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INGESTION OF THE PLANT *FADOGIA MONTICOLA* ROBYNS AS AN ADDITIONAL CAUSE OF GOUSIEKTE IN RUMINANTS

L. R. HURTER[1], T. W. NAUDÉ[2], T. F. ADELAAR[2], J. D. SMIT[2] and L. E. CODD[3]

ABSTRACT

HURTER, L. R., NAUDÉ, T. W., ADELAAR, T. F., SMIT, J. D. & CODD, L. E. Ingestion of the plant *Fadogia monticola* Robyns as an additional cause of gousiekte in ruminants. *Onderstepoort J. vet. Res.* 39 (1), 71–82 (1972).

Investigation of outbreaks of gousiekte in cattle in the northern Transvaal revealed that *Fadogia monticola* Robyns is an additional cause of this disease, which is characterized by sudden heart failure without prodromal signs. It results from a chronic lymphocytic myocarditis and death occurs after a latent period of 4 to 8 weeks.

The condition was reproduced in cattle, sheep and goats in feeding and dosing trials.

This is the first report of gousiekte being caused by a plant of the genus *Fadogia* and brings the total number of plant species incriminated in this syndrome to five, all members of the family Rubiaceae.

INTRODUCTION

Gousiekte is a plant poisoning of ruminants caused by the ingestion of relatively large quantities of material (*c.* 50 to 200 g of air dried material per kg body mass) from certain species of the family Rubiaceae. After a latent period of 4 to 8 weeks, and usually without obvious premonitory symptoms, sudden heart failure results in death — hence the popular Afrikaans name gousiekte, meaning "quick disease".

At autopsy, in addition to a generalized venous congestion, lung oedema, slight hydropericardium, hydrothorax and ascites, dilatation of all four chambers of the heart with atrophy of the ventricular walls are seen in a small percentage of cases. Histological examination of the myocardium reveals a replacement fibrosis of segments of myocardial fibres following necrosis and a round cell infiltration, particularly in the vicinity of the heart apex.

From an economic view-point gousiekte is undoubtedly one of the most important, if not the most important, plant poisoning in South Africa. It was first described by Theiler, Du Toit & Mitchell (1923), who investigated it in sheep that had ingested *Pachystigma pygmaeum* (Schltr.) Robyns. This was the only cause of gousiekte known until Uys & Adelaar (1957) also incriminated *Pavetta harborii* S. Moore. Subsequently Naudé & Adelaar (unpublished data, 1962) also incriminated *Pavetta schumanniana* F. Hoffm. and Adelaar & Terblanche (1967) implicated *Pachystigma thamnus* Robyns.

Gousiekte has been encountered in southern Africa only, viz. the Republic of South Africa, Botswana and, according to J. J. Jackson (Department of Veterinary Services, Rhodesia, personal communication, 1966), Rhodesia. It has invariably been associated with plants of the family Rubiaceae.

A syndrome closely resembling gousiekte, caused by the plant *Mascagnia rigida* Griseb. (fam. Malphigiaceae), has been described in north-eastern Brazil (Tokarnia, Canella & Döbereiner, 1963).

In Australia chronic fluoro-acetate poisoning due to *Acacia georginae* F. M. Bailey (fam. Mimosaceae) also resembles the gousiekte syndrome in some respects but the gross and microscopical myocardial lesions differ (Whittem & Murray, 1963).

In falling disease, a heart failure of cattle occurring in western Australia, some signs are reminiscent of gousiekte (Bennetts, Beck & Harley, 1948). This is, however, associated with a copper deficiency, whereas the copper content of the blood and liver has always been within the range of normality in those gousiekte cases in which this has been determined (Naudé & Adelaar, unpublished data, 1962).

HISTORY

Periodic outbreaks of gousiekte in cattle have been diagnosed in the Vaalwater area of the northern Transvaal for many years (Adelaar, 1936). Ever since the first ranchers settled in the area, severe mortality in cattle has occurred sporadically, usually during November and December. It has been reported by W. K. Oosthuizen (Stock Inspector, Vaalwater, 1967, personal communication) that 2 051 cattle died from gousiekte in an area within a radius of 30 miles from Vaalwater during the 8-year period from 1959 to 1966. Until 1957, it was thought that the poisoning was caused by a plant referred to as *Pachystigma pygmaeum*. However, while investigating an outbreak of the disease at this time, one of us (L.R.H.) submitted specimens of this plant to the Research Institute for Botany, Pretoria, where it was identified as *Pygmaeothamnus zeyheri* var. *rogersii* Robyns of the family Rubiaceae, commonly known as the "harige goorappel" (hairy goorappel*). This is merely a hirsute variety of the well-known and widely distributed "goorappel" *Pygmaeothamnus zeyheri* var. *zeyheri* (Sond.) Robyns, which had been excluded by Theiler *et al.* (1923) as a cause of gousiekte. *P. zeyheri* var. *rogersii* superficially resembles *Pachystigma pygmaeum* very closely and only the experienced eye can differentiate between these two plants.

Subsequently, examination of the vegetation on several occasions on a number of farms on which outbreaks had occurred failed to reveal the presence of either of the plants then known to cause gousiekte (*Pachystigma pygmaeum* or *Pavetta harborii*). Although *P. zeyheri* var. *rogersii* was invariably encountered on these farms attempts to produce gousiekte experimentally by feeding it to cattle failed (*vide infra*).

