Investigations into the Cause of Vomeersiekte in Sheep.

By P. J. DU TOIT, B.A., Dr.Phil., Dr. Med. Vet., Deputy-Director of Veterinary Education and Research, Onderstepoort.

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I.—INTRODUCTION.

Fifty years ago, the first Colonial Veterinary Surgeon, Professor Branford, was appointed by the Government of the Cape of Good Hope, and one of the first diseases to come to his notice (in 1876) was that known to the farmers as Vomeersiekte (vomiting disease). The disease appears to have been particularly severe in the Victoria West and surrounding districts. One farmer reported a loss of 350 out of 2,500 sheep, and on another farm (Bokkepoort) where the disease was supposed to have made its first appearance some twelve or thirteen years earlier, that is, about 1864, the owner stated that in one season he lost 1,500 sheep from Vomeersiekte.

The farmers at that time do not seem to have had a very clear conception regarding the nature and cause of the disease. In a letter, replying to a number of questions put by Branford, dated 16th June, 1877, and signed by 24 farmers, it is stated that: "*the general opinion amongst the Boers is that vomit sickness is caused by the sheep eating fine or very young grass, which when scarce, they are seen scratching the ground away with their feet so as to get at the roots, eating which they also eat sand which causes stoppage in the bowels.*" Branford himself was not able to shed much more light on the cause of this disease.

II.—EARLY EXPERIMENTAL WORK.

In 1880 Dr. Hutcheon was appointed Colonial Veterinary Surgeon and in 1884 he encountered the first cases of Vomeersiekte. It is of interest to note that in his report for the year 1884 Dr. Hutcheon refers to the plant *Geigeria passerinoides*, Harv. (1) as "Vomeerbos-

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* The experiments at Boetsap were undertaken in collaboration with Sir Arnold Theiler and Dr. H. H. Green, and those at Donderbosfontein in collaboration with Dr. P. R. Viljoen, to all of whom the writer wishes to tender his heartiest thanks.

(1) Dr. E. P. Phillips, Senior Botanist of the Division of Botany, Pretoria, has kindly written the following note on the genus *Geigeria*, Griessel., for this report.

The genus *Geigeria* was founded by Griesselich in 1830 on a plant collected near Beaufort West and which was named *G. africana*. This is described as an acaulescent plant similar to *G. passerinoides*, but differing from that species by having all the pappus scales awned. It may not be out of place to remark here that no plant answering to the description of the type species has been seen in any of the South African herbaria, which makes one suspect that *G. africana* and *G. passerinoides* are co-specific. A Rhodesian plant examined exhibits the pappus characters of *G. africana* but is hardly likely to be that species.

In 1864-65 Harvey, in the *Flora Capensis*, published the descriptions of nine species, of which he was the author of eight. Here again it is remarkable

that in the South African herbaria much diversity of opinion and confusion exists as to what constitutes these species of Harvey. His species *G. zeyheri* and *G. burkei* one is now able to recognize, as the type specimens have been examined, but without seeing the type specimens of *G. aspera* and *G. protensa* it is impossible to state definitely the plants to which Harvey applied these names.

In 1893 Schinz (*Bull. l'Herb.* Boiss.) described nineteen species, several of which he described himself. He still retains all the species described in the *Flora Camensis*.

R. Muschelr (Engl. Bot. Jahrb.) in 1912 gives a key to all the known species and mentions thirty-one species. Many of these from South-West Africa he describes as new.

Thonner in 1915 ("Flowering Plants of Africa"), without giving any reasons, however, reduces the number of known species to twenty.

From an examination of all the material available in the South African herbaria it is now possible to recognize twenty-five distinct species, but this number will probably have to be increased by the inclusion of three or four species described from South-West Africa which are not represented in local herbaria.

The genus has proved an exceptionally troublesome one as no well-defined characters are found in the inflorescence which can be used to separate the various species, and to a very large extent reliance must be placed on vegetative characters in conjunction with distribution, to recognize them.

The general generic characters which define the genus are as follows:—

Flowers in heads. *Involucral-bracts* in several rows; the outer produced into long or short foliaceous appendages; the inner lanceolate and usually ciliated above. *Receptacle* flat, convex, or conical, covered with long hairs. *Ray-florets* present, very rarely absent, female. *Disc-florets* tubular, often glandular without. *Anthers* tailed at the base. *Ovary* villous; style-branches linear, obtuse. *Pappus* of ten to fourteen scales; the alternate awned, more rarely with all the scales awned or with awns absent.

Woody plants of various habit, some species being acaulescent, some shrubs up to 3 ft. high; leaves linear to linear lanceolate, obtuse or strongly mucronate, usually entire, glabrous, scabrid or glandular-hirsute, often punctate, sometimes produced at the base into very evident stem wings; heads terminal axillary, solitary or in groups, very often arising in the forks of the branches.

The species *G. passerinoides*, Harv., known as the "Vomeer bos," is the one of economic interest. Over fifty herbarium sheets, all labelled *G. passerinoides* have been examined and there appears to be little doubt that plants of different growth forms will now have to be included under this species. The extreme dwarf form of the species is represented by specimens collected by Mogg at Vryburg (Mogg 7927), while a well-branched form is represented by specimens (Viljoen in Nat. Herb. 2878) collected at Boetsap, in the Barkly West District. There is found all stages in habit between these two forms. Two species recently described from South-West Africa must be included in the group known under the specific name of *passerinoides*. From an examination of herbarium material alone one was led to think that the flower-heads which are situated at the crown of the short stem were those of one season while those on the branches represented flower-heads of the following season. Observations kept on plants raised from seed collected at Boetsap proved this supposition to be incorrect, as the flower-heads both at the crown of the main stem and on the lateral branches appear at the same time.

The peculiar method of branching, with the branches arising round an inflorescence, is also found in the genera *Protea* and *Leucadendron*, but in both these the branches represent a new season's growth.

The geographical distribution of the plants which have been at present grouped together as *G. passerinoides* in a great measure confirms the present grouping, notwithstanding the extremes of growth forms represented. The most southerly records are from the Districts of Beaufort West, Murraysburg, Graaff-Reinet, and Cradock. They are then recorded from the Herbert, Kimberley, and Barkly West Districts and extend eastward into the Bloemfontein District. North of Barkly West, they extend into the Vryburg District and are also found in South-West Africa. It is probable therefore that this species has a wide range of distribution in the Cape Province north of the Roggeveld and Nieuwveld Range and in the western districts of the Orange Free State. A record from the Basutoland plateau must for the present remain doubtful.

G. Zeyheri is recorded from Heilbron (O.F.S.), Pretoria, Rustenburg, Marico, Waterberg, Lydenburg, and the Barberton Districts of the Transvaal.

G. burkei is recorded from the Pretoria (Heidelberg) Districts of the Transvaal, while a variety *intermedia* (*G. intermedia* s. Moore) is found in the Johannesburg and Krugersdorp areas. It differs from *G. Burkei* in having no ray-florets.

G. aspera is recorded from the Bethlehem and Harrismith Districts of the Orange Free State and also from Basutoland, an area which is included in the Eastern Mountain Region (Phillips). The late Dr. Medley Wood described a new species from Harrismith which should be regarded as a glabrous form of the above.

G. protense. At present we do not know what this species is and Harvey's type must first be examined.

The specimens included in the species enumerated above were first grouped on an examination of floral and vegetative characters and as will be seen the grouping fits in with definite floral areas.

Several unrecorded species have come to light during the course of the investigation, but these will be mentioned as soon as it is possible to publish a complete account of the genus.

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sie," threby implying that the farmers at that time associated the disease with this plant. He undertook a feeding experiment, but although " large doses " of Vomeerbossie were consumed by the sheep and goats, no vomiting was produced. In summing up his results Dr. Hutcheon writes: " *I am therefore very doubtful whether the Vomeerbosje does possess the power of inducing vomiting in sheep and goats. I am inclined to attribute the vomiting to some other cause. Very probably the opinion of the farmers in the Victoria West district (see above) with respect to the cause of this disease, is the correct one.*"

A further experiment was carried out by Hutcheon in 1886 in the Hope Town District. All obvious precautions were taken to eliminate possible sources of error which could influence the results. The experiment was conducted on a farm where the disease was actually prevalent at the time; a sheep was repeatedly dosed with large quantities of the bush and then allowed to run with the remainder of the flock. No vomiting occurred, however, and Hutcheon concludes: " *I have, therefore, grave doubts that this particular bush is the guilty one.*" After discussing the post-mortem changes and symptoms of the disease, he further writes regarding the nature of Vomeersiekte: " *I am convinced that the cause of the disease is some irritant which is taken in with the food, whether a distinct plant, or some peculiar fungus on a plant.*"

Dixon, in 1895, continued the study of Vomeersiekte; which disease, he says, " *is attributed to a plant or bush called the Vomeerbosch* (Geigeria passerinoides), *and certainly this bush was very much in evidence on the farms where I saw sheep suffering from the disease.*" He proceeded to feed a few sheep for three days on nothing but the bush without producing any symptoms. In 1899 he repeated the experiment, this time preparing an infusion from the plant and drenching a number of sheep and goats with it. Again the result was entirely negative, so that Dixon came to the conclusion that " *with respect to the Vomeerbos, I think it very doubtful whether the eating of this plant induces Vomeersiekte.*"

In 1902, Hutcheon again refers to Vomeersiekte and quotes the general opinion of the farmers that the so-called Vomeerbosje (*Geigeria passerinoides*) is the cause of the disease. He then reviews the various negative experiments that had been conducted and sums

up his views as follows:—"*There is very little doubt that this peculiar affection is due to some nervous irritant which the animal eats. Whether it is the vomeerbosje at present suspected, or some other plant, or some poisonous fungus that attacks certain plants at certain times of the year, which produces the physiological effects observed, I am unable to say*; further experiments are necessary to determine these points."

These early experiments have been quoted here in some detail in order to illustrate (1) that most farmers at that time had come to the conclusion that Vomeersiekte was caused by *Geigeria passerinoides*, (2) that all feeding and drenching tests conducted with this plant had been negative, and (3) that the veterinary experts, while admitting that suspicion attached to the plant, were reluctant to accept the farmers' theory, and urged that more experiments should be conducted to prove or disprove the etiological rôle of the Vomeerbossie.

A further test was accordingly undertaken by Elley in 1905 and this again gave negative results. In spite of this, Elley was of opinion that the Vomeerbossie was responsible for the disease and gave the following reasons for his belief:—

(1) That wherever the Vomeersiekte bush was most abundant there also was Vomeersiekte commonest.
(2) That he had never met with Vomeersiekte on veld devoid of the bush.
(3) That if goats were grazed on veld where locusts had destroyed almost everything except the Vomeerbush, the disease was almost certain to appear.

Elley suggested that the bush must possibly be eaten perfectly fresh, or for a considerable time, to produce its harmful effects.

III.—MORE NEGATIVE EXPERIMENTS BY OFFICERS OF THE RESEARCH DIVISION.

Although all the experiments conducted with Geigeria during the period referred to above had given negative results the necessity for carrying out further tests was keenly felt. The observations which had led farmers to look upon Geigeria as the definite cause of Vomeersiekte had also impressed the veterinarians; and yet, so long as all attempts to produce the disease by feeding the plant failed, its etiological rôle remained speculative. However strong the arguments appeared in favour of Geigeria as the cause of Vomeersiekte, certainty could only be obtained by actually producing cases of the disease in animals fed on the plant. Until this evidence had been adduced, there was always the possibility that some unknown factor and not the plant might be responsible for the disease.

In this connection Dunsiekte in horses might be quoted as an example of a disease which was assumed by farmers and veterinarians alike to be due to a certain plant (Senecio), but for which carefully conducted experiments subsequently proved that assumption to be wrong. It was, therefore, felt that progress in regard to Vomeersiekte would be held up until its etiology had been established experimentally.

During the years 1908 to 1923 a number of experiments were carried out by officers of the Veterinary Research Division with

Geigeria passerinoides. All these experiments with one exception gave negative results. It will be sufficient for our purposes to give a very brief account of these experiments, and then to discuss the significance of the results:—

Experiment 1.

At the old Laboratory at *Daspoort*, near Pretoria, Sheep No. 1026 was fed from 13.1.1908 to 17.1.1908 daily with 70 grams Vomeerbossie.

Result.—No symptoms were observed.

Experiment 2.

On 21.5.1908 *two sheep, Nos.* 1148 *and* 1193 were each drenched with 800 c.c. of an infusion of *Geigeria passerinoides.* Four days later they were each fed on 90 grams of the bush, and another two days later on 120 grams.

Result.—Negative.

Experiment 3.

At *Christiana* in the Orange Free State a further feeding test was conducted in 1910,

Cow 653 was fed daily from 20.6.1910 to 2.7.1910 on one pound Geigeria finely chopped and mixed with veld hay.

On 9.7.10 the cow was drenched with three bottles of an infusion of Geigeria.

From 17.7.1910 to 26.7.1910 it received daily ½ lb. dry Geigeria in its food.

From 27.7.1910 to 8.9.1910 it was drenched daily with an infusion of the plant.

Result.—No symptoms of Vomeersiekte were noticed at any time.

Heifer 526 received a drench of Geigeria infusion on 10.7.1910, but showed no symptoms.

Experiment 4.

At *Onderstepoort, Cow No.* 2228 received 1 lb. Vomeerbossie with her food on 20.4.1912, and for the ensuing three days was drenched daily with one gallon of an infusion prepared from 2 lb. of the plant.

