EFFECTIVENESS OF GRANULAR INSECTICIDES AGAINST EYE GNATS AND MOSQUITOES AS AFFECTED BY TOXICANT CONCENTRATION [1, 2]

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INTRODUCTION. Granular formulations of insecticides can be applied easily to mosquito and eye gnat breeding sites where a thick plant canopy covers the breeding grounds, and they can also be used under conditions where spray applications are ineffective. The superiority of granular insecticides over sprays in penetrating among rice plants to reach water underneath was pointed out by Whitehead (1951). LaBrecque *et al.* (1956) determined the effectiveness of a large number of impregnated granular insecticides against mosquito larvae in the laboratory and in the field. These studies were aimed at finding a more efficient granular formulation for mosquito control. Weidhaas (1957) studied the release of impregnated formulations of organophosphorus insecticides in the laboratory. Lower releases of parathion and chlorothion into water were obtained from the 10 percent granular formulations than from the 1 percent formulations, using attapulgite, vermiculite, diatomite, and pyrophyllite granules. On montmorillonite, the releases from the 10 percent and 1 percent formulations were essentially the same.

In a study of the basic factors influencing the efficiency of impregnated granular parathion in mosquito control, Mulla and Axelrod (1960) determined that solvents used for the impregnation of the granules have a profound effect on the release of parathion into water. Rate of application of a granular formulation, toxicant concentration in the formulation, and size of granules are also factors influencing and regulating the release of toxicants from granules (Mulla, 1960b).

The incorporation of granular DDT into the soil for the control of *Hippelates* eye gnats has been hopefully considered within the past few years, since granular DDT is cheaper and easier to apply to eye gnat breeding grounds than the sprays. However, no investigation has been made of the basic factors contributing to the behavior of granular DDT when applied to the soil; consequently, the efficiency of DDT granular formulations which can be employed economically for eye gnat control is not known.

The effectiveness against *H. collusor* of various concentrations of DDT on attapulgite granules applied to soil at the rate of 20 pounds actual toxicant per acre was studied in the laboratory (Mulla, 1960a). As the concentration of DDT in the formulation increased, the initial effectiveness decreased. Three months after storage the 10 percent formulation was as effective as sprays but the 20 percent and 35 percent formulations were inferior to the 10 percent formulation and the spray treatment. Similarly, in field trials, 10, 20, and 35 percent DDT-impregnated attapulgite granules yielded poorer control of *H. collusor* and *H. hermsi* than DDT sprays (Mulla 1961). Again the effectiveness of the formulations generally decreased as the DDT concentration increased.

The effect of concentration of parathion in impregnated and coated granules on its release into water has been dealt with during the course of this study. Also, tests on the relationship of rate of applica-

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tion of parathion to water and its release have been carried out. The effectiveness of 10 and 20 percent coated DDT granules against *H. collusor* as soil treatments has been studied and compared with the effectiveness of spray treatment.

METHODS AND MATERIALS. The impregnated granular formulations of parathion were prepared in the laboratory as described by Mulla and Axelrod (1960). Attapulgite granules (Floridin Company, Tallahassee, Florida) were impregnated with parathion solutions using Chevron Light Solvent (Standard Oil Company of California) and AR-60 (Velsicol Corporation, Chicago, Illinois) as solvents. The solvents comprised about 10 percent by weight of the finished product.

The coated parathion and DDT granular formulations were furnished by Niagara Chemical Division, Food Machinery & Chemical Corporation, Richmond, California. (Wettable powders of the toxicants were coated onto sand cores by means of a water-soluble glue.) The coated parathion and DDT granules were considered to conform to 20/28 mesh size.

For evaluating the release of the toxicant into water from the impregnated and coated parathion granules, desired quantities of the formulations were dropped into a mayonnaise jar containing 3500 ml. of tap water (8.25 inches high) having a pH of 8 to 8.25. The water was kept at a constant temperature of 85° F. The impregnated formulations were added at rates to yield a theoretical concentration of 1 p.p.m. of parathion in the water. In one test where the effect of rate of application on the release was studied, the theoretical concentrations were maintained at 0.5, 1.0, 2.0, and 5.0 p.p.m.

