A PRACTICAL, LONG-LASTING EMULSION TYPE LARVICIDE

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From the start of mosquito control it has been the dream of mosquito control workers to find a long-lasting larvicide—one that would remain effective for weeks or months. I think we all now realize that this is a hope unlikely to be fully satisfied, primarily because the forces of nature will in one way or another defeat our purpose.

During the war, I first started experimenting with a method of making such a larvicide, and finally, about four years ago, with the encouragement of Mr. LeRoy Kinsey, Deputy Commissioner of Public Works, in charge of the Mosquito Control Division, the idea was further developed and the larvicide put into use. The basic principle, while not unknown, is one that seems to have been overlookd in compounding emulsion larvicide concentrates. We do not call attention to it as a 100 percent perfect larvicide, but as one that merits consideration. After experiencing the advantages and shortcomings of all types, we have found it to be the most satisfactory for general use.

The larvicide is in the form of a semi-stable emulsion, and because it can be compounded on the job, it is relatively inexpensive. Most DDT and other emulsion concentrates are heavier than water and break quickly. When diluted with water for spraying they settle and break in the spray tank, necessitating frequent agitation, and when applied to a breeding area, within an hour or so start to settle in the water, toward the bottom, where they become lost and ineffective amidst the debris and mud.

Emulsions are made up of oil globules floating submerged in water. Generally speaking, there are three factors that determine emulsion stability: (1) the suitability of the emulsifying agent; (2) the globule size, which is determined by the amount and type of emulsifier, and also by the amount of agitation; and (3) the specific gravity of the oil phase. It is this third factor that we utilize.

If the oil globules have the same specific gravity as the water, they will neither rise nor sink. Perfect specific gravity balance (S.G. 1.00) is difficult, and indeed we believe it advantageous to keep the oil phase slightly lighter than water, that is, about S.G. 0.990–0.995. This has several advantages: first, there is a tendency for the larvicide to remain nearer the surface; and second, in case it is made slightly too heavy, it will not so readily settle out. Before going into details about compounding this larvicide, let me say that it is not difficult, and well within the capability of any mosquito control agency, provided, of course, that a careful and reasonably intelligent man is assigned to the job. The only special equipment needed is a precision type hydrometer about 12" long having a specific gravity range from 0.94 to 1.000 (e.g., Will Corp. #16741), and a hydrometer jar. The use of the latter is advisable, especially at first, because otherwise, should you get your mixture too light, the hydrometer will sink to the bottom of the vat, and you will have a messy job recovering it. Two other hydrometers are also useful, one having the S.G. range from 0.850 to 1.000 (Will Corp. #16756) and the other with a range from 1.000 to 1.200 (Will Corp. #16761).

Regarding the actual mixing, let us assume that we wish to make a DDT emulsion concentrate. Three ingredients are needed:

1. A DDT concentrate (about 30 percent DDT in an aromatic petroleum solvent). It is necessary that the specific gravity of this material be greater than water. Most of them range from S.G. 1.04 to 1.12.
2. A suitable emulsifier.
3. #2 fuel oil.

The trick is to add fuel oil to a mixture of DDT concentrate and emulsifier

to bring down the specific gravity to the desired point. I have worked out and utilize mathematical formulas which give the necessary proportions, but actually they can be found easily by trial and error, preferably on a small scale at first until some idea of the proper proportions is reached. In Table 1 are listed the approximate

TABLE 1.—Example of approximate proportion of components of larvicide emulsion concentrates.

30% DDT concentrate, S.G.	1.040	1.080	1.12
	Gal.	Gal.	Gal.
30% DDT concentrate	28.0	23.5	20.0
#2 Fuel oil (S.G. .0852)	10.5	15.0	18.5
Triton X 171	1.5	1.5	1.5
	40.0	40.0	40.0
Approx. percent DDT by weight	22%	19%	17%

proportions for DDT solutions of various specific gravities as a starting point. As 40 gallons is a convenient amount to mix in a 55-gallon drum, the figures are for this amount. They can be reduced in proportion if you wish first to experiment in your laboratory.

After mixing to the above proportions and stirring well, take a hydrometer reading. If too high, add more fuel oil, if too low, more DDT concentrate. The actual amount must be learned by experience. It is best to add a little at a time, stirring and taking readings between each addition until the desired gravity is reached. If careful notes are kept they will form a basis for more rapid and accurate mixing of future batches. It should be realized however that the success of this larvicide depends on the close control of the specific gravity, therefore each batch should be checked and the gravity corrected if necessary. This is important for two reasons; human error and variations in different batches of ingredients. If the mixing is done at the prevailing outdoor temperature, and if the material is used within a reasonably short time, this will provide all the temperature correction that is necessary and practical.