Result.—Negative.

Experiment 5.

On the farm *Armoedsvlakte*, near Vryburg, Bechuanaland, *Cow No.* 2188 was drenched daily from 10th May, 1912, onward, with an infusion of *Geigeria passerinoides.* On the 18th May, by which date the animal had received a total quantity of 9 lb. 4 oz. of the plant, the cow appeared to be unwell. Daily drenching was continued and on the 17th June, after having received a total quantity of 36 lb. 5 oz., *the cow vomited* after its drench. From that date on the same performance was repeated every day; as soon as the drench had been administered almost the entire quantity was vomited up. The experiment was discontinued on the 27th June after the cow had received no less than 45½ lb. of the plant.

This was the first case in which vomiting was produced experimentally by means of Geigeria.

In comparing this with the previous experiments, it will be noticed that much larger quantities of the plant were used in the case of Cow 2188 than in any of the other animals. It would appear, therefore, as if the earlier negative results may be ascribed, at least partly, to the fact that an insufficient quantity of the plant had been given to the experimental animals.

Further light will be thrown on this question by the later experiments to be described below.

Experiment 6.

In the Fifth and Sixth Reports of the Director of Veterinary Research (1919) Viljoen records a few feeding tests with Geigeria which were carried out at Armoedsvlakte.

The experiment was carried out in November, 1916. *Heifer* 3875 received in all 46 lb. 3 oz. and *Heifer* 3876 4 lb. 10 oz. of *Geigeria zeyheri;* in the former case the feeding extended over 99 days, and in the latter over eight days.

During the same period *Geigeria pectidea* was fed to two heifers. No. 3879 received 45 lb. 13 oz. over a period of 99 days, and No. 2571 4 lb. 12 oz. over a period of eight days.

Result.—In all these cases the result was entirely negative.

Experiment 7.

Early in 1917 Viljoen also fed *Geigeria zeyheri* to a number of sheep at Armoedsvlakte.

Sheep Nos. 6528, 7095, 7199, 7201, 7328, 8106, 9617 and 9624, 9636 and 9611 were taken into experiment on the 18th January, 1917, and fed on the plant daily, until the 24th April, 1917, when the experiment was discontinued.

Result.—Three of the sheep died of gangrenous pneumonia during this period but none showed any symptoms of Vomeersiekte.

Experiment 8.

In January, 1920, a small quantity of *Geigeria passerinoides* was sent to the Onderstepoort Laboratory by a farmer and was fed to sheep No. 116 on the 28.1.1920. Only 4 oz. were consumed, together with other food, and no symptoms developed.

Experiment 9.

Two sheep, Nos. 13624 and 15392 each received 100 grams *Geigeria passerinoides* on the 22nd April, 1920, another 100 grams on the 23rd, 200 grams on the 24th, and 300 grams on the 25th. They, therefore, each received 700 grams of the plant, which was mixed with other green food (lucerne).

Result: The sheep were kept under observation for about a month, but no symptoms of Vomeersiekte were ever observed.

Experiment 10.

At Armoedsvlakte, Mitchell fed *Geigeria passerinoides* to ten sheep in the following amounts:—

4 sheep consumed 26½ lb. between 6.8.20 and 23.9.20.
4 sheep consumed 29 lb. between 1.12.20 and 6.12.20.
1 sheep consumed 15 lb. between 10.12.20 and 15.12.20.
1 sheep consumed 26 lb. between 2.3.21 and 8.3.21.

Result: All these tests yielded entirely negative results.

Experiment 11.

At Onderstepoort three sheep, Nos. 6748, 6759 and 6798 were fed on *Geigeria passerinoides* from 24.7.1923 till 17.8.1923. The first four days they received 5 lb. daily and from then onward 1 lb. each daily. Altogether each of the sheep actually consumed between 20 and 30 lb. of the plant, mixed with the ordinary food of the animals.

Result: All three sheep showed slight diarrhœa about eight days after the commencement of the experiment, but no signs of Vomeersiekte were ever observed.

Experiment 12.

During the year 1923 complaints concerning Vomeersiekte in sheep became so general that a determined effort was made to decide definitely whether *Geigeria passerinoides* could produce the disease, and if so under what conditions. It was thought that the negative results obtained in many of the earlier experiments were probably due to an insufficient quantity of the plant having been fed, and it was therefore decided to experiment with much larger quantities.

Twelve sheep (Nos. 6106, 6115, 6117, 6125, 6132, 6137, 6141, 6147, 6149, 6155, 6167 and 6179) received a total of about 6 lb. of *Geigeria passerinoides* daily from 4.9.1923 to 9.11.1923. The plant was given mixed with other food. Altogether the 12 sheep disposed of over 400 lb. of the plant, including uneaten stems.

Result: These sheep were kept under observation for about three months, but no symptoms of Vomeersiekte ever appeared.

Experiment 13.

Another three sheep, Nos. 7548, 7792 and 7843 were fed on Vomeerbossie obtained from the Prieska district. From 6.10.1923 till 11.11.1923 they received 2 lb. daily, and from 12.11.1923 to 2.12.1923 6 lb. daily; altogether they consumed 200 lb. of the plant.

Result: Again entirely negative.

Experiment 14.

A further quantity of Vomeerbossie was obtained from Marydale and this was fed to eight sheep (Nos. 6075, 7406, 7683, 7802, 7826, 7828, 7835 and 7841). From 17.10.1923—11.11.1923 they received 6 lb. daily, and from 12.11.1923 to 9.12.1923 8 lb. daily, i.e., a total quantity of 380 lb. or about 48 lb. per sheep.

Result: No symptoms of Vomeersiekte were ever observed.

General Discussion of the above Experiments.

With the exception of cow 2188 in Experiment 5, all the animals used in the experiments recorded above remained healthy. It is particularly remarkable that not one of the sheep which were fed on Geigeria showed symptoms of Vomeersiekte. Various possible explanations for these negative results suggest themselves and may be considered seriatim:—

(1) *That Geigeria does not cause Vomeersiekte*: Against this view the field evidence, already referred to, speaks very strongly; as also the fact that one animal actually vomited after being drenched with Geigeria.

(2) *That the plant was not fed in sufficient quantity*: In this connexion it should be noted that, especially in the later experiments (Nos. 11—14), comparatively large quantities were given, so that each sheep received from about 30 to 50 lb. in all.

(3) *That the plant was not fresh enough when fed*: In some of the feeding experiments, however (at Armoedsvlakte and Christiana), the plant was obtained fresh every day.

(4) *That too much additional food was given with the Geigeria*: the idea being that the "toxin" of the plant might become ineffective when the animal receives large supplementary rations of other foodstuffs.

(5) *That only certain sheep are susceptible to the disease*: It was considered remotely possible that perhaps only sheep reared on Geigeria veld would contract the disease, owing to a predisposing effect due to previous continuous ingestion of small quantities of the toxin.

(6) *That other factors in addition to the plant may be necessary to produce the disease*: Such factors might theoretically be of a climatic or telluric nature which would only operate on a Vomeersiekte farm, but would be absent under the laboratory conditions which prevailed in the feeding experiments. Another possibility (assumed by some farmers) was that only sheep suffering from wire worm infection (*Haemonchus contortus*, of the abomasum) were susceptible to Geigeria poisoning.

With the evidence obtained in these experiments, it was impossible to decide whether any of the above hypotheses offered a feasible explanation for the negative results obtained so far. It was felt, therefore, that further experiments, if possible on a much larger scale, should be undertaken and that these should preferably be conducted on a farm where the *disease was actually present*.

The position in regard to Vomeersiekte had by this time become so serious that the work had to be put in hand without delay. A tour of investigation was accordingly undertaken by Dr. Viljoen of this Division in the early summer of 1923, with the object of finding a suitable farm, from the point of view of experimental convenience. Some difficulty was experienced in selection, but finally it was decided to conduct the experiments on the farm Donderbosfontein in the Barkly West district.

IV.—EXPERIMENTS AT DONDERBOSFONTEIN.

The farm Donderbosfontein lies in an area particularly hard hit by the ravages of Vomeersiekte. The Vomeerbossie had spread in the Barkly West and surrounding districts to an alarming extent, so much so that at the time the experiments were conducted, this was the dominant plant over large stretches of country. As a matter of fact on many patches of veld there existed practically a "pure culture" of *Geigeria passerinoides*. Sheep grazing on such veld had to subsist on Geigeria and practically nothing but Geigeria. The explanation offered by the farmers for this remarkable increase of the Vomeerbossie was that during the previous season which had been very dry, a *locust* invasion had cleared off every blade of grass but left the Geigeria untouched.

In many parts of the Barkly West and adjoining districts the losses amongst sheep had been so heavy that the majority of farmers

had " trekked " in search of healthier pastures. It is impossible to estimate the total losses due to Vomeersiekte but it can safely be stated that in the summer of 1923-24 ruination was staring many sheep farmers in the face.

The conditions prevailing at the time in those parts were, of course, peculiarly suitable for our experiments. With sheep dying in hundreds on veld consisting of almost nothing but Geigeria, it seemed a simple matter to determine whether this plant was actually responsible for the disease or not.

The experiments on Donderbosfontein were accordingly planned in the first place to clear up the etiological rôle of *Geigeria passerinoides*. The following experiments were conducted:—

Experiment 1.

Object.—To determine whether sheep grazing on Geigeria alone will contract Vomeersiekte.

Method.—Two portions of the farm were selected for this experiment: (*a*) a spot near the homestead, (*b*) a spot about 2 miles from the homestead in a valley called Pieskloof.

All plants other than Geigeria were removed and a small area about 4 yards by 8 yards enclosed by means of movable hurdles. In the homestead area 15 sheep were kept in the enclosure, and at Pieskloof 10 sheep. As soon as the Geigeria was grazed down a further area was prepared and the hurdles moved on so that the sheep were kept on a constant fresh supply of Geigeria.

These experiments (and also those following) were commenced on the 19th November, 1923, and discontinued just over a month later, on the 20th December, 1923.

Result.—At the conclusion of the experiment, 5 out of the 10 sheep grazing on Geigeria at Pieskloof had died and 3 more were showing symptoms of Vomeersiekte.

On the homestead area none of the experimental sheep had died, but 4 showed symptoms of Vomeersiekte. It should be pointed out, however, that whereas at Pieskloof the growth of Geigeria was abundant and fairly luxurious, the plants were scantier and stunted on the fields near the homestead.

Conclusion.—It appeared justified to conclude from this experiment that *Geigeria passerinoides*, if eaten in sufficient amount and " concentration " by sheep, produced Vomeersiekte.

Experiment 2.

Object.—To observe the effect of grazing sheep on Geigeria plus large shrubs (thus constituting almost the entire edible plant life over large stretches of country at the time). The idea in leaving the large shrubs was to see whether the addition of other plants to the Geigeria, and the consequent " dilution " of the vomeerbos in the stomach of the sheep would tend to lessen the effect of the latter plant.

Method.—All plants except Geigeria and large shrubs (chiefly Vaalbos and Rosyntjiebos) were removed and 15 sheep grazed on this veld in the same way as that adopted in Experiment 1.

Result.—At the conclusion of the experiment 4 sheep in this group had died and 7 showed symptoms of the disease.

Conclusion.—Here again a fairly heavy mortality was produced which was apparently due to the Geigeria. The inclusion of the large shrubs did not prevent the disease.

Experiment 3.

Object.—To determine whether the age or developmental stage of the plant has any influence on its toxicity. In the case of some toxic plants only the young stage is toxic; in others again only the flowering plant. It was important, therefore, to find out whether any of these conditions applied to Geigeria.

Method.—15 sheep were kept in two small kraals and fed on nothing but Geigeria. One kraal contained 7 sheep and these received young specimens of *Geigeria passerinoides* in the pre-flowering stage. In the other kraal there were 8 sheep which were fed on mature flowering plants. The plants were collected every day and given to the sheep in the fresh state. It may be added here that sheep soon get to like the Vomeerbossie and will eat it readily, especially in the fresh state.

Result.—Of the 7 sheep fed on young plants 3 were dead at the end of the experiment and the other 4 all showed symptoms of Vomeersiekte; and of the 8 sheep which received flowering plants 4 were dead and 3 were sick.

Conclusion.—When fed by itself in the fresh state, *Geigeria passerinoides* produced Vomeersiekte in nearly every one of the sheep thus fed. There seemed to be no marked difference in toxicity between young pre-flowering and mature flowering plants.

Experiment 4 *(Control).*

Object.—To note the incidence of Vomeersiekte amongst sheep grazing on "Vomeersiekte-veld."

Method.—41 sheep were grazed on the farm Donderbosfontein, where, prior to our investigations, the mortality from Vomeersiekte had been heavy. The sheep were herded during the day and kraaled at night.

Result.—At the conclusion of the experiment 8 sheep had died of Vomeersiekte and 15 showed symptoms of the disease.

Summary of the above Experiments.

Expt. No.	Description of Experiment.	Number of Sheep.	Number Dead after one Month.	Number Showing Symptoms.	Mortality.	Morbidity.
					per cent.	per cent.
1*a*.....	Grazing on Geigeria alone (Homestead)	15	0	4	0	26
1*b*.....	Grazing on Geigeria alone (Pieskloof)	10	5	3	50	80
2.....	Grazing on Geigeria plus large shrubs	15	4	7	26	73
3*a*.....	Fed on Geigeria, young plants	7	3	4	43	100
3*b*.....	Fed on Geigeria, flowering plants	8	4	3	50	87
.....	Control. Grazing on Vomeersiekte veld	41	8	15	19	56
TOTAL.....		96	24	36	25	62

Notes on the above Experiments.