At intervals of 8, 24, 48 and 72 hours, aliquots of the treated water were aspirated from the top and bottom portions of the jar and composited for further dilutions. Small amounts of the composite samples were added to 100 ml. of water in 6-ounce paper cups to obtain final theoretical concentrations of 0.01 to 0.04 p.p.m. The 0.01 p.p.m. theoretical concentration in the cups corresponded to 95 to 98 percent larval mortality. Prior to the addition of the toxicant, 25 fourth-stage mosquito larvae (*Culex quinquefasciatus* Say) were added to each cup. These larvae were kept in the cups at a temperature of 75°–78° F. and the mortality was recorded 24 hours after exposure of the larvae. Each cup was replicated 3 times. The extent of release of parathion was calculated by reading off the amount of parathion corresponding to the mortality, from a standard dosage mortality line of this material against mosquito larvae.

Eye gnat bio-assay tests for evaluating the coated DDT granules were carried on in the laboratory in the same manner as described earlier (Mulla 1960a). The DDT granular formulations and the sprays were each applied to three 1-gallon quantities of soil. One set of treatments was evaluated immediately. The other two sets were stored for one- and three-month periods at 88° ± 2° F. and were tested at this same temperature. Prior to storage, 800 ml. of water were added to each gallon of soil to keep it moist. Prior to testing, the soil was air-dried, mixed with organic matter, and processed for eye gnat bio-assay. Each soil quantity was divided into 10 portions, each of which was placed in a pint jar. Thus each treatment was replicated 10 times. The soil in each pint jar was seeded with 200 eggs of *H. collusor* and the eye gnat emergence was recorded.

RESULTS AND DISCUSSION. *Release and Concentration Relationship of Parathion.*—In order to investigate the effect of parathion concentration on its release from the granular formulations, three tests were conducted. In the first test, 1, 2, 5, and 10 percent impregnated granular formulations of parathion were prepared on 30/60 AA-LVM attapulgite granules, using Velsicol AR-60 and Chevron Light Solvent for impregnation. The formulations prepared with AR-60 solvent were aged for two weeks and evaluated at 0.02 p.p.m. in the cups; those prepared with Chevron Light Solvent were two days old and were evaluated at 0.0125 p.p.m. in the cups.

The release-concentration relationship of parathion is not a simple one. Different solvents, carriers, grades of carriers, and other factors are believed to influence this relationship. To determine the influence of solvents on the behavior of various concentrations of parathion in granules, two solvents, one a low volatile (AR-60) and the other a highly volatile solvent (Chevron Light Solvent) were selected. For the AR-60 formulations, a direct relationship between the concentration and the release of parathion was observed (Fig. 1). The 5 percent formulation was markedly lower than that from the 1 and 2 percent formulations. The release from the 10 percent formulation was markedly lower than the releases obtained from the other formulations prepared with Chevron Light Solvent.

In mosquito control, practical concentrations of parathion in granular formulations are considered to be either 1 or 2 percent. Formulations containing higher concentrations are liable to result in incomplete coverage and poor distribution of the gran-

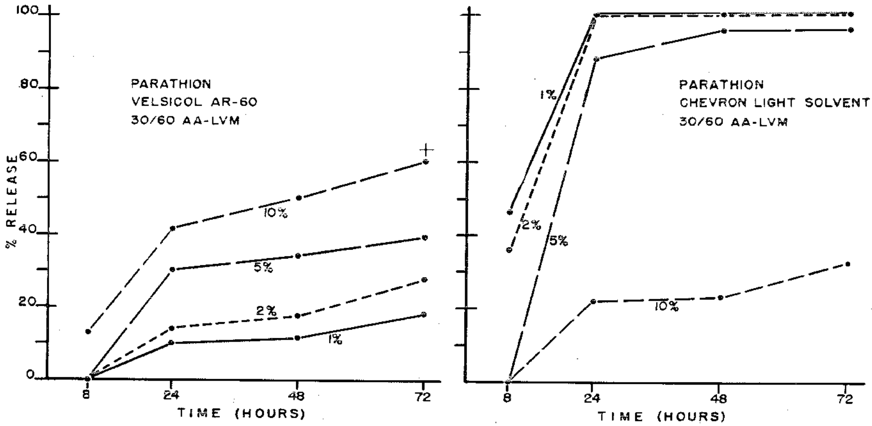

FIG. 1.—Release of parathion into water as related to its concentration in impregnated granular formulations. Attapulgite granules were impregnated with parathion solutions using two solvents. The AR-60 formulations were tested at 0.02 p.p.m. and the Chevron Light Solvent formulations were tested at 0.0125 p.p.m. in the cups.

magnitude of release was the greatest for the 10 percent formulation and the lowest for the 1 percent formulation.

