Insecticides and Rodenticides

1952 Recommendations for use

Laboratory and field investigations to determine the effectiveness and toxic hazards of various economic poisons which offer promise for use in communicable disease control have been conducted for several years by the technical development branch of the Communicable Disease Center. The results of these investigations and a review of work done by other research agencies have been used as a basis for recommendations on materials, dosages, and application techniques for use in field operations.

The rapidly changing status of resistance to insecticides exhibited by some insect species makes it difficult, if not impossible, to make general recommendations for their use in all areas. Consequently, it will be necessary for operators in any given area to adapt these recommendations to the situation at hand.

Mosquito Control

During the past year, there have been indications from several scattered areas in the world that some species of *Anopheles* are developing resistance to DDT. Some evidence has been developed by workers of the Tennessee Valley Authority that *Anopheles quadrimaculatus* may be developing resistance to DDT in some localities in which DDT has been used continuously for more than 5 years. However, in general this species does not appear to have developed resistance to DDT to a degree which would significantly affect control operations. The continuation of previously adopted procedures for the control of *A. quadrimaculatus* is recommended for 1952, namely, the use of 5-percent DDT emulsion residual sprays in homes to control the adult mosquitoes and the use of 0.05 pound of DDT in 1 gallon of fuel oil per acre to control the larvae; DDT at the rate of 0.05 to 0.10 pound per acre, applied as a 20-percent solution in methylated naphthalenes, such as Velsicol NR70 or Sovacide 544B, is recommended for airplane treatment; and a 5-percent DDT emulsion or a 5-percent DDT oil solution for outdoor space spraying to control adult mosquitoes.

The only known mosquito vector of disease which appears definitely to have developed a high degree of resistance to insecticides in the United States is *Culex tarsalis* in California. Observations by the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture indicate that in some localities this species has developed varying degrees of resistance to a number of chlorinated hydrocarbons, including DDT, toxaphene, lindane, aldrin, and heptachlor applied as space sprays. Although no specific recommendations can be made for control of the resistant strains of this species, DDT-DMC combinations, and perhaps other DDT-synergist combinations as they become available, may be used on a field trial basis. Combinations of DDT with DMC (*p*-dichlorodiphenyl methyl carbinol) at ratios from 5:1 to 20:1 have been effective as space sprays against field strains of DDT-resistant houseflies.

DDT Substitutes

Salt-marsh mosquitoes in several areas are unquestionably resistant to DDT and other insecticides. As an initial substitute against DDT-resistant strains, the Bureau of Entomology and Plant Quarantine found lindane at 0.1 pound per acre or technical BHC (benzene hexachloride) at 0.4 pound per acre, both applied as fuel oil solutions from airplanes, to be an effective larvicide. During 1951 poor results were obtained with BHC in some localities. Field trials of DDT-DMC or other DDT-synergist combinations are recommended when salt-marsh or other pest mosquitoes have become resistant to the chlorinated hydrocarbons. Where resistance is not a factor, DDT remains the insecticide of choice.

Against some species of pest mosquitoes which have not developed resistance to DDT, barrier-strip residual spraying with DDT around the outside of individual premises has given effective control. In the Savannah, Ga., area, preliminary tests using 1-percent DDT emulsions applied to the outside of houses, and to shrubbery, grass, and other vegetation for a distance of approximately 100 feet around the houses, gave satisfactory reductions against the common species of salt-marsh mosquitoes for about 3 weeks. It is recommended that similar procedures be used experimentally in situations where other control measures are not more feasible, as for example to protect individual premises or groups of premises in irrigated agricultural areas.

Residual larviciding with technical BHC (12-percent gamma iso-

This paper was prepared by the technical development branch of the Communicable Disease Center, Public Health Service, Savannah, Ga.

mer) emulsions at the rate of 1 pound per acre (in gallons of finished spray per acre applied in the same manner as oil solutions) has given satisfactory mosquito control in small, land-locked, fresh-water ponds against a variety of anopheline and culicine species for periods ranging from 5 to 8 weeks. No damage to fish was observed during 3 consecutive years of treatments with BHC, during which five treatments were made each year spaced at approximately 5-week intervals between April and October for a total of 15 1-pound-per-acre applications during the 3-year period. There was some indication of off-taste in fish from one of the treated ponds in which unusually low water levels had prevailed at the end of the third year of treatment. It appears that technical BHC (12 percent gamma isomer) can be applied safely as emulsions at the rate of 1 pound per acre at approximately 5-week intervals without damage to fish for 3 consecutive years. This procedure is recommended for residual larviciding where fish are present.

