

# BIOCIDES AND MAMMALS

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The most frequently used chlorinated hydrocarbon insecticides are aldrin, DDT, dieldrin, endrin, heptachlor and toxaphene. Although their effectiveness in the control of insect pests has contributed significantly to human health and to the quality and quantity of commercial food and other crops (Jukes, 1963), we now have serious reservations about the advisability of continued widespread and uncontrolled use of them. Rachel Carson (1962) was the first to present the results of research studies in such a way that the attention of the layman (and of many scientists) was directed to the serious disruption of the environment caused by indiscriminate use of "control" chemicals. Despite many vigorous objections and denunciations, none of her major contentions has since been disproven.

It is an unfortunate fact that insecticides do not remain at the site of their application. DDT, for example, has become a ubiquitous contaminant, stored in the body tissue of even the most geographically isolated animals (Sladen *et al*, 1966) and suspended on particles of soil in air and water around the globe (Abbott *et al*, 1965; Risebrough *et al*, 1968). Increased use of other chlorinated hydrocarbons will undoubtedly result in their distribution equalling that of DDT as all have essentially similar chemical and physical properties. As all are virtually insoluble in water but readily soluble in many organic solvents and in fatty acids, living organisms actively concentrate the chemicals in the lipid component of their body tissues. This means that when chlorinated hydrocarbons are introduced into an ecosystem for the control of insect pests they are selectively concentrated out of the physical components of the system, and into the "lipid pool" of the biological components (Rudd, 1964).

Chlorinated hydrocarbon insecticides are directly toxic to most animals because they block the synthesis or

operation of enzymes necessary for the normal functioning of the nervous and muscular systems (O'Brien, 1967). This toxic interference is non-selective as it is not restricted solely to the "target" pest. Further, all these insecticides are indirectly lethal, particularly to vertebrates, by inducing the synthesis of other enzyme systems which disrupt the delicate balance of steroid hormone levels (Conney, 1967; Peakall, 1967). The ramifications of this action are most apparent in certain species of birds where the causes of the "thin-egg shell" phenomenon are now well established (Ratcliffe, 1967; Hickey and Anderson, 1968).

The essential point is that, owing to similarity in mechanism of action and in physical and chemical properties, all of the chlorinated hydrocarbon insecticides should more accurately be considered as **BIOCIDES**.

My concern here is to use evidence from field and laboratory studies to suggest ways in which chlorinated hydrocarbon biocides directly or indirectly disrupt the behaviour, reproduction and ecology of wild mammal populations. Reference is made to Hayes (1965) for a complete review of absorption, metabolism, storage, excretion and general physiology of these chemicals in mammals.

## Effects on Mammals

When confined mammals are given daily doses of chlorinated hydrocarbon biocides in their food, much of the residue is stored in adipose tissue although some is metabolized or excreted. Under certain conditions of stress, such as cold or starvation, the stored residue may be released for circulation and subsequently lead to the death of the animal (Dale *et al*, 1962; Morris, 1968). Such direct cause of mortality is probably rare in wild populations, but there are more subtle ways in which the release of stored residue may affect the health of a population. Transfer through the mam-

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mary glands for excretion in the fatty acid fraction of the milk of nursing females occurs in most mammals, including cows (Henderson, 1965), dogs (Woodward *et al*, 1945), rats (Radomski and Davidow, 1953), and human beings (Quinby *et al*, 1965). Suckling young are therefore directly exposed to potentially serious biocide levels early in their life. Further, at least two chlorinated hydrocarbons (DDT and dieldrin) are known to move across the placenta in dogs (Finnegan *et al*, 1949) and mice (Backstrom *et al*, 1965) and to accumulate subsequently in the adipose tissue, liver, reproductive organs and brain of the embryos.

The demonstration of excretion in milk and of transfer to unborn embryos has serious implications with regard to the reproductive biology of mammals exposed to even low residue levels in the field. Although the magnitude and expression of effect depends on several variables including the biocide itself, the species of mammal and the duration of exposure, laboratory studies suggest that aldrin, dieldrin, DDT and endrin all have essentially similar adverse effects on the reproductive biology of small mammals (Bernard and Gaertner, 1964; Morris, 1968; Treon and Cleveland, 1955). These effects include an increase in adult mortality and in either pre-natal or post-natal mortality of young, a decrease in the size and frequency of litters and a decrease in the number of pregnancies.

