PREDICTING INFLUXES OF *AEDES VEXANS* INTO URBAN AREAS

JOHN L. CLARKE, JR.[1] AND F. C. WRAY[2]

One of the major sources of annoyance in midwest mosquito control programs has been the migration of broods of floodwater mosquitoes into urban areas.

These broods disrupt small town programs and penetrate deep into mosquito abatement districts, often overriding their excellent source reduction programs. Experience has shown that once one of these broods arrives, the mosquito population stabilizes and then the annoyance slowly diminishes over a 2- to 3-week period. The role of the adult control measures has been, in both districts and towns, to destroy the adult mosquitoes as soon as possible after the population has stabilized.

Judging when the population has stabilized has often been on a hit or miss basis. This has resulted in treating too soon and having mosquitoes back by the next night or waiting too long and permitting extra days of annoyance at peak intensity.

To determine the proper night to begin fogging, some districts rely on complaints, which lag behind annoyance by as much as 2 to 3 days, or they rely on light traps which are run once or twice per week. These methods often entail a 3- to 6-day lag in controlling adult mosquito annoyance.

This time-lag may seem insignificant, but with six to nine recognizable broods developing each summer even a 3-day lag per brood could allow annoyance for 27 days of the normal 100 day season.

The Des Plaines Valley Mosquito Abatement District, over a period of years, had collected temperature, humidity, wind and rainfall records that indicated mosquito annoyance would appear approximately 15 days after a flooding rain of one inch or more in a 24-hour period.

The district had also found that when fogging operations began the night after a migration had caused a sharp increase in their New Jersey Light Traps, good results would be obtained.

In hopes of using these migration peaks in giving better control we set two goals.

1. Confirm what a migration peak looked like from mosquito light-trap catches.
2. Provide a method of predicting as far in advance as possible, using readily available weather data, the exact night of the migration peak so that adult mosquito control operations could begin at the earliest effective moment.

As a start, we had to determine first what constituted a migration and how to recognize it from light-trap records. Fortunately the South Cook County Mosquito Abatement District had excellent night-by-night light-trap counts of female *Aedes vexans* for a 3-year period. We found in these data 21 light-trap peaks that could be equated with a definite rain.

We averaged these peaks and Figure 1 shows the readily recognizable 3-night sequence of a migration peak. Taking the night of the peak as 100 percent, the preceding night's catch would be about 49 percent. The night's catch following the peak would be about 36 percent. The light-trap sequence of the migration in a sense could be likened to a ripple moving from a stone dropped in the center of a pond. The light-trap, being stationary, records the migration as a wave form pattern passing over it. The third night's catch seems to be the residue—the stable population, that is left for us to contend with.

In later studies, where we kept records of both male and female *vexans,* there was an interesting ratio of males to females for the 3-night sequence:

[1] Manager, Clarke Outdoor Spraying Co., La Grange, Illinois.

[2] Director, Des Plaines Valley Mosquito Abatement District, Lyons, Illinois. Now deceased.

First night	21% Males	79% Females
Second Night	19% Males	81% Females
Third Night	28% Males	72% Females

Thus, if one is looking for a migration peak, a constant ratio of males to females, two nights in a row with a sharp increase

