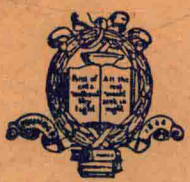
MOLLUSCICIDES

ALAN MOZLEY



LONDON
H. K. LEWIS & Co. Ltd.

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ALAN MOZLEY

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With 10 illustrations

LONDON

H. K. LEWIS & CO. LTD.

1952

PRINTED IN GREAT BRITAIN FOR
H. K. LEWIS AND CO. LTD. BY
HAZELL, WATSON AND VINEY, LTD., AYLESBURY AND LONDON

PREFACE

THE following account is based upon first-hand experience of dangerous snails and substances which can be used to destroy them. In preparing it I have been guided more by the need for practical methods of disease control in the countries with which I am familiar, than by a desire to record every known instance of a substance which is poisonous to snails. I have included original and hitherto unpublished observations. Thus the work is not a simple compilation, but is the result of a search, over a period of years, for the most useful snail-killing substances, and effective methods of using them.

I have dealt with well-known molluscicides, but had I confined attention to substances which have been proved to be effective snail destroyers under field conditions, I should have taken what I consider to be too narrow a view. I have cast the net wide, and under the circumstances have had to exercise a certain amount of selection. For that I take responsibility. Doubtless there are omissions. Also, about some snail poisons there are, as yet, only vague reports or rumours. If the publication of this account stimulates discussion it will serve a useful purpose.

It is a great pleasure for me to acknowledge the help and kindly advice which I have received from Sir Malcolm Watson, LL.D., M.D., C.M., D.P.H., L.M.S., F.R.F.P.S., and Professor R. T. Leiper, M.D., D.Sc., F.R.S., while I have been carrying out the scientific investigations which form the basis of this work. I am also greatly indebted to many colleagues, private persons, and officials in different countries who have assisted me and made my journeys enjoyable as well as instructive. Several colleagues have been kind enough to read this account in manuscript and make suggestions. To all who have helped I express my thanks.

The observations in Tanganyika, Zanzibar, and Pemba were made during my tenure of the Wandsworth Scholarship of the London School of Hygiene and Tropical Medicine. The work in

Southern Rhodesia was carried out with the aid of grants made by the Trustees of the State Lottery of that Colony. The observations in Bechuanaland were made under the auspices of the Government of the Protectorate. The work in other countries was carried out in the course of journeys made independently.

In Egypt I have been able to see something of the work of the Bilharzia Snail Destruction Section of the Ministry of Public Health by courtesy of Dr. Mahmoud Bey Abdel Azim, to whom I am greatly indebted.

For permission to publish results of work done in Bechuanaland I should like to express my thanks to H.H. The Resident Commissioner. In Southern Rhodesia, Dr. A. P. Martin, then Medical Director of the Colony, and the Trustees of the State Lottery authorized publication of the work done there. The Trustees of the British Museum (Natural History) have very kindly supplied me with photographs of certain shells in the Museum collections, and have given me permission to publish them. Mr. E. T. Brown, of Umtali, Southern Rhodesia, has thoughtfully provided me with a photograph of *Tephrosia vogelii*, and has been good enough to give me permission to reproduce it.

ALAN MOZLEY.

BALTIMORE,
9th September, 1951.

INTRODUCTION

MOLLUSCICIDES are substances which are used for killing snails and other molluscs. In many different parts of the world it has been necessary to find ways of destroying the snails which transmit human and animal diseases. For that purpose the use of a great many different substances has been suggested, and the more significant of them are dealt with here.

Molluscicides are not the same as insecticides. It frequently happens that the problems which confront the man who has to deal with dangerous snails are different from those which arise in the study of economic entomology. In the first place, snails and other molluscs, as organisms, are entirely distinct from insects in their nature and ways of life. Some degree of likeness does exist, but it is remote and can be compared with the likeness that a farm cart bears to an aeroplane. What might be termed the rhythm of infestation in molluscs is different from that among insects. Furthermore, certain substances which have been used with spectacular success in the control of insect pests have little or no effect upon snails. From all of this it follows that there is need for a consideration of the properties and methods of application of molluscicides as distinct from insecticides.

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MOLLUSCICIDES

CHAPTER I

THE FIELD FOR MOLLUSCICIDES

THERE is a wide field for the use of molluscicides. Human and animal diseases which are transmitted by snails have a profound influence upon social and economic welfare in many countries. There is great need for effective counter-measures. In the paragraphs which follow I give a brief outline of the situation.