(*a*) *Mortality.*—As stated previously, the experiment continued for just over one month. During that period 25 per cent. of the total number of experimental animals died of Vomeersiekte. At the conclusion of the experiment fresh cases were appearing every day. It is reasonable to suppose, therefore, that if the experiment had gone on, the mortality would have been much higher.

The mortality and morbidity varied somewhat in the different experiments. The percentage was remarkably low in the grazing experiment near the homestead (1*a*) but this was probably due to the fact that the supply of Geigeria was very restricted so that animals did not get enough toxin to produce death. Cases of the disease were beginning to appear in this group just before discontinuation of the experiment.

In the other groups the variation was not very great, but, on the whole, it can be said that the incidence of the disease was highest in those experiments where the sheep got nothing but Geigeria (1*b*, 3*a* and 3*b*), whereas it was lower in those cases where other food was taken with the Vomeerbossie (2 and 4). This seemed to support the farmers' view that supplementary foodstuffs lessened the toxic effect of Geigeria.

(*b*) *Influence of Breed and Origin of Sheep.*—When the experiments were started it was thought that the source from which the sheep were obtained might influence the results. Thus sheep reared on Vomeersiekte-veld might have acquired a certain amount of tolerance for the Geigeria toxin, or on the contrary such sheep might prove to be more susceptible to the effects of the plant. In order to settle this point it was decided to get some sheep from a part of the Free State where Vomeersiekte was unknown, and an equal number from the owner of the farm Donderbosfontein. This was done and the experiments so arranged that in each of the groups discussed above, approximately half the sheep were from the Free State and the other half local sheep.

The result of the test was that the two classes of sheep behaved exactly alike. Approximately equal numbers contracted the disease. The only difference was that the local sheep began to show symptoms a few days before the Free State sheep, presumably because the former were used to the plant and ate it more readily, and possibly also because the former had already, prior to the commencement of the experiment, consumed a comparatively large quantity of Geigeria, so that a smaller amount was subsequently needed to produce symptoms.

In the experiments under discussion *breed* seemed to have no effect. The Free State sheep referred to in the previous paragraph where *merinos*, whereas the local sheep were "*bastards.*"

(*c*) *Influence of Wireworm* (*Haemonchus contortus*) *Infection.*—As indicated above, some farmers were inclined to associate the appearance of Vomeersiekte with wireworm infection of sheep. It was believed that only those sheep contracted the disease which were badly infected with stomach worms. According to this conception the disease could easily be prevented by treating the sheep for wireworms.

This view was also put to actual test. Approximately half the sheep in each group above were dosed with the Government Wireworm Remedy before the commencement of the experiment, and the

other half left untreated. Both groups suffered equally from Vomeersiekte. Amongst the sheep that died there were many which were completely free from wireworms, whereas others showed a comparatively heavy infection.

(*d*) *Symptoms.*—It is not the purpose of this article to give a detailed description of all the symptoms which may be observed in cases of Vomeersiekte since this has already been done by the earlier authors. It should, however, be stated here that in these experiments, the first symptoms appeared about a fortnight after the beginning of the tests. It would appear, therefore, that a considerable amount of the plant is necessary to produce the disease. Sick sheep can usually be picked out by the green discoloration around the nose and mouth. It also frequently happens that the greenish material vomited up by the sheep is found on the backs of other sheep and this may first draw attention to the presence of the disease. Vomiting occurs at irregular intervals and is usually accompanied by severe coughing. After vomiting, and sometimes independently of this act, spasmic contractions of the œsophagus can be observed. Apart from the actual vomiting the sheep at first appear perfectly healthy. Almost as soon as they stop vomiting they will continue to graze until they are seized by another attack. Drinking water or driving will frequently bring on an attack. After a few days the sheep become weaker, lie down, and rapidly lose condition. Death may ensue after a few days, or a longer period, and is usually the result of a broncho-pneumonia caused by the sheep inhaling the vomit.

Farmers also describe a rapid form of the disease accompanied by tympanitis, and state that this form appears when the sheep cannot get relief by vomiting. However, no such cases were observed in our experiments.

On the other hand an atypical form of the disease was observed which has been referred to as the " lame " or " stiff " or " laminitic " or " paralytic " form, and has also been erroneously called " lamsiekte in sheep." At the beginning of this form of the disease the animals show a stiff gait and are inclined to lie down. The feet seem to be painful although no local changes can be found. The animals grow weaker and after a few days are unable to support themselves. When lifted they stand with arched back and the feet close together, show muscular tremors, perhaps take a few steps and then collapse. After another few days these animals may be completely paralysed. They usually continue feeding for some time, but ultimately die of exhaustion and debility. In the observations recorded above sheep which showed the paralytic form of Vomeersiekte never showed signs of vomiting.

General Conclusions.

The main results obtained at Donderbosfontein permit of the following conclusions:—

1. *Geigeria passerinoides* is the cause and probably the only cause of Vomeersiekte.
2. Sheep which eat nothing but Geigeria seem more liable to develop the disease than those which get other material in addition to the Vomeerbossie.

3. *Geigeria passerinoides* in any stage of its development can produce the disease.
4. There appears to be no difference in susceptibility between sheep reared on Vomeerbossie veld and those brought from clean veld.
5. Merinos and Bastard sheep appear to be equally susceptible.
6. There is no relation between wireworm infection and Vomeersiekte.
7. After ingestion of a sufficient quantity of Geigeria the disease may show itself in some sheep as a true vomiting disease, and in other sheep in the form of general stiffness or paralysis.

V.—EXPERIMENTS AT BOETSAP.

At the conclusion of the experiments at Donderbosfontein it was anticipated that the rains would soon commence and that Vomeersiekte would automatically cease with the appearance of new grass. The rains, however, came very late and the position in the autumn of 1924 seemed worse than the year before. In many districts the veld consisted of practically nothing but Vomeerbossie and farmers viewed the future with grave concern.

Although the Donderbosfontein experiments had yielded valuable results, the necessity was felt of conducting further experiments and clearing up the many obscure points in connexion with Vomeersiekte. Enquiries were made to find a suitable locality and finally the farm Pienaarsfontein, near the little village of Boetsap, situated about 25 miles west of Border Station on the Kimberley-Vryburg line, was selected. The owner stated that during the previous year he had lost 12 per cent. of his entire flock from Vomeersiekte and that his losses would have been much heavier if he had not trekked with his flocks. In the autumn of 1924 his veld was covered with Vomeerbossie and heavy losses were expected as soon as the first frost killed the new grass.

Preparations were accordingly made at Boetsap to carry out experiments on a fairly large scale. It will be convenient to describe the experiments under general headings indicating the object of the experiments.

A.—How much Fresh Geigeria will a Sheep eat per Day.

Experiment 1.

Object.—To determine the amount of Geigeria eaten per day and to observe when symptoms of Vomeersiekte will appear.

Method.—Five sheep were kept in a small kraal and a sufficient amount of Geigeria was pulled up fresh every morning and fed to them. The plants were weighed in the morning and the amount left over weighed in the evening, so that an accurate record of the amount eaten could be kept. It was found that the sheep preferred the tops of the shrubs, including the flowerheads, and left the thicker branches and stems. Feeding was continued until the animal actually showed symptoms of Vomeersiekte. It was then transferred to the "hospital camp," where it was kept under further observation and fed on 6 ounces maize per day and as much hay as it would eat.

Result.—In the following table the amount of Geigeria consumed is given opposite the number of sheep, which decreased as the experiment went on owing to the removal of sick sheep to the "hospital camp":—

Day of Experiment.	Number of Sheep in Experiment.	Amount of Geigeria Consumed.
		lb.
1	5	12½
2	5	11½
3	5	10½
4	5	14
5	5	12
6	3	8
7	3	3½
8	2	4
9	2	1½
10	2	3
11	2	3
12	2	3½
13	1	2
14	1	2½
15	1	2
16	1	2
17	1	3
TOTAL	46	98½

If the number of sheep is totalled up and divided into the total quantity of plant consumed, we get the average amount eaten per sheep per day. In the present experiment this amount is about 2.1 lb. It was thought that a full-grown sheep would probably eat about 6 lb. of fresh plant per day if no other food was available. The figures of this experiment, therefore, were unexpected, but are probably due to the fact that the moisture content of the pulled plant was much lower than anticipated.

On the fourth day of the experiment one sheep began to vomit. It vomited again on the 5th day and was then removed to the hospital camp. Another sheep showed a green nasal discharge and was removed at the same time. A third sheep showed signs of Vomeersiekte on the 7th day and a fourth one developed the "stiff" or paralytic form and was removed on the 13th day. Only one sheep remained healthy during the course of this experiment (17 days).

It is of interest to note further that the sheep which first vomited on the 4th day and was placed in hospital on the 5th day continued to vomit at intervals in spite of the fact that it received ordinary food (hay and maize). In some of the other sheep the same observation was made.

Conclusion.—The amount of Geigeria eaten by sheep when the plant is pulled fresh every morning and fed exclusively seems to be much smaller than was anticipated; namely, about 2 lb. per head per day.

Experiment 2.

Object.—To see whether the addition of a small amount of salt would have any effect on the amount of Geigeria eaten or precipitate the onset of symptoms of Vomeersiekte as believed by some farmers.

Method.—Five sheep were treated exactly as in Experiment 1, but in addition to the Geigeria each of them received ¼ oz. salt per head per day.

Result.—The consumption of Geigeria is recorded in the following table:—

Day of Experiment.	Number of Sheep in Experiment.	Amount of Geigeria Consumed.
		lb.
1	5	10½
2	5	9
3	5	9½
4	5	13
5	5	12
6	4	10½
7	4	6
8	4	8½
9	4	6½
10	3	7
11	3	6
12	3	5
13	3	5½
14	2	4
15	2	4
16	2	4½
17	1	3
TOTAL	60	124½

If we calculate the average amount of Geigeria eaten per sheep per day we arrive at practically the same figure as in the previous experiment; approximately 2 lb.

One sheep vomited on the 5th day and was placed in the hospital camp. Here it again vomited in spite of the fact that it received no more Geigeria, on the 9th, 11th and 15th day after the beginning of the experiment. This sheep died 24 days after its removal from the experimental lot. A second sheep in this lot showed stiffness on the 9th day and vomited on the 10th day. A third one developed the disease on the 13th and a fourth on the 17th day of the experiment. Again one sheep escaped altogether.

Conclusion.—The addition of common salt had no influence on the amount of Geigeria consumed by the sheep, the quantity eaten being approximately the same as in Experiment 1, just over 2 lb. per sheep per day; neither did the salt appear to have any effect on the incidence of the disease; nor was the outbreak precipitated in any way as a result of the addition of salt. Cases appeared in this lot at approximately the same rate and in the same proportion as in Experiment 1. It can, therefore, definitely be stated that the farmers' view that the consumption of salt accelerates or is essential for an outbreak of Vomeersiekte is incorrect.

B.—How much Geigeria is required to produce Vomeersiekte?

Experiment 3.

Object.—To determine the minimum quantity of Geigeria which, when eaten alone, will produce Vomeersiekte.

Method.—Five sheep (Nos. 158, 159, 160, 161, and 162) were individually offered 3 lb. Geigeria per day. When this experiment was planned it was thought that the sheep would eat even more if

they had free access to the plant. Without knowing the moisture content of the veld material, it was roughly estimated that the calorific requirements of the sheep would probably be met if they consumed about 6 lb. of the fresh green plant. The amount fed in this experiment was therefore considered as representing roughly half the total requirements, and the sheep were meant to be in a state of semi-starvation.

Result.—In reality it was found (as in the case of the two previous experiments) that the material was much drier than expected and the sheep would not eat more than an average of about 2 lb. per day. The following table shows the amounts actually consumed and also indicates when the sheep were taken ill and had to be transferred to the Hospital camp (Hosp.):—

Day of Experiment.	Amount of Geigeria Consumed by Sheep.				
	No. 158.	No. 159.	No. 160.	No. 161.	No. 162.
	lb.	lb.	lb.	lb.	lb.
1st	1¾	1¾	2¼	2¼	0
2nd	1½	1½	1½	2	2
3rd	2	2	1¾	1¾	2
4th	2¼	2¼	2	2	2
5th	1¾	1¾	2¼	2¼	2
6th	2	Hosp.	2¼	2¼	2
7th	2		2	2	2
8th	2½		2	1½	2½
9th	2		2	Hosp.	2
10th	1½		2		2
11th	1		2		2
12th	1½		2		2
13th	2		2		1½
14th	1½		1½		2
15th	Hosp.		2		Hosp.
16th			2		
17th			2		
TOTAL	25¼	9¼	33½	16	26

Sheep 159 first vomited on the 4th day when it had only consumed 7½ lb. of Geigeria. It vomited again the next day and was then removed to the hospital camp. As seen in previous cases this sheep continued to vomit after its removal; it was actually observed to do so on the 9th and 11th day of the experiment.

Sheep 161 seemed "off colour" on the 8th day; the next day it vomited (after having consumed 16 lb.) and was taken out of the experiment. While in the hospital camp this sheep developed the "stiff" form of the disease.

Sheep 158 and 162 both showed symptoms on the 15th day of the experiment. The former had consumed 25¼ and the latter 26 lb. No. 158 developed the "stiff" or "paralytic" form of the disease and died on the 22nd day after the commencement of the experiment. No. 162 vomited on the 15th day and died the next day.