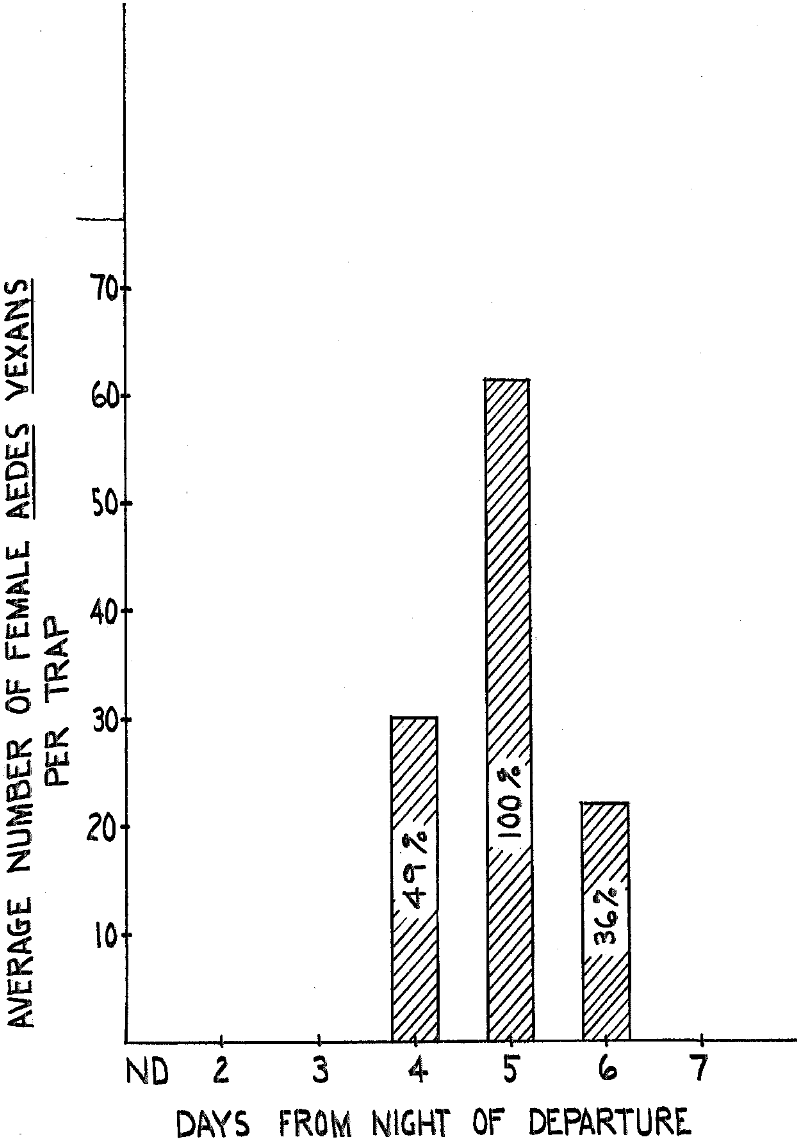

FIG. 1.—Light trap sequence of female *Aedes vexans* catches during 24 migrations.

in total population the second night, would indicate that the migration peak had been reached.

Observations made during a flight study in 1941 and subsequent field observations indicated that after the mosquitoes emerge as adults there is a 3- to 4-day period before they begin showing up in light-traps and biting.

These observations indicated that a further extension of recognizable behavior could be made from the peak in the light-trap back to the point of emergence as adults.

Figure 2 shows what we believed to be the normal sequence of events from the point of emergence. First we moved four days back from the peak in the light-traps to the night the migration began, then we moved back an additional 18 hours to a theoretical emergence point. The emergence point was deduced from work on *Aedes taeniorhynchus* (Nielsen, 1958) which showed that the males had to be a minimum of 14 hours old before they migrated at dusk.

Now, having worked out a tentative adult behavior sequence, we had to return to the other end of the problem and determine just what conditions had to be to hatch a recognizable brood. We found that 4/10 of an inch of rain within a 24-hour period would produce a small brood that could exceed the arbitrary 20 female *vexans* per night annoyance level. The only restriction was that the temperature had to be above 60° F. during the rainfall or rise to 60° F. immediately after the rainfall.

During early spring, in April and May, the temperature would often shoot up to 60°–70° F. for a few hours during or after a heavy rain, sufficient to produce a new hatch. Then after the hatch, the temperature would often drop into the thirties without seeming to harm the larvae. They apparently remained in a dormant condition.

The third step was to determine length of time required for the intermediate or aquatic stage to develop. Experiments in Florida (Nielsen and Evans, 1960) have shown that during the aquatic stage the growth rate of mosquito larvae and pupae respond to temperature. The higher the temperature the faster the larvae and pupae develop. The colder the temperature the slower they develop.