At approximately the same time as this investigation, outbreaks of gousiekte in cattle were diagnosed and

*Goorappel literally translated from the Afrikaans means putrid or rancid apple and refers to the obnoxious taste of the ripe brown fruit of this plant.

[1]Veterinary Investigation Centre, Private Bag 2476, Potgietersrus
[2]Veterinary Research Institute, P.O. Onderstepoort
[3]Botanical Research Institute, P.O. Box 994, Pretoria

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confirmed histologically in the Bronkhorstspruit and Warmbaths districts. Again no plants known to cause gousiekte were found in the veld and it was therefore imperative that the aetiological agent should be identified.

A survey of the plants other than grasses which were eaten by cattle was carried out in the early spring of 1961 on four farms in the Vaalwater area on which it was anticipated that gousiekte would occur. The vegetation in this area is of the typical "sour bushveld" type, with trees such as *Burkea africana* Hook (wild seringa, "sandsering"), *Terminalia sericea* Burch. ex DC (Transvaal silverleaf, "sandvaalboom"), *Combretum zeyheri* Sond. (Zeyher's bush willow, "raasblaar") and *Ochna pulchra* Hook ("lekkerbreek") and a ground covering of sour grasses, of which *Eragrostis pallens* Hack., *Elyonurus argenteus* Nees., *Trachypogon capensis* (Thunb.) Trin., *Aristida diffusa* Trin. var. *burkei* (Stapf.) Schweick. and *Panicum natalense* Hochst. are the most prevalent. It is common practice to burn this veld annually to remove the hard, wiry grasses with the result that there is an upsurge of numerous dwarf shrublets and herbs just before and especially after the first rain. On these farms cattle were followed as closely as possible during grazing and all the trees and shrubs from which leaves were eaten were noted (binoculars were used where necessary). When the animal had moved away, a leaf from the specific plant was picked and placed in a plastic bag - the number of leaves collected and bagged represented the number of times that species was grazed by the animal. At the end of each day the leaves were sorted, identified and the total numbers recorded.

During the 22 hours that the cattle were followed 23 identified plus several unidentified plants were eaten. The eight plants eaten most often and the frequency of their ingestion are listed in Table 1.

TABLE 1 Plants eaten most frequently on four farms in the Vaalwater district in October, 1961

Plant Species		Grazing frequency
Species	Popular Name	
1. *Burkea africana* . .	Wild seringa, "sandsering"	245
2. *Pygmaeothamnus zeyheri* var. *zeyheri*	"Goorappel"	117
3. *Fadogia monticola* . .	Wild date, "wildedadel"	111
4. *Ochna pulchra* . . .	"Lekkerbreek"	85
5. *Triumfetta sonderi* . .	—	57
6. *Hypoxis nitida* . . .	—	47
7. *Clematopsis scabiosifolia*.	—	30
8. *Pygmaeothamnus zeyheri* var. *rogersii*	"Harige goorappel"	26
Fifteen other identified and several unidentified species		136

The sixth plant listed, *Hypoxis nitida* Verdoorn, was not tested because it was sparsely distributed and, although the cattle usually ate it when they found it, the actual quantity they ingested was small in comparison with the other plants.

TOXICITY TRIALS WITH SUSPECTED PLANTS

With the exception of the experiments performed on *F. monticola* at Onderstepoort described below, all the plant material was collected daily, preferably from farms where gousiekte had occurred previously, chaffed while it was still fresh, mixed with small quantities of dry lucerne hay and maize meal and fed immediately. This mixture was provided *ad libitum*. The suspected plant material always formed the major portion of the daily ration. In the initial experiments, attempts were made to feed the suspected plants for periods of approximately 1 to 2 months.

Experimental cattle were donated by farmers from the Vaalwater area. They were therefore acclimatized to the tickborne diseases of this area but prior to the experiments they were dosed with anthelmintics and immunized against anthrax and black-quarter. The sheep and goats used at Vaalwater came from Onderstepoort and before these trials they were treated with anthelmintics and immunized against enterotoxaemia, bluetongue and heartwater.

All the experimental animals were confined to small pens where they were fed and watered. Twice a week the cattle were exercised by walking them rapidly for 6 miles whereas the sheep and goats were chased around their pens daily for exercise. This regimen was instituted because death from gousiekte is known to be precipitated by exercise. In the experiment at Vaalwater, masses of experimental animals were estimated, in the case of the cattle by means of a mass band. At Onderstepoort, the sheep and goats were accurately mass-measured. Daily clinical observations were made on experimental animals. At Vaalwater this was done by the Stock Inspector to the best of his ability and the animals were checked by the authors during intermittent visits to the area.

A. *Plants tested with negative or inconclusive results*

Details of these experiments are given in Tables 2 and 3.

Pygmaeothamnus zeyheri var. *rogersii:* The first trials were conducted with this species because it closely resembles *Pachystigma pygmaeum* and almost always grew on those farms where gousiekte of unknown origin occurred. In March 1959, the feeding trials were negative. These were, however, performed after the seasonal period during which outbreaks of gousiekte usually occurred in the Vaalwater area. Moreover it is suspected that plants causing gousiekte vary in toxicity from year to year, season to season and locality to locality. Therefore an additional experiment was conducted in October and November 1961 in which cattle consumed two to three times their own mass of plant material without any deleterious effects and even showed gains in mass during the trial.