Sheep 160 consumed altogether 33½ lb. of Geigeria, but never showed any symptoms.

Conclusion.—In the case of one sheep the comparatively small quantity of 7½ lb. of Geigeria was sufficient to produce vomiting. In another instance 33½ lb. had no effect. The individual susceptibility of sheep to the poison of Geigeria seems to vary within wide limits.

Experiment 4.

Object.—To determine the amount of Geigeria which will produce Vomeersiekte when Geigeria and hay are taken in about equal quantities.

Method.—In this experiment, as in the previous one, the assumption was that much more Geigeria would be eaten than actually proved to be the case. The idea was that the sheep should get 3 lb. Geigeria per day, and when that was completely consumed, they should be allowed to eat as much hay as they would take. On the assumption that 3 lb. of fresh Geigeria represented about half their daily calorific requirements, they were expected to eat another few pounds of hay per day, so as to satisfy the other half. This experiment differed from the preceding one in so far as the total intake was concerned. In Experiment 3 the sheep were intended to remain in a state of semi-starvation; whereas in Experiment 4 they were allowed to fill themselves. In view of opinions expressed by farmers concerning the relative incidence of the disease amongst sheep receiving supplementary rations, it was thought that the results of the two experiments might vary in accordance with this difference.

Result.—Here again the fact that much less Geigeria than expected seemed to cover the requirements of the sheep upset the intention of the experiment. On the first day none of the five sheep finished the 3 lb. of Geigeria which was allowed; they therefore received no hay. On the second day they were again given 3 lb. Geigeria each and it was decided to let them finish this completely before any hay was offered. This took three days; it was therefore only on the 4th day that they were allowed to eat hay. The next (5th) day they again received 3 lb. Geigeria each, which they finished on the 7th day and were thereupon allowed hay. A summary of the entire experiment is given in the following table:—

Day of Experiment.	Amount of Geigeria (G.) and Hay (H.) Consumed by Sheep.				
	No. 116.	No. 117.	No. 118.	No. 119.	No. 121.
	G. H.	G. H.	G. H.	G. H.	G. H.
	lb.	lb.	lb.	lb.	lb.
1st	½+0	2½+0	2½+0	0+0	2½+0
2nd to 4th	3+1¾	3+2¼	3+2¾	3+1¾	3+1¾
5th to 7th	3+1¼	3+1¾	3+1¾	3+1¼	Hosp.
8th to 9th	2+0	3+1¾	3+1¾	2+0	
10th to 11th	Hosp.	3+0	3+0	Hosp.	
12th to 13th		3+0	3+0		
14th		3+1¾	3+1¾		
15th		—	3+0		
16th to 17th		3+2	3+2¼		
TOTAL	8½+3	23½+9½	26½+10¼	8+3	5½+1¾

Sheep No. 121 vomited on the 5th day after it had consumed only 5½ lb. of Geigeria and 1¾ lb. of hay.

Both Nos. 116 and 119 vomited on the 9th day; the former had consumed 8½ lb. of Geigeria and 3 lb. of hay, the latter 8 lb. of Geigeria and 3 lb. of hay. The other two sheep showed no symptoms at all, although they ate 23½ plus 9½, and 26½ plus 10¼ lb., respectively of Geigeria and hay.

Conclusion.—As in the preceding experiment a comparatively small quantity of Geigeria was sufficient in some cases to produce vomiting. One sheep vomited after consuming 5½ lb., another after 8 lb., and a third after 8½ lb. The hay taken with the Geigeria seemed to have no effect upon the appearance of the disease.

C.—Is there a Latent ("Incubation Period") in the Development of Vomeersiekte?

Experiment 5.

Object.—To determine whether a definite period must elapse after eating *Geigeria passerinoides* before symptoms will appear.

Method.—Five sheep were fed for five days as in Experiment 1, that is, they received every morning a quantity of fresh Geigeria; at the end of the day the remainder was weighed and the amount actually consumed thus determined. At the end of the five days this feeding was stopped and the sheep transferred to the "hospital camp" and kept under observation.

The idea underlying this method of procedure was that the sheep might perhaps absorb sufficient toxin during the first five days, but that possibly a further period would have to elapse before the symptoms of Vomeersiekte appeared.

The following amounts of Geigeria were consumed by the five sheep in the present experiment:—

1st day, 8 lb.; 2nd day, 8 lb.; 3rd day, 12 lb.; 4th day, 12 lb.; 5th day, 10 lb.; total, 50 lb.; or an average of 10 lb. per sheep for the five days (i.e. 2 lb. per sheep per day).

The sheep were then put on ordinary food and kept under observation.

One sheep vomited on the seventh day (i.e. on the 2nd day in the hospital camp), and continued to do so for about a fortnight. A second sheep vomited on the 8th day and a third on the 9th. Both these sheep continued to vomit for several days after the first appearance of the symptoms. A fourth animal showed a green discharge from the nostrils on and after the 12th day, but was never actually seen to vomit. The fifth sheep remained healthy.

Conclusion.—This experiment showed that the symptoms of Vomeersiekte may appear after discontinuation of the feeding of Geigeria, thus indicating that the toxin takes some time to produce its effects.

The result of this experiment indicated the desirability of reducing the feeding period still further. This was done in the two following experiments:—

Experiment 6 (23).

Object.—Same as in Experiment 5.

Method.—In this experiment eight sheep were fed on Geigeria for three days only (instead of five days as in the previous experiment) and then transferred to the hospital camp and kept under observation.

Result.—The eight sheep consumed:—

16 lb. of Geigeria on the 1st day.
12½ lb. of Geigeria on the 2nd day.
17 lb. of Geigeria on the 3rd day.

Total 45½ lb. or (on an average) about 5.7 lb. per sheep for the three days.

On the fourth day two of the eight sheep vomited; no symptoms were shown by the other six. All the sheep were eventually discharged from the experiment in good condition.

Conclusion.—It would appear that sufficient Geigeria can be consumed in the course of three days to produce Vomeersiekte, although the incidence of the disease after this short feeding period was low. Here again the symptoms were shown after the sheep had been removed from the Geigeria, thus indicating that a certain period must elapse before the effect of the toxin becomes apparent.

The small percentage of positive cases in this experiment seems to show that the "*minimum toxic dose*" of Geigeria had practically been reached. The average consumption per sheep over the three days was 5·7 lb., and in Experiment 4, it will be remembered, one sheep vomited after consuming 5½ lb. of Geigeria. Probably, therefore, 5 to 6 lb. of Geigeria "tops" is the smallest quantity that will produce the disease in some sheep; others, we know, can consume many times this quantity without showing symptoms.

It seems likely, therefore, that in the present experiment, "amount of Geigeria consumed" rather than "duration of feeding" was the limiting factor in the production of positive cases.

Experiment 7 (22).

Object.—Same as in Experiments 5 and 6.

Method.—Five sheep were fed on Geigeria for one day only and then transferred to the hospital camp and kept under observation.

Result.—The five sheep consumed 14 lb. of Geigeria during the one day, i.e. 2·8 lb. per sheep. No symptoms of Vomeersiekte were ever observed in these sheep.

Conclusion.—The previous considerations lead us to conclude that the amount of Geigeria eaten by the sheep in this experiment was too small to produce the disease; in other words, the sheep received a "subtoxic dose."

This experiment, therefore, gives no information about the "latent period." If the sheep could have been induced to eat 6 lb. Geigeria in one day, i.e. at least a "minimal toxic dose," cases of Vomeersiekte might have occurred and it would then have been interesting to note what time elapsed between feeding and vomiting.

D.—Does an Attack of Vomeersiekte produce "Immunity"?

Experiment 8 (15*a*).

Object.—To determine whether sheep which previously showed symptoms of Vomeersiekte and recovered are in any way less susceptible to the action of the Geigeria toxin, or whether they will contract the disease again when fed on this plant.

Method.—Five sheep were selected which in previous experiments had actually vomited, but had completely recovered after being transferred to the hospital camp and fed on ordinary food (maize and hay).

These five animals were fed on fresh Geigeria in the ordinary way.

Result.—The following table indicates the previous history of these sheep and also the result of the present test:—

No. of Sheep.	In Previous Experiments Vomited		In Present Experiment Vomited	
	After Eating about	On Day of Experiment.	After Eating	On Day of Experiment.
			lb.	
119.....	8 lb. Geigeria	9th day	29	14th day
131.....	8½ lb. dry Geigeria	6th ,,	25	12th ,,
139.....	5 lb. autolyzed ,,	6th ,,	17½	8th ,,
153.....	22 lb. Geigeria	14th ,,	30	15th ,,
156.....	10½ lb. Geigeria	5th ,,	31	16th ,,

It will be noted that all five sheep contracted the disease a second time. As soon as symptoms (vomiting, and in the case of Sheep 119 and 156, stiffness as well) appeared, they were transferred to the hospital camp for further observation. Sheep 153 died about four weeks after the transfer; the others recovered.

Conclusion.—From these results we may conclude that the first attack of Vomeersiekte did not render these sheep "immune."

The fact that in every case an appreciable quantity (17-31 lb.) of Geigeria had to be eaten before symptoms were produced might be considered as an indication that a certain amount of "tolerance" had been produced by the first attack, although even in the first experiment these sheep proved rather more "resistant" than others. The amount of concrete evidence on this particular point is perhaps not sufficient to admit of a definite conclusion being drawn. The fact, however, that sheep can contract Vomeersiekte for a second time was definitely established by this experiment and is in accordance with the experience of farmers. Perhaps the analogy with "bad sailors" among human beings is permissible, where similar symptoms will recur every time the patient is subjected to the same conditions.

E.—Do some Sheep possess a natural "Immunity" against Vomeersiekte?

Experiment 9 (15*b*).

Object.—To determine whether the resistance which some sheep exhibit against Vomeersiekte is absolute.

Method.—Five sheep were selected which in previous experiments had consumed comparatively large quantities of Geigeria and had remained healthy throughout the course of the experiments lasting 17 days. These sheep were now fed on fresh Geigeria in the usual way.

Result.—The following table records the results obtained:—

No. of Sheep.	In Previous Experiments.			In Present Experiment Symptoms Shown.	
	Quantity of Geigeria Consumed.	In the Course of	Result.	After Eating	On Day of Experiment.
	lb.	Days.		lb.	
104.....	35	17	Negative	31½	16th day
107.....	35½	17	„	80	42nd „
117.....	23½	17	„	23½	11th „
118.....	26½	17	„	28½	14th „
160.....	33½	17	„	26½	13th „

As indicated in the table all five sheep contracted the disease. In most cases the sheep did not even "resist" the action of the Geigeria poison quite so long as in the previous experiments. Four out of the five sheep began vomiting between the 11th and 16th day of the experiment, whereas at the previous feeding they were quite well after 17 days and after having consumed a similar quantity of Geigeria. Only one sheep (No. 107) withstood the action of Geigeria for 42 days, during which time it had eaten no less than 80 lb., but on the 42nd day it also vomited.

Conclusion: The results of this experiment seem to indicate that most if not all sheep will contract Vomeersiekte if the feeding with Geigeria is continued long enough. It is also interesting to note again the widely different susceptibility of individual sheep towards Geigeria poison; in Experiments 4 and 6 cases are recorded of sheep which vomited after eating only 5 to 6 lb. of Geigeria, whereas we have a case here of a sheep consuming first 35½ lb. and then 80 lb. before vomiting for the first time.

F.—Does Geigeria always produce the same Symptoms in the same Animals?

Experiment 10.

Object: To observe whether sheep which in previous experiments developed the stiff or paralytic form of Vomeersiekte will show this form again on being fed a second time on Geigeria.

Method: Ten sheep were selected which had all had the stiff form of the disease and recovered. They were fed on fresh Geigeria in the usual way and the weight of plant eaten recorded. In this experiment the sheep were not removed as soon as symptoms developed, but were kept with the others and continued to feed on Geigeria.

Result: In the following table the quantity of Geigeria eaten by the total number of sheep in the experiment is given, and the symptoms shown by the individual sheep (vomiting or stiffness) indicated:—

Day of Expt.	Number of Sheep in Expt.	Amount of Geigeria Eaten.	Symptoms shown by Sheep.									
			No. 128.	No. 163.	No. 167.	No. 168.	No. 176.	No. 178.	No. 179.	No. 180.	No. 182.	No. 188.
		lb.										
1st....	10	26½										
2nd....	10	25½										
3rd....	10	21										
4th....	10	17½										
5th....	10	21										
6th....	10	19½										
7th....	10	27½										
8th....	10	30										
9th....	10	27½										
10th....	10	24										
11th....	10	22½		Vom.		Vom.	Vom.					
12th....	10	17½										Vom.
13th....	10	18½						Vom. and Stiff				
14th....	10	15										
15th....	10	10½		Died								
16th....	9	9	Stiff			Vom. and Stiff			Vom.			
17th....	9	15				Stiff	Stiff	Stiff	Stiff			Died
18th....	8	14				Died						
19th....	7	12½										
20th....	7	12½										
21st....	7	9										
22nd...	7	11½								Stiff and Vom.		
23rd....	7	11	Stiff				Vom.	Vom.	Vom.	Vom.		
24th....	7	15½										
25th....	7	10½					Died					
26th....	6	10½										
27th....	6	6½								Vom. and Stiff		
28th....	6	8	Stiff		Vom.			Vom.	Vom.	Died	Vom.	
29th....	5	10	Vom.									
30th....	5	11										
31st....	5	5½										
32nd...	5	13½										
33rd....	5	7										
34th....	5	8½										
35th....	5	10										
36th....	5	10										
37th....	5	8										
38th....	5	6½										
39th....	5	6						Died				
40th....	4	7										
41st....	4	6½										
42nd...	4	6										
	310	585		Dead		Dead	Dead	Dead		Dead		Dead

As indicated in this table, every one of the ten sheep vomited during the course of the experiment. Some began by showing symptoms of the stiff form, but ultimately vomited; others vomited early in the experiment without showing signs of stiffness. Attention may be directed to Nos. 128 and 180 which showed stiffness for a considerable time before vomiting, whereas in Nos. 168 and 176 vomiting preceded the symptoms of the stiff form by a considerable number of days.