In order to find this relationship between growth and temperature, we took

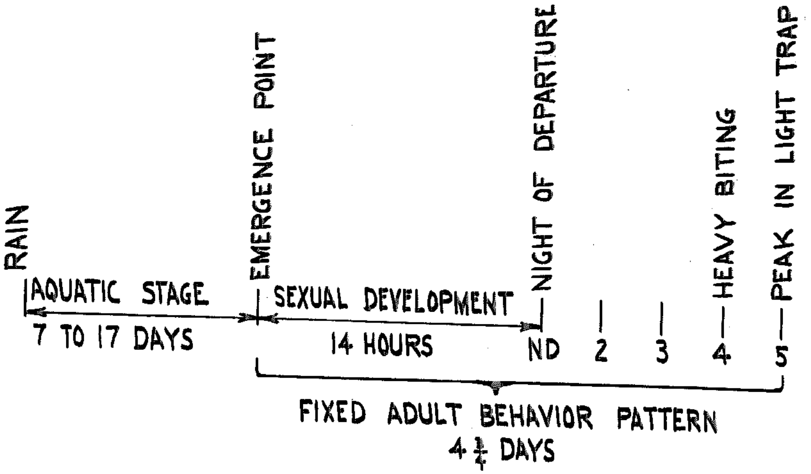

FIG. 2.—Sequence of development in an *Aedes vexans* brood.

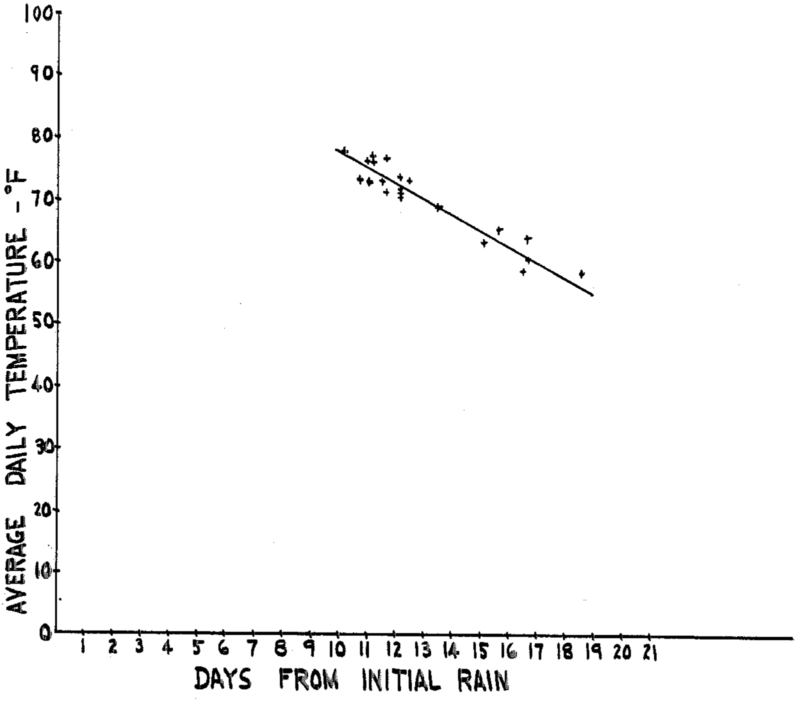

FIG. 3.—Average daily temperature vs. estimated emergence point 4¾ days before light trap peak.

the average daily temperature between the initiating rain and the theoretical emergence point and plotted this average temperature against the number of days between the two points.

As can be seen in Figure 3, the points seem to fall along a straight line. This line shows a definite relationship between the temperature and the rate of development of the aquatic stages. Notice how this close relationship held with a variation of less than plus or minus ½ day until the 14th day.

If development took longer than 14 days, the points began to stray and the variation increased to a plus or minus 1 day. The next step was to construct a chart where days were plotted against cumulative daily mean temperature or degree days.

When the information from the average temperature chart, Figure 3, was transferred to the cumulative chart Figure 4, we had a curve that represented all possible emergence points between 55° F. and 79° F. average temperature.

A replica was then made of the emergence curve (Fig. 5) which could be placed at any rainfall point on a season's wall chart made to the same scale.

