctivitis.

16.12.30.—Pronounced diarrhœa. Losing in condition. Alopecia progressing. Acute catarrhal conjunctivitis and rhinitis. Temperature: 103·4° F. Pulse: 118, strong.

17.12.30, 18.12.30, 19.12.30, 20.12.30.—Condition growing worse. Pronounced diarrhœa and loss in condition. Acute purulent conjunctivitis and rhinitis. Shedding of coat and dermatitis progressing. Temperature: 102·8° F. Pulse: 124, strong.

22.12.30.—Pronounced diarrhœa. New hair appearing on the hairless portion of the skin. From this date onwards there was steady improvement in the condition of the animal until complete recovery on 5.1.31.

TABLE II (Experiment I).

Dried Willowmore "Bitterkarroo".

Goat No.	Date on which dosage commenced.	Period of dosage.	Quantity of dry plant received.	Kid No.	Date of birth.	Date of appearance of alopecia symptoms.	Remarks.
29207	27/10/30	11 days	4 kg.	—	—	—	Aborted on 8/11/30.
29203	10/11/30	35 days	12·4 kg.	29371	30/11/30	9/12/30	Diarrhœa appeared on 9/12/30, and alopecia on 10/12/30. Kid died on 26/12/30.
29214	27/10/30	29 days	23·2 kg.	29373	5/12/30	11/12/30	Alopecia. Complete recovery had taken place on 5/1/31.
29205	10/11/30	33 days	12·6 kg.	29368	20/11/30	—	Goat No. 29205, was found dead on 11/12/30. Cause of death unknown. Kid developed on symptoms of alopecia.

Goat 29205.—This animal kidded on 20.11.30 (kid 29368). From 10.11.30 up to the time of death from an unknown cause on 11.12.30 it had received 12·6 kilograms of the dry "bitterkarroo".

Goat 29205 was in perfect health up to 11.12.30 and was found dead in the stable the next morning.

Post-mortem Appearance.—Heart in diastole with both ventricles markedly distended with coagulated blood; marked hyperaemia and slight oedema of the lungs; degenerative changes in the liver; at the junction of the intermediate zone and medulla of the kidney there was deposition of a gritty material; haemorrhages in the peritracheal tissues; a slight chronic duodenitis and jejunitis.

Histology.—Liver: Slight hyperaemia; severe fatty changes more marked at the peripheri. Kidneys: Marked fatty changes; peculiar bodies in medulla of unknown significance.

Kid 29368.—This animal remained perfectly healthy in spite of the fact that it was suckled by its mother, which was drenched in the same way as goats 29203 and 29214 for three weeks.

Discussion.

Four pregnant goats were employed in this experiment (Table II), with the result that two typical cases of alopecia in kids were produced. One animal aborted on the twelfth day of the experiment and one died from an unknown cause three weeks after it had given birth to a normal kid. It will be noticed from Table II that 12·4 kg. and 23·2 kg. of the dry plant sufficed to produce the disease, while in another case was 12·6 kg. apparently below the minimum toxic dose necessary for the production of the disease.

Experiment III.

To determine whether the Colesberg "bitterkarroo" (*Chrysocoma tenuifolia* Berg.) will produce alopecia in kids.

Table III (Experiment III).
Dried Colesberg "Bitterkarroo".

Goat No.	Date of which dosage commenced.	Period of dosage.	Quantity of dry plant received.	Kid No.	Date of birth.	Date of appearance of alopecia symptoms.	Remarks.
29208	3/11/30	2 days	800 g.m.	—	—	—	Developed a profuse diarrhœa on 4/11/30 and aborted on 10/11/30. Recovered after treatment.
29210	3/11/30	2 days	800 g.m.	—	—	—	Profuse diarrhœa on 4/11/30, and died during the night of 5/11/30.
29219	3/11/30	2 days	800 g.m.	—	—	—	Profuse diarrhœa on 4/11/30, and died during the night of 4/11/30.
29206	6/11/30	19 days	1·4 kg.	29357 29358	16/11/30	—	A profuse diarrhœa developed after the animal had received 200 gm. of the plant on two consecutive days. After treatment with limewater and raw linseed oil recovery took place. Subsequently the animal received 1,000 gm. as described in the experiment. One of the kids died on 17/11/30, and the other one had to be discharged as the mother had no milk.
29211	6/11/30	60 days	6·7 kg.	29374	6/12/30	—	The mother developed a diarrhœa which disappeared after treatment The kid developed no symptoms of alopecia up to 5/1/31.
29212	6/11/30	35 days	3·95 kg.	29370	30/11/30	—	Both mother and kid developed a diarrhœa. No symptoms of alopecia appeared.
29218	6/11/30	2 days	400 gm.	—	—	—	On 8/11/30, the animal developed a pronounced diarrhœa and died during the night of 9/11/30.