Pygmaeothamnus zeyheri var. *zeyheri* was tested again in spite of the negative results obtained by Theiler *et al.* (1923) and their results were confirmed.

Ochna pulchra, especially in the early stages of growth, is regarded by many Bantu and farmers as a highly toxic plant. It frequently grows in the same places as, and is sometimes eaten with, small quantities of *Dichapetalum cymosum* (Hook) Engl., "gifblaar" (i.e. poison leaf) which contains fluoro-acetate and is highly toxic. Steyn (1931) managed to kill a sheep with a total of 3,6 kg of a mixture of fresh young leaves and flowers of *O. pulchra* dosed over a 7-day period but Adelaar (unpublished observations) was unable to confirm its toxicity in either the fresh or dry state. In these trials a more extensive experiment was carried out and the plant was tested for toxicity on the "gousiekte basis", i.e.

TABLE 2 Details of *Pygmaeothamnus zeyheri* var. *rogersii* feeding trials at Vaalwater

Experiment No.	Year	Experimental Animal	Identification	Days fed on plant	Mass of fresh plant eaten	
					Total mass in kg	kg/kg body mass (approximately)
1	Autumn 1959	Ox	1	26	33,5	+
		Ox	2	26	33,5	+
2	Spring 1959	Ox	1	48	212	+
		Ox	2	48	212	+
3	Spring 1961	Africander ox	3	61	464	1,95
		Friesland ox	4	61	586	2,91
		Africander cow with calf	5	61	759	2,21
		Jersey ox and Jersey bull calf	6	66	614	2,68
		Five Merino sheep	—	61	537	+
		Four improved native goats	—	61	311	+

+ Not estimated

TABLE 3 Negative feeding trials with five further plants fed for 60 days at Vaalwater in the summer, 1961

Plant Species	Experimental animal	Total mass of fresh plant eaten (kg)
Burkea africana (Leguminosae)	Two Merino sheep	50
Pygmaeothamnus zeyheri var. *zeyheri* (Rubiaceae)	Two Friesland oxen Two Merino Sheep	775* 55
Ochna pulchra (Ochnaceae)	Two Friesland oxen Two Merino sheep	776** 58
Triumfetta sonderi (Tiliaceae)	Two Merino sheep	54
Clematopsis scabiosifolia (Ranunculaceae)	Two Merino sheep	70

*Each animal consumed a total of *c.* 1,94 kg plant material/kg body mass
**Each animal consumed a total of *c.* 1,67 kg plant material/kg body mass

by feeding large quantities over a long period. The plant material tested proved to be completely non-toxic.

Burkea africana, Triumfetta sonderi Ficalho & Hiern and *Clematopsis scabiosifolia* (DC.) Hutch. were only tested on sheep because although they were grazed, there was no circumstantial evidence to suggest that they might cause gousiekte. The experiments were completely negative.

B. *Gousiekte caused by feeding of* Fadogia monticola

During the grazing survey (Table 1) it was noted that *F. monticola* was third on the list of plants that were selected by grazing cattle and as it belongs to the Rubiaceae, it became suspect. A goat that had been in the *Pygmaeothamnus zeyheri* var. *rogersii* feeding experiment for a few days was therefore withdrawn and fed exclusively on this plant.

At the same time a visit was paid to a farm in the Rooiberg area of the Warmbaths district where 64 cattle had died in one specific camp during 1960. Gousiekte was confirmed histologically in this outbreak. D. B. J. Killick and B. de Winter (Research Institute for Botany, Pretoria, personal communication, 1960) visited the farm and systematically searched this camp. They found no plants then known to cause gousiekte and only one small patch of *P. zeyheri* var. *rogersii* but *F. monticola* was present in large quantities and as some of it had been recently grazed they strongly suspected it as the possible cause of gousiekte. However, a previous experiment conducted at Onderstepoort, in which sheep were fed limited quantities of material, gave negative results. It is now clear that the dose employed was too low.

It was decided to conduct further toxicity trials with material from this farm at Onderstepoort, in addition to the feeding experiments already in progress at Vaalwater.

DESCRIPTION AND DISTRIBUTION OF *F. MONTICOLA*

Fadogia monticola Robyns, Fig. 1, (syn. *F. oleoides* Robyns; *F. fragrans* Robyns) is a perennial, dwarf, rubiaceous shrublet with a deep root system. The aerial parts of the plant are usually frosted during winter and disappear but during spring (approximately September to October) clusters of slender, erect, yellowish stems which reach a height of 30 to 40 cm grow from the rootstock and short underground stems. Whorls of three to five leaves, which are shiny, dark-green and glabrous on the upper surface and greyish-white felted below, are spaced at intervals up each stem. Small clusters of small, yellowish-green flowers are produced in the axils of the leaves and are followed by globose berries, *c.* 1 cm in diameter when mature, which are shiny green at first, turning purplish-black when ripe and containing a sappy pulp. These berries are fairly frequently eaten by humans and have a rather pleasant flavour. The superficial resemblance of the fruit to a small date is the origin of the common name "wilde-dadel" or wild date. If the stems survive winter frost they bud in spring.