Formulations prepared with Chevron Light Solvent indicated an inverse relationship between the concentration and the release of parathion (see Fig. 1). Increasing the concentration of parathion in the formulation resulted in decreased release of the toxicant into the water. The overall patterns of release from the 1, 2, and 5 percent formulations were similar except at the 8-hour interval. At the 8-hour interval the release of parathion from the

ules. Lower concentrations, though desirable for good coverage and uniform distribution of the particles, are expensive to use.

Size of granular particles was found to influence the release of parathion from 0.5 and 1 percent granular formulations (Fig. 2). The 0.5 and 1 percent formulations prepared with Chevron Light Solvent on 30/60 A-LVM attapulgite granules gave essentially the same release of parathion. However, the same concentrations prepared on coarser grades of attapulgite granules (20/40 and 16/30 meshes) yielded different results. Releases from the 0.5 percent formulations on both the 20/40 and 16/30 meshes were greater than releases from the 1 percent formulations on the same sizes. It can be said that, within limits, the concentration of parathion is not of as much consequence on finer-mesh attapulgite granules as on coarser-mesh attapulgite granules.

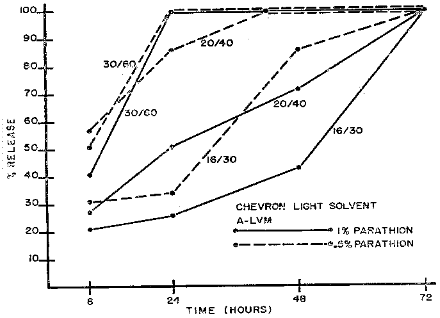

Fig. 2.—Release of parathion into water as related to its concentration using three grades of impregnated granular formulations. The parathion solution was impregnated on A-LVM attapulgite granules and tested at 0.01 p.p.m. in the cups.

The concentration-release relationship of coated parathion granules was also studied. One, 2 and 5 percent formulations were evaluated at 2 p.p.m. concentration in the jars and 0.01 p.p.m. concentration in the cups (Fig. 3). The over-all magnitude of release from the 1 percent formulation was slightly greater than from the 2 and 5 percent formulations, even though at the 8-hour interval the release was less than that from the other formulations.

The differences in the magnitude of releases of these three coated granular formulations are not too great. The 1, 2, and 5 percent impregnated formulations prepared with Chevron Light Solvent also indicated a similar trend (see Fig. 1). Slight differences may be due to experimental variations. It is possible that higher concentration formulations (e.g., 10 percent) of the coated granules may result in marked reduced release of parathion as was observed for the impregnated granules (see Fig. 1).

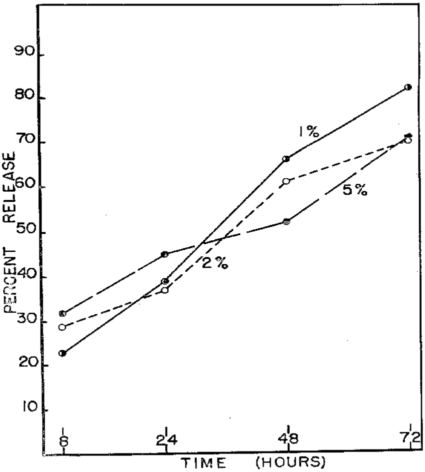

Fig. 3.—Release of parathion into water as related to its concentration in coated granular formulations. All the formulations were graded to be 20/28 mesh.

Rate of Application and Release of Parathion.—The percent release of parathion from granular formulations was believed to be influenced by the rate of application. To obtain experimental evidence on this phase of the work, attapulgite granules (30/60 AA-LVM) were impregnated with parathion using Chevron Light Solvent and AR-60 as solvents. The granules were added to water in the mayonnaise jars to yield theoretical concentrations of 0.5, 1.0, 2.0, and 5.0 p.p.m. of parathion. Aliquots of water were tested at 0.015 and 0.0125 p.p.m. in the cups for the Chevron Light Solvent formulation and at 0.04 p.p.m. in the cups for the AR-60 formulation.

