

## TESTS ON SUSCEPTIBILITY OF *CULEX GELIDUS* THEOBALD TO DDT, DIELDRIN AND BHC IN THAILAND

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**INTRODUCTION.** Relatively little information is available on the status of susceptibility of mosquitoes to insecticides in Thailand. *Culex gelidus* Theobald, a widely distributed species in that country, feeds readily on man and animals and has been implicated in the transmission of Japanese B encephalitis virus in Thailand (Rohitayodhin *et al.*, 1967, personal communication) and Malaysia (Gould *et al.*, 1962). However, the only available reports on its susceptibility to DDT and/or dieldrin are those from India (Pal, 1958) and from Malaysia (Wharton, 1955 and Thomas, 1962) where this species was found to be highly susceptible.

This paper presents the results of tests made in Thailand from 1965 to 1967 on the susceptibility of this species to DDT, BHC and dieldrin. It also reports the first known record of the development of resistance in *C. gelidus* to DDT and dieldrin.

**MATERIALS AND METHODS.** Mosquitoes tested included both adults and larvae obtained from the experimental farm of Kasetsart University in the Bang Khen District of Bangkok and adults only from Bang Phra, Chon Buri Province. Dwellings in the latter province have been sprayed with DDT for several years under the malaria eradication program. At the Kasetsart experimental farm several insecticides, including parathion, various chlorinated hydrocarbons and paris green, have been in frequent use in experimental trials. All adults, except for those tested in March 1967, were captured while biting cattle, and only those which had com-

pleted engorgement were tested. Adults tested during March 1967 were reared from wild collected larvae; these mosquitoes were fed on 5 percent sucrose solution and were tested when 4-5 days old. Adults from the Kasetsart farm were tested for susceptibility to DDT and dieldrin while those collected at Bang Phra were tested against DDT only. Late third and/or early fourth stage larvae were tested against DDT, BHC and dieldrin.

The standard WHO adult and larval tests (WHO, 1963) were used throughout. Observed mortalities of mosquitoes obtained in the various tests were corrected for control mortality using Abbott's Formula. The method of Litchfield and Wilcoxon (1949) was followed for the calculation of the limits of confidence of the LC<sub>50</sub>.

When it was necessary to use the "time in concentration" technique (French and Kitzmiller, 1963) to demonstrate low levels of resistance, late fourth stage larvae were exposed to discriminating dosages of 8 ppm of dieldrin and 2.5 ppm of DDT. Mortality counts were made every 15 minutes after the larvae were placed in the test solutions. The percentage mortality versus time was plotted on log probit paper.

**RESULTS AND DISCUSSION.** Susceptibility tests indicated that the population of *Culex gelidus* adults at Bang Khen was intermediate in resistance to DDT and resistant to dieldrin while the Bang Phra population was susceptible to DDT. In the initial test 13 percent of the adults from Bang Khen survived exposures to the highest concentration (4 percent) of the toxicant (Table 1), and in the follow-up test a slightly higher percentage of survivors was observed. Later tests with

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TABLE 1.—Results of DDT<sup>a</sup> susceptibility tests on adult *Culex gelidus* from Bang Khen and Bang Phra (1966-1967).

Test No.	Date	Percent mortality at each concentration					Percent control mortality	LC <sub>50</sub>	95% confidence limits of LC <sub>50</sub>	LC <sub>90</sub>	Slope
		0.25%	0.5%	1%	2%	4%					
<i>Bang Khen</i>											
1	30 Mar.- 5 Apr. 66	15(104)	27(105)	29(105)	61(105)	87(105)	5(105)*	1.23%	1.03-1.46	6.75%	1.73
2	28 Apr.- 4 May 66	7(70)	23(70)	42(70)	36(70)	84(70)	0(70)	1.59%	1.29-1.96	8.41%	1.77
3	10-12 May 66	8(61)	17(60)	32(60)	50(59)	86(60)	2(60)	1.49%	1.19-1.87	6.61%	1.98
4	27 May 66	6(79)	21(77)	27(80)	57(80)	96(75)	1(79)	1.19%	1.003-1.41	3.81%	2.54
5	Mar. 67	3(139)	6(140)	23(139)	69(136)	94(137)	4(138)	1.40%	1.22-1.60	3.81%	2.96
<i>Bang Phra</i>											
6	Feb. 67	7(80)	35(80)	79(80)	81(80)	100(80)	14(80)	0.66%	0.58-0.75	1.41%	3.89

<sup>a</sup> Figures shown in parentheses represent the number of adults tested at each concentration.