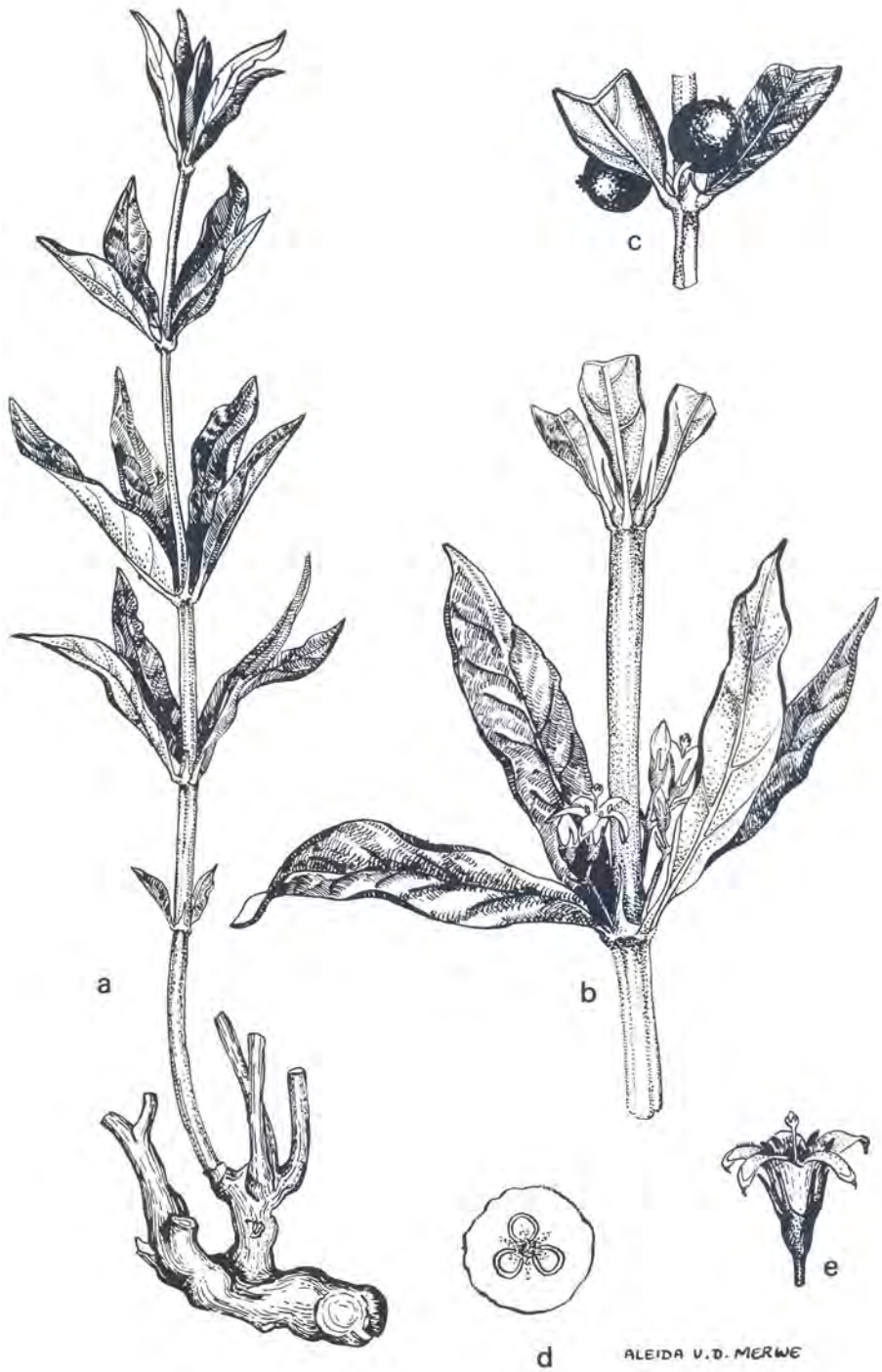

FIG. 1 *Fadogia monticola,* (a) habit × ½; (b) flowering stem; (c) fruiting twig, both natural size; (d) cross-section of ovary, × 2; (e) flower, × 2 (Reproduced from Codd & Voorendyk, 1966)