Then, as shown in Figure 6, if the emergence curve replica's zero point is set at a point of heavy rainfall, a curve can be drawn on the season's chart that would show all possible points of emergence for that brood. Then, if the average daily temperature is accumulated every day and put on the chart, the rising temperature line will show the progress of development of the brood. If the tempera-

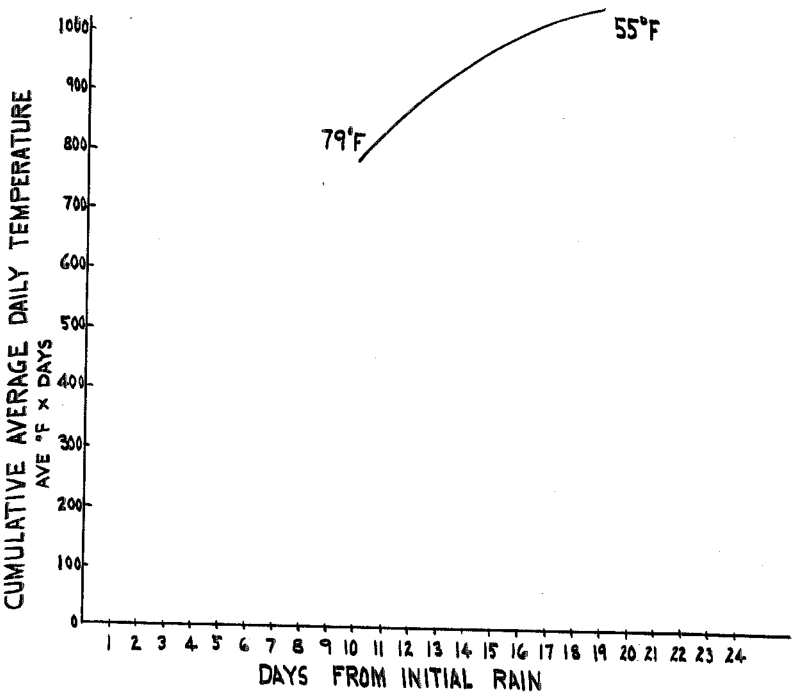

FIG. 4.—Estimated *Aedes vexans* emergence curve.

ture is low the line flattens out and intersects the emergence curve late; if the temperature is high, the line rises rapidly and intersects the emergence curve earlier.

With this device it is possible to keep track of how fast each brood is developing, when it emerges, and when each brood's probable light-trap peak is going to be five days in advance.

This method of predicting influxes of *Aedes vexans* is reliable if these rules are followed:

1. Establishing the starting point:
   (a) 4/10 inch of rain in 24 hours is required.
   (b) The temperature must be at, or rise to a minimum of, 60° F. within 24 hours after the rain.
   (c) The starting point must be from the nearest four hour increment after 0.4 inch of rain is reached.
2. Accumulating temperatures:
   (a) 1st day temperature is found by multiplying the fraction of the day remaining after the starting point times the average daily temperature for that day.
   (b) For succeeding days, add each day's average temperature to the preceding total temperature until the emergence curve is reached. At this point where the temperature line intersects the emergence curve 80 to 90 percent of the mosquitoes will have emerged.
3. Predicting the light-trap peak:
   (a) If the emergence curve is crossed before 6 a.m. this will allow the bulk of the mosquitoes time to mature before dusk so that the N.D., night of departure, will be that night.
   (b) If the curve is crossed after 6 a.m. the night of departure will be the next night.
   (c) Count N. D. as one, then count 2,

