FIELD OBSERVATIONS ON TWENTY-EIGHT BROODS OF FLOODWATER MOSQUITOES RESULTING FROM CONTROLLED FLOODINGS OF A NATURAL HABITAT IN THE TENNESSEE VALLEY

S. G. BREELAND and EUGENE PICKARD

Reservoir Ecology Branch, Division of Health and Safety, Tennessee Valley Authority, Muscle Shoals, Alabama

Introduction

Springtime preflood treatments of important floodwater mosquito habitats are a routine mosquito control measure employed by the Tennessee Valley Authority. Such treatments are in selected areas, being based on soil sampling evidence of winter egg deposits in populated sections of the watershed that receive an annual spring surcharge (abrupt elevation of water above top pool level) to help control permanent pool mosquitoes along the main river reservoirs. The schedule of this operation is known far enough in advance to allow the application of water-soluble insecticides in floodwater mosquito habitats prior to the surcharge. Larvae which hatch as a result of the surcharge do not survive the preflood treatment. The success of this measure obviously depends upon precise knowledge of egg populations, habitat, and water level operations.

The simplicity of control presented by the combination of a univoltine species (one brood per year) and a predictable "loaded" surcharge, not followed by later inundations during the same season, would be the fulfillment of a dream to the mosquito control biologist. However, not all floodwater mosquitoes are of the cooperative univoltine type—some are multivoltine (several broods per year)—and not always does nature allow man to fully manage the water. Thus, the development of a really adequate program of floodwater mosquito control in the Tennessee Valley depends upon a more thorough knowledge of the many variables of floodwater mosquito ecology as related to floodwater itself.

From a control standpoint, floodwater mosquitoes offer a unique challenge. In this respect their advantage over other mosquitoes lies in the fact that they remain dormant in the egg stage for long and irregular periods of time—not unlike so many time bombs ready to explode at the most inopportune time for man but at favorable times for themselves. Here their similarity to time bombs ends, for they are not sacrificed in the "explosion" but have the biological advantage of being able, upon maturity, to propagate many offspring which are replanted and reset for subsequent, unpredictable explosions.

Obviously, the ultimate control of floodwater mosquitoes lies in the destruction of the egg itself. Until we can actually destroy the eggs (oviciding, predation, etc.), perhaps we can learn to control their hatching. One approach might be that of causing, by some material or method, a simultaneous hatching of the entire egg population of a given habitat at an unfavorable time for the species. We now know that not all eggs of a population in the soil hatch at a given inundation but rather in installments (Gjullin *et al.*, 1950; Mallack *et al.*, 1964; Breeland *et al.*, 1965). Thus, if 90 percent control is accomplished by larviciding a population of larvae, we don't really have the apparent 90 percent control, but perhaps 90 percent control of only 5 percent of the population represented by the hatched eggs; and the most damaging portion, the 95 percent represented by the unhatched eggs, remains. If simultaneous hatching of all eggs of a population could be induced, then ordinary larviciding or preflood treatments would be highly effective, and perhaps chemosterilants could be considered.

Until ovicides or simultaneous hatching procedures can be developed, successful control will depend upon accumulated knowledge of the bionomics of the group (oviposition behavior, hatching phenomena, developmental time, brood patterns, seasonal cycle, mating habits, flight range, etc.). Results from basic studies, aside from being useful for conventional control, may lead to specific information needed for the means of developing ovicidal or simultaneous hatching procedures.

Principal reservoir breeding areas are in grassy flood plains adjacent to river and stream channels. These flats are subject to inundation by reservoir fluctuation and rainfall. A typical breeding site is a river bottom known as McFarland Bottom located in Florence, Alabama, on Pickwick Reservoir below Wilson Dam (Fig. 1). Since this area typifies problem areas throughout the Valley and is close to our facilities, it was chosen as the site for this study.

The purpose of this paper is to present results of a five-year study (1962–66) of 28 broods of floodwater mosquitoes resulting from controlled floodings of a natural habitat in the Tennessee Valley. Emphasis is on those aspects of floodwater mosquito biology associated with egg hatching and brood development phenomena.

MATERIALS AND METHODS

Several depressions within McFarland Bottom have a history of being natural oviposition sites for floodwater mosquito species, always producing sizable populations when flooded. One such depression (Fig. 2), about three-fourths acre in size and characterized by vegetation typical of floodwater mosquito habitats (*Carex lupulina, Juncus effusus, Polygonum hydropiperoides, Ludwigia palustris, Rumex crispus, R. verticillatus, Pancium agrostoides,* etc.), was used throughout this study.

