

THE EPIDEMIOLOGY AND CONTROL OF GASTROINTESTINAL NEMATODE INFESTATION OF SHEEP AND CATTLE IN SOUTH AFRICA. I. THE HISTORIC ROLE OF ONDERSTEPOORT AND A SHORT DISCUSSION OF PRESENT RESEARCH PRIORITIES

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ABSTRACT

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The research activities of the Veterinary Research Institute, Onderstepoort, from its inception in 1908 until recent times are reviewed in this first article of a series on nematode epidemiology of sheep and cattle.

While the taxonomic and certain biological aspects of the subject and the testing of anthelmintic compounds have been well covered on the whole in various parts of the country, the testing of control methods under field conditions has largely been neglected.

It is suggested that all known methods of integrated worm control should be scrutinized and the most promising methods be tested under practical farming conditions in the country to reduce our dependence on anthelmintic compounds for worm control. Furthermore, unless we are able to employ the available anthelmintics to better advantage and thus reduce the tempo of selection for resistance, the situation may well develop where highly effective remedies are no longer available for worm control.

INTRODUCTION

Over the past decade or two, numerous excellent and very comprehensive reviews have been written on the epidemiology and control of the economically important gastrointestinal nematodes of sheep and cattle (Michel, 1969, 1976; Gordon, 1973; Anderson, Dash, Donald, Southcott & Waller, 1978; Barger, 1978; Armour, 1980; Brunsdon, 1980; Horak, 1980; Morley & Donald, 1980; Donald & Waller, 1982; Anderson, Donald & Waller, 1983; Barger, Bremner & Waller, 1983; Reinecke, 1983; Winks, Bremner & Barger, 1983). Consequently, the present series of papers is not intended as another review of a field that has been thoroughly covered, but rather to relate knowledge of the local scene to important new discoveries in the rest of the world and to serve as a guide-line for further research requirements in South Africa.

In this introductory paper an account is given of the historic role of Onderstepoort in helminth research and a short philosophical discussion of helminthiasis in the country is included. The rest of the series deals with the latest knowledge of integrated worm control in the world, relates this in detail to what is already known in South Africa, and suggests possible fruitful lines and methods of further research in the country.

Liberal use is made of quotations from various papers to emphasize and highlight the more important findings of authors from various parts of the world.

THE PAST AND PRESENT CONSIDERATIONS

The Section of Helminthology has been part of Onderstepoort since its inception.

In 1908, Dr L. A. Gough was appointed as zoologist at Onderstepoort (Ortlepp, 1961). In the words of Dr Ortlepp (1961), translated from Afrikaans*: "He [Dr Gough] was particularly interested in certain tapeworms occurring in sheep as well as in antelope, his results being published in 1911. At the beginning of 1912, the helminthological work was taken over by Dr Veglia, who continued his research at Onderstepoort until 1927, when he returned to Italy. His main work concerned 2 very important worm parasites of sheep, the wireworm and the nodular worm. In a splendid monograph on the former worm, published in 1916 [SIC], he analysed and described the anatomy and development from egg to

adult in the minutest detail. Apparently Veglia did not pay much attention to the helminths of our game animals, as no particulars could be found in any of his reports.

Whereas the workers in general in the early days took merely a few uncertain steps on the road to our helminthological realm, Sir Arnold Theiler, the first Director of Onderstepoort, made bold strides in this direction. He realised the value of a thorough knowledge of not only the worms occurring in our domestic animals but also of those infesting our indigenous animals. Owing to the multiplicity of his other duties he was unable to process our South African material himself. What he could do, however, he did; he had collections of parasites made in our game in the vicinity of Pretoria. In this way he stimulated great interest in our South African helminths... The roundworms in the collection were examined by Dr H. O. Mönnig, and among the 32 species present he discovered and described 4 new species in 1923...

A period of increased interest in our helminths now followed. Dr H. O. Mönnig, who succeeded Dr Veglia, and Dr P. L. le Roux were appointed to Onderstepoort and on Dr le Roux's departure to N. Rhodesia in 1930, [Dr Ortlepp] was appointed in his place at Onderstepoort. In this period of about 40 years, every available piece of material was examined for the possible presence of helminths... The result was that, apart from the then familiar worms of game, more than 150 new species were discovered and described, 13 by Le Roux, 46 by Mönnig and about 100 by the author".

It is therefore clear that initially merely the taxonomy and, to a smaller extent, the biology of the helminths received attention. As Ortlepp (1961) put it (translated from Afrikaans)*: "Heretofore, only the taxonomic aspects of helminthology have been emphasized; the biological aspect is equally, if not more, important. At Onderstepoort much work has been done on the life cycles and control of the worms occurring in our domestic animals. However, there are numerous problems in this field awaiting a solution. Only when more workers become available can the problems be tackled with any hope of success. At Onderstepoort, only the most urgent problems can be dealt with, with the result that other problems, whose solutions could cast light on various factors or extend our knowledge of parasites, must be shelved, at least for the moment".