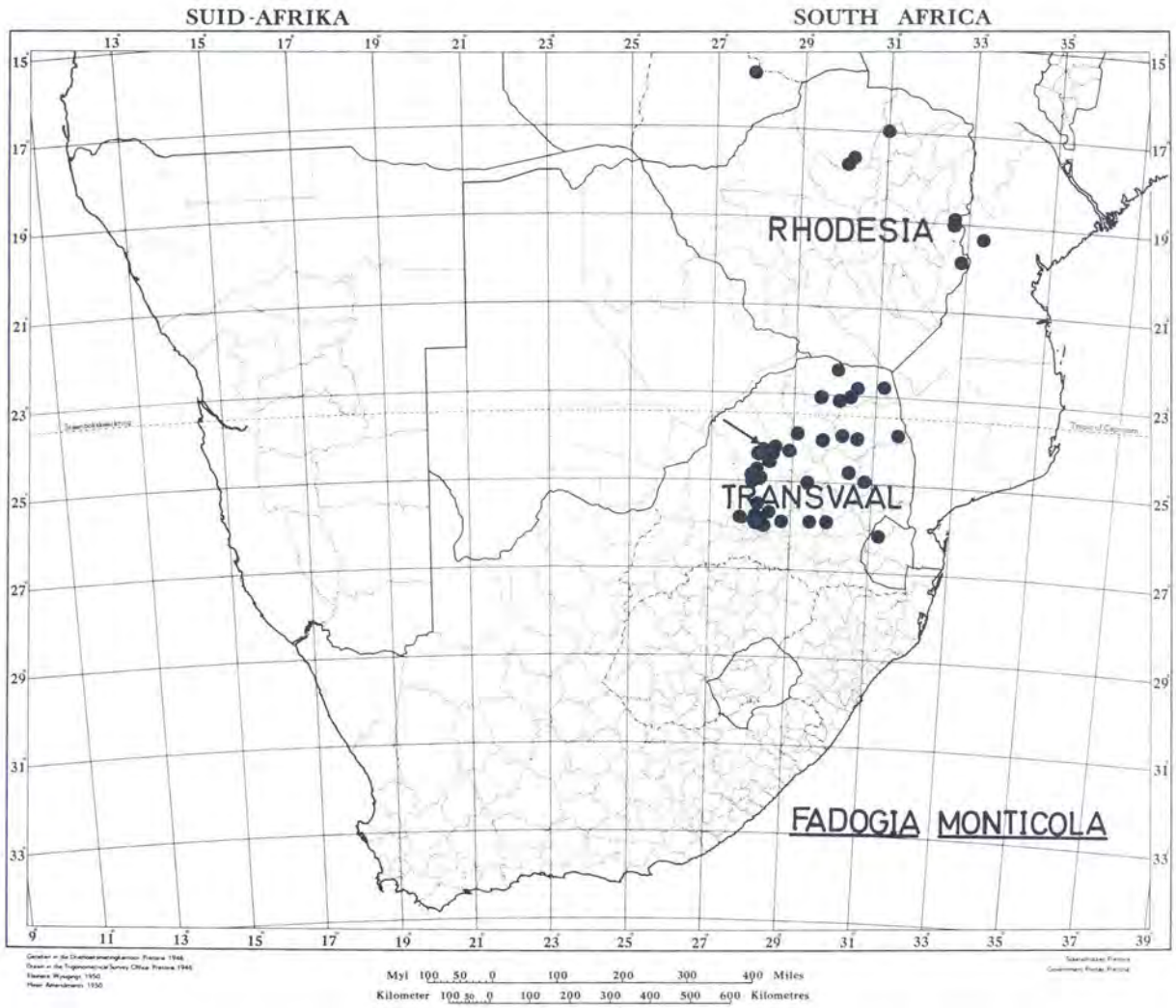

FIG. 2 Distribution of *Fadogia monticola*. The position of Vaalwater is indicated by an arrow (Adapted from Codd & Voorendyk, 1966)

The distribution of the plant in southern Africa is illustrated in Fig. 2. It is a common species growing especially on white, grey or pale red sands extending from Pretoria eastwards to Swaziland and northwards to the districts of Waterberg, Potgietersrus, Soutpansberg and Sibasa, and into Rhodesia, Zambia and Moçambique.

In South Africa a closely related species, *F. tetraquetra* K. Krause, is found in the higher rainfall areas of the eastern Transvaal, while a third species, *F. thamnus* K. Schum., occurs in northern South West Africa. Several species have been described in tropical Africa, of which the most widespread, *F. cienkowskii* Schweinf., extends from Rhodesia to Ethiopia.

Toxicity trials: susceptibility of different animals

Several experiments were conducted using cattle, sheep and goats (Tables 4 to 7). At Vaalwater fresh material was fed. At Onderstepoort material originating from the Rooiberg and Vaalwater areas was dried and dosed directly into the rumen through permanent rumen fistulas.

A. Cattle

In cattle only freshly cut plant material was used and the experiments were all conducted at Vaalwater.

In the first field trial (Table 4) material fed during spring and early summer caused the death of two oxen fed a total of 0,38 and 0,64 kg *Fadogia* per kg body mass respectively. Histopathologically the lesions encountered were, however, not entirely typical of gousiekte as encountered in the veld in this area.

Seasonal variation in toxicity was encountered as will be noted from the data in Table 5. As a result of a veld fire during April 1962, plants started growing during winter and were consequently rather stunted.

TABLE 4 *Fadogia monticola:* first field trial with fresh plant material at Vaalwater in the summer, 1961 to 1962

Experimental animal	Identification	Days fed	Mass plant eaten in kg/kg body mass	Clinical signs	Death or slaughter	Necropsy	Histopathology	Histopathological diagnosis
A. GOAT	10713	61	Not estimated	Anorexia, poor condition, lethargic and weak last few days	Died on exercising 64th day	Hydrothorax, hydropericardium, lung oedema, supepicardical petechiae	Marked focal fibrosis of myocard; kidney congestion	Gousiekte
B. CATTLE Friesland ox	35	31	0,38	Tachycardia from 40th day, reduplication 54th day	Dropped dead after running around in camp on 64th day	Hydrothorax, ascites	Light focal fibrosis and focal lymphocyte infiltration in myocard; lymphocyte infiltration in liver and bile duct proliferation; lymphocyte infiltration and focal lymphocyte proliferation in kidney	Atypical gousiekte complicated by liver and kidney lesions
Friesland ox	20	57	0,64	Lethargy, weakness, ataxia last month. Jugular pulse and reduplication on 53rd day	Dropped dead during exercise on 57th day	Nothing unusual	Diffuse generalized degeneration of myocardial fibres, fibroblast proliferation between fibres, slight lymphocyte infiltration	Heart failure but not typical of gousiekte
C. SHEEP Merino	9951	33	*c.* 0,5	Severe arrhythmia and tachycardia from 27th day onwards	Slaughtered on 71st day	Nothing unusual	Severe focal fibrosis in myocard. More connective tissue between muscle fibres but in places muscle fibres replaced	Gousiekte
Merino	11308	62	*c.* 0,8	Tachycardia and reduplication between 50th and 70th day followed by complete recovery	Slaughtered on 121st day	Nothing unusual	Focal degeneration and early stages of connective tissue deposition in heart; biliary cirrhosis; focal chronic lymphocytic nephritis	Gousiekte and chronic nephritis