The patterns of release for the Chevron Light Solvent formulation at the 0.5 and 1.0 p.p.m. rates tested at 0.015 and 0.0125 p.p.m. concentrations in the cups were essentially the same (Fig. 4). Although the release for the 0.5 and 1.0 p.p.m. rates calculated at the 0.015 p.p.m. concentration

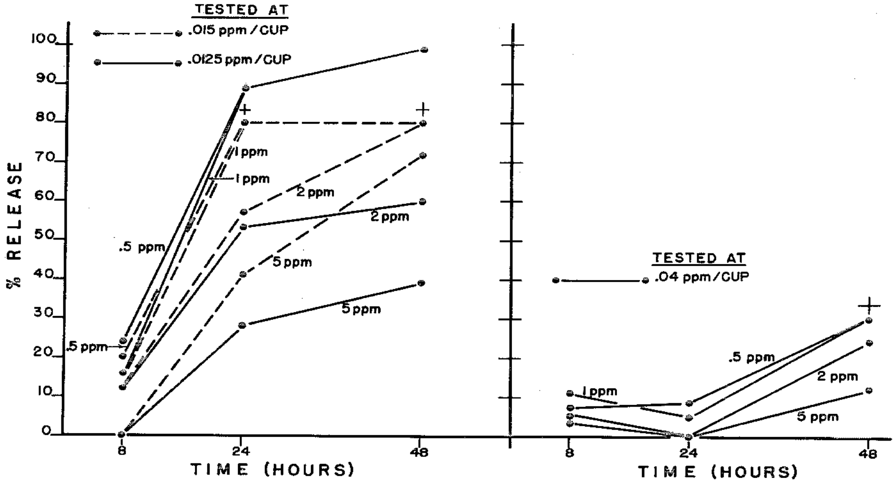

FIG. 4.—Release of parathion into water from its 2 percent impregnated attapulgite (30/60 AA-LVM) granular formulations, applied at various rates. Formulation on the left was prepared with Chevron Light Solvent and the one on the right was prepared with AR-60 solvent.

in the cup was lower than the release at the 0.0125 p.p.m. concentration, the plus sign (+) would place the release for the higher concentration in line with the lower concentration. The release for the 2.0 and 5.0 p.p.m. rates was found to be markedly different from the release for other rates at both the 0.015 and 0.0125 p.p.m. concentrations. The 0.015 p.p.m. concentration level in both the 2.0 and 5.0 p.p.m. rates yielded higher releases than the 0.0125 p.p.m. concentrations; this trend was expected.

Release from the AR-60 formulation was very low at all rates. An inverse relationship between the rate of application and the release of parathion is obvious. The 0.5 and 1.0 p.p.m. rates yielded similar results.

In practice the rate of application of parathion for effective mosquito control is less than 1.0 p.p.m. Therefore, a variation in the rate of application at this concentration or at a lower level may not be of great importance. However, the rate of application may be critical for some other granular insecticides that must be used at higher dosages in order to obtain efficient control of mosquitoes.

DDT Granules Against Eye Gnats.—DDT spray and 10 and 30 percent coated DDT granules were evaluated as soil treatments against the eye gnat *H. collusor* at the rate of 20 pounds actual DDT per acre. Both granular formulations resulted in poor reduction of the emerging eye gnats, initially as well as one month and three months after storage (Table 1). The spray treatments proved more effective at all three intervals.

The effectiveness of the 10 percent granular formulation increased on storage and was higher at all testing intervals than that of the 30 percent formulation. The latter formulation also increased in effectiveness three months after storage, but the over-all effectiveness was lower than that of the 10 percent formulation.

It has been realized that DDT granular formulations manifest increased activity in soil as time elapses. However, the lower effectiveness for the first 3 months, or for longer periods, discourages the use of these formulations for eye gnat control.

TABLE 1.—Effectiveness of spray and granular formulations of DDT applied to soil at the rate of 20 lbs. toxicant per acre against the eye gnat *H. collusor*

Treatment and formulation	Average no. gnats/jar and % reduction after (months)					
	0		1		3	
	Gnats/jar	% reduction	Gnats/jar	% reduction	Gnats/jar	% reduction
Emulsion conc.[1] (2 lbs./gal.)	2	98	1	99	27	78
10% coated [2] granules	83	16	72	36	80	33
30% coated [2] granules	85	13	101	10	89	25
Control	98	—	112	—	119	—

[1] The spray was applied at the rate of 100 gallons per acre.
[2] The granule size was 20/28 mesh. The granules were prepared by coating attapulgite wettable powder of DDT onto sand cores, using water-soluble glue.

It seems that there is a great need for the development of improved and fast-acting impregnated and coated DDT granular formulations to be used as soil treatments for the control of *Hippelates* eye gnats.

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