# USE OF A MATHEMATICAL MODEL TO PREDICT LEVELS OF ADULT *CULEX PIPIENS* IN ALAMEDA COUNTY

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INTRODUCTION.–*Culex pipiens* is one of the important species of pest mosquitoes in Alameda County. The primary source of this species during the summer and early fall is the catch basin and storm drain systems. Because of the high costs associated with physical correction of the sources, the District, until recently, relied heavily upon routine chemical applications to provide control (Dill and Roberts 1975). Organophosphate resistance was detected in *Culex pipiens* in 1974. To reduce insecticide pressure, only selected catch basins and storm drains were treated with oil (GB1313) in the years 1975 through 1978.

TOLERANCE THRESHOLD.–It was expected that the levels of *Culex pipiens* would increase above that of the years prior to the selective treatment program. A "tolerance threshold" was established to be used as a treatment guideline. The tolerance threshold was based upon numbers of service requests by the public. The acceptable level of service requests for any given month was the number of requests that could be properly processed by District staff. The selective treatment program would be conducted as planned unless the mosquitoes reached a level above the established "tolerance threshold" at which time emergency chemical control would be applied to bring about the desired level of control.

The problems with such a program are obvious. One would not know if the tolerance threshold is exceeded until the technicians have more service requests to process than they can complete. These requests would have to be ignored to implement the required emergency control, resulting in poor public relations. Finally, the emergency treatment of catch basin and storm drain systems would not immediately reduce the high levels of adult mosquitoes. Ideally, what would be needed to make the program operate effectively would be an early warning system that would forecast levels of *Culex pipiens* and predict if and when they would approach the tolerance threshold.

MESSAGE OF PROPOSITION 13.–With the passage of Proposition 13, the District's revenue was cut back by 63% in the fiscal year 1978/79. Program decisions were made to emphasize physical and biological methods to control the important mosquito species. In the case of *Culex pipiens*, treatment of all catch basins and storm drains was curtailed until and unless they were determined to actually be the cause of service requests. Due to the relatively low levels of service requests that occurred in the summer and fall of 1978, chemical treatments dropped far below previous years and the levels of adult *Culex pipiens* rose dramatically as evidenced by light trap data. By the end of September, the population of *Culex pipiens* reached levels greater than twice as high as the previous year, and the population curve had followed a classical pattern of exponential growth during the months of June through September (Figure 1).

PREDICTIVE MODEL.–The population curve that was exhibited by the uncontrolled population of *Culex pipiens*, being obviously exponential in nature, strongly suggested that a well known demographic equation might assist in predicting future levels of the population (Clark, Geier, Hughes and Morris 1967). The equation is as follows:

$$N_t = N_o e^{k_t}$$

t = times in months

$N_t$ = the numbers of adult *Culex pipiens* after time t (adults/trap night)

$N_o$ = the numbers of adult *Culex pipiens* at the beginning

k = constant for growth rate (birth rate - death rate)

e = the base of the natural logarithms.

By making the following assumptions, the equation may be used to assist in predicting levels of adult *Culex pipiens*:

1) The light trap samples adequately represent the relative densities of adult *Culex pipiens*.
2) The reproductive rate and movements of the population are relatively consistent from year-to-year.
3) Natural mortality factors remain essentially the same each year.
4) The carrying capacity of the storm drains and catch basins is not exceeded.
5) The greatest preponderance of the population of *Culex pipiens* produced June through October is produced from catch basin and storm drain systems.

UTILITY OF THE EQUATION.–By solving for K during each of the months from June through September 1978 a rate of growth can be established for each month. When a light trap index for *Culex pipiens* is determined in June of 1979, these K values can be used in the formula to predict the approximate levels of the species in the months of July, August and September. If predicted levels exceed acceptable levels (the tolerance threshold) a preventive chemical treatment can be made in advance of high adult emergence. In order to predict whether the forecasted light trap levels exceed the tolerance threshold, correlations between light trap and service request data must be established. The treatment decision, of course, should be made in light of other information such as larval collection data.

The simplicity of the equation, and the advent of relatively inexpensive scientific calculators and micro-computers, makes the manipulation of the equation quite simple. For illustrative purposes, a program has been developed for use in the TRS-80 micro-computer system with video display. The program represents predicted monthly levels of adult *Culex pipiens* by bar graphs and graphically depicts whether or not the predicted levels exceed an established tolerance threshold.

