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*DILEMMAS IN CONSERVATION FOR APPLIED BIOLOGISTS

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Prevention of the use of DDT has been made the target of a powerful propaganda drive in certain prosperous countries because, it is stated, DDT is a danger to man and harms wild life. On the other hand, DDT is by far the most economical, effective and safe insecticide for many uses, particularly for protecting men from certain insect-borne diseases and for enabling cotton to be grown in poor countries. Some risks can be reduced by eliminating those uses of DDT for which adequately safe, economical and effective substitutes exist, whether chemical or not; other risks can be reduced in other ways. The known risks to men are trivial, except when DDT concentrate is deliberately drunk, and the scare is made up of unknown risks—which could equally exist with any object or material, new or old. Risks to wild life have been greatly exaggerated and scares depending on falsehoods have become current. The postulated threat of progressive accumulation of DDT along a long food chain is not adequately supported by evidence, much of which has been misinterpreted.

Thus the main dilemma is how to balance the great and undoubted benefits of DDT to millions of men, women and children against harm to wild life, sometimes genuine and remediable and sometimes dubious.

People who campaign for banning have possibly failed to recognize this delimma. On the other hand, they may have made a deliberate choice in favour of wild life. In that case, to be logical, they should also oppose all other means of preventing premature death of other people, which they might justify as a means of postponing over-population. The use or abuse of DDT is a minor component in the rise of the world's population.

INTRODUCTION

We are here as people with special knowledge and responsibility in a field related to the conservation of the environment. Most of us have wide sympathies and understanding, even outside our special fields, and we are not so fixed in our ideas and beliefs as to refuse to consider changing them, in the light of new information. Few though we are, we have a part to play in moulding public opinion on the current political activities in the conservation of the environment.

Public opinion in this subject is mainly formed by deliberate propaganda and by what readers of newspapers and books (and watchers of television) find exciting and not merely dull and true. The government seeks expert advice from some of our members, but of course its actions depend on other expert advice too, and on political pressures, which are themselves partly determined by propaganda. Perhaps even we are not entirely immune to unreasonable or false propaganda, especially if we are unable to search out the true facts. Consequently it is necessary to examine the facts afresh.

*Address of the President of the Association of Applied Biologists delivered on Thursday, 6 July, 1972.

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Within the field of conservation I am restricting my remarks to pollution, especially by organochlorine insecticides and particularly by DDT. After considering certain real situations, I shall pose what I believe to be the central dilemma.

ATTITUDES

First of all, what are we considering? The concise dictionaries give the meaning of 'conservation' as 'preservation'. But this is not at all what we mean when we speak of conserving natural resources, which implies using them no more than wisely and does *not* mean preserving them as in a museum. We do *not* want to preserve the countryside as it was in the 1920s and 1930s, with run-down farms, unkempt and unproductive fields, miserable stock, and a depressed rural population. Every way we turn, we have to make judgements about what we want; and we do *not* want simply to preserve the past, so much of which was natural enough in its way, but bad of its kind and even, by human standards, evil.

I have heard a wild-life research worker assert that he was not making value judgements and that value judgements did not affect his speech. This was, of course, breath-taking nonsense. The choices of subject of research, of species of animals to work on, of data to present, and of what to omit, all revealed clearly his value judgements. It is because so much work on environmental hazards to wild life is so obviously one-sided that we must carefully seek the missing information. For although our final judgements will be something more than the evident conclusion from facts, they must not fly in the face of truth.

Unfortunately, in this subject it is essential to look behind what is said and written, to seek motives and attitudes that are not explicit, if statements are to be accurately evaluated. About ten years ago I went to a technical meeting dealing with proposals for controlling DDT and its relatives. Before the meeting I was invited by the representative of another country to discuss plans. He was professionally concerned with conservation of wild life. To my surprise, he said he proposed to do no more than touch upon risks to wild life from DDT, but to make the case on grounds of risks of human cancer from DDT. This would appeal more effectively to human emotions. I asked if there was some new work to justify this. He said not and referred to Rachel Carson's (1962) *Silent Spring*. Now one of her statements about cancer is the exact opposite of what was written by the author she quoted as the authority for it, and the rest of her so-called evidence is scientifically childish. So I said I could not go along with that plan and I referred to life-saving by DDT, especially in the tropics. His attitude was unchanged and it left me with a deep distrust. This is a recurrent theme. You cannot take the statements of some conservationists at their face value. The rule is 'Know your conservationist—and then check.'

In passing, since that time many attempts have been made to produce cancers with DDT. If any one succeded, of course, we would have to look very carefully at the use of DDT, especially in advanced countries, where many people live along enough to die of cancer. At the present time, however, no responsible national medical authority considers DDT to be carcinogenic, in the sense of producing malignant growths; but every dubious experiment gets its publicity unofficially and has to be investigated by scientists. Public figures often hint at unspecified cancer risks without quoting any supporting evidence (McDonald, 1972; Gillette, 1972; Anon, 1972).