The plant was collected in the flowering stage during October on the farm Springfontein, Colesberg District. Another attempt was made to persuade the experimental animals to take the plant voluntarily, but this had to be abandoned, as after three days' starvation they still refused to take the fresh plant.

Goat 29208.—On each of two consecutive days this animal received 400 grams of the dry plant.

Result.—Six hours after the second dose the animal exhibited a profuse diarrhœa associated with pronounced straining, complete inappetence, and drowsiness. An almost hairless kid was aborted, with the result that the animal had to be discharged from this experiment. Respiration and pulse accelerated. On each of three consecutive days she received a mixture of 200 c.c. of lime-water and 100 c.c. of raw linseed oil, and had completely recovered in a week. The total quantity of dry plant received was 800 grams.

Goat 29210.—Received 400 grams of the dry plant on each of two consecutive days.

Result.—Six hours after the second dose a profuse diarrhœa set in. Tympanites, apathy, salivation, straining, and an accelerated pulse and respiration were the most outstanding symptoms. A mixture of 200 c.c. of limewater and 100 c.c. raw linseed oil was of no avail, death occurring sixty hours after the commencement of the experiment. The total quantity of dry plant received was 800 grams.

Post-mortem Appearances.—General cyanosis; numerous subepicardial haemorrhages; heart in diastole and the ventricles and auricles distended with coagulated blood; hyperaemia and oedema of the lungs; hyperaemia of the liver; atrophy of the spleen; an acute catarrhal gastro-enteritis. The uterus contained an almost mature foetus.

Goat 29219.—This animal, after having received 400 grams of the dry plant on each of two consecutive days, developed the above-described symptoms and died 40 hours after the commencement of the experiment. The total quantity of dry plant received was 800 grams.

Post-mortem Appearances.—General cyanosis; heart in diastole and both ventricles distended with coagulated blood; numerous subendocardial haemorrhages in left ventricles; hyperaemia and slight oedema of the lungs; hyperaemia of the liver; haemorrhages in the abomasum; an acute catarrhal enteritis.

The uterus contained an almost mature foetus.

As the Colesberg "bitterkarroo" proved to be more toxic than the Willowmore specimen, the following pregnant goats were drenched with smaller quantities of the plant.

Goat 29206—

6.11.30.—200 grams of the dry plant.

7.11.30.—200 grams of the dry plant.

8.11.30.—Pronounced diarrhœa and other symptoms as previously described. Treated with raw linseed oil and limewater.

9.11.30.—Marked improvement. Again treated.

10.11.30.—Completely recovered.

11.11.30–16.11.30.—50 grams of dry plant daily.

16.11.30.—Twin kids born (Nos. 29357 and 29359).

17.11.30.—100 grams of the dry plant.

18.11.30.—100 grams of the dry plant.

19.11.30.—Slight diarrhœa; inappetence and apathy; 100 grams of the dry plant.

20.11.30.—Profuse diarrhœa; treated with raw linseed oil and limewater as previously described.

21.11.30.—Recovering.

22.11.30.—Completely recovered; 100 grams of the dry plant.

23.11.30–25.11.30.—100 grams of the dry plant daily.

The animal was in a poor condition with a consequent low milk yield, with the result that she had to be discharged from the experiment.

The total quantity of dry plant received was 1,400 grams in the course of nineteen days.

Kid 29357.—This animal, together with kid 29368, had to be partly hand-reared as their mother (goat 29206) had very little milk. As was expected on account of the little mother's milk obtained, this kid developed no symptoms of alopecia.

Kid 29358.—It died twenty-four hours after birth, the post-mortem revealing an acute catarrhal duodenitis and jejunitis.

Goat 29211—

6.11.30.—200 grams of the dry plant.

7.11.30.—200 grams of the dry plant.

8.11.30.—Diarrhœa with the accompanying symptoms.

9.11.30-10.11.30.—Treated with raw linseed oil and limewater as previously described.

11.11.30.—Completely recovered.

11.11.30-5.12.30.—50 grams of the dry plant daily.

6.12.30.—Gave birth to a normal kid (No. 29374); 300 grams of the dry plant.

8.11.30.—300 grams of the dry plant.

9.11.30.—400 grams of the dry plant.

10.12.30.—400 grams of the dry plant.

