Lamsiekte (botulism): Solving the aetiology riddle

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Abstract

The reason or reasons why it took Sir Arnold Theiler so many years to unravel the riddle of the aetiology of lamsiekte in cattle and whether P.R. Viljoen's lifelong grudge for receiving insufficient credit from Theiler for his research contribution was justified are analysed in this paper. By 1912, Theiler knew that Duncan Hutcheon had advocated the use of bonemeal as a prophylactic against the disease in the early 1880s. Hutcheon's colleague, J.D. Borthwick, had shown conclusively in a field experiment in 1895 that lamsiekte did not occur in cattle fed a liberal allowance of bonemeal; and bone-craving had been identified by Hutcheon and several farmers as being associated with the occurrence of the disease (a 'premonitory' sign). Hutcheon regarded a phosphate deficiency of the pastures as the direct cause of lamsiekte. However, Theiler did not accept this, was convinced that intoxication was involved and developed a 'grass toxin' theory. Viljoen (1918) also latched onto the grass toxin theory. He did not believe that osteophagia existed, stating categorically that he had not observed it on the experimental farm Armoedsvlakte where > 100 cases of lamsiekte had occurred during the > 3 years that he spent there. Moreover, he did not believe in the prophylactic value of bonemeal. However, careful analysis of a subsequent publication, of which he was a co-author, revealed that in late 1918 and early 1919 he reproduced the disease by drenching cattle with blowfly pupae and larvae as well as with crushed bones from decomposing bovine carcasses. For this breakthrough he did not get proper credit from Theiler. Reappointed to study lamsiekte on Armoedsvlakte in the autumn of 1919, Theiler, probably already aware that the toxin he was seeking was in the decomposing bones or carcass material rather than the grass, deliberately 'walked with the cattle' on the farm to encounter a classic manifestation of bone-craving (osteophagia). The penny then immediately dropped. Theiler, actually rationalising an hypothesis that was about four decades old, did so with a vengeance. Within less than two years he had reproduced lamsiekte by exposing cattle with natural bone-craving to rotten carcass material, had chemical proof that the grazing was phosphorus-deficient, had developed a satisfactory bonemeal prophylactic dosage programme, and the bacterial toxin concerned – perhaps the trickiest contribution – had been produced in culture. Hence the table was set for the later development of an excellent lamsiekte vaccine.

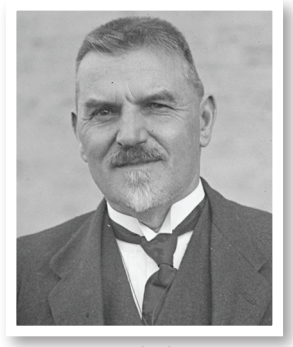
Introduction

There are three things that have intrigued the author about lamsiekte: (1) Why it took Sir Arnold Theiler so many years to unravel the riddle of its aetiology, (2) whether P.R. Viljoen's lifelong grudge against Theiler for receiving insufficient credit for his research contribution (Gutsche 1979) was justified and (3) whether the 'in one stroke, like – [a] "flash of lightning", all the elements of the Lamziekte syndrome had fallen into place' episode, as described by Theiler's biographer, Thelma Gutsche, really happened.

Theiler becomes involved

Theiler started getting involved in lamsiekte research in 1908. By 1912 (Theiler 1912), he knew that:

- The French explorer Le Vaillant had described lamsiekte and also the phenomenon of a craving for bones as early as 1796 in the Cape Colony (Henning 1956). It is not clear whether or not Le Vaillant linked the two conditions to each other.
- A few very observant farmers had gone further by linking bone craving with lamsiekte, some actually stating that when their cattle developed a severe craving for rotten carcass material, outbreaks of lamsiekte invariably followed a few days later (Theiler 1912).
- Duncan Hutcheon, who served as Colonial Veterinary Surgeon in the Cape Colony from 1880: (1) had advocated the use of bonemeal as a prophylactic against lamsiekte from the early 1880s (Hutcheon 1884, 1885), (2) had in 1883 observed cattle with a great craving for rotten bones and linked it to lamsiekte, Theiler interpreting the phenomenon as a 'definite premonitory symptom' of lamsiekte (Hutcheon 1884; Theiler *et al*. 1927) and (3) had regarded a deficiency of phosphorus in the pasture as being the direct cause of both bone craving and of lamsiekte (Hutcheon 1885).
- Observing in 1890 that local oat hay was very low in phosphorus, the chemist C.F. Juritz surmised that Cape Colony soils generally were probably deficient in



A Theiler

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phosphates. This he confirmed in further comprehensive studies (Juritz 1909).