The most widespread and important human disease which is transmitted by snails is schistosomiasis, commonly called bilharzia. An immense amount of misery and backwardness in many countries is directly attributable to that disease. The indirect consequences are felt by a very much larger number of people than those actually infected. The effects have been summed-up by Watson (*Jour. Royal Fac. Med. Iraq*, 12, pp. 10–11, 1948) as follows, "Bilharziasis is an insidious disease, the effects of which upon the human host only become manifest after a considerable lapse of time from the date of infection. At first the symptoms are comparatively trivial and the patient is inclined to ignore them or even regard them as normal, remaining in ignorance of the grave pathological changes which accompany the appearance of blood in the urine, the sensation of burning pain on micturition and the increase of lower abdominal discomfort. By the time that the victim seeks treatment complications have usually set in and secondary infection has further damaged the organs involved. At this stage the mere treatment of the parasitic infection will do little to relieve the sufferings of the patient and surgical intervention is often necessary.

"There is little doubt that bilharzial infection of the urinary tract, especially with its sequelæ of calculi, calcification of the

bladder, polypi, and cancer, shortens the life of the sufferer by fifteen to twenty years or more and enormously reduces his working capacity unless adequate treatment is given early. Moreover, in his or her weakened condition the bilharzia patient is more susceptible to other infections."

As a result of the debilitating effect of the disease, which gives rise to much inefficiency, vaguely defined ill-health and apparent laziness, the consequences of bilharzia upon the economic life of a country are likely to be very serious indeed. Especially among the poorest people, lethargy induced by infection with bilharzia and other diseases reduces the capacity for work. The situation in an area in which conditions have been "improved" by the building of dams, or the introduction of irrigation, gradually becomes worse because of the increased infection which can result in turn in still less enterprise and initiative amongst the inhabitants. Poverty and ignorance doubtless play a part in the situation, but the key factor is the presence of the snails which transmit disease, and without which the parasite cannot continue to exist. The snails responsible can be destroyed promptly by the use of molluscicides.

Schistosome parasites, usually of different species to those found in man, infect animals. The diseases are commonly referred to as animal bilharzias. Bhalerao (*Proc. 4th Internat. Cong. Trop. Med. & Malaria*, 2, p. 1386, 1948) refers to these parasites in the following terms, "Although human schistosomiasis plays great havoc in endemic areas, the problem of animal schistosomiasis is no less distressing to human society. On a close consideration it would appear that a larger percentage of people in the world are affected, and are more deeply concerned with animal schistosomiasis than human schistosomiasis, for there is hardly any country where animal schistosomiasis does not occur, while human schistosomiasis is comparatively restricted in distribution. Compared with any single group of parasites schistosomes rank foremost in undermining the health of almost all species of domestic animals. . . .

"The principal losses are due to parasitism which drains the vitality of animals and lessens their production and renders some of their organs, such as intestines, liver, etc., unsuitable

as commercial products, without actually killing them. In other words, the losses chargeable to morbidity are much greater than those which can be charged to mortality."

Another parasitic disease which is transmitted by snails is fascioliasis, commonly called liver-rot. That is a serious menace to successful agriculture in many parts of the world. The disease is caused by a trematode (or fluke parasite) which lives in the bile ducts of many domestic and wild animals. The disease is practically cosmopolitan, and is transmitted in a given area usually by one single species of snail.

Sheep and cattle are the beasts most commonly affected by liver-rot, but the fluke parasite is known to occur in numbers in many other grass-eating animals, including rabbits, hares, buffalo, and deer. It is found less commonly in pigs, horses, dogs, cats, and human beings. As a human parasite it is only of minor importance, although several hundred genuine cases are on record.

The loss sustained from liver-rot by farmers who raise sheep and cattle is enormous. At irregular intervals in the past, when weather conditions have been suitable, there have been severe outbreaks of the disease in Britain. Then the sudden and unforeseen death of a large part of their stock has brought ruin to many farmers. Less spectacular, but of greater significance in the long run, is the steady drain on resources caused by the parasite.

The indirect economic loss due to liver-fluke infection takes several forms. Experienced veterinarians in rural areas agree that the mortality of farm animals from other causes, ranging from worm infestation to exposure to hard weather, is greatly increased because of the debilitating effect of fluke disease. In other words, because the beasts are in poor condition or have lowered resistance, they succumb more readily to other diseases or to temporary shortage of food.

An increase in sterility among infected animals, and their tendency to abort, is less frequently mentioned by country veterinarians than by physiologists, who evidently regard fluke infection as a contributory factor.