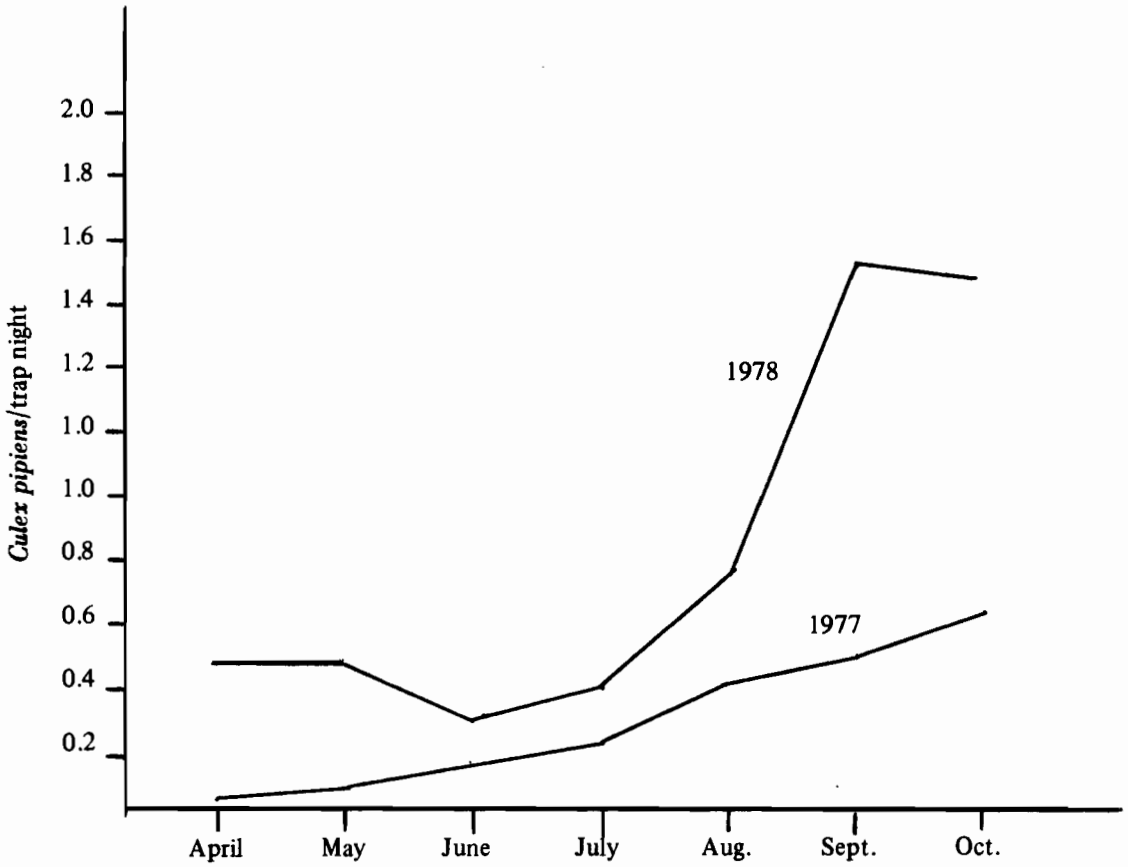


Figure 1.– Light trap data indicating levels of adult *Culex pipiens* in Alameda County Mosquito Abatement District.

The reliability of the equation in this application has not yet been tested. Continued efforts will be made to correlate larval collection data, service requests and light trap data. It is hoped that a similar predictive model can be established with larval data to further aid in making treatment decisions.

SUMMARY AND CONCLUSIONS.–A critical need exists in the Alameda County Mosquito Abatement District to reduce chemical treatments of *Culex pipiens*. The need stems from severe financial constraints and organophosphate resistance. Recent cutbacks in the treatment program have enabled the District to determine the natural growth rates of *Culex pipiens* produced in storm drains and catch basins. A simple mathematical equation will be used to predict levels of adult *Culex pipiens* to aid in treatment decisions. The reliability and utility of the model will be further tested.

REFERENCES CITED

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