- Hutcheon's colleague, J.D. Borthwick, had shown in a well-controlled field experiment in the eastern Cape in 1895 that lamsiekte rarely occurred in cattle 'receiving a liberal allowance' of bonemeal (Borthwick 1896 cited by Theiler 1912 and Theiler *et al*. 1927; Henning 1956).
- J. Spreull had listed 'a craving for bones' as an 'exiting cause' of lamsiekte in 1908. However, 'where a liberal lick of bonemeal is supplied' the craving ceased with time (Spreull 1908).
- His assistant J. Walker had in 1910 (published in 1912) produced four cases (called toxaemia), of what could only have been lamsiekte (Theiler *et al.,* 1927), by drenching cattle with decomposing intestinal tissues from lamsiekte cases (Walker 1912). Keeling Roberts recorded a similar observation in 1911 (Keeling Roberts 1911 cited by Theiler *et al.* 1927).
- His assistant D.T. Mitchell had in 1911 (published in 1912) observed that the first sign preceding an outbreak was 'an aggravated form of pica' and produced two cases (also called toxaemia), of what must have been lamsiekte (Theiler *et al.,* 1927), by drenching cattle with decomposing crushed bones from a lamsiekte case (Mitchell 1912).

Theiler's 'grass toxin' theory

Theiler agreed with Hutcheon that aphosphorosis of the pastures was the cause of 'styfsiekte' (osteomalacia) but could not accept his contention that it was also the direct cause of lamsiekte. He was convinced that the disease was caused by a toxin but incorrectly thought it was in the pastures (Theiler 1912). He therefore developed a curious 'accumulative vegetable poison theory'. In it he maintained that lamsiekte was a disease of the muscular system caused by a toxin accumulating in the muscles that was obtained from pasture grasses in certain regions where it was produced under certain climatic and soil conditions; more simply: a grass toxin theory. Theiler even argued at length in favour of:

- the grass toxins causing bone craving
- bonemeal neutralising the grass toxins.

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Viljoen's research on the farm Armoedsvlakte

The third main role player in the saga was P.R. Viljoen. He was the second South African to qualify as a veterinarian, Jotello F. Soga being the first (Gutsche 1979). Viljoen was stationed at Armoedsvlakte from the middle of 1915 until early 1919, to conduct research on lamsiekte. He published his early findings in 1918 (Viljoen 1918), sticking doggedly to Theiler's grass toxin theory and amazingly concluding that:

- a craving for bones did not occur on the farm and therefore was not a 'premonitory symptom' of lamsiekte – this despite the fact that more than 100 fatal cases of lamsiekte had occurred on Armoedsvlakte whilst he was there and that as many must therefore have shown bone craving before developing the disease
- bonemeal was not an effective prophylactic for lamsiekte
- there was no proof of a deficiency of phosphorus in the veld – this despite the dramatic improvement he observed in the condition of cattle receiving bonemeal.

PR Viljoen

However, there was one weak ray of light! Viljoen sent some blowfly pupae collected from a rotten lamsiekte carcass to Theiler at Onderstepoort, who produced two cases of paralysis (ascribed to toxaemia) in cattle by drenching them with the pupae.