*C. gelidus* from Bang Khen continued to show the presence of resistant individuals (Table 1). The slight changes observed in the positions of the dosage-mortality lines (ld-p lines) for the Bang Khen tests (Fig. 1) may have been due to variations in one or more of the following factors—temperature, humidity, insecticide or vigor tolerance of test mosquitoes.

The  $LC_{50}$  of DDT observed for adult *C. gelidus* tested from Bang Phra was approximately half the values observed for Bang Khen adults and that reported for *C. gelidus* in India by Pal (1958). The  $LC_{90}$  values obtained for Bang Khen adults were from two to six times higher than for Bang Phra adults (Table 1). In addition, the slope of the ld-p line (Fig.

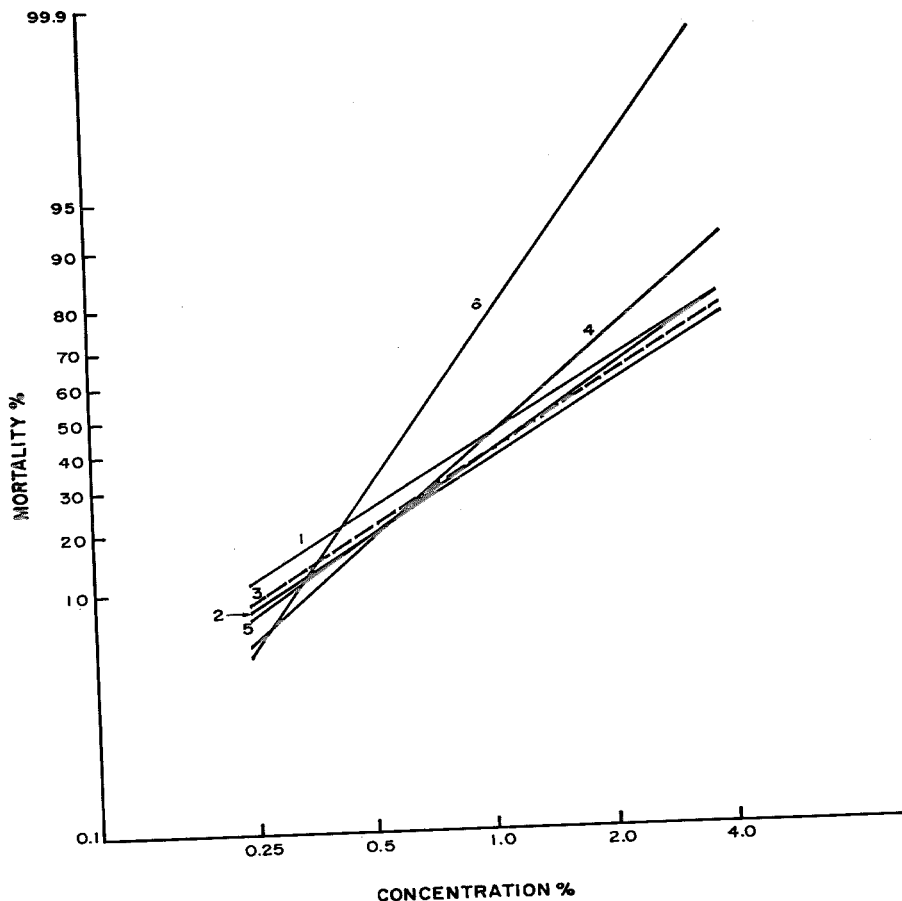


FIG. 1.—Dosage-mortality regression lines of DDT against adult *Culex gelidus* from Bang Khen and Bang Phra.