When fish are not present, effective control for periods ranging from 3 to 6 months has been accomplished near Savannah by residual larviciding with DDT emulsion at the rate of 3 pounds per acre (in 2 gallons of finished spray), using the method usually employed in applying oil-mist sprays as mosquito larvicides. *This treatment is totally destructive to fish present in the ponds at the time of treatment, and should not be used where fish are present.*

Dieldrin applied as an emulsion concentrate or a wettable powder suspension at the rate of 1 pound per acre will also prevent mosquito breeding for more than 1 year. *However, it is completely destructive to certain other aquatic life,* and should not be used except in emergency or in other unusual circumstances.

Fly Control

Residual Sprays

In most areas of extensive use of residual sprays, houseflies have become highly resistant to DDT and in some instances to several other chlorinated hydrocarbons. Unfortunately, the work of the past year with residual insecticides has produced very few promising leads for the solution of this problem.

DDT is still the insecticide of choice in areas where houseflies remain susceptible to it, except in dairy barns and other places where it may contaminate milk. A 5-percent emulsion or suspension applied at the rate of 4 ml. of spray per square foot of treated surface area is recommended for general use. Where outdoor treatments are required, the addition of pine gum rosin to give 2 percent rosin in the finished spray increases the residual effectiveness of the DDT.

Dieldrin applied as a 0.625-percent emulsion is recommended as an outdoor residual spray for use by trained personnel in organized fly control programs in areas where DDT-resistant flies may still be susceptible to this compound. However, fly populations may develop resistance to dieldrin in less than one season and in some areas it has already become ineffective through the development of such resistance. The precautions which have been recommended in the "Operational Memorandum for Dieldrin," issued by the technical development branch of the Communicable Disease Center, should continue to be observed in dieldrin spraying operations.

Chlordan is recommended for selective spot treatment inside dwellings and on porches, insides of outbuildings, and other locations relatively protected from the weather, in areas where flies have not yet become resistant to this insecticide. A 5-percent emulsion is recommended for this general use, except that formulations used within dwellings should not contain more than 2.5 percent chlordan.

Lindane applied at the rate of 25 mg. per square foot, or methoxychlor at 200 mg. per square foot, is recommended for use in dairy barns, feed barns, and other places where the use of other chlorinated hydrocarbons might contaminate milk. However, neither of these may be expected to give the degree of control originally achieved with DDT residuals, particularly where flies are already highly resistant to DDT.

Dilan is suggested as a residual spray for experimental testing on operational fly control programs. Current information indicates that 2.5- to 5-percent suspensions of water-wettable dilan are effective as a residual spray against DDT-resistant flies. However, there is already evidence from laboratory studies that flies may develop resistance to dilan within a relatively short time.

Larvicides

The use of larvicides may be desirable for fly control in certain situations, as in the treatment of dirty garbage cans and privies or of concentrated fly breeding areas such as at stockyards or chicken farms. Several of the chlorinated hydrocarbons are effective fly larvicides, but their use may result in the development of the same resistance encountered when they are used as adulticides. Among the more promising larvicides for general use are chlordan, lindane, and BHC. Dieldrin and aldrin are also effective fly larvicides. These materials should be applied at the same dosages per square foot as recommended for residual sprays. In general, it appears desirable to dilute the residual spray emulsions or solutions to three to five times their original volume in order to provide better penetration of the larvae breeding medium. The same precautions in applying dieldrin or aldrin as larvicides should be observed as when dieldrin is used as a residual spray.

In small-scale field tests, applications of paradichlorobenzene crystals (PDB) at the rate of 2 oz. per garbage can has controlled fly breeding for 1 to 2 weeks. This procedure is suggested for trial in areas where flies are resistant to other types of larvicides.