The virtually negative results recorded by Viljoen (1918) may lead one to the conclusion that he did not deserve more credit than he got from Theiler, as this author did in a previous publication (Bigalke 2008). But this is not correct. In the magnum opus article by Theiler *et al.* (1927) dealing with Theiler's lamsiekte research in 1919 and 1920 and which consists of more than 500 pages, the exact dates were recorded on which the experiments were conducted. On studying these dates, the author surprisingly found that, in the middle of November 1918, lamsiekte – the actual diagnosis now recorded was toxaemia (lamsiekte) – was being very successfully produced by drenching cattle with blowfly pupae and larvae collected from decomposing carcasses. However, having semi-retired prematurely to the Cape in 1918, Theiler was at this stage nowhere near Armoedsvlakte and had nothing to do with lamsiekte research. The work was clearly being done by Viljoen, although no specific mention is made of this in the 1927 article by Theiler *et al*. of which Viljoen is the second of six authors. This blowfly research continued until the end of 1918.

Further successful drenching experiments in the middle of January 1919 are recorded in the 1927 article, this time using material such as crushed bones from decomposing carcasses, the diagnosis still being: toxaemia (lamsiekte). We know that Viljoen was on Armoedsvlakte on 31 December 1918 and that he left in 1919 (Theiler *et al.,* 1927), probably at the end of January. The middle of January 1919 was therefore still more than a month before Theiler, re-appointed specifically to study lamsiekte on Armoedsvlakte, arrived on the farm. There can be no doubt that this research was also conducted on Viljoen's,

not Theiler's, initiative. Gutsche (1979) indeed credits Viljoen with the work, but there is no special mention of Viljoen's January 1919 breakthrough in the 1927 article by Theiler *et al.*

Viljoen obviously therefore deserves considerably more credit for making the breakthrough in reproducing lamsiekte consistently and systematically than merely being made a second author of the above mentioned publication. As senior author, Theiler was clearly taking the credit for himself. Viljoen's grudge against Theiler was therefore justified.

Theiler arrives at Armoedsvlakte

Having semi-retired prematurely early in 1918 to Cape Town (Gutsche 1979), Theiler was reappointed specifically to study lamsiekte at Armoedsvlakte, as mentioned above. He arrived on the farm on 24 February 1919 (Gutsche 1979).

At the Annual General Meeting of the Vryburg Farmers Association in January 1918, the president, P.H. de Kock, said: 'it would do no harm if some experts became cattle herds' to find the cause of the disease, to which Theiler took great exception (Gutsche 1979).

It is therefore ironic that this is exactly what he did, two days after arriving on Armoedsvlakte. Theiler *et al.* (1927) recorded that on 26 February 1919 Theiler visited a small paddock where some cattle, having broken down a gate to get in, were avidly chewing bones that had been dumped on a rubbish heap close to a farm worker's homestead. Theiler (1927) remarks:

The sight of the chewing cattle was an impressive and very remarkable one, as well as the roaming about on the rubbish heap where the animals were apparently looking for bones. (p. 929)

Theiler (1927) continues with:

The suggestion now occurred [to me] that bones eaten by cattle might carry the cause of the disease – and that the disease so conveyed would be identical to the one which had been produced previously [by Viljoen] by dosing fly pupae. (pp. 929–930)

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Clearly Theiler was aware of Viljoen's production of lamsiekte in November 1918 by drenching cattle with blowfly pupae from decomposing carcasses and certainly also knew of the success the latter had obtained by drenching with carcass material in January 1919, although it is not mentioned in the 1927 publication. In his heart of hearts Theiler must have already deduced, before actually seeing the cattle on the rubbish dump, that the toxin he was looking for was not in the grass, but in the bones or carcass material.

The 'flash of lighting' probably consisted of the realisation that the cattle on Armoedsvlakte did develop a craving for toxin-containing carcass material under natural conditions, contrary to what Viljoen (1918) had maintained. Theiler also now clearly understood all the links in the complex lamsiekte aetiology chain.