* See Appendix I for the original Afrikaans text

* The original text of this passage appears in Appendix II

Mönnig (1944, 1947, 1949) did pioneering work on the epidemiology of the common gastro-intestinal roundworms of sheep and cattle, but a progressive change in emphasis from taxonomy to epidemiology was ushered in mainly by Prof. R. K. Reinecke (see below), who succeeded Dr Ortlepp.

To quote Meldal-Johnsen (1961): "In the past, a considerable amount of work has been done on the identification of the helminths concerned, with the result that the identity of at least the more important genera and species in the various regions of the country is known fairly accurately. Based on this knowledge and coupled with the available information of the life cycle and ecology of the parasites, there have been evolved therapeutic and prophylactic measures which have been of material benefit to sheep husbandrymen. Experience has shown that these measures have not always been fully effective. Consequently it was thought that if more accurate data were accumulated on possible seasonal fluctuations in the incidence of the parasites more effective control measures could be worked out . . .".

Gradually more attention was paid to the chemotherapy of helminths, a development brought about largely by the advent of the modern safer and relatively more effective generation of anthelmintics rather more than 2 decades ago. While numerous remedies had been developed and tested previously in the country (Theiler & Robertson, 1915; Veglia, 1928; Le Roux, 1930; Mönnig, 1930, 1931, 1933, 1935, 1936, 1937, 1942, 1944, 1947, 1949; Ortlepp & Mönnig, 1936; Mönnig & Ortlepp, 1939), the more concentrated effort in this field was instigated chiefly by Reinecke, who concentrated on the methodology of anthelmintic testing, the effort culminating in the larval anthelmintic test (Reinecke, 1973) and a revolutionary new method of statistical analysis (Groeneveld & Reinecke, 1969).

While Reinecke was virtually alone at Onderstepoort in the new directions, he stimulated others in veterinary services and in commerce to follow his example. As a result, a fair number of surveys were conducted to determine the seasonal incidence of especially nematodes in the various parts of the country (Thomas, 1959; Reinecke, 1960; Hobbs, 1961; Meldal-Johnsen, 1961; Rositer, 1961; Barrow, 1964; Reinecke, 1964; Viljoen, 1964; Thomas, 1967; Muller, 1968; Thomas, 1968; Viljoen, 1969; Snijders, Stapelberg & Muller, 1971; Horak, Honer & Schröder, 1976; Horak & Louw, 1977; Horak, 1978a, 1978b, 1978c, 1978d; Horak & Louw, 1978; Schröder, 1979; Horak, 1981a, 1981b; Biggs & Anthonissen, 1982; Malan, Reinecke & Roper, 1982). A few production trials, comparing the production of groups of control and treated animals, were also reported (Snijders *et al.*, 1971; Horak *et al.*, 1976).

Consequently, for many or perhaps most parts of the country we have a good idea of what to expect in each locality, and also when outbreaks of helminthosis are likely to occur (Horak, 1981a; Reinecke, 1983).

Unfortunately, with the advent of the modern anthelmintics, a state of euphoria developed in this country (as elsewhere in the world) regarding worm control. Research on worm control and practical control under field conditions became more and more centred on anthelmintics, to the exclusion of other principles, such as managerial practices aimed at reducing the changes of contact between worm and host. Brunson (1980) summed up the international situation as follows: "Progress towards improved control systems has been erratic. This situation was probably occasioned by the advent of the broad spectrum anthelmintics and the false sense of security which they engendered".

In this regard one needs to consider the extreme diversity and versatility of the helminth kingdom, there being virtually a worm for every occasion, one may say. Consider, for example, that worms occur in hosts as different as locusts and elephants; the vast range in size of adult nematodes from the 2 mm long *Probstmayria vivipara* of equids to the gigantic *Placentonema gigantissima* (the female of which reaches a length of more than 8 m); and the complex and almost uncanny life cycles known to us today, such as the migration of the fluke *Dicrocoelium* to the submandibular nerve ganglion of the ant (Hohorst & Graefe, 1961; Schneider & Hohorst, 1971), dispersion of infective larvae of the lungworm *Dictyocaulus viviparus* by sporangia of the fungus *Pilobolus* spp. (Robinson, 1962; Robinson, Poynter & Terry, 1962; Doncaster, 1981) and *P. gigantissima*, that can apparently mature only in the placenta of a pregnant whale (Skrjabin, Sobolev & Ivashkin, 1967).