Of the 10 sheep six died; and of the four which survived three were in very poor condition at the conclusion of the experiment. Only No. 167 was in fair condition. The average consumption of Geigeria per sheep per day was about 1.9 lb.

Conclusion: Any sheep appears to be liable to contract either the one or the other form of Vomeersiekte, or both. If the one form appears first, the other may follow if feeding with Geigeria is continued long enough.

This experiment also seems to prove the identity of causation in the two forms of the disease described.

G.—Does Dried Geigeria produce the Disease?

Experiment 11.

Object: To determine whether drying Geigeria in the sun will destroy the toxin.

Method: A large quantity of Geigeria was pulled up and spread out in the sun. After a few days the plants were completely dry so that the leaves and thinner twigs could be rubbed to powder in the hand.

Five sheep were fed on this material and as soon as symptoms developed they were removed to the hospital camp and kept under observation. The quantities eaten are recorded in the following table:—

Day of Experiment.	Number of Sheep in Experiment.	Amount of Dried Geigeria Consumed.	Remarks.
		lb.	
1.....	5	10	
2.....	5	6	One sheep vomits.
3.....	5	10	
4.....	5	8	
5.....	5	9½	
6.....	5	6	Second sheep vomits.
7.....	3	3	
8.....	3	4	Third sheep vomits.
9.....	2	4½	
10.....	2	5	Fourth sheep stiff.
11.....	2	3½	
12.....	2	3	
13.....	1	2½	
14.....	1	2½	
15.....	1	2½	
16.....	1	3	
17.....	1	2	
Total.....	49	85	

Four out of the five sheep developed Vomeersiekte. One sheep actually vomited on the second day of the experiment; another on the 6th and a third on the 8th day. All three sheep continued vomiting after their removal to the hospital camp and one of them also showed symptoms of the stiff form. The fourth sheep contracted the stiff form of Vomeersiekte; symptoms were first observed on the 10th day and continued after its removal to the hospital camp on the 12th day. The fifth sheep remained healthy.

These sheep consumed on an average about $1\frac{3}{4}$ lb. of dried Geigeria per head per day, which is not much less than the amount of so-called "fresh Geigeria" eaten by sheep in the other experiments; material, however, which was already drier than anticipated. Since the experiment showed that the toxin was not destroyed in the sun-dried material of very low moisture content, we can assume that the sheep got larger amounts than in the preceding experiments; no wonder, therefore, that one sheep vomited on the second day of the experiment when it had probably only consumed about 3 lb. of dried Geigeria. This latter case lends support to the view already formulated, that the amount of Geigeria consumed and not the period which elapses after feeding, is the important factor in the production of cases of Vomeersiekte.

Conclusion.—Sun-drying of Geigeria does not appear to destroy its toxin.

Experiment 12.

Object: The same as in the preceding experiment. In view of the importance of settling this point beyond doubt, it was decided to confirm the experiment on a larger scale. There were two main reasons for establishing complete certainty on this point. One was that if, as some farmers contended, dry Geigeria was harmless for sheep and even gave a certain amount of protection against the toxin contained in the fresh plant, then the prospect of dealing with the disease in a relatively simple manner would be considerably brighter. All that would be necessary would be to pull up the plants, allow them to dry in the sun and let the sheep eat as much of the dried material as they would take. This would have afforded quite an "elegant" solution to the problem.

The second reason was that if dry Geigeria proved to be toxic, there would be no necessity to continue the experiments under the limitations of veld conditions; material could be dried in sufficient amount on the spot and forwarded to the Laboratory where the experiments could be continued under more ideal conditions.

Method.—In the present experiment 15 sheep were fed on Geigeria dried in the sun even longer than in the last experiment. The only difference was that the sheep were not removed from the experiment after vomiting commenced, but were allowed to die in order to obtain mortality data.

It is unnecessary to give all the details of the experiment. Suffice it to say that on an average the sheep ate about $1\frac{1}{4}$ lb. dry Geigeria per head per day.

The following table gives a brief summary of events in this experiment:—

Sheep No.	First Symptom.		Subsequent History.	Result.	
	Nature.	Day of Expt.			Day of Expt.
101	Vomiting	20th day	Stiff next day	Died	30th day.
114	,,	12th ,,	Vomited repeatedly	,,	25th ,,
127	,,	11th ,,	,, ,,	,,	42nd ,,
130	,,	9th ,,	,, ,,	,,	23rd ,,
134	,,	11th ,,	,, ,,	,,	40th ,,
136	,,	5th ,,	,, ,,	,,	41st ,,
138	,,	11th ,,	,, ,,	Discharged	42nd ,,
142	,,	23rd ,,	,, ,,	Died	40th ,,
147	,,	13th ,,	,, ,,	,,	23rd ,,
172	,,	35th ,,	,, ,,	,,	42nd ,,
204	,,	14th ,,	,, ,,	Discharged	42nd ,,
206	No symptoms	—	—	,,	42nd ,,
214	Vomiting	17th ,,	,, ,,	Died	32nd ,,
217	,,	13th ,,	,, ,,	Discharged	42nd ,,
225	,,	11th ,,	,, ,,	Died	13th ,,

The experiment lasted 42 days and during that time 14 out of the 15 sheep contracted the disease and 11 died. Sheep 206, which never showed any symptoms, was in fair condition at the end of the experiment. The other three which survived (Nos. 138, 204, and 206) were in very poor condition.

Conclusion.—This experiment which was continued for a considerably longer period than Experiment 11, confirmed the conclusion arrived at there, namely that Geigeria dried in the sun is capable of causing Vomeersiekte. The toxin appears to be fairly stable and not easily volatile.

H.—Does "Wilted" Geigeria produce the Disease?

Experiment 13.

Object.—To determine whether Geigeria which has been allowed to "wilt" can produce Vomeersiekte. It was thought that the metabolic changes in the plant during the process of wilting might perhaps destroy the toxin.

Method.—Geigeria was pulled up and left in the sun for a few hours to wilt and then fed to five sheep as in previous experiments.

Result.—The sheep consumed on an average about 2¼ lb. per head per day. One sheep vomited on the 6th day and was removed to the hospital camp, another on the 7th day, a third on the 10th day; and a fourth sheep developed the stiff form on the 17th day of the experiment. The fifth sheep remained healthy.

Conclusion.—Wilted Geigeria does produce cases of Vomeersiekte in the same way as the fresh plant.

Experiment 14.

Object.—To determine whether partially "autolysed" Geigeria can produce the disease.

Method.—Fresh Geigeria was packed loosely into bags and a few drops of chloroform sprinkled over each layer of a few inches. The bags were kept for two days and then the plants were removed and spread out for half an hour to remove the odour of chloroform, after which they were fed to five sheep according to the usual procedure.

Result.—The average consumption of the Geigeria treated in this way was about 1.2 lb. per sheep per day. The first case of Vomeersiekte occurred on the 6th day, the second on the 9th, the 3rd on the 13th, and the 4th on the 14th day of the experiment. Again one sheep remained healthy during the experiment which lasted 17 days. One sheep showed stiffness in addition to vomiting.

Conclusion.—Geigeria, treated in a way calculated to induce ensymic changes or incipient autolysis, produces cases of Vomeersiekte in about the same proportion of animals as fresh or dried Geigeria. We conclude that the toxin was not affected.

I.—Does Supplementary Feeding prevent the Disease?

Experiment 15.

Object.—To determine whether the addition of one ounce maize to a daily ration of Geigeria can prevent the disease.

It has already been mentioned that the farmers generally were of opinion that if the sheep receive a supplementary ration they will not contract Vomeersiekte when grazing on Geigeria veld.

The object of this and the following experiments was therefore to find out, first of all, whether this view was correct, and, if so, what quantities would be required.

Method.—Five sheep were taken into this experiment and given one ounce of maize per day, with Geigeria *ad libitum*.

The following table indicates the amounts eaten and also shows when symptoms were first observed, and when the animals were removed to the hospital camp:—

Day of Expt.	Amount of Geigeria (G.) and Maize (M.) eaten by Sheep.														
	No. 143.			No. 144.			No. 145.			No. 146.			No. 147		
	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.
	lb.	oz.		lb.	oz.		lb.	oz.		lb.	oz.		lb.	oz.	
1st....	1½	0		2¼	0		1½	0		2½	0		2¼	0	
2nd...	2	1		2	0		2	1		2	0		2	0	
3rd....	2	1		2	1		2	1		2½	½		2	1	
4th....	1¾	1		1⅝	1		1¾	1		2	1		1⅝	1	
5th....	2¼	0		1¾	1		2¼	1		2	0		1¾	1	Vom.
6th....	2	1		2	1		2	1		2	0				Hosp.
7th....			Stiff	1½	1		2	1		2	0				
8th....			Hosp.	1	1	Vom.	1½	1		2½	0				
9th....				1	1		2	1		2	0	Stiff			
10th....				1½	1		2½	1				Hosp.			
11th....			Very stiff	1	1		1½	1							Recovered
12th....						Vom.	1½	1							
13th....						Hosp.	1½	1							
14th....						—	2	1							
15th....			Stiff			Vom.	1½	1							
16th....							2	1							
17th....							2½	1							
TOTAL.	11½	4		17½	9		32	16		18½	1½		9½	3	

It will be seen that four out of the five sheep contracted the disease. Two vomited and two showed the stiff form. One sheep remained healthy.

The average amount of Geigeria eaten was rather less than 2 lb. per sheep per day. Some sheep did not eat their ration of maize very well.

Conclusion.—The quantity of maize given to the sheep in this experiment, namely one ounce per day, did not prevent Vomeersiekte.

Experiment 16.

Object.—To see whether the addition of three ounces of maize daily to a ration of Geigeria can prevent the disease.

Method.—Five sheep were fed on fresh Geigeria in the usual way, but received in addition three ounces maize each daily.

Result.—In the following table the results are recorded in the same way as in the last experiment:—

Day of Expt.	Amount of Geigeria (G.) and Maize (M.) eaten by Sheep.														
	No. 148.			No. 149.			No. 150.			No. 151.			No. 152.		
	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.
	lb.	oz.		lb.	oz.		lb.	oz.		lb.	oz.		lb.	oz.	
1st....	2½	0		2½	0		2½	0		2½	0		2	0	
2nd...	3	3		2½	1		2½	2		3	3		3	0	
3rd....	2⅓	3		2½	3		2½	3		2½	3		2½	0	
4th....	2¾	3		2¼	3		2¼	3		2¾	3		½	0	
5th....	2¾	3		2	3		2	3		2¾	3		2	0	
6th....	2⅓	3		1½	3		1¾	3		2½	3		2	0	
7th....	2	3		½	3		2⅓	3		2	3		2	3	
8th....	2¼	3				Very stiff	2⅔	3		2¼	3		2½	3	
9th....	2⅓	3				Hosp.	2	3		2	3				*Died*
10th....	½	3					1	3		½	3				
11th....	1	3	Stiff			Very stiff	1½	3		½	3	Stiff Hosp.			
12th....			Hosp.				1½	3							
13th....							2	3							
14th....							2	3							
15th....			Very Stiff			Stiff	0	3				Stiff			
16th....			*Died*				0	0							
17th....							½	3							
TOTAL.	24¼	30		14	16		25	44		23¼	30		16½	6	

It is remarkable that in this experiment none of the sheep actually vomited. Three sheep developed the stiff form and one of them died in the hospital camp. A fourth sheep (No. 152) died in the experiment on the 9th day without having been observed to show any symptoms. The fifth sheep (No. 150) was distinctly "off colour" towards the end of the experiment and ate very little, but was not seen to show symptoms of Vomeersiekte.

On an average the sheep consumed nearly 2 lb. of Geigeria per head per day. The daily ration of maize was finished by most of the sheep except No. 152.

Conclusion.—A supplementary ration of three ounces of maize per day did not prevent Vomeersiekte.

Experiment 17.

Object.—To see whether the feeding of seven ounces of maize daily to sheep which eat nothing else but Geigeria, can prevent Vomeersiekte.

Method.—Five sheep were treated in the same way as in the previous experiments but received seven ounces of maize daily instead of the one ounce and three ounces fed in Experiments 15 and 16 respectively.

It might be added that even if three ounces of maize had proved to be effective it would scarcely have been an economical proposition to try and prevent the disease in this way; nevertheless the larger amount (seven ounces) was tried to see whether it was possible at all to prevent the disease by this means.