Theiler's own research at Armoedsvlakte

Theiler had therefore actually rationalised a hypothesis – a few farmers' deductions were correct and Hutcheon was oh so close – that was almost four decades old. But he did so with a vengeance (Theiler *et al.,* 1927). Within less than two years he had:

- Consistently and convincingly produced lamsiekte by deliberately exposing Armoedsvlakte cattle with bone craving to carcass material such as decomposing bones.
- Studied bone craving in all its manifestations and related it to the aphosphorosis of the natural pasture on Armoedsvlakte.
- Obtained chemical proof that the pasture was definitely phosphorus-deficient, and had followed the phosphorus cycle over the four seasons, showing that the phosphorus content was lowest in autumn and winter.
- Developed a satisfactory prophylactic dosage programme for lamsiekte prevention with bonemeal, which amounted to approximately 100 g/animal/day.
- Confirmed previous observations on the crucial importance of phosphorus in the growth and production of cattle.
- Most importantly, isolated in culture, from carcass material the anerobic generators – later identified as *Clostridium botulinum*, the anaerobic bacterial generators of the toxin or toxins that cause the paralysis of cattle.

The latter was Theiler's only entirely original research contribution to unravelling the riddle of the aetiology of lamsiekte.

More than a decade was to elapse before Mason, Steyn and Bisschop (1938) of Onderstepoort produced a toxoided vaccine against the disease. This was vastly improved by Sterne and Wentzel (1950) and is currently still used, basically unchanged, mainly in cattle, as a very good vaccine against lamsiekte (botulism) in all countries where the disease is prevalent.

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References

Bigalke, R.D., 2008, 'Theiler and the "Spirit of Onderstepoort": Introductory keynote address to Pan African Veterinary Conference', *Onderstepoort Journal of Veterinary Research* 76, 3–7.

Borthwick, J., 1896, 'Cape of Good Hope', *Report of the Colonial*

Veterinary Surgeon for the Year 1895, 107–264.
Gutsche, T., 1979, *There was a man: The life and times of Sir Arnold Theiler K.C.M.G. of Onderstepoort*, Howard Timmins, Cape Town.
Henning, M.W., 1956, *Animal diseases in South Africa*, 3rd edn., Central News Agency (Ltd), Johannesburg.
Hutcheon, D., 1884, 'Cape of Good Hope', *Report of the Colonial Veterinary Surgeon for the Year 1883*, 1–80.
Hutcheon, D., 1885, 'Cape of Good Hope', *Report of the Colonial Veterinary Surgeon for the Year 1884*, 1–47.
Juritz, C.F., 1909, *A study of the agricultural soils of the Cape Colony*, Cape Times Limited, Government Printer, Cape Town.
Keeling Roberts, H., 1911, *'Lamsiekte', Second Annual Report of the Agricultural Department of the Orange Free State*, 105–108.
Mason, J.H., Steyn, H.P. & Bisschop, J.H.R., 1938, 'The immunization of bovines against lamsiekte', *Journal of the South African Veterinary Medical Association* 9, 65–70.
Mitchell, D.T., 1912, 'Lamziekte', *Second Report of the Director of Veterinary Research, Union of South Afric*a, 161–180.
Spreull, J., 1908, 'Lamziekte on the Kaap Plateau', *Journal of Comparative Pathology and Therapeutics* 21, 193–206.
Sterne, M. & Wentzel, L.M., 1950, 'A new method for the large-scale production of high-titre botulinum formol-toxoid Types C and D', *Journal of Immunology* 65, 175–183.
Theiler, A., 1912, 'Facts and theories about stijfziekte and lamziekte', *Second Report of the Director of Veterinary Research*, *Union of South Afric*a, 7–78.
Theiler, A., Viljoen, P.R., Green, H.H., Du Toit, P.J., Meier, H. & Robinson, E.M., 1927, 'Lamziekte (parabotulism) in cattle in South Africa', *11th and 12th Reports of the Director of Veterinary Education and Research, Union of South Africa*, 821–1361.
Viljoen, P.R., 1918, 'Investigations into lamziekte of cattle', *5th and 6th Reports of the Director of Veterinary Services, Union of South Africa*, 255–320.
Walker, J., 1912, 'Investigations into the disease lamziekte in cattle', *Second Report of the Director of Veterinary Research, Union of South Africa*, 79–160.