11.12.30.—Pronounced diarrhœa with the accompanying symptoms; received a mixture consisting of 40 c.c. raw linseed oil, 100 c.c. limewater, and 1 gram tannic acid.

12.12.30.—Pronounced improvement.

13.12.30.—Pronounced improvement.

14.12.30.—Completely recovered.

15.12.30.—300 grams of the dry plant.

17.12.30.—Slight diarrhœa.

18.12.30.—Slight diarrhœa; 200 grams of the dry plant.

19.12.30.—Slight diarrhœa.

20.12.30.—300 grams of the dry plant.

22.12.30.—300 grams of the dry plant.

23.12.30.—300 grams of the dry plant.

24.12.30.—300 grams of the dry plant.

27.12.33.—300 grams of the dry plant.

29.12.30-5.1.31.—Daily 300 grams of the dry plant.

The animal received a total of 6·7 kilograms of the dry plant in the course of two months.

Kid 29374.—It developed no symptoms of alopecia.

Goat 29212—

6.11.30.—200 grams of the dry plant.

7.11.30.—200 grams of the dry plant.

8.11.30.—Diarrhœa with its accompanying symptoms; treated with a mixture of raw linseed oil, limewater and tannic acid as described before.

9.11.30.—Improved; again treated.

10.11.30.—Improved; again treated.

11.11.30.—Complete recovery.

11.11.30-30.11.30.—50 grams of the dry plant daily.

30.11.30.—Gave birth to a normal kid (No. 29370).

1.12.30.—150 grams of the dry plant.

2.12.30.—150 grams of the dry plant.

3.12.30-10.12.30.—300 grams of the dry plant daily.

11.12.30.—Pronounced diarrhœa with its accompanying symptoms; treated with a mixture of raw linseed oil, limewater, and tannic acid.

12.12.30.—Marked improvement.

13.12.30.—Improving.

14.12.30.—Complete recovery, but poor in condition with a consequent low milk yield.

As this animal was in such a poor condition, it was decided to discontinue the drenching. It received 3·95 kilograms of the dry plant in the course of thirty-five days.

Kid 29370 (born on 30.11.30).—On 13.12.30 the kid developed a pronounced diarrhœa and showed apathy and inappetence. From 15.12.30 rapid improvement set in until complete recovery on 17.12.30.

No symptom of alopecia appeared.

Goat 29218—

6.11.30.—200 grams of the dry plant.

7.11.30.—200 grams of the dry plant.

8.11.30.—Pronounced diarrhœa and listlessness, pulse extremely accelerated and weak; respiration hurried.

9.11.30.—Died previous night.

Post-mortem Appearances.—Advanced decomposition; an acute catarrhal gastro-enteritis; an almost full-grown foetus in uterus.

Result.

Seven pregnant goats were engaged in this experiment (Table III). The Colesberg "bitterkarroo" proved to be much more toxic than the Willowmore variety, with the result that one animal aborted and three died. The milk yield of two of the goats was very low. Unfortunately the conclusions concerning alopecia in this experiment have to be drawn from one case (No. 29211) only, and this was negative.

In the case of kid 29370 (mother goat 29212) a pronounced diarrhœa developed at the age of twelve days, and had the drenching of its mother not been discontinued from the fourth day after birth, the possibility exists that it would have developed alopecia, as diarrhœa sometimes precedes the shedding of the hair.

EXPERIMENT IV.

To ascertain whether it is possible to produce alopecia in kids by drenching their mothers from the day of parturition.

Goat 29215.—Kidded on 13.11.30 (kid 29355). From 13.11.30 to 8.12.30 this animal received 11·6 kilograms of the dry Willowmore "bitterkarroo".

Kid 29355.—It developed no symptoms of alopecia.

Goat 29209.—Kidded on 15.11.30 (Kid 29356).

15.11.30 to 9.12.30 this goat received 11·2 kilograms of the Willowmore "bitterkarroo".

Kid 29356.—It developed no symptoms of alopecia.

Result.

From the above it would appear that for the production of alopecia in kids it is necessary that they be exposed to the effects of the toxin during a part of their intra-uterine life. This point will be discussed at the conclusion of this article.

EXPERIMENT V.

To determine whether alopecia can be produced in kids by drenching them with the Willowmore "bitterkarroo".

Kid 29246 (Mother 29216).—This animal, which was born on 1.11.30, received the following amounts of the dry plant.