Result.—Again the results may be recorded as in the previous experiments:—

Day of Expt.	Amount of Geigeria (G.) and Maize (M.) eaten by Sheep.														
	No. 153.			No. 154.			No. 155.			No. 156.			No. 157.		
	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.	G.	M.	Symp.
	lb.	oz.		lb.	oz.		lb.	oz.		lb.	oz.		lb.	oz.	
1st....	1½	0		2¼	0		2¼	0		2½	0		2½	0	
2nd...	2	0		2½	7		2½	7		2	7		2	7	
3rd....	2	0		2	7		2	7		2	7		2	7	
4th....	2¾	0		2	7		2	7		2	7		2	7	
5th....	2	0		2¼	7		2¼	7		2	7	Vom.	2	7	
6th....	2	0		2¼	7		2¼	7				Hosp.	2	7	
7th....	2	0		2	7		2	7					2	7	
8th....	1½	0		2¼	7		2¼	7					2	7	
9th....	2	0		2	7		2	7				Stiff	2	7	
10th....	1	0		1½	7		1½	7					2	7	
11th....	1½	0				Stiff	1	7				Stiff	0	7	
						Hosp.									
12th....	1	0					1½	7					2	7	
13th....	1	0					2½	7					2	7	
14th....			Vom.				2	7					2½	7	
			Hosp.												
15th....			Vom.				2½	7					2½	7	
16th....							2	7					2½	7	
17th....							2½	7					2	7	
TOTAL.	22¼	0		21	63		35	112		10½	28		34	112	

Three out of the five sheep developed symptoms of Vomeersiekte. Sheep 156 vomited after having consumed 10½ lb. of Geigeria and 28 ounces maize; later on this sheep also showed stiffness. Sheep 154 developed the stiff form on the 10th day after eating 21 lb. of Geigeria and about 4 lb. of maize. Sheep 153, which vomited on the 14th day consistently refused its maize and therefore can hardly count in this experiment. The other two sheep remained healthy.

Conclusion.—A supplementary ration of seven ounces of maize daily did not prevent Vomeersiekte in all cases. However, on the whole, the results of this experiment were rather more favourable than those of the previous two where the supplementary maize ration was smaller. It seemed desirable therefore to carry out another experiment with a still higher ration, which might be expected to reduce more definitely the quantity of Geigeria voluntarily eaten.

Experiment 18.

Object.—To determine whether it is possible to prevent Vomeersiekte by feeding a supplementary ration of 10 ounces of maize per day.

Method.—Fifteen sheep were selected and 10 ounces of maize given each per day; thereafter they were allowed to eat as much fresh Geigeria as they would. Symptoms were observed and the sick animals removed to the hospital camp.

Result.—It seems worth while recording the results again in tabular form:—

Day of Experiment.	Number of Sheep in Experiment.	Amount Eaten.		Symptoms Shown by Sheep.														
		Geigeria.	Maize.	No. 116.	No. 141.	No. 145.	No. 150.	No. 155.	No. 157.	No. 184.	No. 190.	No. 191.	No. 192.	No. 211.	No. 216.	No. 222.	No. 223.	No. 226.
		lb.	oz.															
1st	15	28	150															
2nd	15	30	150			Stiff		Stiff										
3rd	15	23½	150															
4th	15	20	150															
5th	15	25½	150			Stiff		Stiff										
6th	15	20½	150															
7th	15	28	150															
8th	15	19	150															
9th	15	28½	150			Stiff		Stiff					Vom. Hosp.					
10th	14	20	140															
11th	14	19	140															
12th	13	17	130									**Vom. Hosp.**						
13th	11	21	110	Vom. Hosp.				Vom. Hosp.										
14th	9	16½	90		Vom. Hosp.						Vom. Hosp.							
15th	9	11½	90															
16th	9	12½	90															
17th	9	9½	90															
18th	8	11½	80													**Vom. Hosp.**		
19th	8	7	80															
20th	7	7½	70			Vom.												
21st	5	5	50				Vom. Hosp.										Very Stiff Hosp.	Very Stiff Hosp.
22nd	5	8½	50															
23rd	5	11½	50															
24th	5	7	50															
25th	4	7	40											Vom. Hosp.				
26th	4	5½	40															
27th	4	6½	40															
28th	4	6½	40															
29th	4	7	40															
30th	3	4½	30												Very Stiff Hosp.			
31st	3	4	30															
32nd	3	5½	30															
	295	**354½**	**2,950**															

In the above table the results are shown up to the 32nd day of the experiment. During the next ten days the three sheep which remained continued to eat about 1½ lb. of Geigeria and 10 ounces of maize each per day without showing any ill effects.

It will be seen that 13 out of the 15 sheep showed symptoms of Vomeersiekte; nine actually vomited and were transferred to the hospital camp; of the four which showed the stiff form one (No. 145) got better and remained in the experiment until the end, the other three (Nos. 216, 223, and 226) had to be transferred.

It is interesting to note that the sheep, in spite of the comparatively large amount of maize which they got, consumed on an average over 1½ lb. Geigeria per head per day, which is not much less than the amount consumed in those experiments where nothing but Geigeria was eaten.

Conclusion.—Even 10 ounces of maize per head per day did not prevent Vomeersiekte from appearing amongst sheep eating fresh Geigeria and did not materially reduce the amount of Geigeria consumed. In the following experiments a bulky feed instead of a concentrate was tried.

Experiment 19.

Object.—To determine whether the addition of a bulky fodder such as hay to a daily ration of Geigeria can prevent Vomeersiekte.

Maize as a supplementary feed for the prevention of Vomeersiekte would, of course, have had many advantages, notably its small transport bulk and its reasonable cost; on the other hand, hay would have the advantage of being obtainable almost everywhere in good seasons. If dry Geigeria had itself proved to be a harmless roughage equivalent to hay, and hay as such could have prevented Vomeersiekte, the solution of the problem would have been very neat. Unfortunately, both of these possibilities proved to be wrong.

Method.—Five sheep received daily ½ lb. of hay each, and after this had been consumed were allowed to eat as much fresh Geigeria as they would take.

Result.—The quantity of material consumed is indicated in the following table, which also shows when the animals were transferred to the hospital camp:—

Day of Expt.	No. of Sheep in Expt.	Amount Eaten.		Symptoms shown by Sheep.				
		Geigeria.	Hay.	No. 111.	No. 112.	No. 113.	No. 114.	No. 115.
		lb.	lb.					
1st...	5	3½	2½					
2nd..	5	6	2½					
3rd..	5	9½	2½					
4th..	5	9	2½					
5th..	5	7	2½					
6th..	5	5½	2½				Vom. hosp.	
7th..	4	6½	2	Stiff hosp.				
8th..	3	6	1½					
9th..	3	3	1½				Vom.	Vom. hosp.
10th..	2	3	1	Very stiff				
11th..	2	2	1				Vom.	Vom.
12th..	2	2½	1					
13th..	2	1½	1					
14th..	2	0	1					
15th..	2	1	1	Vom.			Vom.	Vom.
16th..	2	2	1					
17th..	2	2½	1					
TOTAL	56	70½	28					

Three sheep contracted Vomeersiekte. The other two never showed any symptoms in the course of the experiment.

The ½ lb. of hay which was given to every sheep daily was readily consumed. The average amount of Geigeria eaten per head per day was about 1¼ lb., i.e., the hay replaced approximately its own bulk of Geigeria.

Conclusion.—A supplementary ration of ½ lb. of hay per sheep per day in addition to fresh Geigeria did not prevent Vomeersiekte. The amount of Geigeria eaten in addition to the hay was more than sufficient to produce the disease.

Experiment 20.

Object.—To see if Vomeersiekte can be prevented by feeding hay as a supplementary ration, i.e., a repetition of Experiment 19.

Method.—Six sheep were selected and given ½ lb. of hay each per day; after this had been eaten fresh Geigeria was given *ad libitum.*

Result.—In the following table the main results are recorded:—

Day of Expt.	No. of Sheep in Expt.	Amount Eaten.		Symptoms shown by Sheep.					
		Geigeria.	Hay.	No. 108.	No. 112.	No. 113.	No. 121.	No. 135.	No. 159.
		lb.	lb.						
1st...	6	7½	3						
2nd..	6	12	3						
3rd..	6	12½	3						
4th..	6	10	3						
5th..	6	13½	3						
6th..	6	9	3						
7th..	6	11½	3						Vom.
8th..	6	8	3						
9th..	6	9½	3						
10th..	6	13½	3						
11th..	5	11½	2½						Vom. hosp.
12th..	5	7½	2½						
13th..	4	6	2	Vom. hosp.					
14th..	4	5	2						
15th..	1	0	½			Stiff hosp.	Vom. hosp.	Vom. hosp.	
16th..		2½	0						
17th..					Vom. hosp.				
TOTAL	79	139½	39½						

All six sheep contracted Vomeersiekte; five vomited and the sixth showed the stiff form of the disease. The results of this experiment were therefore even more conclusive than those of the previous experiment.

The average daily consumption of Geigeria was about 1¾ lb. per sheep in addition to the ½ lb. of hay which each sheep got.

Conclusion.—Here, as in Experiment 19, ½ lb. of hay given to each sheep daily in addition to Geigeria did not prevent Vomeersiekte.

In the following experiment a still higher ration of hay was given, in order to ascertain whether this would reduce the natural consumption of Geigeria below the danger point.

Experiment 21.

Object.—Similar to that of the two previous experiments.

Method.—The six sheep in this experiment were offered 1 lb. of hay each daily before being given the fresh Geigeria.

Result.—The full results may again be quoted in the usual form:—

Day of Expt.	No. of Sheep in Expt.	Amount Eaten.		Symptoms shown by Sheep.					
		Geigeria.	Hay.	No. 144.	No. 161.	No. 174.	No. 215.	No. 219.	No. 227.
		lb.	lb.						
1st...	6	6	6						
2nd..	6	7	6						
3rd..	6	3½	6						
4th..	6	7½	6						
5th..	6	8	6						
6th..	6	2½	6						
7th..	6	8½	6						
8th..	6	4½	6						
9th..	6	7½	6						
10th..	6	8½	6						
11th..	6	6½	6						
12th...	6	9	6		Vom.				
13th..	3	3½	3		Vom. hosp.	Vom. hosp.	Vom. hosp.		
14th..	3	6	3						
15th..	3	0	3						
16th..	3	8½	0						
17th..	3	3	3						
18th..	3	3	3						
19th..	3	3	2						
20th..	3	0	3						
21st...	3	8	0						
22nd..	3	0	3						
23rd..	3	6	0						
24th..	3	0	3						
25th..	3	7	0						
26th..	3	3	0						
27th..	3	6½	0						
28th..	3	0	3						
29th..	3	7	0						
30th..	3	0	3						
31st...	3	6	0						
32nd..	3	0	3	Vom.					
33rd..	2	6	0	Hosp.					
34th..	2	0	2						
35th..	2	6	0						
36th..	2	0	2						
37th..	2	5	0						
38th..	2	0	1					Vom. hosp.	Vom. hosp.
TOTAL	144	166½	112						

It will be noticed that all six sheep had contracted Vomeersiekte by the 38th day of the experiment; they all vomited.

The average daily consumption of Geigeria was about 1⅛th lb. per sheep, and of hay about 12½ ounces, i.e., the consumption of Geigeria was reduced by an amount equivalent to the hay given.

Towards the end of the experiment the remaining sheep did not finish their rations very well. At first, however, they ate freely, and it will be seen from the table that during the first 12 days of the experiment the six sheep finished their 6 lb. of hay every day; in spite of this three sheep started vomiting on the 12th and 13th days.

Conclusion.—A supplementary ration of 1 lb. of hay per sheep per day given in addition to fresh Geigeria did not prevent Vomeersiekte.

Experiment 22.

Object.—Similar to that of the three preceding experiments.

Method.—Six sheep were selected and it was decided to offer them 2 lb. of hay each per day and then allow them to eat as much Geigeria as they would take.

Result.—On the first day of the experiment the six sheep were given 12 lb. of hay. This they had not finished by the end of the day. On the morning of the second day they therefore did not get fresh hay but were allowed to finish the hay of the previous day. After they had eaten all the hay, they were given fresh Geigeria and consumed 14½ lb. by the evening. On the third day they again started with 12 lb. hay which they only finished in the course of the fourth day; and thereupon they ate 12 lb. of Geigeria. The same thing happened the following two days and so on right through the experiment.

It will be seen, therefore, that instead of each of the sheep consuming 2 lb. of hay every day, they only did so every second day. On an average they, therefore, only consumed 1 lb. per day (the same as in Experiment 21), and this rate of consumption was kept up throughout the experiment. Although in this experiment they were free to cover their whole requirements on hay alone, and eat as little Geigeria as they pleased, they made no attempt to avoid the plant producing the disease.

A detailed table need not be given; suffice it to say that the experiment lasted 42 days and that during that time the sheep consumed on an average little over 1 lb. of Geigeria per day and exactly 1 lb. of hay.

One sheep vomited on the 11th day of the experiment, a second one on the 14th, and a third on the 26th day. The other three sheep remained healthy till the conclusion of the experiment on the 42nd day.

Conclusion.—Again, as in Experiment 21, a liberal supplementary ration of hay did not prevent Vomeersiekte, and the sheep took no advantage of the opportunity to reduce their intake of Geigeria to sub-toxic limits.

These experiments seem to dispose definitely of the farmers' theory that supplementary feeding will prevent the disease. Obviously if 1 lb. of hay or 10 ounces of maize cannot stop the disease from appearing amongst a flock, the method has no practical value. To feed more would mean discarding the natural pasture altogether, at all times when Geigeria was abundant.

J.—Has Bonemeal any Influence on the Incidence of Vomeersiekte.

Experiment 23.

Object.—To see whether a dose of bonemeal daily can prevent Vomeersiekte or influence the incidence of the disease in any other way.