TABLE 5 *Fadogia monticola:* second field trial with fresh plant material in the winter, 1962

Experimental animal	Identification	Period fed - days	Total mass plant eaten in kg/kg body mass	Outcome	Histopathological diagnosis
Friesland ox	1	16	0,22	Slaughtered after 107 days	Negative
Africander heifer . . .	2	16	0,38	do	do
Friesland cow	3	22	0,5	Discharged after 3 months and used in third trial	—
Africander cow	4	50	0,96	do	—
Friesland cross	5	50	1,0	do	—

This material proved for all practical purposes to be non-toxic, i.e. as much as 1 kg/kg had no apparent effect.

The third field trial (Table 6), also conducted during spring and early summer, revealed that material fed during this period produced gousiekte when the total quantity consumed amounted to 0,21 kg or more per kg body mass. Allowing for an average moisture content of 75% this was equivalent to *c.* 53 g of air-dried material per kg.

There was no correlation between the amount of plant ingested and the day of death. The shortest latent period after which a positive histopathological diagnosis could be made at autopsy was 28 days; the longest was 67 days.

Individual variations in toxicity were observed: nine animals that had eaten from 0,21 to 0,53 kg/kg died suddenly and in seven of these myocardial lesions were encountered on histopathological examination. However, one animal that had consumed a total of 0,71 kg/kg did not die (Table 6, Friesland cross calf 5).

B. *Goats*

Experiments using improved native goats (boerbokke) proved them to be more susceptible than sheep.

Only one was fed fresh *Fadogia* at Vaalwater (Table 4). It had consumed 35,5 kg over a period of 60 days and died after being exercised on the 64th day after the experiment had commenced. Gousiekte was confirmed histologically.

In the experiments conducted at Onderstepoort (Table 7) milled, air dried material was dosed through rumen fistulas. The approximate lethal dose of the air dried material was 130 to 140 g/kg. Of five animals that had received between 133 and 176 g/kg, four died after showing typical clinical signs and classical myocardial fibrosis was found in two of them. The other two also showed heart lesions but histologically these were not entirely typical for gousiekte.

Individual susceptibility was also evident in these animals: a goat that had received 145 g/kg was not affected at all whereas two that had received lower doses, viz. 133 and 140 g/kg respectively, both died of gousiekte (Table 7, Groups A & C).

C. *Sheep*

Sheep seem to be more resistant to poisoning than cattle or goats. Two sheep (Merino 9951 and Merino 11308), fed fresh plant material at rates of *c.* 0,5 and 0,8 kg/kg over 33 and 62 days respectively, developed clinical heart deviations on auscultation but neither died (Table 4). The first was slaughtered on the 71st day of the experiment and characteristic lesions were encountered histologically. The other was slaughtered on the 121st day, by which time all clinical heart aberrations had disappeared but gousiekte was confirmed histologically. In contrast two cattle fed at the same time at rates of 0,38 and 0,64 kg/kg respectively, both died of typical gousiekte (Table 4, Group B).

Merino 8695 and Goat 10695 were dosed a total of 152 and 140 g of dry material/kg respectively at a rate of 250 g/day over a period of 25 days. The goat died on the 38th day whereas the sheep showed no signs at all (Table 7, Group A).

Goat 11834 and Sheep 11306 were dosed at a rate of 500g of dried plant material per day until they died. In the goat a systolic murmur was present from the 17th day and tachycardia was followed by death on the 19th day. Histopathologically myocardial fibrosis was absent, probably because the poisoning had been too acute. In the sheep, however, no cardiac deviations were ever encountered *ante mortem* and it only died on the 40th day, by which time a total dose of 550 g/kg had been administered. Typical myocardial fibrosis was present.

CLINICAL SIGNS

The signs noted in these experiments are listed in Tables 4, 6 and 7. Sudden death was observed in most of the animals dying in these experiments, confirming observations made on natural cases of the disease. Exercise precipitated the death of some animals; others, on the other hand, died during the night without overt signs being manifested. In the majority of cases, however, careful auscultation of the heart revealed deviations from a few days to a few weeks before death. These consisted of tachycardia, arrhythmia, systolic murmers and reduplication of the first heart sound.

In a few cases that had received large quantities of material, signs regarded as atypical were seen. These consisted of severe listlessness, disinclination to move and ataxia.

NECROPSY AND HISTOPATHOLOGY

Theiler *et al.* (1923) described severe distension of the heart in sheep dying from gousiekte caused by *Pachystigma pygmaeum*. This was not observed with *Fadogia* poisoning but the heart was almost invariably found to be in diastole and *rigor mortis* of the myocardium did not occur.

Obvious macroscopic scars under the epi- or endocardium were not noted in either field or experimental cases. A few subepi- and subendocardial haemorrhages were occasionally encountered. Generalized venous congestion, hyperaemia, oedema and emphysema of the lungs, as well as hydropericardium, hydrothorax and ascites were usually encountered to a greater or lesser extent.