It should be observed that this idea is equally applicable to other emulsifiable toxicants or toxicant solutions, also for controlling other types of aquatic animal or plant life.

While the stability of commercial emulsions can frequently be greatly improved by decreasing the gravity by this method, we have found it desirable to start with a DDT concentrate oil solution and adding our own emulsifying agent as we can thereby use the type and quantity we have found to be most suitable and economical. There are literally hundreds of different emulsifiers made for hundreds of different purposes. For this reason an emulsifier must be selected for the particular job it is to do. Emulsifiers that work well for us may not work as well with other water conditions. Emulsifiers that are satisfactory for a DDT aromatic petroleum solution may work quite poorly with other materials. Therefore, when seeking an emulsifier, one should seek the advice of reliable manufacturers, informing them exactly what materials are to be used, the nature of the water in which they will be used, and what is to be accomplished. Finally, when there is a choice of several different emulsifiers it is worthwhile to take the trouble to run small scale stability tests. As the Rohm and Haas Company have been especially active in the insecticide field, and most cooperative in providing information and samples, we have been using their products. During the past year we used their Triton X-171 for our general purpose larvicide, and a smaller quantity of X-161 for a special salt water emulsion. In their literature this company points out that where water hardness is encountered better results can frequently be obtained by using various combinations of their X-151, X-161 and X-171 emulsifiers. We use approximately 4 percent by weight, based on the estimated quantity of the finished product. It is added to the 30 percent concentrate first, then the fuel oil

is added to bring the mixture down to the desired specific gravity, as previously explained.

This material, when diluted 1 part to 9 parts water, makes a larvicide emulsion for spraying containing approximately 2 percent DDT by weight. It will remain in the spray truck tanks for several weeks without noticeable creaming or breaking, and when sprayed onto the breeding area, it becomes intimately mixed with the water. For this reason, when treating a large, deep, breeding pool, the total volume of water must be taken into account if a residual effect is desired. If valuable fish are present, extra care should be used.

As this article deals primarily with a specfic type of larvicide emulsion, rather than with the toxicant used, I will not go into details regarding the results obtained in Nassau County. It is sufficient to say that we still find DDT satisfactory, although resistance has undoubtedly developed in some locations. The highest resistance is found among the *Culex pipiens,* in some cases requiring as much as 3 to 4 parts of DDT to 1,000,000 parts water for a complete kill. During the past summer we used this larvicide in an old water-filled sand pit now being used as a town rubbish dump. Using approximately 1 part DDT to 1,500,000 parts water by weight, we obtained an average of three weeks control before larvae again appeared. Considering the probability of resistance, this was a relatively weak dose. Like most emulsions, it cannot be depended upon to kill pupae. In recent tests, high gamma BHC has shown a definite superiority over DDT.

Among other tests made was one using a heavy aromatic petroleum product to make an emulsion concentrate having a gravity of .99 without the addition of a toxic agent. The purpose was to find out if the oil emulsion alone would give a satisfactory kill. Even at concentrations as high as 1 part to 50,000 parts water, it did not do so.

I mentioned previously a special emulsion concentrate for use with salt water. This is supplied to our boat crews. When diluted 1 part to 9 parts bay or ocean water for spraying, it will remain stable for several hours or even days. When sprayed on brackish water, it tends to rise to the surface and break in a period of hours or days, depending upon the total amount of salts present. I have been watching this carefully and the boat crews all report satisfactory kills. As a residual effect cannot be expected on tidal marsh areas, the lack of long period stability is not serious.

One of the factors I mentioned which affects the stability of an emulsion is the amount of agitation with which the oil and water phases are mixed. For best results this factor must be taken into account. If they are just poured together a spontaneous emulsion will result, but the more they are agitated as they are mixed, the better the result will be. At least they should be paddled vigorously while they are being mixed and for a short time after, or better yet, direct a jet of water against the emulsion concentrate as it is being poured into the tank. The stream from the filling hose or spray pump can be used for this purpose.

We would be pleased to hear from any agency that utilizes the idea here presented; either to answer questions, or to learn of results.

SUMMARY. This article brings to the attention of mosquito control workers a tested, practical method of making an improved larvicide emulsion, which because of its greater stability has a considerably longer effective life than those now in general use. Sufficient details are given in order that it can be mixed and utilized satisfactorily by any mosquito control agency with commonly used equipment.