Beginning in the spring of 1962, the pool was subjected to a series of controlled floodings by pumping water from the adjacent Tennessee River. A water pump on the bank of the river delivered approximately 300 gallons per minute through 200 feet of 2.5-inch fire hose (Fig. 3). Filling occurred in about 8 hours under favorable conditions. Hatching of mosquito eggs normally began within 30 minutes after pumping started, and a large population of larvae could be expected by the time the pool had filled. This procedure provided a means of observing a natural population of floodwater mosquitoes under controlled conditions.

Eight plots, 96 square feet each, were established within the experimental pool by constructing sandbox-type frames 8′ x 12′ x 12″. Four of the frames were equipped with tight-fitting aluminum wire screen lids to prevent oviposition, thus providing a closed mosquito habitat. The remaining four plots were left open at the top to allow oviposition in an open mosquito habitat (Fig. 4). All plots were chosen to reflect habitat and contour differences within the depression. In each case the screened plot was an ecologic counterpart to the open plot.

Floodings were begun in May 1962 and continued at approximate one-month intervals thereafter during each mosquito breeding season for a total of 5 years (28 floodings). Occasionally, natural inundation occurred. On these few occasions, where needed, supplemental pumping served to complete flooding to desired levels and natural floodings never interfered with observations. Six floodings were accomplished in 1962, six in 1963, five in 1964, six in 1965, and five in 1966 for a total of 28 sequential floodings of the same plots over a 5-year period, 1962–66.

Each brood of mosquitoes so produced was observed from eclosion to adult emergence and blood feeding. Typically,

FIG. 1.—Downstream view of Tennessee River and McFarland Bottom, Florence, Alabama.

FIG. 2.—Floodwater mosquito habitat of low depression within McFarland Bottom; note *Juncus* and *Carex* in foreground.

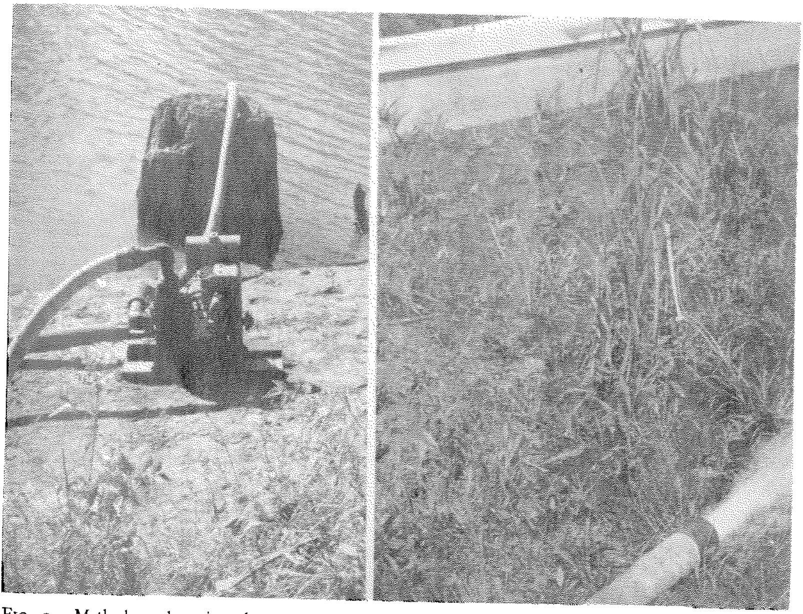


FIG. 3.—Method used to inundate experimental plots. Left: water pump in operating position on bank of river; Right: water entering plot area 200 feet from pump.

FIG. 4.—Example of screened and open plot arrangement. Note counterpart plots in upper left portion of photo.

sampling was begun 24 hours after flooding was initiated and at intervals of 24 hours thereafter. Each sampling consisted of taking five dips for aquatic stages from all eight plots. This was supplemented by temperature readings and related observations in each plot. Screens were removed only long enough to make the samples, usually by lifting the lid in place. The number of larvae or pupae in each dip was recorded and a representative sample collected and preserved in 5 percent formalin for later identification as to species and stage. This formed the basis for detailed observations on population size, species distribution, developmental time, and seasonal cycle. Observations were made on resulting adult populations as to emergence pattern, blood feeding, flower feeding, dispersal habits, etc.

At intervals during early emergence, before it was likely that any of the current population was of age to have had a blood meal, accumulated adults were flushed from beneath screens to allow their escape. Late-emerging adults were sacrificed beneath the screen where blood meals were not available.

Soil samples were taken at the beginning of these experiments and again toward the conclusion to indicate changes in the egg population.