The histopathology of the myocardial lesions differed to some extent between cases produced experimentally and those occurring in nature. Usually a more acute lesion was observed in the former, probably due to the high dosage administered. In these cases a fairly severe focal degeneration of myocardial fibres, congestion,

TABLE 6 *Fadogia monticola:* third field trial with fresh material in the summer 1962 to 1963 (animals fed up to day of death)

Experimental animal	Identification	Total mass plant eaten in kg/kg body mass	Clinical signs and remarks	Outcome	Autopsy	Histopathological examination for gousiekte
Africander ox	6	0,13	Refused to eat, Discharged after one month	Still alive 6 months later.	—	—
Jersey ox	7	0,16	Appeared sick 25th day - constipated	Died 27th day	Nothing unusual	Negative
Africander cow	8	0,21	Irregular cardiac rhythm noted on 28th day; severely irregular on 34th day	Died 34th day	Heart in diastole with petechiae; slight ascites and hydrothorax	Positive
Africander cow	9	0,22	Irregular cardiac rhythm first noted on 35th day; still present on 47th day	Died 49th day	do	Positive
Friesland cow	3*	0,27	Irregular cardiac rhythm noted from 16th day up to death	Died 35th day	Heart in diastole, subepicardial petechiae	Positive
Africander cow	4*	0,27	Too wild for auscultation	Died on 28th day	Heart in diastole	Positive
Jersey heifer	10	0,31	Severely irregular cardiac rhythm from 35th day; visibly affected on 37th day	Died on 38th day	Heart in diastole, slight hydrothorax	Negative
Africander cow	11	0,5	Irregular cardiac rhythm noted from 35th day up to death	Died 54th day	Heart in diastole; slight ascites and hydrothorax	Positive
Friesland ox	12	0,53	Irregular cardiac rhythm first noted on 37th day; severely irregular from 44th day	Died 56th day	Subepicardial petechiae; lung oedema; slight ascites	Negative
Friesland cross calf	5*	0,71	Irregular cardiac rhythm noted on 37th day but gradually improved	Recovered completely. Still alive 6 months later	—	—

*Previously used in second field trial (Table 5)

TABLE 7 *Fadogia monticola:* dosing trials with dried plant material at Onderstepoort 1961 to 1962

Experimental animal	Identification	Number of days dosed	Total dosed in g/kg body mass	Clinical signs	Death, slaughter or discharge	Necropsy	Histopathology	Histopathological diagnosis
Group A:	*250 g/day for 25 days*							
Goat wether	10695	25	140	Tachycardia from 29th day, systolic murmur from 36th day	Found dead on 38th day	General congestion; oedema of lungs; heart in diastole; localized pneumonia	Severe myocardial congestion with haemorrhages and light focal fibrosis - connective tissue more inbetween fibres than replacing it; severe central congestion of liver; kidney congestion	Inconclusive, probably gousiekte
Merino wether	8695	25	152	No effect	Discharged after 3 months	—	—	—
Group B:	*500 g/day until death*							
Goat wether	11834	18	300	Tachycardia and systolic murmur from the 17th day	Found dead on 19th day	Pronounced generalized venous congestion; hydrothorax; lung oedema; ruminal atony	Diffuse lymphocyte infiltration in left ventricle of heart; severe lung congestion and oedema	Negative for gousiekte
Merino wether	11360	39	550	Lethargic, tired easily on exercising and then refused to move. Listless, ataxia and weakness on the 39th day	Found dead on 40th day	Hydrothorax; oedema of lungs; slight tumor splenis and tumor hepatis	Severe focal degeneration with replacement of heart fibres by connective tissue; severe central liver necrosis; lymphocytic nephritis	Gousiekte with liver necrosis and lymphocytic nephritis
Group C:	*Goats: 200 g/day*							
(1) Ewe	11948	8	66	No effect	Slaughtered at 12 months	Nothing unusual	Nothing unusual	Negative for gousiekte
(2) Wether	12741	10	88	Slight reduplication from 14th to 60th day	Slaughtered at 12 months	Nothing unusual	Nothing unusual	Negative for gousiekte
(3) Ewe	11940	14	110	No effect	Slaughtered at 12 months	Nothing unusual	Nothing unusual	Negative for gousiekte
(4) Wether	12440	22	133	Tachycardia from 32nd day onward	Found dead on 50th day	Slight hydropericardium; few subepicardial petechiae; oedema of lungs	Marked focal fibrosis of heart; congestion of liver; marked interlobular lung oedema	Gousiekte
(5) Ewe	12904	22	145	No effect	Slaughtered at 10 months	Nothing unusual	Nothing unusual	Negative for gousiekte
(6) Ewe	12902	23	176	No apparent effect	Found dead on 46th day	Hydropericardium; pronounced oedema of lungs; centrilobular degeneration of liver	Focal fibrosis, focal lymphocyte infiltration and congestion of heart; liver congestion, Kupfer cells prominent, single focus of lymphocyte infiltration	Gousiekte

oedema and small haemorrhages often occurred. Lymphocyte infiltration was a consistent feature and the early stages of replacement of degenerating muscle fibres by actively proliferating fibroblasts were particularly noticeable in the apex, interventricular and left ventricular walls of the heart.