5.11.30–8.11.30.—10 grams daily.
10.11.30.—15 grams daily.
14.11.30.—20 grams.
15.11.30.—20 grams.
17.11.30.—25 grams.
18.11.30.—25 grams.
19.11.30.—30 grams.
20.11.30.—30 grams.
21.11.30.—35 grams.
22.11.30.—40 grams.
24.11.30.—45 grams.
25.11.30.—50 grams.
26.11.30.—50 grams.
27.11.30.—60 grams.
28.11.30.—80 grams.
29.11.30.—90 grams.
1.12.30.—100 grams.
2.12.30.—100 grams.
3.12.30–8.12.30.—120 grams daily.

It, therefore, received 1·62 kilograms of the dry plant in the course of thirty-four days.

Result.

Complete negative.

Kid 29361 (mother 29217).—It was born on 15.11.30 and was drenched with the following amounts of the dry Willowmore "bitterkarroo".

19.11.30.—10 grams.
20.11.30.—10 grams.
21.11.30.—15 grams.
22.11.30.—20 grams.
24.11.30.—25 grams.
25.11.30.—30 grams.
26.11.30.—30 grams. Slight diarrhœa.
27.11.30.—30 grams. Slight diarrhœa.
28.11.30.—40 grams. Diarrhœa improving.
29.11.30.—50 grams. Diarrhœa worse.
1.12.30.—60 grams. Diarrhœa improving.
2.12.30.—60 grams. Diarrhœa improving.
3.12.30.—80 grams. Complete recovery.
4.12.30.—80 grams. Vomited after being drenched.
5.12.30.—100 grams. Vomited after being drenched.
6.12.30.—80 grams. Vomited after being drenched.
8.12.30.—80 grams. Vomited after being drenched.
9.12.30.—80 grams. Vomited after being drenched.
10.12.30.—80 grams. Vomited after being drenched.
11.12.30.—100 grams. Vomited after being drenched.
12.12.30.—100 grams. Vomited after being drenched.
13.12.30.—100 grams. Vomited after being drenched.
15.12.30.—100 grams. Vomited after being drenched.

This kid received 1·36 kilograms of the dry plant during a period of twenty-six days without developing any symptoms of alopecia, the only noticeable ill-effect being a transitory diarrhœa. Emesis was probably due to the large amount of fluid given.

Result.

None of the kids developed symptoms of alopecia, in spite of the fact that they received maximum amounts of the dry plant over a long period.

EXPERIMENT VI.

To ascertain whether Merino lambs are susceptible to alopecia.

For this purpose four pregnant Merino ewes were drenched with the dry Willowmore "bitterkarroo". The dry plant as such was offered to the sheep, but was refused. Small quantities were then mixed with dry lucerne-hay, but still the animals bluntly refused to take any of the mixture. Hence it was resorted to drenching.

As nothing was known about the effects of the plant on Merino sheep, it was decided first to determine these before commencing the actual experiment. To this end sheep 38412 was drenched with the dry plant.

Sheep 38412—

13.10.30—400 grams.
14.10.30.—400 grams.
15.10.30.—400 grams.
16.10.30.—400 grams in the morning and 400 grams in the afternoon.
17.10.30.—400 grams in the morning and 400 grams in the afternoon.
18.10.30.—Slight diarrhœa. 400 grams.
20.10.30.—400 grams in the morning and 400 grams in the afternoon. Slight diarrhœa.
21.10.34.—400 grams; diarrhœa; listlessness; accelerated pulse and respiration; thirst.

TABLE IV (Experiment VI).

The Effect of Willowmore "Bitterkarroo" on Merino Ewes and their Lambs.

Ewe No.	Date on which dosage commenced.	Period of dosage.	Quantity of dry plant received.	Lambs No.	Date of birth.	Date of appearance of alopecia symptoms.	Remarks.
29199	27/10/30	6 days	2·8 kg.	29243	29/10/30	—	On 1/11/30, the ewe developed a diarrhœa and died on 3/11/30. Lamb developed no symptoms of alopecia.
29196	29/10/30	7 days	2·8 kg.	29242	3/11/30	—	On 5/11/30, a slight diarrhœa set in, which disappeared after treatment. On 8/11/30, another 200 grams of the plant were given with the result that diarrhœa again developed. On account of the lamb had to be discharged from the experiment on 17/11/30. On the morning of 19/11/30 the ewe was found dead.
29197	29/10/30	7 days	2·8 kg.	29241	3/11/30	—	On 5/11/30 diarrhœa developed and, in spite of treatment, death accurred on 8/11/30. The lamb died from a bilateral acute lobar pneumonia during the night of 13/11/30, without having developed any symptoms of alopecia.
29195	29/10/30	7 days	2·8 kg.	Not numbered	4/11/30	—	Ewe had no milk and was discharged from the experiment. It developed an acute diarrhœa on 6/11/30, and died during the night of 7/11/30. The lamb was found dead on the morning of 6/11/30.