Peters and Clapham (*Jour. Helm.*, xx, p. 138, 1942) have

estimated that the normal economic loss to the meat industry in Great Britain resulting from the livers of cattle being condemned is in the region of £200,000 per annum. This is a minor item, however, in comparison with the results of loss of condition in the animals due to liver-fluke infection, with its attendant lowering of meat and milk production.

The most significant factor in the losses due to liver-fluke, however, is not their total amount, but the widespread crippling wastage which is sustained by hundreds of thousands of sheep and cattle raisers in all parts of the world. The key importance of liver-fluke infestation lies in the fact that in marginal areas this one kind of parasite is often the deciding factor which determines whether a given area of land will support a man and his family in poverty or in relative prosperity. The loss of a hundred sheep over a period of a few years will often make the difference between plenty and poverty.

From these paragraphs the reader will have gathered some idea of the part that diseases transmitted by snails play in human misfortune. Only the most widespread diseases have been mentioned, but there is no need to prolong the description. It only remains to point out that the diseases can be prevented if the particular species of transmitting snail in each case (not snails generally) is destroyed. Molluscicides which are available here and now, at trifling costs per individual, can bring about that condition promptly.

CHAPTER II

POSSIBLE DANGERS TO HUMAN BEINGS

SAFETY must be the first consideration in the choice of any substance used for destroying undesirable animals. The real test of the value of a molluscicide lies in the twin properties of harmlessness to human beings and deadliness to snails. The former is the more essential. It is also desirable that domestic animals should come to no harm if they are exposed to the molluscicide. Furthermore, since irrigation waters are often infested with snails, it is necessary that no damage should be done to field crops following the addition of a molluscicide to canal water.

Some of the newer insecticides are highly poisonous to man, and to his domestic animals. There appears to have been a tendency in recent years to consider the possibility of using the same or comparable substances for destroying snails. That seems to me to be unwise. Although it may be possible, with only an occasional accident, to use the highly toxic insecticides in their own sphere, the results of using such poisons upon bilharzia-infested waters which people commonly use for bathing and drinking are likely to be regrettable. I do not think it is unfair to suggest (as I have done in another place) that scientists who advocate the use of chemicals in waters should be prepared to test the safety of the measures which they recommend by partaking of the treated waters themselves.

Lehman (*Proc. 4th Internat. Cong. Trop. Med. & Malaria*, 2, pp. 1713–20, 1948) has discussed the properties of twelve of the newer insecticides, namely:

T E P (or T.E.P.P.) (tetraethylpyrophosphate).
Parathion (O, O-diethyl O-p-nitrophenylthiophosphate).
H E T P (hexaethyltetraphosphate).
Chlorinated camphene (68 per cent. chlorine).
G B H (or G.B.H.C.) (gamma isomer of benzene hexachloride).

D D T (dichloro-diphenyl-trichloroethane).
Chlorodane (or Chlordane) (1, 2, 4, 5, 6, 7, 8, 8-octochloro-4, 7 methano-3a, 4, 7, 7a-tetrahydroindan).
T D E (dichloro-diphenyl-dichloroethane).
Methoxychlor (dimethoxy-diphenyl-trichloroethane).
N-propyl isome (di-n-propyl-6, 7-methylenedioxy-3 methyl-1, 2, 3, 4-tetrahydro-naphthalene-1, 2-dicarboxylate).
Piperonyl butoxide (butylcarbityl (6-propylpiperonyl) ether).
Heptachlor (1, 2, 4, 5, 6, 7, 8, 8-octochloro-4, 7 methano-3a, 4, 7, 7a-tetrahydroindan dehydrohalogenated).

Lehman sums up the situation in the following words: "It would appear from the preliminary studies conducted with the newer insecticides that they are all toxic agents and present specific hazards. Until sufficient experimental evidence is accumulated to warrant an adequate appraisal of the hazards from the point of view of long-range effects, it is believed that the use of the new insecticidal chemicals should be considered experimental. Caution should be exercised in any recommendations for use."

Nolan and Berry (*U.S. Public Health Reports*, 64, pp. 942–9, 1949) describe pentachlorophenol (which was tested under field conditions and was found to kill snails) as being caustic, and causing people to have a choking sensation, with much coughing. Other workers have regarded dinitro compounds as being promising molluscicides, and although the actual dinitro substances which were used in the experiments are apparently harmless to mammals, some allied substances, such as dinitro-ortho-cresol (which also kills snails), are poisonous.