Space Sprays

When flies have become resistant to the aforementioned materials applied as residual sprays or larvicides, space sprays are the only alternative for chemical control. Selective treatment of night-time resting places with space sprays appears to be a

promising approach because of the concentration of flies in limited areas at night. In urban areas, houseflies and the more common blowflies generally rest at night in the lower branches of trees and in bushes, grasses, and weeds. During cool weather, houseflies tend to seek the protection of outbuildings. Species of *Drosophila* appear to rest predominantly in privy pits or buildings. In rural areas, the inside of unscreened dwellings is a favorite resting place. On premises with screened dwellings, the flies rest on porches and in animal shelters during cool weather, and on the lower branches of trees and on shrubs in warm weather (minimum daily temperature 70° F. or above). Since temperatures and local environmental conditions affect the flies' choice of nocturnal resting place, limited local surveys should be conducted as a guide to night-time space spraying operations.

Combinations of DDT with DMC at ratios ranging up to 20:1 have given effective kills when applied as space sprays against field strains of DDT-resistant flies. Emulsions or fuel oil solutions of this combination, using 5 percent DDT, may be used as space sprays for fly control. Other DDT-synergist combinations are under investigation.

In small-scale field tests 2.5-percent emulsions of dilan applied as outdoor space sprays at dosages of 0.05 pound per acre were highly effective against DDT-resistant flies. The emulsions were prepared with technical dilan in the same manner as with DDT. It is recommended that technical dilan be utilized at 2.5-percent concentrations in operational programs where flies are resistant to other insecticides.

Among the most reliable and least toxic to humans of the space sprays are pyrethrum formulations, which are usually used in indoor space sprays and are the insecticide of choice for this purpose. Pyrethrum formulations are used in combination with synergists such as piperonyl butoxide, in emulsions or oil solutions containing from 0.05 to 0.1 percent pyrethrins and 0.5 to 1.0 percent of the synergist. However, they are currently in short supply and are too expensive for general large-scale use in fly control.

Where flies are still susceptible to BHC, a 5-percent technical BHC (12 percent gamma isomer) or a 2-percent lindane emulsion is recommended as an outdoor space spray for use against flies resistant to DDT and chlordan. Where odor is not a factor, the technical BHC is favored because it is cheaper. The development of fly resistance to these compounds may be expected if they are used regularly.

A 2.5-percent emulsion of chlordan may be used as an outdoor space spray against DDT-resistant flies. Houseflies in some areas have developed resistance to space sprays of this material. Housefly resistance to it may be expected to appear if it is used continuously for fly control.

Sanitation

The development of housefly resistance to many different types of insecticides has refocused attention upon the importance of sanitation as a fly control measure. There is universal agreement that sanitation should be exploited to the fullest degree possible in conjunction with the use of chemicals for fly control. Insecticides are more than ever a supplement to sanitation rather than a substitute for it. The value of screening as a fly control measure is also worthy of re-emphasis.

Flea Control

In field tests conducted over a period of 3 months, a 5-percent DDT dust has been found to be as effective as a 10-percent dust when applied to rat runs and harborage areas for the control of the oriental rat flea. The 5-percent dust has been used on some operational programs. However, most operators have preferred to use the 10-percent formulation, particularly where it was desirable to control other ectoparasites more resistant to DDT, for example, the cat flea.

A 10-percent chlordan dust is recommended for use in controlling soil infestations of cat and dog fleas. A single application of this material has given effective control of infestations, whereas repeated applications of DDT would have been required.

Roach Control

A 2- to 2.5-percent emulsion or oil solution of chlordan is recommended for spot spraying for roach control in homes. Such treatment should be confined to limited harborage areas, such as space behind baseboards, in cracks and crevices, and around openings through which roaches may gain entrance from the outdoors. Over-all applications of chlordan should not be made in homes.

Rodenticides

The possibilities of rodent control appear to be more encouraging than ever before, for, unlike insects, rats do not seem to have developed resistance to poisons.