22.10.30.—400 grams in the morning and 400 grams in the afternoon; diarrhœa pronounced.

23.10.30.—Pronounced diarrhœa and straining; general weakness; pulse extremely accelerated; respiration hurried; losing condition; drenching discontinued.

These symptoms culminated in death during the night of 25.10.30.

Post-mortem Appearances.—Decomposition too advanced to discern any definite lesions.

Result.

The animal developed a slight diarrhœa after having received 2·8 kilograms of the dry plant in the course of five days. The doses for the pregnant animals were based on the effects of the above quantities of the plant on this sheep. In order to be able to draw definite conclusions from the results of this experiment the ewes will have to receive maximum quantities of the plant. As the above sheep apparently tolerated 2·8 kilograms of the dry plant given in five days with very slight ill-effects, it was decided to give the pregnant ewes 400 grams daily.

Ewe 29199—

27.10.30.—400 grams.

28.10.30.—400 grams.

29.10.30.—400 grams. Gave birth to a normal lamb (No. 29243).

30.10.30.—400 grams.

31.10.30.—400 grams in the morning and 400 grams in the afternoon.

1.11.30.—400 grams; slight diarrhœa in the afternoon.

2.11.30.—Diarrhœa; salivation; pronounced thirst; straining; accelerated pulse and respiration.

3.11.30.—Died.

Post-mortem Appearances.—General cyanosis; numerous sub-epicardial haemorrhages; degeneration of myocard; hyperaemia and slight oedema of the lungs; pronounced degeneration of the liver and kidneys; atrophy of the spleen; pronounced acute catarrhal enteritis affecting the whole of the small and big intestine.

Lamb 29243 (born 29.10.30).—It was suckled by its mother for five days only, and as a result of her death it had to be fed on cow's milk.

Result.

No symptoms of alopecia developed.

Ewe 29196—

29.10.30–4.11.30.—400 grams daily.

3.11.30.—Gave birth to a normal lamb (No. 29242).

5.11.30.—Slight diarrhœa; treated with a mixture of limewater and raw linseed oil.

6.11.30.—Diarrhœa; treated as above.

7.11.30.—Recovered.

8.11.30.—200 grams.

10.11.30.—Diarrhœa; limewater and raw linseed oil.

11.11.30.—Diarrhœa improving, but condition poor.

12.11.30.—Milk yield very low; condition poor.

13.11.30–14.11.30.—Milk yield very low; condition poor.

This animal, with its lamb, No. 29242, were discharged on 17.11.30, as it had very little milk. On the morning of 19.11.30 it was found dead.

Post-mortem Appearances.—Anaemia; cachexia; hyperaemia; oedema and emphysema of the lungs, with a large amount of coagulated blood in the bronchi and trachea; heart in systole.

Lamb 29241 (born on 3.11.30).—As its mother (Ewe 29196) had very little milk, it had to be partly hand-reared.

Result.

This animal developed no symptoms of alopecia.

Ewe 29197—

29.10.30-4.11.30.—400 grams daily.

3.11.30.—Gave birth to a normal lamb (No. 29241).

5.11.30.—Slight diarrhœa; treated with a mixture of limewater and raw linseed oil.

6.11.30.—Diarrhœa; treated as above.

7.11.30.—Diarrhœa; treated as above.

8.11.30.—Pronounced diarrhœa; vomiting; apathetic; accelerated and weak pulse; hurried respiration.

Died at 9 a.m.

Post-mortem Appearances.—General cyanosis; marked hydrothorax; both ventricles of the heart distended with coagulated blood; hyperaemia and oedema of the lungs with ruminal contents in the trachea and bronchi; slight haemonchosis; an acute catarrhal enteritits affecting both the small and big intestine.

Histology.—Heart, liver, spleen, and kidneys: Negative.

Lamb 29241.—Died from a bilateral acute lobar pneumonia during the night on 13.11.30 without having developed any symptoms of alopecia.

Ewe 29195—

29.10.30-4.11.30.—400 grams daily.

4.11.30.—Gave birth to a normal lamb. Animal was discharged from the experiment, as it had no milk.

On 6.11.30 it developed a diarrhœa, and in spite of treatment with limewater and raw linseed oil it died during the night of 7.11.30.