TABLE 2.—Results of dieldrin susceptibility tests of adult *Culex gelidus* from Bang Khen District, Bangkok—March, 1967.

Exposure time	Percent mortality at each concentration							Percent control mortality
	4%	1.6%	0.8%	0.4%	0.2%	0.1%	0.05%	
1 hour	32(91)*	19(92)	17(92)	5(97)	0(85)	0(96)	0(98)	1(97)
2 hours	53(20)	10(21)	.....	.....	.....	.....	.....	5(20)

\* Figures shown in parentheses represent the number of adults tested.

1, #6) was significantly steeper for the Bang Phra adults than for those derived for the Bang Khen samples.

Approximately 68 percent of the adults from Bang Khen survived a 1-hour exposure to 4 percent dieldrin, and when exposed to the same concentration for a 2-hour period, 47 percent of those tested survived through the 24-hour period following exposure (Table 2).

It is interesting to note that while resistant adults were found at Bang Khen, larvae collected from that site were still susceptible to DDT. The  $LC_{50}$  was 0.0089 ppm of DDT in November, 1965 (Fig. 2, 1) and 0.0085 ppm of DDT when tested later in March 1967 (Fig. 2, 2). These values were less than those (0.012 to 0.018 ppm) reported from Malaysia by Thomas (1962) who tested larvae from

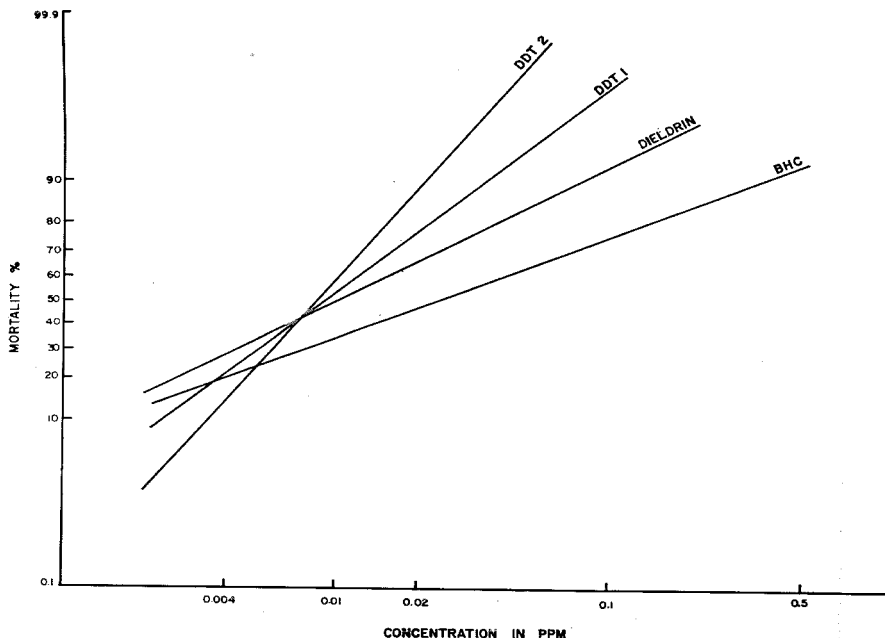


FIG. 2.—Dosage-mortality regression lines of some chlorinated hydrocarbons against larvae of *Culex gelidus* from Bang Khen District, Bangkok.

several generations of this species. Larvae were also found susceptible to both dieldrin and BHC during 1965 with  $LC_{50}$  values of 0.010 and 0.24 ppm respectively. The dosage-mortality regression lines in Figure 2 show a slightly greater larval tolerance to dieldrin and BHC than to DDT.

The absence of resistance among larvae and its appearance among adults from the same locality suggested the further testing of these larvae by the "time in concentration" technique. The reliability of the WHO test for resistance in larval populations, especially where resistance is not pronounced, has been open to criticism, and the "time in concentration" technique has been substituted in these studies for detection of resistance in larvae.

In the dieldrin tests the regression lines of samples A and B reflected a similar genetic constitution (Fig. 3). The pronounced inflections of the regression lines clearly indicated the presence of two phenotypes. Each regression line showed a plateau distinguishing the susceptible from the resistant larvae. In this test approximately 72 percent of the larvae were susceptible and 28 percent were resistant to dieldrin.

