ARTICLES

TOXICITY OF ALLETHRIN TO MOSQUITOES, AS COMPARED WITH PYRETHRINS *

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The synthesis by Schechter, Green and LaForge (1949) of organic esters analogous to cinerin, one of the toxic constituents of pyrethrum, has opened a new lead toward the preparation of insecticides relatively non-toxic to higher mammals (Starr et al., 1950). Because of the present high cost of pyrethrum this achievement has aroused great interest among insecticide manufacturers and scientific investigators. One of these synthetic compounds is now manufactured commercially under the assigned name "allethrin."

Chemically, allethrin has been designated as dl-2-allyl-4-hydroxy-3-methyl-2-cyclopentene-1-one ester of dl-cistrans-chrysanthemum monocarboxylic acid (Schechter, et al., 1949). Commercial allethrin is about 92 per cent pure; high boiling, clear yellow liquid; sp. gr. 1.005, refractive index 1.504 at 20° C.; insoluble in water, but completely miscible with petroleum distillates (McNamee, 1950).

Federal and state agencies as well as commercial laboratories are now engaged in testing allethrin on different species of insects, in comparison with pyrethrins. Gersdorf (1949), reported this compound to be more toxic to houseflies than the natural pyrethrins. Stoddard and Dove (1949) indicated that allethrin is about equal to pyrethrins in toxicity to houseflies, but is considerably less effective on other insects, including German cockroach, confused flour beetle, and nine species of truck-crop insects. Piquett (1949) showed that allethrin is less effective on adult males of the American cockroach than is pyrethrins. By the addition of certain synergists at the ratio of 5 to 1, the effectiveness was increased to that of pyrethrins. Jones, Schroeder and Incho (1950) tested allethrin with and without synergists in comparison with pyrethrins on houseflies, German cockroaches, rice weevil, confused flour beetle, Mexican bean beetle and other insects. From their preliminary studies they concluded that though "the effectiveness of allethrin and pyrethrins with synergists varies with the synergist employed, and insect species; combinations of allethrin with synergists show a lower order of insecticidal effectiveness than similar combinations of pyrethrins with the same synergists." Nast (1950) summarized results from several laboratories with allethrin on houseflies and roaches. On flies, allethrin was almost, but not quite, as effective as pyrethrins. On roaches "it seems safe to conclude that from two to four times as much allethrin as pyrethrins is required to obtain the same kill." On the other hand, residual tests, conducted on glass panels treated with acetone solutions of the toxicants and exposed to houseflies 8 days later, indicate that the residue from allethrin is superior to that of pyrethrins.

The writer became interested in investigating the toxic properties of allethrin to mosquitoes, as a possible substitute for pyrethrins in the New Jersey Mosquito Larvicide, which is essentially a kerosene pyrethrin emulsion (Ginsburg, 1930, 1939). Accordingly, laboratory tests were conducted with allethrin, in comparison with pyrethrins, as colloidal dispersions and oil-emulsions on larvae, pupae and emerg-

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ing adults of *Aedes aegypti*. Allethrin was also tested in combintaion with several synergists.

Material and Methods

A commercial sample of allethrin, about 92 per cent pure, and a concentrated extract of pyrethrum, containing 22.4 per cent actual pyrethrins, were employed in preparing the desired formulations.

Tests on larvae and pupae.—For the colloidal dispersions, 1 ml. of acetone containing various concentrations of the toxicants was stirred in 100 ml. distilled water in beakers containing either 50 third and fourth instar larvae or 25 pupae. The emulsified larvicides were prepared by incorporating various concentrations of either allethrin or pyrethrins in kerosene and emulsifying the solutions with sodium lauryl sulfate. The concentrated emulsions contained 66 per cent kerosene and desired amounts of toxicants; 33.5 per cent water and 0.5 per cent emulsifier. Before testing, the concentrated larvicide was thoroughly mixed, diluted with nine parts of water and applied at the rate of 25 gallons per acre (2.5 gal. concentrate). The tests with the emulsion were carried out in porcelain dishes containing 500 ml. of water and larvae or pupae. The area of the water surface in the dish was approximately 0.27 sq. feet. The tests were run for 24 hours, in three or four replicates. During this period some larvae had pupated, and the live pupae were included with the surviving larvae. Likewise, emerging adults in the pupae tests were counted with the live pupae.

To ascertain whether some of the known synergists may enhance the toxicity of allethrin to larvae, the following three compounds, which had been reported to synergize pyrethrins on flies and other insects, were selected:

1. Piperonyl butoxide (3,4-Methylenedioxy benzyl-butyl diethyleneglycol ether)
2. N-Propyl Isome (di N-propyl maleate iso-safrol condensate)
3. Sulfox-cide (n-Octyl sulfoxide isosafrole)

The synergists were incorporated in the kerosene before emulsification at the ratio of 5:1, that is, for each part of allethrin, five parts of synergist were added. Two concentrations of allethrin, 0.033 per cent and 0.0165 per cent, which when tested without synergists gave less than 100 per cent larvae mortality, were used.

Emerging mosquito adults.—It had been observed by the writer in previous laboratory and field experiments that mosquito adults emerging in waters sprayed with low dosages of pyrethrum larvicide, even sublethal to larvae and pupae, become affected to the extent that they could not fly away, resulting in a high percentage of mortality. It became of interest to ascertain whether allethrin functions in the same manner. Comparative tests of pyrethrins and allethrin were, therefore, made under identical laboratory conditions. Concentrations of toxicants, ranging from 0.1 down to 0.0125 p.p.m. were colloidally dispersed in beakers of water containing pupae. Observations on the emerging adults were made over a period of 40 hours after treatment.