Residue contamination is not, of course, restricted to small mammals. However, the biological significance of residue levels found in large mammals is generally not so well known as it is in small mammals. The fat component in tissues of large mammal game species including wild mule deer, white-tailed deer, pronghorns and elk in Montana (Pillmore and Finley, 1963) and South Dakota (Greenwood *et al*, 1967) contains dangerously high residues of DDT (maximum, 42 ppm) and dieldrin (maximum, 4 ppm). It is noted here that the tolerance level set by the United States Food and Drug Administration (USFDA) for residue

contamination in domestic livestock for human consumption is 7 ppm (DDT) and zero ppm (dieldrin). Parenthetically, by these standards citizens of the United States are unfit for human consumption. They carry, on average, a body burden of 13 ppm DDT and 0.15 ppm dieldrin (Hayes, 1964).

Trophic concentration (see Hunt, 1966) significantly increases the biocide load of species of predators. The effect becomes more serious if the vertebrate prey develops resistance to a biocide. Individuals from mouse populations with a history of exposure to biocides have developed resistance to DDT in the laboratory (Ozburn and Morrison, 1967) and to endrin in the field (Webb and Horsfall, 1967). The presence of resistant types in a population produces a biological product which is "poison bait" for any consumer, including man. Residents of Mississippi consume fresh-water green sunfish whose edible tissues contain up to 27 ppm endrin (Ferguson, 1967). The USFDA tolerance level for endrin in human food is zero ppm.

In addition to the stated specific instances of the effects of biocides on mammals, the major kinds of effects produced on populations of wild mammals are summarized in Figure 1. These include direct lethal and sublethal toxic effects, and indirect non-toxic effects. Such effects need not be restricted to local populations living in or near a chemical spray area, but can spread in time and space to affect populations far removed from the site of application.

The figure is generalized in that it could apply, if modified slightly, to most species of vertebrate. For example, McEwan & Brown (1966) working with Sharp-tailed Grouse demonstrated that a single sublethal dose of dieldrin caused changes in social hierarchy among males, and increased vulnerability to predators. Further, as different species of insects react differently to the same insecticide (Pimental, 1961), the pathways described need not apply equally to all vertebrate species.