The regression line constructed for the DDT test also showed a less pronounced but definite inflection indicating the presence of two phenotypes. While 98 percent of the larvae appeared to be susceptible, the presence of resistant larvae, though in small numbers, was indicated.

The development of physiological re-

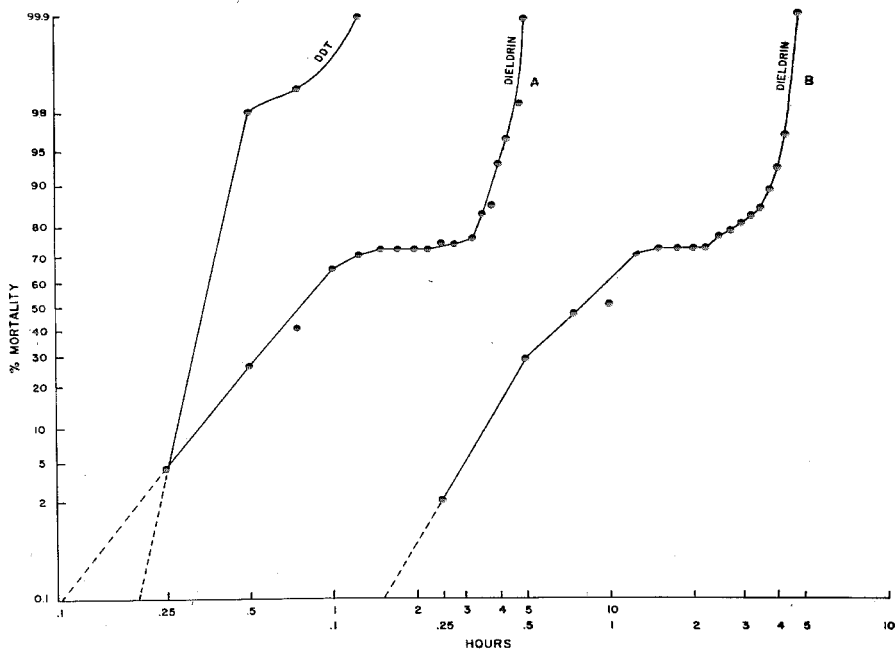


FIG. 3.—Mortality regression lines of DDT and dieldrin when tested against *Culex gelidus* larvae by the "Time In Concentration" technique.

sistance in *Culex gelidus* at Bang Khen is possibly the result of the selection pressures imposed on the population through the extensive use of insecticides in that area.

**SUMMARY.** The susceptibility of *Culex gelidus* from two areas of Thailand to DDT, BHC and dieldrin was tested. Results showed that larvae from Bang Khen near Bangkok were susceptible to DDT, BHC, and dieldrin while the adult population in the same locality was intermediate in resistance to DDT and resistant to dieldrin. By means of the "time in concentration" technique susceptible and resistant phenotypes were recognized for both insecticides in the Bang Khen population. The development of this physiological resistance is attributed to the extensive use of insecticides in the area. Adults tested from Bang Phra in Chon Buri Province were still susceptible to DDT (the only insecticide tested).

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## BIOLOGICAL STUDIES OF TABANIDAE: A PRELIMINARY STUDY OF FEMALE TABANIDS ATTRACTED TO A BAIT ANIMAL<sup>1, 2</sup>

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The propensity of female tabanids to obtain food from cattle is well known. However, observations made during collection of engorged tabanids from a bait animal (Roberts, 1966) indicated that avidity differed between species and that environmental factors such as tempera-

ture, relative humidity, and light intensity influenced activity. A preliminary study was therefore made to obtain data on which an experiment to determine the relationship between fly activity and environmental factors could be based. This paper presents the results of that preliminary study.

**MATERIALS AND METHODS.** A 7-year-old Hereford steer was tethered to one of the few trees in a 20-acre pasture and used as bait. Other cattle were present but did not come near the study area.

Two types of collections were made. A landing collection in which all tabanids that came to the bait animal were collected

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