Indeed, some of these life cycles border so closely on the impossible, that Gordon (1949) was prompted to state: "Many life cycles appear so full of hazards that there seems almost to be an element of 'sportiness' about them".

This versatility of the worm has presented us with seemingly insurmountable practical problems in the control of helminths in domestic stock, and more so in game. Not only is there such a variety of nematode species adapted to such extremes as long-standing desiccation of infective stages on one hand and aquatic transmission on the other, but also within populations of the same species adaptation can occur rapidly under conditions of extreme selection. This was lost sight of locally, as elsewhere in the world. Michel stated in 1982: "It is scarcely necessary to remind the present audience that the control of nematodes imposes selection in favour of characters enabling worms to survive. The effective use of anthelmintics obviously selects worms that resist their action . . .".

No sooner did we see the advent of our modern, highly effective anthelmintics a little more than 2 decades ago than the first reports [reviewed by Le Jambre (1978)] of failure of these remedies against supposedly susceptible worm species were received. Initially, 1 or 2 populations of a given species appeared to be relatively non-susceptible to a very effective remedy. But gradually it became obvious that in other instances the continual use of a given compound was selective for resistant individuals and was increasing the chances of interbreeding of these resistant individuals to cause a sudden escalation of resistance.

Despite the example of drug selection that occurred widely in the entomological field, and despite the few initial and much more numerous subsequent reports of resistance to anthelmintics in the world (Prichard, Hall, Kelly, Martin & Donald, 1980), until fairly recently most helminthologists did not seriously consider the possibility that resistance would become a practical problem (Le Jambre, 1978; Donald & Waller, 1982).

In this way, in a manner of speaking, the trickle of resistance leaking through the dike of susceptibility became progressively erosive, and soon it became obvious that the tide of resistance could not be stemmed. Particularly in a country like Australia, where anthelmintics were used relatively intensively, resistance has become widespread, and field resistance to all but a handful of anthelmintic compounds has been encountered. The situation is summed up by Herd, Streitl, McClure & Parker (1984) in the USA: "The sole reliance on chemicals for parasite control and their haphazard use without any serious thought to conserve their efficiency has led to the drug resistance problem, and the pharmaceutical

companies cannot be expected to keep discovering new anthelmintics with different modes of action to salvage the position temporarily. There is a need for veterinarians to become aware of the problem and to warn farmers against overuse of drugs or control strategies that are likely to select strongly for drug resistance”.

Unfortunately, in South Africa as well, almost all the trials conducted to test worm control or the effects of worms on production were centred on various anthelmintics. In a summary of his field trials Horak (1980, 1981b), who has probably done the most extensive field investigations into the seasonal incidence of helminths of domestic and wild animals in this country, stated: “Despite husbandry playing an important part in any control programme it is in the development of highly effective anthelmintics and their application that the greatest strides have been made, and I will concentrate on this aspect of control”. While these anthelmintics show signs of letting us down in the future unless drastic steps are taken to conserve their efficacy, we have not commenced work of any magnitude locally on practical alternatives and measures aimed at extending the useful life of these compounds.

Furthermore, with 1 or 2 possible exceptions, none of the drenching programmes recommended for routine worm control has apparently been evaluated under realistic field conditions in this country. Even the 1 or 2 exceptions I am aware of were unrealistic in that either control and treated groups of animals ran together on the same pasture and were not changed to safe pastures after treatment (Horak *et al.*, 1976) or control depended on continual low-level administration of anthelmintics (Snijders *et al.*, 1971), a practice which can be expected to favour the development of resistance (Donald & Waller, 1982; Southcott, 1982; Campbell, 1983).

Most frequently, drenching recommendations were offered by the various investigators (such as Reinecke & Thomas, 1959; Rossiter, 1961; Barrow, 1964; Muller, 1964; Viljoen, 1964; Thomas, 1968; Horak, 1981b) after their surveys to determine the seasonal incidence of nematodes, but these recommendations were not evaluated at all. In other words, control was based solely on extrapolations from the knowledge of the epidemiology of each worm species and not on trials designed to test the best control measures and times of treatment.

It need be pointed out, however, that it is better to base control programmes on such knowledge than on no knowledge at all of the epidemiology and seasonal incidence, as was discussed by Anderson *et al.*, 1978: “... drenching recommendations are often no more than epidemiological extrapolations unsupported by experimental verification. It is unfair to be too critical of this, since a given epidemiological situation can be attacked with a wide range of possible drenching times and frequencies, and searching for the optimum by experiment is very slow and costly, given also the variation between localities and years in weather, pasture and management conditions”.

Seventy-five years after the inception of this Section of Helminthology, the important questions to be considered in South Africa today are:

How far have we come?