In the natural cases the fibrosis was usually more advanced with more mature fibroblasts and collagen fibres being present. Vascular changes were not a consistent feature and lymphocytic cell infiltration not as prominent as those produced in experimental cases.

Sixteen animals (eight head of cattle, five goats and one sheep) died after ingestion of, or dosing with, *Fadogia*. One ox died from an undiagnosed disease which was considered not to be gousiekte (Table 6, Jersey ox 7). Characteristic microscopic lesions were seen in the hearts of 10 of the 15 other animals: one revealed the presence of myocardial lesions considered to be suspicious for gousiekte; one had atypical myocardial degeneration and three were negative for gousiekte.

Of the latter, one was a goat that had died on the 19th day after receiving a very high dose of 500 g dry material/kg/day: *ante mortem* it showed obvious cardiac deviations (Table 7, Goat 11834). The other two were cattle that had shown typical cardiac abnormalities prior to death (Table 6, Jersey heifer 10 and Friesland ox 12). Such cases are encountered in gousiekte and have been described by other workers (Theiler *et al.*, 1923; Pretorius & Terblanche, 1967).

In four animals lesions were encountered which do not normally occur in natural cases of gousiekte. Kidney lesions varying from lymphocyte infiltration and focal lymphocyte proliferation to a focal chronic lymphocytic nephritis were present in one of the cattle (Ox 35, Table 4) and in two sheep (Sheep 11308, Table 4 and Sheep 11360, Table 7). Liver lesions varying from central congestion, even central necrosis, lymphocyte infiltration and bile duct proliferation to cirrhosis were seen in the same three animals just mentioned as well as in one goat (Goat 12902, Table 7). Except for the bovine, these atypical lesions occurred only in animals that had received very much larger quantities of *Fadogia* than they would probably have eaten under natural conditions and this may account for these unusual lesions.

Similar lesions were also observed by Theiler *et al.* (1923) in a certain percentage of sheep that had died of gousiekte caused by *Pachystigma pygmaeum*. Some of these lesions, especially in experimental cases, may have been incidental findings: focal lymphocytic cell infiltrations in various organs and biliary cirrhosis are lesions often seen in animals dying of other causes at Onderstepoort.

Discussion

Five species of the family Rubiaceae are now known to cause gousiekte. They are *Pachystigma pygmaeum*, *P. thamnus*, *Pavetta harborii*, *P. schumanniana* and *Fadogia monticola*.

The distribution of *Fadogia monticola* is very much wider than the occurrence of the poisoning syndrome. In this respect it resembles *Pachystigma pygmaeum*. It is assumed that the plant is always toxic but that poisoning only occurs when animals have eaten it in large quantities. This happens either when they are forced to eat it because no other grazing is available or when they find it preferable to the unpalatable grass in the sour veld.

With minor inconsistent variations the syndrome caused by each of these five plants is the same and it can be postulated that their toxic principles must be closely related although it has been impossible so far to isolate these principles and verify this.

It is extraordinary that the gousiekte syndrome, which is of such serious economic importance in southern Africa, has not been encountered in any other continent. The detailed comparison between gousiekte and the condition described by Tokarnia *et al.* (1963) in Brazil should be very interesting.

Too few animals had been used in these experiments for any definite conclusions but it appears that cattle only develop gousiekte after consuming a total quantity of fresh *Fadogia* measuring more than 20% of their own body mass. The plant, however, was found to be completely non-toxic at a rate of 1 kg/kg when abnormal growth during winter was stimulated by a late autumn veld fire. Consequently it seems probable that toxicity is specifically correlated with the exact stage of growth and possibly other unknown factors.

Furthermore toxicity may possibly be decreased by drying of plant material and consequently, no precise comparison between cattle and smaller ruminants is justified on grounds of the present work. Goats, however, are much more susceptible than sheep.

We were unable to reproduce experimentally the very chronic myocardial lesion which is normally encountered histologically in field cases of *Fadogia* poisoning. The overall histopathological picture obtained, however, was adequate to confirm the diagnosis. In addition, certain abnormalities not usually encountered in gousiekte in natural cases were produced experimentally. These are probably due to the unnatural method of force-feeding or to dosing at relatively high levels.

Summary

Outbreaks of gousiekte in cattle and other ruminants occurred in central and northern Transvaal and were confirmed by the pathognomonic histopathological changes encountered in the cardiac musculature.

This plant poisoning syndrome is characterized by the development of a chronic lymphocytic myocarditis. After a latent period of from 4 to 8 weeks during which no obvious prodromal symptoms are seen, sudden death from heart failure occurs.

In this case, however, the plants known to cause gousiekte were either absent or their presence in these areas were inadequate to cause outbreaks.

After thorough botanical investigations and field evaluation of the problem, a grazing survey was conducted during the danger period on farms where the disease regularly occurred. Seven plant species were selected and tested for toxicity on the gousiekte basis, i.e. they were fed in large quantities over several weeks to ruminants.

Fadogia monticola Robyns ("wildedadel") proved to be the causative agent. The condition was experimentally reproduced both by the feeding of freshly collected material and/or dosing of dried material to cattle, sheep and goats and was confirmed by histopathological examination.

In cattle material freshly collected in early summer was found to be lethal at approximately 0,2 kg/kg body mass. Sheep were more resistant to poisoning than goats.

This is the first report of gousiekte being caused by a plant of the genus *Fadogia* and brings the total number

of plant species involved in this syndrome to five, all of which belong to the family Rubiaceae.

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