Post-mortem Appearances.—General cyanosis; hyperaemia and oedema of the lungs; slight hydroperitoneum and hydrothorax; both auricles and ventricles of the heart distended with coagulated blood; atrophy of the spleen; acute catarrhal abomasitis duodenitis, typhlitis and colitis; a croupous jenunitis.

Histology.—Liver, heart, spleen, and kidney: Negative.

Lamb (died before it was numbered).—It was found dead on the morning of 6.11.30, and the post-mortem revealed an acute catarrhal gastritis.

Result.

The results of this experiment as far as alopecia is concerned are inconclusive, owing to the fact that the quantities of the plant given had pronounced toxic effects on the sheep, with the result that they either had very little or no milk for the lambs or died. The dry plant proved to be more toxic to sheep than to goats.

The Effects of Potassium Iodide on Pregnant Angora Goats.

It is of interest to submit on the next page a table of the abortions which occurred in the experimental groups of Angora goats receiving potassium iodide. The calculations of the daily doses of potassium iodide for the pregnant goats was based upon the work of Kelly* (1925).

* Kelly, F. C. (1925): The Influence of Small Quantities of KI on the Assimilation of N.P. and Ca in the Growing Pig. *Biochem. Jnl.*, 19, 559-568.

TABLE V.

Effects of Potassium Iodide on Pregnant Angora Goats.

Goat No.	Amount of Potassium Iodide per day.	Period of dosage.	Total amount of Potassium Iodide received.	Additional treatment.	Date dosage with Potassium Iodide was commenced.	Date of abortion.
	Grams.	Days.	Grams.			
1	0·1	8	0·8	Ingested daily approximately 4 lb. of "bitterkarroo" per head (figures from the Willowmore Experiment I)	12/8/30	19/8/30
2	0·1	9	0·9		12/8/30	20/8/30
3	0·1	12	1·2		12/8/30	23/8/30
4	0·05	16	0·8		1/9/30	16/9/30
5	0·05	16	0·8		1/9/30	16/9/30
6	0·1	10	1·0	Ingested daily approximately 2 lb. of flowers and leaves of Bothablombos (figures from the Willowmore Experiment II)	12/8/30	21/8/30
7	0·1	12	1·2		12/8/30	23/8/30
8	0·05	16	0·8		1/9/30	16/9/30
9	0·1	17	1·7	These animals belong to the group of 20 pregnant goats which were running with the remainder of the flock (figures from the Willowmore Experiment III)	12/8/30	28/8/30
10	0·1	20	2·0		12/8/30	1/9/30
11	0·1 gm. from 12/8/30–31/8/30 0·05 gm. from 1/9/30–11/9/30	31	2·55		12/8/30	11/9/30
12	0·1 gm. from 12/8/30–31/8/30 0·05 gm. from 1/9/30–14/9/30	34	2·7		12/8/30	14/9/30
13	0·1 gm. from 12/8/30–31/8/30 0·05 gm. from 1/9/30–14/9/30	34	2·7		12/8/30	14/9/30

The facts contained in the above table must be viewed in the light of the following information. The total number of pregnant goats employed in Experiment I was twenty-four and of these eight received potassium iodide. Of these twenty-four animals six aborted, five of which were engaged in the potassium iodide group and one in the salt-bonemeal group. Hence the abortions in the the Bothablombos group. The abortions in the potassium iodide group therefore amounted to 43 per cent., whereas in the rest of the animals in Experiment II they amounted to 10·5 per cent.

In Experiment II nineteen pregnant goats were engaged and of these seven belonged to the potassium iodide group. Of the seven potassium iodide animals three aborted, whereas in the rest of the animals one abortion occurred in the salt-bonemeal group and one in the Bothalombos group. The abortion in the potassum group therefore amounted to 43 per cent., whereas in the rest of the animals in Experiment II they amounted to 10·5 per cent.

In Experiment III twenty pregnant goats, which received potassium iodide as described before, were allowed to run with the flock of pregnant goats. Of these animals five aborted, the percentage of abortions being 25 per cent.

The twenty pregnant goats receiving 5 grams of sulphur daily, and running with the twenty potassium iodide goats in the same flock, as well as the flock of three hundred pregnant goats, served as controls to the animals receiving potassium iodide. No abortions occurred in the sulphur group, whereas only six occurred in the flock of three hundred pregnant goats.

From the above it is evident that the percentage abortions in the potassium iodide-bitterkarroo group in comparison with the other potassium iodide groups is abnormally high. As the bitterkarroo itself is inclined to produce abortions this high percentage is quite conceivable.

With regard to the abortions in the flock cotyledonosis must be taken into consideration.