The reason why bonemeal was tried was that this substance had been found to improve the general condition of sheep and other animals, and to increase their power of resisting disease, probably owing to the fact that it supplies the phosphorus lacking in so much of the natural pasturage of South Africa.

Method.—Ten sheep were fed for three weeks on an ordinary ration of maize and hay (six ounces maize per head per day, and hay *ad libitum*). In addition to this, each sheep was dosed every day with ½ ounce of bonemeal.

After three weeks of this preliminary feeding the sheep were put in a Geigeria feeding test. They still got their dose of bonemeal every day but were then allowed to eat as much fresh Geigeria as they would take.

The following table records the results for this second period of the experiment:—

Day of Expt.	No. of Sheep in Expt.	Amount Eaten.		Symptoms shown by Sheep.									
		Geigeria.	Bonemeal.	No. 193.	No. 194.	No. 195.	No. 196.	No. 197.	No. 198.	No. 199.	No. 200.	No. 201.	No. 202.
		lb.	oz.										
1st...	10	26½	5										
2nd..	10	10½	5										
3rd...	10	16½	5										
4th...	10	16½	5										
5th...	10	18	5										
6th...	10	14½	5										
7th...	10	27	5										
8th...	10	22½	5						vom.				
9th...	9	18	4½						hosp.				vom. hosp.
10th..	8	19	4										
11th..	8	15½	4										
12th..	8	16½	4			Vom.					Vom.		
13th..	6	11½	3			Hosp.				Vom.	Hosp.		
14th..	5	10½	2½							Hosp.			
15th..	5	9	2½	Vom.								Vom.	
16th..	3	10	1½	Hosp.								Hosp.	
17th..	3	8	1½										
18th..	3	4½	1½					Vom.					
19th..	2	5	1					Hosp.					
20th..	2	2½	1										
21st..	2	5	1										
22nd.	2	2	1										
23rd..	2	3	1										
24th..	2	2	1				Vom.						
25th..	1	1	½				Hosp.						
26th..	1	1½	½										
27th..	1	1	½		Dull								
28th..	1	½	½				Died						
29th..	1	2	½										
30th..	1	1	½										
31st..	1	1	½										
32nd.	1	½	½		Dull								
Total.	158	302½	79										

It will be seen that nine out of the ten sheep vomited and were transferred to the hospital camp. The tenth sheep (No. 194) was dull towards the end of the experiment but was never seen to vomit actually.

The average consumption of Geigeria in this experiment was nearly 2 lb. per head per day. Of the bonemeal each sheep received ½ ounce per day with a spoon.

Conclusion.—The addition of ½ ounce bonemeal per day to sheep feeding on Geigeria seems to have no influence on the incidence of the disease.

K.—Control and Specific Effect of Salt.

Experiment 24.

Object.—To note the incidence of Vomeersiekte amongst sheep running on Geigeria veld; and, at the same time, to determine whether common salt has any influence on the disease when given as a lick. As already mentioned some farmers were of opinion that the symptoms of Vomeersiekte only appeared when sheep had access to salt, and others considered that the actual licking of salt accelerated an attack of vomiting.

Method.—Thirty sheep were run on Geigeria veld on the farm Pienaarsfontein where all the above experiments were conducted. The sheep were herded during the day and kraaled at night. Before kraaling, 15 sheep were allowed access to a salt lick, whereas the other 15 were kept away from the salt.

Result.—Of the 30 animals not one escaped completely.

Amongst the 15 controls which received no salt, one vomited on the 6th day and was transferred to the hospital camp; a second one vomited on the 8th day, a third and fourth on the 9th day, and a fifth and sixth on the 10th day; one of these latter died the next day. On the 14th day a seventh sheep vomited (which died two days later), and on the 15th day three more sheep (8th, 9th, and 10th of the experiment) showed definite symptoms of the stiff form. An eleventh animal was stiff on the 19th day, and a twelfth vomited on the 24th and died the next day. The thirteenth sheep vomited on the 29th, the fourteenth on the 34th, and the fifteenth on the 36th day of the experiment.

Of the 15 which had access to the salt lick two vomited on the 6th day, and three more on the 10th day. Six further sheep were stiff on the 15th day and another one (the twelfth sheep) on the 17th day. The thirteenth sheep vomited on the 29th day and died the next day. The fourteenth sheep was stiff for a few days and vomited on the 34th day. The fifteenth sheep was apparently well for more than seven weeks; on the 53rd day of the experiment it began to develop the stiff form of the disease and had to be transferred to the hospital camp on the 58th day.

Conclusion.—If sheep are left on Geigeria veld for a sufficiently long period, 100 per cent. may contract Vomeersiekte. It seems to make no difference whether the sheep have access to salt or not.

L.—Do other Animals get Vomeersiekte?

Experiment 25.

Object.—To find out whether Geigeria will produce Vomeersiekte in *cattle.*

Method.—Six small cattle were kept in a small enclosure and fed on fresh Geigeria every day. The plants were weighed before and after feeding so as determine the quantity consumed.

Result.—The experiment was continued for 29 days and the total weight of Geigeria consumed by the six cattle during that period was 1,714 lb. or an average of 9.85 lb. per head per day.

None of the cattle showed symptoms of Vomeersiekte during that period.

Conclusion.—In the present experiment six head of cattle fed on fresh Geigeria for 29 days and consuming on an average nearly 10 lb. per head per day (as sole ration) did not contract Vomeersiekte, and the only conclusion which can be drawn is that cattle are less susceptible than sheep.

The experience of farmers, however, is that cattle can contract the disease. In bad years, such as 1923 and 1924, cattle have definitely been known to show symptoms of Vomeersiekte (vomiting, etc.) and even to die. It will also be recalled that in an experiment conducted at Armoedsvlakte in 1912 (see page 113 of this report), a cow vomited after having been drenched with Geigeria daily for over a month.

It is likely that if the experiment now recorded had been continued longer, some of the cattle would have contracted the disease. Cattle are undoubtedly much less susceptible than sheep, and even in this latter class of animals many individuals will resist the action of the Geigeria poison for a month and more, as the preceding experiments have shown. Unfortunately the experiment could not be extended owing to cessation of the main programme of work on the farm concerned.

Experiment 26.

Object.—To determine whether Geigeria will produce Vomeersiekte in *donkeys.*

Method.—Six donkeys were fed on fresh Geigeria for 29 days and the weight of plant consumed determined.

Result.—The total amount of Geigeria consumed was 199$8\frac{1}{2}$ lb., which works out at $11\frac{1}{2}$ lb. per head per day.

None of the donkeys showed any suspicious symptoms.

Conclusion.—In the experiment, six donkeys eating fresh Geigeria at the rate of about $11\frac{1}{2}$ lb. per head per day for 29 days did not contract Vomeersiekte.

Here again it should be noted that donkeys have been reported to die of this disease. The symptoms, according to report, are not very definite, the animals just falling off in condition and ultimately dying of emaciation and weakness. The duration of this experiment was too short to obtain verification.

Experiment 27.

Object.—To see whether *goats* will get Vomeersiekte when fed on Geigeria, and if so, to note the symptoms.

Method.—Twenty goats were fed on fresh Geigeria daily as in the previous experiments.

Result.—All 20 goats contracted the " stiff " form of the disease. One goat began to show symptoms on the second day of the experiment; it grew steadily worse and was transferred to the hospital camp on the 20th day. On this latter day three more goats showed definite symptoms and were transferred. Two days later seven more goats had to be transferred. The twelfth goat was stiff on the 24th day, and three more on the 26th day of the experiment. The last five goats were all stiff and had to be transferred on the 34th day. During this period five of the goats died.

The average consumption of Geigeria was 3.4 lb. per head per day, which is considerably more than the sheep ate. The selection of flowering heads and leaves from the tougher stems, however, may have been less perfect in the case of the goats.

Conclusion.—Goats seem to contract Vomeersiekte readily when fed on Geigeria, which they relish. However, they were not observed to vomit but without exception showed the stiff form of the disease. This is strictly in accordance with the experience of farmers.

SUMMARY OF CONCLUSIONS REACHED AT BOETSAP.

1. Sheep, if kept in confinement in small enclosures and fed on fresh *Geigeria passerinoides*, develop a specific disease " Vomeersiekte " or " Vomiting sickness." When confined to the plant they consume an average of about 2 lb. of " tops " (flower-heads, leaves, and small twigs) per head per day. This amount, however, seems to cover their actual food requirements, since those which survive longest remain in fair condition.

2. The addition of salt does not effect the consumption of Geigeria nor the incidence of the disease.

3. The first symptoms of Vomeersiekte may be observed on about the 4th day of feeding exclusively on Geigeria, but most sheep do not react so rapidly.

4. If sheep showing symptoms of Vomeersiekte are removed from their Geigeria feed and given an ordinary ration of hay and maize, they may continue to show symptoms for a considerable time and may ultimately die of Vomeersiekte.

5. The smallest quantity of fresh Geigeria that will produce Vomeersiekte seems to be about 5-6 lb.

6. On the other hand, some sheep can eat very large quantities of Geigeria (up to 80 lb. over a period of six weeks) without showing symptoms.

Individual susceptibility seems to play an important rôle.

7. It is not certain whether the minimum observed period of three days must elapse between feeding of the plant and appearance of the disease; in other words, whether or not there is a " latent period " in Vomeersiekte. It seems more likely that the quantity of plant eaten is the deciding factor; thus after consumption of the minimum " toxic dose " the disease may appear very rapidly irrespective of the fact whether the feeding was limited to three days or extended over eight or ten days.

8. Sheep which pass through an attack of Vomeersiekte and recover can contract the disease again when again fed on Geigeria. No " immunity " against Geigeria toxin is produced by such an attack.

9. There is no reason to believe that some sheep possess a natural " immunity " against Vormeersiekte. The individual susceptibility is, however, so variable that in some cases feeding with Geigeria has to be continued over a long period (42 days) and large quantities (80 lb.) have to be fed before symptoms are produced.

10. Sheep which contract the " stiff form " of the disease may subsequently show vomiting either in the course of the same attack or in a later attack; and conversely, sheep which first vomit may later on show stiffness or paralysis. There is no doubt that both types of symptoms are produced by *Geigeria passerinoides*.

11. Geigeria dried in the sun until the leaves are quite brittle will still produce Vomeersiekte; the toxin is not destroyed by this process. One sheep vomited after having eaten only about 3 lb. of dried Geigeria.

12. Wilted Geigeria or Geigeria "autolysed" by chloroform vapour produces Vomeersiekte; the toxin appears to be unaltered.

13. The addition of maize, as supplementary concentrate, to a ration of Geigeria, did not prevent Vomeersiekte in sheep. Even when the supplementary ration of maize was increased to 10 ounces per sheep per day, so covering a fair proportion of total energy requirements, the amount of Geigeria consumed remained high and its toxic effect unaltered.

14. The same negative result was obtained when a bulky fodder (hay) was substituted for maize. A supplementary ration of 1 lb. hay per sheep per day reduced the consumption of Geigeria but did not prevent Vomeersiekte.

15. A ration of ½ ounce of bonemeal per head per day, to improve the general nutritive condition of the sheep, had no influence upon the incidence of Vomeersiekte due to Geigeria feeding.

16. If sheep are grazed on Geigeria veld for a sufficiently long period, the incidence of the disease may rise to 100 per cent. Of 30 control sheep running on such veld, the last one showed symptoms during the 8th week of the experiment.

17. It seems to make no difference to the onset of symptoms whether the sheep have free access to a salt lick or not.

18. In the feeding experiment conducted with six cattle, no symptoms of Vomeersiekte were produced within a month although the animals consumed about 10 lb. fresh Geigeria per head per day; and cattle are therefore less susceptible than sheep.

Cattle have, however, been known to contract the disease, and it is probable that symptoms would have appeared if the experiment had been continued for a sufficient length of time.

19. Negative results were obtained with six donkeys fed exclusively on Geigeria for nearly a month, and consuming about 11½ lb. per head per day. In the case of these animals, however, a few farmers have reported illness, and death due to Geigeria, but without symptoms of vomiting.

20. Goats contract Vomeersiekte readily, but show the "stiff" or "paralytic" form of the disease. In an experiment conducted with 20 goats all 20 contracted the disease in this form within five weeks but none vomited.

The average consumption of Geigeria by the goats was over 3 lb. per head per day, as against about 2 lb. by sheep, but the selection of leaves and flowering heads was probably less perfect.

VI.—EXPERIMENTS AT ONDERSTEPOORT.

The results of Experiments 11 and 12 at Boetsap seemed to indicate very clearly that dried Geigeria retained its toxin in an unaltered form and was capable of producting Vomeersiekte as readily as the fresh plant. As soon as this fact was established, arrangements were made to dry large quantities of Geigeria so that the experiments could be continued "at leisure" at the Onderstepoort Laboratory. Accordingly, several hundred bags of Geigeria were dried and despatched from Boetsap to Onderstepoort during the early summer of 1924.

The experiments at Donderbosfontein and Boetsap had not yielded much of practical value to the farmer who was losing his sheep from Vomeersiekte. It was quite interesting to know definitely that *Geigeria passerinoides* caused the disease, although the majority of farmers felt certain of this all the time. Also the fact that a wire-worm infection or a salt lick was not necessary for the production of the disease, did not help the farmer much. His great hope had always been to prevent the disease by means of a supplementary ration, and his chief difficulty had been to procure the necessary foodstuffs; but now our experiments had shown that supplementary rations of maize or hay would not stop the disease however large the amount.

At this stage the only hope of finding some practical solution seemed to be to continue the work along chemical lines. If the nature of the Geigeria toxin were known it might be possible to devise some means of counteracting it.