Results

The average results are presented in four tables. The data in Table 1, from colloidal solutions, indicate that allethrin

Table 1. Comparative Toxicity of Allethrin and Pyrethrins in Colloidal Solutions to Mosquito Larvae

Toxicant Tested	*Dilutions in p.p.m. for Mortalities of* 50%		100%	
	Larvae	*Pupae*	*Larvae*	*Pupae*
Pyrethrins	0.033	0.05	0.10	0.125
Allethrin	0.083	0.20	0.25	0.50

is decidedly less toxic than pyrethrins to larvae and pupae. Based on the LD-50, pyrethrins appear to be 2.5 and 4 times as toxic as allethrin to larvae and pupae respectively.

Analogous results were also obtained with the oil-emulsion larvicide. The percentage of allethrin in the concentrated larvicide required to give 100 per cent dead larvae was 0.134, or twice the amount of pyrethrins (Table 2). However, the effect of allethrin on mosquito adults emerging from pupae in waters receiving sublethal doses of the toxicants (Table 3) seems to be only slightly lower than that of pyrethrins. In concentrations of 0.0125 p.p.m., both insecticides were virtually non-toxic to pupae, but the percentage of dead adults was 87 per cent for pyrethrins and 70 per cent for allethrin.

Table 2. Comparative Toxicity of Allethrin and Pyrethrins in Oil Emulsions to Mosquito Larvae

% toxicant in concentrated emulsion		*Average % mortality in 24 hours*
Pyrethrins	*Allethrin*	
0.0335	—	98
0.0670	—	100
—	0.0335	75
—	0.0670	97
—	0.1340	100

Table 3. Mortalities of Adult Mosquitoes Emerging from Pupae, Subjected to Sublethal Dosages of Pyrethrins or Allethrin

Series No.	*Toxicant p.p.m.*		*% Dead Pupae*	*Adult Mosquitoes*	
	Pyrethrins	*Allethrin*		*No. Emerged*	*% Dead*
20	0.05	—	56	4	100
40	0.025	—	18	28	100
80	0.0125	—	6	44	87
10	—	0.10	0	50	100
20	—	0.05	0	42	90
40	—	0.025	5	48	82
80	—	0.0125	5	40	70
Check	—	—	4	48	8

None of the three synergists incorporated in the larvicides showed any significant increases in the toxicity of allethrin to larvae (Table 4). At concentrations of 0.0165 per cent of allethrin, the mortalities were 67 per cent without synergist, 63 per cent with piperonyl butoxide, 76 per cent with n-propyl isome and 65 per cent with sulfox-cide. With twice the above concentration of allethrin (.033 per cent), some increases in mortality of larvae in the presence of the synergists were observed, but in no case was 100 per cent kill obtained. The results indicate that the toxicity of allethrin to *Aedes aegypti* larvae was not materially increased by the addition of any one of the three synergists here tested in 5:1 ratios.

Table 4. Toxicity of Allethrin in Oil Emulsions Containing Various Synergists to Mosquito Larvae

% Allethrin in the concentrate emulsion	*Synergist added (5:1)*	*Average % Mortality in 24 hours*
0.033	none	75
0.0165	none	67
.033	pip.-butoxide	87
.0165	pip.-butoxide	63
.033	n-propyl isome	93
.0165	n-propyl isome	76
.033	sulfox-cide	95
.0165	sulfox-cide	65

In general, the results show that although allethrin possesses high toxicity to *Aedes aegypti* it is decidedly less effective than pyrethrins.

Summary and Conclusions

Laboratory tests were conducted with allethrin in comparison with pyrethrins in form of colloidal water solutions and oil emulsions on *Aedes aegypti* larvae, pupae and emerging adults. A study was also made of the effect of the three synergists piperonyl butoxide, n-propyl isome and sulfox-cide on increasing the toxicity of allethrin to mosquito larvae. The results brought out the following information:

1. Allethrin possesses high toxicity to mosquitoes, but is less toxic than pyrethrins. Measured in p.p.m., the LD-50 on mosquito larvae was .033 for pyrethrins and .083 for allethrin.

2. In colloidal water solutions, pyre-

thrins were 2.5 and 4 times as toxic to larvae and pupae respectively as allethrin.

3. In oil emulsion-larvicides, applied on water surfaces, pyrethrins also exhibited higher toxicity to larvae than allethrin.

4. The addition of synergists did not materially increase the toxic properties of allethrin to mosquito larvae.

5. Allethrin was nearly as toxic as pyrethrins to mosquito adults emerging from pupae subjected to sublethal dosages of the toxicants.

6. As a substitution in the New Jersey Mosquito Larvicide, the amount of allethrin required to kill 100 per cent mosquito larvae is approximately twice that of pyrethrins.

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MOSQUITO CONTROL TECHNIQUES FOR CONTROL OF *HIPPELATES* SPP (Diptera: Chloropidae)

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During the spring of 1948, tests were conducted in the Coachella Valley of California in order to determine the effectiveness of presently used mosquito control measures in the control of *Hippelates* spp. These gnats, principally *Hippelates pusio* Loew, for many years have been a plague to the residents of the Valley. They have been implicated in the transmission of follicular conjunctivitis which is endemic in the area (Herms, 1939). This disease is particularly prevalent among pre-school and school-age children, although adults are sometimes victims of this malady.

In addition to the public health implication of the problem, the gnats are an economic liability because of their annoying habit of swarming about one's head, particularly the eyes and ears. As a result, much time is lost by agricultural workers, processors of fruits and vegetables, and others accessible to the gnats. In the area, a winter resort section, tourist trade has been discouraged by the swarms of these gnats and real estate values have suffered as a consequence. The predominant agricultural products are dates, grapes, grapefruit, and truck crops.