Many expositions of the effects of man-made pollution on the conservation of nature are one sided. Extreme conservationists attack without inhibitions, sometimes without much regard for the truth. Innuendoes—the smear technique—are com-

monplace. Out of many books on the subject I know of only one that is reasonably balanced, namely Kenneth Mellanby's (1967) *Pesticides and Pollution*; and even there I do not go along with his conclusions on predatory birds. On the other side, the defence of the use of modern technology in agriculture and public health, for the improvement of the conditions of human beings, is generally not defensive in tone; it seldom responds to specific attacks and it simply expounds the advantages of machines and pesticides and other chemicals. This is all very gentlemanly, but it leaves ordinary people puzzled about what to believe. Untruth is seldom exposed and pros and contras are seldom set out for all to weigh up. Never having had any allegiance to any commercial firm and, indeed, now having no allegiance to any employer at all, I can speak bluntly. I shall refer to falsehood, and I hope to provide material to balance the picture a little better.

DDT EVERYWHERE?

What is the size of the DDT situation? In 1966 Sladen, Menzie & Reichel showed that this insecticide occurs in Antarctic penguins that travel fast and far but never leave the Antarctic nor approach stable human habitations. There was some doubt about the origin of the DDT, for the birds were taken within easy penguin-swim of the American base that seasonally held some 2000 men. Presumably the food of those men came mostly from the U.S.A. and carried DDT in much the normal concentrations for American food. Most of this DDT would enter the sea, either in wasted food or in excretions, for presumably the men would not store much additional DDT. Although detoxication occurs, it is not fast. Indeed, it was later found that the proximity of the base did affect the amounts in penguins (Brewerton, 1969). Before that, however, I had arranged with the Foreign Office and then with Dr Martin Holdgate for samples to be sent from the British base on Signey Island in the South Orkneys, thousands of miles away from the American base. In the characteristic manner, the British base is manned by fewer than ten men and is therefore not a large source of DDT. Analysed in the Laboratory of the Government Chemist, these penguins showed concentrations of DDT much the same as did the American samples; they also contained other organochlorine insecticides that had not previously been found in penguins (Tatton & Ruzicka, 1967). Insecticides were also found in the food of the penguins, which is mainly krill (*Euphausia* spp.).

That is to say, if DDT is not everywhere in the superficial parts of the planet, it is in some pretty unlikely places and is quite probably everywhere. The British Agricultural Research Service demonstrated the occurrence of these insecticides in rain in central England (Wheatley & Hardman, 1965) and the Government Chemist's Laboratory showed that they are present all the year round in analysable quantities in rain all over the country, from Shetland to Land's End (Tarrant & Tatton, 1968). They were also found by analysing the air itself (Abbott, Harrison, Tatton & Thomson, 1966).

WHAT IS POLLUTION?

Is this a cause for alarm? The fact is that physico-chemical analysis of these organochlorine insecticides is now more sensitive than any other technique of analysis in general use for complex compounds. If analysis improved so much as to detect a single molecule, ought we to regard that molecule as constituting pollution? Clearly, if we did, the word would lose all useful meaning. We have to bear in mind the definitions of pollution given on both sides of the Atlantic. The U.S. President's Science Advisory Committee (PSAC, 1965) laid down that 'environmental pollution

TABLE 1 — *Scale of values of concentrations of DDT and its relatives, DDE and TDE*

1 % dust or spray	1 in 10^2
Found in fat of live wild pheasants*	2.7 in 10^3
Found in fat of healthy DDT-factory workers	1 in 10^3
Fed safely to monkeys for 7 years in whole diet	2 in 10^4
Apparently harmless in muscle of certain fish-eating birds (more in fat)	1 in 10^5
Found in human fat, general population	
Isfael (1963-4)	2 in 10^5
U.S.A. (1967-70)†	6 in 10^6
Britain (1961-4)	3 in 10^6
Kills trout, in their muscles	5 in 10^6
Food tolerances, various foods	5 in 10^6 to 1 in 10^8
In fat of Antarctic penguins	1 in 10^7
Saturated true solution pp-DDT in pure water	1 in 10^9
In water kills some trout in 100 days	1 in 10^9
In London rain	2 in 10^{10}
In English rural rain, average	8 in 10^{11}
In London air (one sample)	1 in 10^{11}
In Scottish streams	1 in 10^{11} to 1 in 10^{12}

The figures are rounded off for simplicity.

* In recording their figures for the pheasants, Keith & Hunt (1966) stated that there were indications that the reproductive success was affected, in birds feeding on dressed rice seed.

† Hilton (1971) reported that of the 6 ppm in the population of the U.S.A., about one-third was pp'-DDT and two-thirds pp'-DDE.

is the... unfavourable alteration of our surroundings... .' Moore (1965) of the Nature Conservancy wrote that 'contaminate' and its synonym 'pollute' ought not to be used unless the substances concerned are toxic and occur 'at concentrations which are likely to be hazardous'. On present evidence the presence of DDT in the air, in the rain, and anywhere else at such small concentrations ought not to be referred to as contamination or pollution. There is, of course, more to be said about this. If I were to expand this thesis now, it would unbalance my talk; to balance it with equal attention to similar matters would, I estimate, take 60,000 words rather than 10,000.