Discussion.

It has been definitely proved both during the course of field experiments in the Willowmore district and at Onderstepoort that *Chrysocoma tenuifolio* is the cause of alopecia in kids and the lambs of cross-breeds of sheep. This plant is ingested by the pregnant and lactating animals and the " toxin " producing alopecia eliminated in the milk, which is ingested by the kids and lambs. It is in this way that the latter animals contract alopecia. Furthermore, it has been shown that the sun-dried plant is also capable of causing the disease. In the experimental animals the earliest case of alopecia occurred in a three-day-old kid and the latest case in an eleven-day-old kid.

Prevention.

In order to prevent the disease it is obvious that the pregnant and suckling animals should be kept away from veld where there is luxurious growth of the " bitterkarroo ". On farms where the mountain grazing is of a good quality, and where there is a sufficient water

supply for the growing of green foodstuffs, this method of preventing the disease can be applied with great success. The position is different on farms where the above conditions do not exist. It is on the latter farms that the owners completely discontinued kidding and lambing, as they suffered losses up to 100 per cent.

It was previously mentioned that many farmers combat the disease with great success by removing the pregnant animals from " bitterkarroo-veld " fourteen days before kidding and lambing and not returning them to such veld before the kids and lambs are fourteen days old. There is no experimental evidence to bear this out, but both from field observations and experimental results it appears that after the age of fourteen days kids and lambs will not, or very rarely, develop the disease. Very few cases are known where three and four weeks' old kids and lambs suffered from alopecia.

Another method practised by farmers with a fair degree of success in preventing alopecia is the partly milking of the suckling goats and ewes. This milk is taken by the natives without any deleterious effects.

The Susceptibility of the Young of Different Classes of Stock to Alopecia.

Up to the present alopecia has been known to occur only in kids and lambs of Blackhead Persians and all cross-breeds of sheep. No cases have been reported in Merino lambs or any species of domestic animals, except those mentioned in Merino lambs by Van Rensburg (1925). Nothing definite can be said concerning the susceptibility of Merino lambs to alopecia, as no Merino sheep are kept in the alopecia areas. The results of the experiment conducted at Onderstepoort to determine the susceptibility of Merino lambs to alopecia are inconclusive.

The Susceptibility of Full-grown Sheep and Goats to the Effects of the " Bitterkarroo ".

Merino ewes proved to be more susceptible than Angora goats. A noteworthy fact is that in the course of the Willowmore experiments it was found that when the fresh flowering " bitterkarroo " alone was fed to the Angora goats at the rate of four pounds per head per day the animals developed a fatal diarrhœa, whereas the same amount of plant, when supplemented by lucerne-hay and green barley, had no ill-effects, with the exception of loss in condition. It might be stated that at Onderstepoort excellent results were obtained by treating the diarrhœa with a mixture of 100 c.c. raw linseed oil, 100 c.c. limewater and 1·0 gram tannic acid. Both at Willowmore and at Onderstepoort a large number of animals, which suffered from diarrhœa caused by the " bitterkarroo ", were treated with limewater and raw linseed oil, and with a mixture of limewater, raw linseed oil and tannic acide and the latter mixture was found to be far superior to the former.

The Direct Effects of the "Bitterkarroo" on Kids.

Two four-day-old kids were drenched daily with comparatively large amounts of the dry plant without any apparent ill-effects, one of the kids showing a slight transient diarrhœa. No symptoms of alopecia developed. From these results it appears that either (*a*) the "alopecia-toxin" is not present as such in the plant, but has to be formed or modified by the mother goat or ewe, or (*b*) for the appearance of alopecia it is essential that the "alopecia-toxin" must act on the fœtus for a certain period, or (*c*) the amount of plant given, although maximum quantities were administered, was too small. In the last case it must be remembered that the mother-goats consumed approximately four pounds of the fresh plant per head per day and the possibility exists that the "alopecia-toxin" might be excreted in the milk in a concentrated solution. It is obvious that such enormous amounts of plant cannot be administered to kids and lambs.

In this connection it might be stated that two goats were drenched for twenty-five days with the dry plant from the day they kidded and their young did not develope alopecia.

The Relative Toxicity of the Colesberg and Willowmore "Bitterkarroo" to Full-grown Angora Goats.

Both varieties of the plant were utilized in the dry state and in the flowering stage. The Colesberg variety proved to be much more toxic than that obtained from Willowmore. The only noticeable difference in the two varieties was that the Colesberg plant showed a much more luxuriant growth than the Willowmore variety. The rainfall three months prior to the collection of the plant was much higher in the Willowmore than in the Colesberg District. The soil on which the "bitterkarroo" was collected in the Colesberg District is of a much superior quality than that of the farm on which the Willowmore plant was collected.