Warfarin

The most recent addition to the rodenticides, warfarin, maintains its early promise. It is the first effective slow-acting rodenticide, and its characteristics—(*a*) failure to induce bait shyness, (*b*) necessity for repeated ingestion if control is to be achieved, and (*c*) relatively small hazard to man and useful animals compared to the hazard offered by most other effective rodenticides—make it the first effective residual rodenticide ever developed. According to results of tests completed during the past year, the warfarin susceptibility of the different species of commensal rodents differs. This has been confirmed by laboratory field studies. Therefore, in the interest of economy and safety, it appears only reasonable to use the lowest bait concentration consistent with the most effective control.

Dependable control of the roof rat, *Rattus rattus*, requires the use of a concentration of 0.250 mg. of warfarin per gram of bait (0.025 percent). However, field tests have shown that a concentration of 0.050 mg. per gram (0.005 percent) is effective for control of the Norway rat (*Rattus norvegicus*). Mice react in the same general way as Norway rats although they show more individual variation. There is

evidence that under certain conditions Norway rats may be controlled a little more rapidly, though no more surely, by use of bait containing 0.100 mg. of warfarin per gram of bait instead of a concentration of 0.050 mg. per gram. There is a real opportunity for those associated with city and county programs to determine by careful operational observations which of these two concentrations is more desirable for use in organized control campaigns carried out by personnel who have received some training in rodent control but who make no claim to be experts in the field. However, if the species of rat concerned is not definitely known, the 0.025 mg. per gram concentration should be used.

Warfarin may be used for initial rodent control under essentially all conditions, using a minimum baiting period of 2 weeks. In addition, consideration should be given to establishing bait stations for permanent control of rats in places which are subject to reinfestation. Two years of experience has shown that Norway rats can be controlled in non-ratproof buildings so long as poisoned bait is available. No difference in this residual effectiveness of the 0.100 and the 0.050 mg. per gram bait concentrations was observed. The bait stations were inspected approximately every 6 weeks and fresh poisoned bait was supplied.

ANTU

ANTU still holds a definite place as a quick-acting poison for the Norway rat. Its use to reduce large populations rapidly may be followed by the use of warfarin to achieve complete and lasting control. ANTU should not be used against the same population more often than about once a year. It induces a very persistent bait shyness in rats and this property makes it ineffective for repeated use against the same population. It is not effective for the control of roof rats or mice. Its safety record is good so that it may be used in residences and food-handling establishments.

Sodium Monofluoroacetate (1080)

Sodium monofluoroacetate (1080) is still the most effective, fast-acting rodenticide, but its extreme toxicity to man and animals requires that it be used only on certain types of premises and only by carefully trained crews. The precautions necessary for the safe use of 1080 are numerous and involved. They are described in "Operational Memoranda on 1080," issued by the technical development branch of the Communicable Disease Center.

Baiting Problems

In tests in Savannah, corn meal has proved to be the most readily accepted cheap bait. In general, any available cereal bait is recommended for use. It is worth emphasizing again that under certain conditions it is very difficult to get rodents to take bait; for example, where food is available in great variety and abundance, as in some warehouses. Such conditions constitute baiting problems, a term which implies that the origin of the problem is not in the particular poison used but in the ecology of the animals themselves. Obviously, in testing any given rodenticide formulation, it is necessary to make sure that apparent failure of the formulation is not caused by baiting problems. These problems can be solved efficiently only through extensive knowledge of the habits of the rodents. They do not occur more frequently when simple cereal baits such as corn meal are used than when complex bait mixtures are used.

Sanitation

The importance of sanitation, including proper garbage disposal, food storage, harborage elimination, and ratproofing must be emphasized. Sanitation is essential to the permanent control of commensal rats and mice and the use of rodenticides should be regarded as supplementary to sanitation.

Conference on Aging

"Housing the Aging" will be the topic for a conference to be held in Ann Arbor, Mich., July 24–26, 1952, under the co-sponsorship of the University of Michigan, the Michigan State Medical Society, the Committee on Aging and Geriatrics of the Federal Security Agency, and the Housing and Home Finance Agency.

The 3-day conference will consider the housing needs of healthy, chronically ill, and disabled older people. Types of housing and living arrangements, architectural designs and costs, hygiene and safety standards, social and economic aspects of housing, and auxiliary services will be discussed.

Registration information may be obtained by writing to Dr. Wilma Donahue, Institute for Human Adjustment, Room 1510, Rackham Building, Ann Arbor, Mich.