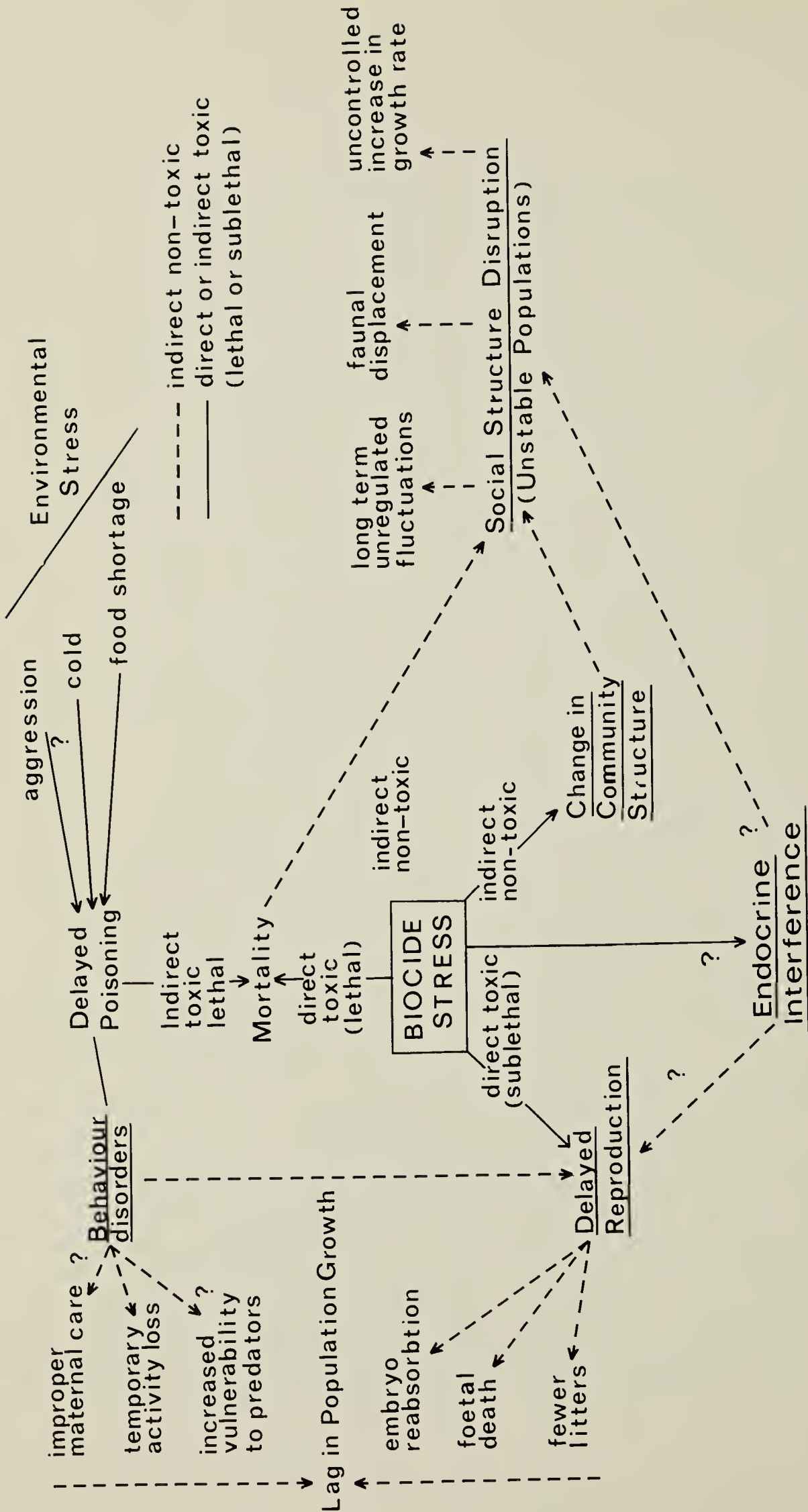


Figure 1. Generalized concept of the way in which a biocide may affect a non-target mammal population. Responses which have not been demonstrated in wild mammal populations are shown (?). Based partly on Barret (1968), Barret and Darnell (1967), Morris (1970), Rudd (1964), and Snyder (1963).

## Conclusions

The government of Canada is to be commended for recent DDT control legislation. By this step, Canada joins a growing list of political regions, local and national, which have declared controls on the sale and use of DDT (see MacMullen, 1968; Mosquin, 1969). Twenty-five years of intensive research has established the basis for such legislation by demonstrating that DDT is a significant and dangerous environmental pollutant. The physiological and ecological actions of aldrin, dieldrin, endrin, heptachlor and toxaphene are actually or potentially more serious than those of DDT. It should be clear that the physiology of individual human beings and the ecology of human populations is sufficiently similar to those of other mammals that similar responses to chlorinated hydrocarbon biocides might be expected.

The weight of evidence is overwhelmingly against the continued practice of *uncontrolled* use of chlorinated hydrocarbon chemicals. Chant (1969) has already urged the government of Canada to "impose an absolute ban on the further manufacture, sale or use of DDT, aldrin, dieldrin, and heptachlor." A large portion of his resolution dealt with adverse effects on the health of man. I submit that the government of Canada need not further reserve judgment in the matter of meaningful legislative controls on all chlorinated hydrocarbon chemicals. The current practice of requiring a demonstration of actual or potential lethality to humans before taking action is unnecessary and should be abandoned.

The Minister of Health and Welfare of Canada and the Minister of Agriculture of Canada should be urged in the strongest possible terms to give thoughtful consideration to the following recommendations:

1) that the government of Canada recognize the similarities in the physiological and ecological actions of all chlorinated hydrocarbon chemicals and extend the existing DDT legislation to include aldrin, dieldrin, endrin, heptachlor and toxaphene.

2) that the government of Canada encourage the use of alternate chemicals which are less residual than the chlorinated hydrocarbons. In order that such a step be effective, the manufacture, sale and application procedures should be under strict government control so that purchase and use by private individuals will be better regulated.

3) that the government of Canada develop a program of cash incentives to encourage farmers to a) leave natural areas of grassland and woodland adjacent to food crop fields, and b) plant shelter-belts of native vegetation within and adjacent to food crop fields. It has been clearly demonstrated that over-simplification of an ecosystem by the removal of all natural vegetation (monoculture) encourages insect pest outbreaks (Cole, 1964; 1966; Egler, 1966). With this practice, ecological diversity is disrupted and instability is encouraged so that chemicals are not as effective as claimed. In fact, insect numbers may actually reach higher densities following biocide treatment (reviewed by Ripper, 1956). The reasons are related to development of resistance (Brown, 1958), to removal of competitor insect species (Pimental, 1961) or to reduction of predaceous insect species (Pickett, 1961). More reliance should be placed on natural controls or on the selective use of chemicals.

4) that the government of Canada recognize local or national legislative controls to be insufficient protection for a global environment already seriously threatened by a dangerously high load of chlorinated hydrocarbon and other insecticides (Wurster, 1969; see also, Erhlich, 1969). Presentation of a resolution to the United Nations encouraging a ban on all uncontrolled sale or use of the chlorinated hydrocarbon biocides is suggested. The expected defensive argument of "more insecticides to feed more people" is considered invalid (Paddock and Paddock, 1967).

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