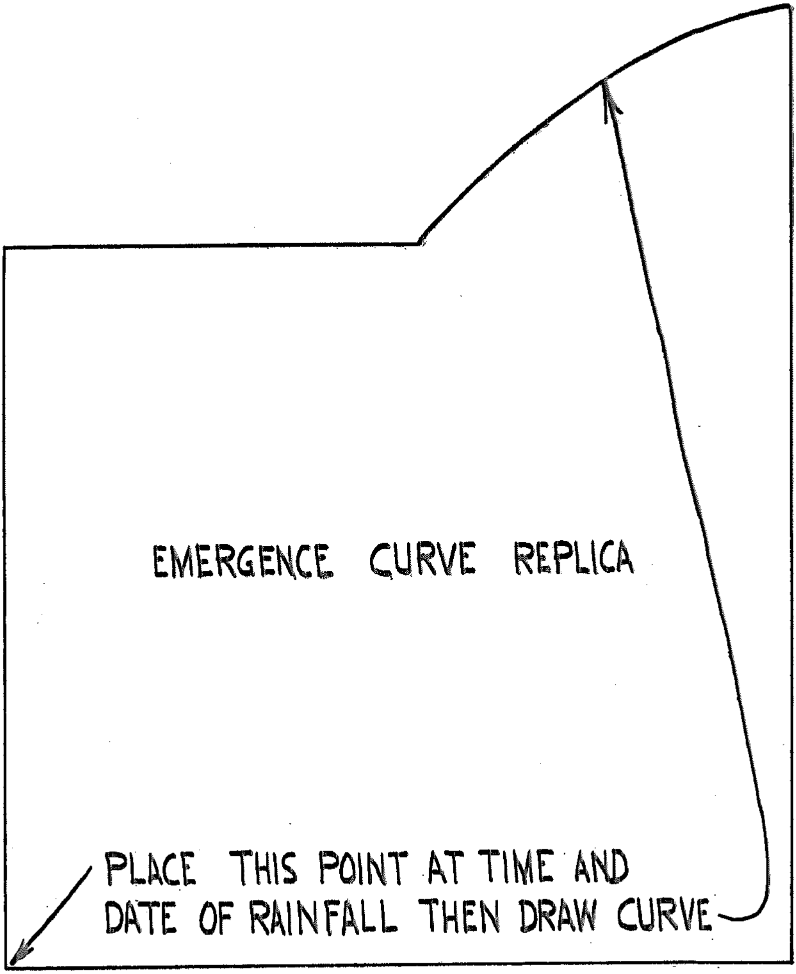

FIG. 5.—Emergence curve replica.

3, 4, 5. The 5th night will be the peak in the light trap, if conditions are as follows between 7 p.m. and 11 p.m. on the night of departure.

(1) The temperature is above 67.5° F.
(2) The wind speed is below 10 miles per hour.
(3) The relative humidity is between 41 percent and 79 percent.

The Des Plaines Valley Mosquito Abatement District has run a mosquito light-trap each night for four seasons at the same location, to check the validity of the system. The trap was located in Riverside, Illinois, a minimum of 5 miles from any known uncontrolled *Aedes vexans* breeding areas.

The results were that:

1. Migration peaks, depending upon temperature, appeared 13 to 22 days after a flooding rain.

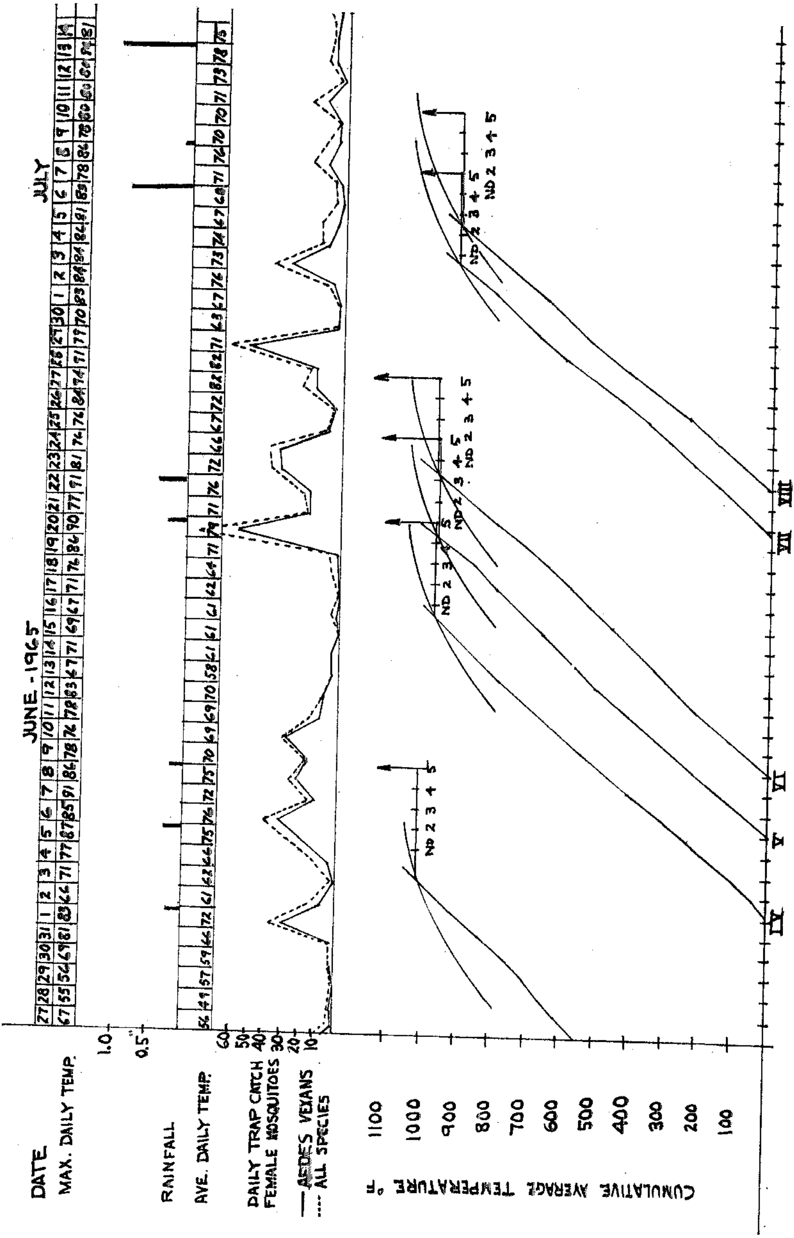

Fig. 6.—Portion of seasons brood prediction chart.

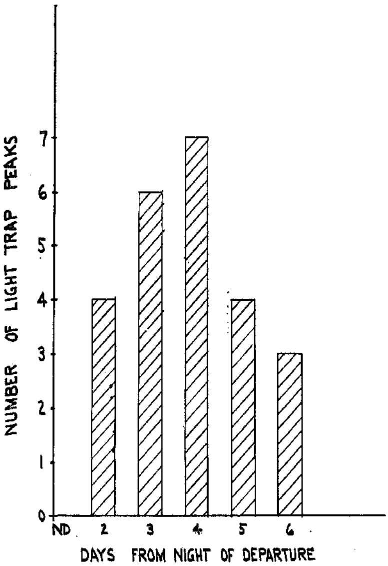

FIG. 7.—Arrival date of light trap peaks after emergence.

2. 82 percent of the 24 major broods arrived between the night of departure and the night of the predicted peak.

Figure No. 7 shows the distribution of arrivals. The results were disappointing so far as predicting the exact night of arrival. However, once the emergence curve is crossed and the night of departure is established, there is an 82 percent chance of success if we wait until the 5th night to begin adulticiding, or a 100 percent chance of success if we watch each night's light-trap catch between the night of departure and the predicted night of arrival for the readily recognizable migration peak.

We feel this predicting technique can be used in several ways:

1. Conditions in the field can be anticipated from readily available weather bureau statistics.

2. The emergence curve provides an easily determined cut off point for larviciding operations.

3. Adulticiding operations can be started at the earliest possible moment that guarantees success.

4. The public can be warned well in advance of impending annoyance.

SUMMARY. An empirical curve showing the relationship between the rate of development of the aquatic stages of *Aedes vexans* and average daily temperature was derived from mosquito light-trap data and weather data.

This curve was used in construction of a nomograph. The nomograph was used to:

1. Keep a running record of all potential migrations of *Aedes vexans* into a given area.

2. Predict the most likely night of any potential *Aedes vexan* migration.

3. Predict the earliest night effective adulticiding operation could begin.

References

NIELSEN, E. T. 1958. The initial stage of migration in salt marsh mosquitoes. Bulletin Entomological Res. 49(2):305–313.

NIELSEN, E. T., and EVANS, D. G. 1960. Duration of the pupal stage of *Aedes taeniorhynchus* with a discussion of the velocity of development as a function of temperature. Oikos 11:200–222.

PROVOST, M. W. 1952. The dispersal of *Aedes taeniorhynchus* I Preliminary studies. Mosq. News 12:174–190.

———. 1957. The dispersal of *Aedes taeniorhynchus* II The second experiment. Mosq. News 17:233–247.

———. 1960. The dispersal of *Aedes taeniorhynchus* III Study methods for the migratory exodus. Mosq. News 20:148–161.