Dr. M. Abdel Azim, Director of the Bilharzia Snail Destruction Section of the Egyptian Ministry of Public Health, has expressed his opinion of compounds of this kind as follows, "K 604, G 562, D 289, C 456, and D 307. These compounds are derivatives of Dinitro-Phenol, whose insecticidal action is based upon metabolic stimulation. In vitro, K 604 powder proved effective in relatively low concentrations. A suspension in water at 1 p.p.m. killed snails in 48 hours, 5 p.p.m. in 24 hours. Its solubility is very low and the mixing with water, to

obtain even suspensions, is troublesome when large quantities are required. For this reason the slightly more soluble related liquids G 562 and D 289 and the substances C 456 and D 307 were tried out with approximately similar results. Since, however, the concentrates of these compounds are toxic and their ingestion or inhalation must be avoided, and since the improper disposal of the sludge or residue left after application may lead to serious consequences, the Section does not propose to use these drugs" (*6th Annual Rept.*, Bil. Snail Des. Section, Min. Public Health, Egypt, 1947–48, Cairo, 1950, p. 22).

Particular synthetic snail-killers may be discovered in the future which are harmless to man, but the prospect in the experimental stages is disagreeable. At this point, therefore, one is forced to consider the properties of the traditional molluscicide, namely copper. In any event it is worth noting that the next significant development in this field of work will not necessarily be the discovery of a new and effective synthetic molluscicide which is safe to use, but the development of biological and geographical means of control, which are commonly referred to as natural or "naturalistic" control measures. In the meantime copper presents a unique combination of properties, namely, effectiveness against snails in high dilution, harmlessness to man, domestic animals, and crops, and also relatively low cost.

For many years copper sulphate has been used in the reservoirs of urban water-supplies for the purpose of controlling the growth of algæ. There has been no trouble with the poisoning of mammals. Thresh, Beale, and Suckling, foremost authorities on the subject of the chemistry of water-supplies, state (*The Examination of Waters and Water Supplies*, ed. 5, p. 110, London, Churchill, 1944) that, "Copper is not a cumulative poison like lead, and there is no evidence that cases of ill-health or poisoning have ever arisen from the consumption of copper in water."

The form in which copper remains in natural waters, after being added as copper sulphate, is not known with certainty. There is evidence that in some instances it reacts with substances in solution in the water to form carbonates. Several

years ago experiments were carried out to ascertain the toxicity, if any, of malachite, a naturally occurring carbonate of copper, for the human being and a domestic animal. The results, which were quoted by Mozley (*Snail Hosts of Bilharzia*, London, H. K. Lewis, 1951) proved the harmlessness of that substance for human beings. Other experiments with cattle also quoted gave similar results.

CHAPTER III

PRACTICAL CONSIDERATIONS IN THE USE OF MOLLUSCICIDES

PRACTICAL considerations, which are not necessarily connected with the particular properties of the substances used, often determine the degree of success attained with molluscicides. I mention several such matters in the paragraphs which follow. These are simply examples of a large number of complications and minor difficulties which are likely to arise, and which have to be dealt with as part of the day's work. Matters of this sort may be very confusing to the beginner, and so I have thought it worth while to devote a few pages to them. At the same time I take the opportunity of mentioning certain methods which are still in the experimental stage. I do this because it is highly desirable that workers starting out in this field should realize the wide scope that exists for ingenuity in the application of our present existing knowledge, quite apart from fresh discoveries. Continual emphasis upon new discoveries (perhaps not yet made) is not always a healthy sign, and often it pays to look back over our existing knowledge for possible improvements and practical applications.

Survey and Field Trial.—Survey should precede treatment with molluscicides. It is essential to find out *exactly* where the dangerous snails live, and apply the molluscicides to those places. That may seem fairly obvious, but it is surprising to see how frequently people apply molluscicides to places where there are either no snails at all, or only harmless species. That is a pity, because it leads to misunderstanding and complaints about the high cost of the work. Then, subsequently, it is almost inevitable that dangerous sites are left untreated, and that in turn leads to complaints about the ineffectiveness of the molluscicide. Therefore one must find out exactly where the dangerous snails live before beginning to use the molluscicide. A little extra time devoted to making an accurate survey before

the treatment begins, and even a little money expended on getting confirmation by an expert, will be an economy in the long run.

A snail survey, based upon collections made over a wide area, will probably indicate the most important sites. In addition, I

FIG. 1.—Habitat of *Lymnæa truncatula*, Wilton, near Salisbury, England. During dry weather this snail lives in the hoof-prints seen partly shaded in the foreground. In moist weather it is found on the mud-flat exposed to the sun near the hat and watch.

frequently carry out tests to see whether or not the snails found are actually infected with the particular disease I happen to be studying. Directions for making these tests are given in Appendix B. I do not attach great significance to negative results (*not* finding infected snails) in these snail tests, but the