What needs to be done now? and

What needs to be done in the future?

While the distribution, prevalence and seasonal incidence of many of our important worm species have been mapped out to a large extent and the efficacy and safety of the anthelmintics have been tested extremely thor-

oughly, the anthelmintics show signs of letting us down in future, as regards the development of very prevalent resistance among previously susceptible worm species or strains.

In my opinion, the methods of integrated worm control known at present should be closely examined to see what can be applied locally to reduce our dependence on anthelmintics, as the principal, or even sole, method of worm control.

It is neither practical nor desirable to exclude anthelmintics from control programmes, but unless we use them to better advantage we may find ourselves in the situation where we no longer have effective remedies available for worm control.

In the following numbers of the series, it is intended to examine in detail the different possibilities for integrated control to determine what indications we have from previous local work of the extent to which such possible control methods may be effective under South African conditions and to discuss what is required for testing the possibilities under our conditions.

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APPENDIX I

Ortlepp (1961): “Hy [Dr. Gough] het veral belang gestel in sekere lintwurms wat in ons skape sowel as in wildsbokke voorkom en sy resultate is saamgevat in ’n publikasie in 1911. Aan die begin van 1912 het Dr. Veglia die helmintologiese werk oorgeneem en hy het te Onderstepoort werksaam gebly tot 1927 toe hy terug is na Italië. Sy werk het veral gehandel oor twee baie belangrike wurmparasiete van ons skape, naamlik, die haarwurm en die knoppieswurm. ’n Pragtige stuk werk van hom oor eersgenoemde wurm is in 1916 [SIC] gepubliseer. Hierin het hy tot in die fynste besonderhede die anatomie en ontwikkeling vanaf die eier tot die volwasse stadium ontleed en beskryf. Skynbaar het Veglia nie veel aandag aan die helminte van ons wilde diere gegee nie, want nêrens kon gegewens verkry word van enige werk wat hy oor hulle gedoen het nie.

Waar bogenoemde werkers slegs ’n paar onsekere treë gegee het op die pad na ons helmintologiese ryk, kan dit met reg gesê word dat Sir Arnold Theiler, eerste Direkteur van Onderstepoort, met forse treë die pad ingeslaan het. Hy het die waarde besef van ’n deeglike kennis van nie alleen wurms wat in ons huisdiere voorkom nie, maar ook van dié wat in ons inheemse diere leef. Weens die menigvuldigheid van sy ander pligte was die voorreg hom nie gegun om ons Suid-Afrikaanse materiaal self te verwerk nie. Wat hy egter kon doen, het hy gedoen, naamlik om versamelings te laat maak van die parasiete wat voorkom in ons wilde diere in die omgewing van Pretoria. Op dié manier het hy die belangstelling in ons Suid-Afrikaanse helminte ’n geweldige stoot vorentoe gegee. . . . Die rondewurms in die versameling is deur

dr. H. O. Mönnig ondersoek, en onder die 32 soorte aanwesig, het hy vier nuwe soorte ontdek en in 1923 beskrywe . . .

’n Tydperk van groter belangstelling in ons helminte het nou aangebreek: Dr. H. O. Mönnig, wat dr. Veglia opgevolg het, en dr. P. L. le Roux, het aanstellings te Onderstepoort aanvaar en na dr. le Roux se vertrek na N. Rhodesië (1930) is die skrywer [Dr. Ortlepp] ook te Onderstepoort aangestel. In die tydperk van sowat 40 jaar is alles wat in die hande gekry kon word, vir die moontlike aanwesigheid van helminte ondersoek . . . Die gevolg was dat, afgesien van die alreeds bekende wilde diere wurms, daar in die tydperk meer as 150 nuwe soorte wurms ontdek en beskrywe is, naamlik 13 deur Le Roux, 46 deur Mönnig en sowat 100 deur die skrywer”.

APPENDIX II

Ortlepp (1961): “Hierbo is nadruk alleenlik gelê op die taksonomiese aspek van die helmintologie; die biologiese aspek is net so belangrik indien nie belangriker nie. Te Onderstepoort is al heelwat werk gedoen in verband met die lewenslope en bestryding van die wurms wat in ons huisdiere voorkom. Daar is egter nog baie probleme in verband met hulle wat nog op ’n oplossing wag; alleenlik wanneer daar meer werkers op die gebied beskikbaar word, sal die probleme aangepak kan word. Te Onderstepoort kan alleenlik die dringendste vraagstukke aangepak word, met die gevolg dat ander vraagstukke waarvan die oplossing lig op die menige probleme kan werp, of die kennis van ons parasiete kan aanvul, agterweë gelaat moet word”.