The first experiments at Onderstepoort were, therefore, undertaken with a view to establishing the toxic dose of the dried material so that later on attempts could be made to extract the toxin from this material.

Experiment 1*a*.

Object.—To determine the toxic dose for sheep of dried Geigeria received from Boetsap.

Method.—The experiment was begun with four sheep and two goats, which received as much dry Geigeria as they would eat, the amount being determined by weight as in previous experiments.

Result.—The experiment was continued for 25 days, during which period the six animals consumed 105 lb. of dried Geigeria, i.e. on an average 0.7 lb. per head per day. No symptoms were shown by any of these animals.

Conclusion.—In the amount eaten the dried material did not produce the disease.

As will be seen from the above figures, the animals used in this experiment ate very little Geigeria, and this seemed to account for the negative results. It was thought that if sheep which were accustomed to this plant were to be used, positive results were more likely to be obtained. Accordingly a number of sheep were ordered from Boetsap and drafted into the following experiments.

Experiment 1*b*.

Object.—Same as in Experiment 1*a*.

Method.—Ten sheep received from Boetsap were added to the four sheep and two goats used in Experiment 1*a*, and the feeding with dried Geigeria continued as before.

Result.—During the first 32 days of the experiment the fourteen sheep and two goats consumed 665½ lb. of the dried Geigeria, that is on an average 1.3 lb. per day per head.

On the 31st day of the experiment one of the Boetsap sheep vomited. The next day two of the original sheep in Experiment 1*a* died, but in all probability these animals died of starvation since they ate very little from the start.

To prevent further losses from starvation, the sheep were thereupon given about ½ lb. of maize per head per day. It was felt that

this could be done without influencing the course of the experiment, since the results at Boetsap had shown that a supplementary ration of maize did not prevent Vomeersiekte.

Thereafter the experiment continued with 12 sheep and two goats for another seven days, during which time two of the Boetsap sheep were seen to vomit on one occasion (the 35th day of the experiment).

Conclusion.—During the 39 days that this experiment was conducted only three out of the 14 sheep were observed to vomit, a single time each. The two goats showed no symptoms.

Experiment 1*c.*

Object.—Same as in Experiment 1*a*.

Method.—Another 10 sheep from Boetsap were added to the 12 already in Experiment 1*b* and the feeding with Geigeria continued as before.

Result.—The experiment lasted 27 days and during that time the 22 sheep and two goats ate on an average just about exactly 1 lb. of Geigeria per head per day.

No symptoms of Vomeersiekte were shown by any of the animals.

Conclusion.—In this experiment the dried Geigeria failed to produce cases of Vomeersiekte.

Experiment 1*d.*

Object.—Same as in Experiment 1*a*.

Method.—Twenty fresh sheep from Boetsap were fed on dried Geigeria for nearly seven weeks.

Result.—The 20 animals again consumed on an average just about 1 lb. dried Geigeria per head per day.

One sheep (No. 10234) vomited on the 26th day of the experiment and continued to do so at intervals until the end of the experiment. Between the 38th and 45th day of the experiment a few more sheep showed symptoms; one was observed to vomit, six others had dirty nostrils, possibly due to vomiting, and one developed the stiff form of the disease.

Conclusion.—Again, as in the preceding experiments the action of the dried Geigeria was slow and uncertain. After 26 days feeding the first case of Vomeersiekte was produced and the second after 38 days. These were the only two definite cases amongst 20 sheep.

It was difficult to account for this very weak action of the dried Geigeria after the positive results obtained at Boetsap. Perhaps the explanation is to be sought in the fact that the "dried" Geigeria of Boetsap had laid in the sun only for about a week to a fortnight and was then fed, whereas the material used at Onderstepoort was first collected and dried, then transported and stored for several months before being fed. This would lead us to surmise that the Geigeria toxin is of an unstable nature and affected by prolonged drying; or perhaps by slow processes of oxidative resinification known to occur with certain other plant toxins.

After the above unsatisfactory results another attempt was made to set up cases of Vomeersiekte with the dried Geigeria in the following ways:—

Experiment 2.

Object.—To produce cases of Vomeersiekte with dried ground Geigeria.

Method.—The dried plant was ground to a moderately fine powder and given to sheep mixed with some bran.

Four sheep were fed in two groups of two.

Result.—The first two sheep were fed on the powdered Geigeria for 24 days and consumed together on an average 3½ lb. per day. This must be considered quite a large quantity seeing that the plant was dry and in powder form, so that there was no waste. Nevertheless, neither of these two sheep showed any symptoms.

Two more sheep were thereupon taken and treated in the same way. They were fed for 46 days on dried powdered Geigeria and consumed on an average very nearly 3½ lbs. per day. On the 23rd day of the experiment one sheep vomited, but was not seen to vomit again during the remainder of the experiment. The other one had a dirty nose on the 41st day, but was never seen to vomit.

Conclusion.—The result was again disappointing. It was thought that the dried and powdered Geigeria would produce the disease without fail in a very short time. However, only one out of four sheep vomited after having consumed about 40 lb. We conclude that the toxin must have been partially destroyed.

Experiment 3.

Object.—To produce cases of Vomeersiekte by force-feeding.

Method.—Dried Geigeria ground up as in the preceding experiment was fed to sheep with a spoon so as to ensure a definite intake. The method proved to be exceedingly cumbersome. It took two natives several hours each day to get 1 or 1½ lb. of the bulky powder down a sheep's throat.

Result.—The first sheep consumed during the first nine days of the experiment 13.6 lb., i.e., 1½ lb. per day. It then showed digestive troubles and feeding was discontinued for a few days. Thereafter the sheep was again force-fed for a fortnight and took on an average 1.4 lb. per day, but never showed any signs of vomiting.

Another sheep was then taken into the experiment and given 1½ lb. of dried powdered Geigeria per day. On the 34th day of the experiment the sheep vomited repeatedly, and again on the 35th, 36th, 39th, and 40th day. The experiment was stopped on the 47th day.

Conclusion.—With the material used it was possible to produce vomiting in a sheep but only after a very large quantity (about 50 lb.) had been fed over a long period (34 days). The toxin appeared to have fallen off in effectiveness during the long period elapsing between collecting and feeding the plant.

Experiment 4.

Object.—To produce a case of Vomeersiekte by drenching with a concentrated extract of Geigeria.

Method.—15 lb. of heads, separated from woody stems, were ground up, treated with 45 litres of hot water (about 95° C.) and allowed to stand overnight. The extract was then filtered and evaporated over a low flame, finally over a steam bath, to a bulk of about 700 c.c. This was then administered to one sheep during the course of one day.

Result.—The day after drenching the sheep showed diarrhoea, which remained for two days. The sheep was kept under observation for three weeks but never showed any signs of Vomeersiekte.

Conclusion.—Either that the aqueous extract made from 15 lb. of Geigeria did not contain sufficient toxin to produce Vomeersiekte or that the toxin was destroyed in the process of extraction.

NOTE ON THE ONDERSTEPOORT EXPERIMENTS.

After the clear and convincing results obtained at Boetsap the Onderstepoort experiments were most disappointing. It was thought that the dried Geigeria would produce the disease as readily here as it did at Boetsap, and it was expected that with the large amount of dry material available (over 400 bags) a serious attempt could be made to study the nature of the toxin. However, as seen in the above experiment, the toxin seemed to have become so weak that amongst nearly 50 animals fed on the plant only a few vomited, and that only after a prolonged period of feeding. Even when the plant was given in powdered form or as a drench, the result was uncertain. There was therefore no object in starting chemical work with the dry material available, and this work was consequently abandoned until the following season.

REVIEW OF EXPERIMENTAL WORK.

It is unnecessary to summarise again the results of all experiments recorded in this paper. Summaries of the different groups of experiments have been given on pages 120 and 146.

The outstanding features of the work may, however, be recapitulated as follows:—

1. It was established for the first time experimentally that the disease "Vomeersiekte" is caused by *Geigeria passerinoides*, Harv.

2. Other factors previously suspected by farmers, such as the eating of salt and the concomitant occurrence of wire worm infection, have no influence on the disease.

3. The amount of Geigeria usually eaten by sheep varied up to 2 lb. per head per day of flowering heads and leaves. The minimal quantity necessary to produce Vomeersiekte was determined as about 5 lb. consumed over three days, although some sheep only showed symptoms after consuming 80 lb. over 42 days.

4. Various interesting points in connection with the disease were observed, e.g. that the symptoms may continue after removal of the sheep from a Geigeria diet, and that sheep may show the symptoms of Vomeersiekte in any order, first vomiting, then stiffness, or *vice versa*, or both forms together.

5. An attack of Vomeersiekte does not produce "immunity" nor does it seem likely that there are sheep which possess a "natural immunity" against the toxin; although the degree of susceptibility varies within wide limits.

6. Drying Geigeria in the sun does not destroy the toxin, nor is it destroyed by wilting. On the other hand, the final experiments showed that the toxin does deteriorate in dried plants after a few months. It seems, therefore, to be a "labile" toxin.

7. Contrary to the common belief of farmers, it was shown that the feeding of supplementary rations (maize or hay) to sheep on a Geigeria diet does not prevent the disease. So long as the plant is ingested at all the incidence of the disease appears to depend only on the amount consumed and the individual susceptibility of the sheep.

CONCLUSION.

The foregoing experiments were quite satisfactory from the point of view of elucidating the cause and nature of Vomeersiekte and determining many facts in connection with the disease. From the farmer's point of view, however, the results were disappointing. At the conclusion of our researches, sheep were still dying in hundreds of Vomeersiekte, but there was very little we could tell the farmer about the treatment or prevention of the disease.

Treatment.—It may be stated here, that some attempts at treatment were made during the course of the experiments, with a variety of drugs, but nothing was found that seemed in any way to counteract the Geigeria poison. There was, of course, a hope that when once the nature of the toxin was accurately known, treatment might be formulated. But even with a specific antidote no satisfactory solution of the problem would have been found. As pointed out previously, the sheep in the Vomeersiekte areas subsisted on a diet, 90 per cent. of which, in many instances, consisted of Geigeria. If, therefore, the sheep filled their bellies day after day with a plant containing an active poison, there would seem to be very little hope of keeping such sheep in health by means of curative treatment.

Prevention, therefore, had to be aimed at. The farmer's simplest method of prevention is to trek with his flock to healthy pastures, but this can only be considered as a temporary measure in time of distress, saving his flock by deserting his customary pasture, and other means of preventing the disease were accordingly looked for. The method to which many farmers had pinned their faith and which we also were inclined to regard as promising, was limited supplementary feeding. It was, therefore, a great disappointment when the experiments at Boetsap showed that even large quantities of supplementary foodstuffs would not prevent the disease. The possibility of eradicating the plant by mechanical means is out of the question in view of its extraordinary dominance in bad years, and the low value of the land concerned.

What then, it may be asked, are the prospects for the future? At the beginning of this article it was pointed out that *Geigeria passerinoides* had spread to an alarming extent over vast areas during the last few years. The question now is, will it continue to spread and if so will the disease become an increasingly serious menace to sheep farming in South Africa?

It should be mentioned here that even in 1923 and 1924 when the position was at its worst, the idea was expressed that Geigeria might perhaps disappear in the same way as it had appeared; in other words that the 1923-24 position was just a passing phase in the course of a plant succession. Conditions, it was assumed, had been particularly favourable for the propagation of Geigeria. It has already been mentioned that the drought and locusts had actually favoured its spread, and it was thought reasonable to suppose that those conditions would change and that with the changed conditions other plants would replace the Geigeria. Another possibility was that some pest might attack the Geigeria and destroy it, or, at any rate, stay its progress.

In reality reports began to reach us in 1925 from different districts indicating that the Geigeria plants were actually dying in great numbers. Most observers were inclined to incriminate an insect

larva which hatches and lives at the base of the stems. This explanation seemed hardly satisfactory since the same larva had been known for years to infest the plant, and never seemed to harm it in any way.

Dr. I. B. Pole Evans, the Chief of the Division of Botany, was accordingly requested to investigate the conditions, and the following is a quotation from his report:—

"I visited Boetsap on the 8th October, 1925, and found that in the Veld Reserve which we have established there and on which there were at least one to two Geigeria plants per square foot, I found every one of these within the Reserve dead at the time of my visit. Also on my journey from Fourteen Streams to Boetsap and back I saw no living plants of Geigeria. There were, however, plenty of old dead plants and young ones at various stages. It was clear, however, that none of the plants had survived the frost. While at Boetsap I also made a careful examination of the old feeding camp established by the Veterinary Research Division. In this camp where the Geigeria had been stacked into heaps I found one or two Geigeria plants which had just managed to survive the winter and which were making new growth from the old shoots. I only found these plants where they were protected from frosts by the heavy deposit of dead plant remains and this was also probably responsible for preserving a certain amount of moisture in the soil. As a result of my last visit to Boetsap, I am quite satisfied that *Geigeria passerinoides* on the Kaap Plateau is an annual."

The prospects for the future, therefore, do not appear to be quite so black. The plant is undoubtedly disappearing, whatever the various factors contributing towards this result may be. It is to be hoped, therefore, that the losses from Vomeersiekte during the coming years will be light. In the meantime, the researches which were begun at Donderbosfontein and Boetsap will be continued, and it is yet hoped that some means will be found of controlling the occurrence of this disease, which during the past fifty years must have killed hundreds of thousands of sheep over the various occasions upon which it flared into prominence.

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