The Relation between Alopecia and the Diarrhœa.

In a number of cases of alopecia in kids and lambs the alopecia was preceded by a diarrhœa, but in the great majority of cases, alopecia was the first noticeable symptom. Apparently the cause of diarrhœa in the kids and lambs is a two-fold one, namely, a toxin contained in the "bitterkarroo" plant and excreted in the milk and one caused by the mechanical irritation of the ingested hair. After the appearance of alopecia these two factors will act as synergists. Most probably the above toxin is also responsible for the diarrhœa in the full-grown goats and sheep. Whether this "diarrhœa-producing toxin" is identical with the "alopecia-producing toxin" is an open question. The "diarrhœa-producing toxin" complicates the alopecia experiments, as large amounts of the plant have to be given in order to produce the disease, and on the other hand a sub-toxic dose must be given, as it is essential for the suckling sheep and goats to have a high milk-yield.

Potassium Iodide and its Relation to Abortion.

A summary of the abortions in all the different experiments at Willowmore and in the controls is given in Table VI.

Conclusions.

(1) *Chrysocoma tenuifolia* Berg. (" bitterkarroo "), has been established as the cause of alopecia in kids and lambs. The " toxin " is eliminated through the milk.

(2) The disease can be successfully prevented by avoiding *Chrysocoma tenuifolia* veld for a period of fourteen days prior to, and after kidding and lambing.

(3) Up to the present alopecia has been known to occur in kids of all breeds of goats, and all cross-breeds of sheep. Cases in Merino sheep have been reported.

(4) *Chrysocoma tenuifolia* when ingested in large quantities produces abortions in pregnant sheep and goats as well as symptoms of severe gastro-intestinal irritation.

(5) Two four-day old Angora kids drenched with large amounts of *Chrysocoma tenuifolia* for a period of twenty days developed no symptoms of alopecia.

Table VI.

The Effect of Potassium Iodide on Pregnant Angora Goats.

Exp. No.	Number of goats in experiment.	Number of goats which received KI.	Total number of goats which received KI.	Number of KI goats which aborted.	Total Number of KI goats which aborted.	Total Number of goats in the experiment — controls.	Percentage abortions in KI groups.	Percentage abortions in rest of experimental goats and controls.
I	24	8	35	5	13	383	37	2·3
II	19	7		3				
III	20	20		5				
IV	20	None (all received sulphur)		None				

(6) The Colesberg *Chrysocoma tenuifolia* was found much more toxic to sheep and goats than the Willowmore variety.

(7) A point to be investigated is the relation between the " diarrhœa-toxin " and " alopecia-toxin " contained in *Chrysocoma tenuifolia*.

(8) The abortions in the goats receiving potassium iodide amounted to 37 per cent., whereas in the rest of the experimental animals and the controls they amounted to 2·3 per cent. only.

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LITERATURE.

Reko (1928) described a disease in horses, mules, cattle, sheep and goats occurring in the southern parts of the United States of America, in the course of which the animals shed their coat. In advanced cases of this disease there is pronounced inflammation of the joints, which ultimately causes death. Stock-owners incriminate the " loco-weed " *(Astragalus lambertii, Astragalus molissimus* and *Cystium diphysium)*. Reko has not seen the disease where *Astragalus* sp. do not occur.

A similar disease occurs in Mexico in animals which ingest *Tamarindus indica* over long periods. As soon as the animals are prevented from feeding on the plant the hair commences growing. The aborigines of South Mexico daily partake of the ground Tamarindus seeds to depilate themselves.

These seeds are used to breed the small hairless Chihuahua dogs. Pneumonia and dropsy frequently are the cause of death in these hairless animals.

Furthermore, thallium salts are active poisons and may lead to alopecia (Ward, 1930). Since 1930 thallium has been used in America as a proprietary rat-poison and thallium poisoned grain for the control of prairie dogs, with the result that many losses have occurred in sheep due to the ingestion of this poisoned grain. It was found that sub-lethal doses of thallium down to 9 milligrams per Kg. body-weight cause alopecia in sheep.

Landauer (1931) found that treatment of mature cockerels and pullets with thallium acetate is followed by a diffuse loss of feathers. Thallium poisoning is furthermore referred to by Buschke and Peiser (1932), Ginsberg and Nixon (1932), Landauer (1931), Leschke (1931), Ward (1930), and others.

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