These definitions require us to consider these matters quantitatively. Table 1 provides a scale of concentrations of DDT that have been found in various situations. Some of the analyses did not differentiate between DDT and its analogues, DDE and TDE. Hilton (1971) indicated that the average concentration (6 ppm) in the fat of Americans in recent years is actually only one-third pp'-DDT and is two thirds pp'-DDE.

The scale extends from a 1% spray to one part in a million millions in Scottish highland streams. DDT has not been detected directly in oceanic waters, though it must be there, but probably generally much below the limits of analysis at present. Trout die when the muscle contains around 5 ppm but of course the DDT would actually be practically all in lipoids, where its concentration would be much higher. But some trout die after three months exposure to a nearly saturated solution of DDT, with only one part of DDT in a thousand million parts of water. From that concentration upwards, harm from DDT must be considered, though harm may be entirely absent; thus pheasants and men can carry far more in their fat and stay alive. Keith & Hunt (1966) stated that the reproductive success of the pheasants had apparently begun to be affected at about 2700 ppm in fat.

Since DDT is found almost everywhere, when it is sought by sensitive methods, whether direct or biological, the next step is to find out what it is doing. We know of no case that stands up to investigation in which concentrations weaker than one part in 10^9, whether outside or inside a vertebrate animal, have any adverse effects on it. And it is here that people begin to go off the rails.

DEPRIVING THE WORLD OF OXYGEN

This story begins with a jeremiad by Cole (1968) at Christmas 1967, entitled 'Can the world be saved?'. He suggested that pesticides in the ocean could reduce the world's photosynthetically produced oxygen by 70% and eventually lead to oxygen shortage, especially in winter and at night. Then Wurster (1968) described the effects of DDT on photosynthesis by diatoms. He wrote 'concentrations of DDT as low as a few parts per [American] billion in water reduced photosynthesis' and 'this inhibition may be of ecological importance'. Two facts aroused suspicion. First, the author himself stated that the maximum solubility of DDT in water is 1.2 parts in a billion (but in fact Biggar, Dutt & Riggs (1967) should be referred to for accuracy) but in none of his experiments did reductions of photosynthesis occur in water that was merely saturated with DDT. It had to be super-saturated, up to 100 times, a situation probably rarely possible in nature. (Nevertheless, publications still appear from the same laboratory, implying effects in nature from such situations (Mosser, Fisher & Wurster, 1972)). Secondly, it is impossible for oceanic water in general to contain as much as one-thousandth part of saturation. The amount so far manufactured (say 1.5 million tons $\pm$ 30%) is not enough to provide more than one part in 10^{12}, even if it all still existed and were all in the oceans (about 1.45×10^{18} tons).

Nevertheless the story soon became established as a reason for worrying about DDT, with its implied threat to the very breath of life, and it continues to this day (Anon., 1968*a*; Ingersoll, 1969; Graham, 1970; Woodwell, 1970; Hillaby, 1972). Even when the story has been shown to be as foolish as it is, its effect on the minds of the public will remain.

Before long, members of Wood's Hole Oceanographic Institute in Massachusetts and other reputable laboratories pronounced on the story, showing: that other species of plankton were unaffected by considerably supersaturated DDT (Menzel, Anderson & Randtke, 1970); that the oxygen produced by marine photosynthesis is about half what Cole (1968) said it was (Ryther, 1970); that photosynthesis yields only 15 x 10 tons oxygen annually, compared with 12 x 10 tons already present, so that if marine production were stopped, it would take a million years to reduce our supply from 21% to 19% of the atmosphere (Ryther, 1970; Broecker, 1970); and that from 1910 to 1970 the actual percentage has varied from 20.946% only by amounts less than the uncertainty of the measurements (Machta & Hughes, 1970).

Unfortunately these papers did not appear in time to affect various official reports. The Mrak Report to the U.S. Department of Health, Education and Welfare (1969) quoted the oxygen scare in at least four places without criticism. The Neuberger Committee (1970) regarded it as an unlikely tale but encouraged further investigations. The Report of the Study of Critical Environmental Problems (SCEP, 1970) was in two minds, on page 75 naming it a non-problem; and on page 127 merely doubting if it was 'ecologically meaningful' and thus not disturbing its dissemination.

To cap it all, Ehrlich (1970) predicted 'the end of the ocean' in 1979, quoting Wurster (1968). In a preface to the volume in which this article appeared, the editor enjoined British readers to write to their M.P.s about the matter. The volume is entitled *The Year's Best Science Fiction*.

What was evidently untrue from the start has not been stopped by mere truth. It has spread and produced its propaganda effects. In my view, we ought not to tolerate this kind of thing and we ought to combat it.