RESULTS AND DISCUSSION

PLOT ARRANGEMENT AND VALIDITY. Table 1 indicates the ecologic similarity of the open and closed plots just prior to the first flooding in May 1962. Even though plot differences are apparent in the initial preflood egg samples (Table 1), the total number of eggs recovered from the screened plots was 854 versus 793 from the open plots, indicating similar population densities. This similarity in initial population density is further indicated by comparing larval population sizes in the open and screened plots for the 1962 season (Fig. 5). In terms of average number of larvae per dip, the ratio in the screened plots versus the open plots was 0.77:1 in May; 0.91:1 in June; 1.1:1 in July; 1.1:1 in August; 1.1:1 in September; and 1:1 in October. Thereafter (1963–65) divergence was considerable with the screened plots, showing fewer and fewer larvae in relation to the open plots which were subject to additional oviposition.

The screened plots were devised to help us determine, without the complications of overlapping populations, the brood pattern of floodwater mosquitoes under conditions already described. We wanted answers to such questions as: (1) Do we have one large spring brood, a spring and fall brood, or broods limited only by the number of inundations, etc.? (2) What species make up the various broods? (3) How long can eggs remain dormant in the field before hatching? (4) Do the majority of eggs in a population hatch during the first favorable flooding? (5) Of what significance is partial (installment) hatching to the brood pattern and thus to our control efforts?

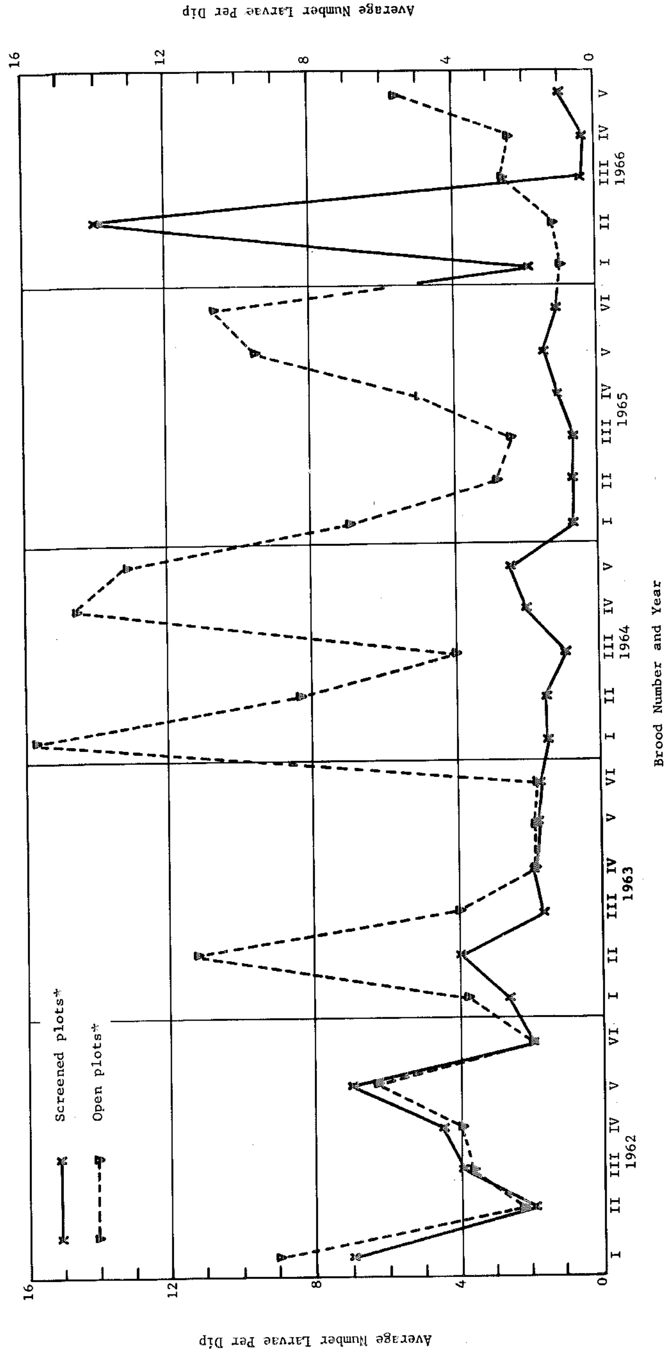
The open plots served as a control for the screened plots, as a means of determining population size, and as a means of determining developmental time of the various species.

The reliability of the data, as well as the significance of the results presented in this paper, depends on the effectiveness of the barrier against oviposition in the screened plots and the confinement of larvae in all plots. We are confident that the screened plots provided a closed habitat for mosquitoes, that is, we feel that eggs hatching during each inundation within the screened plots were eggs that had been in the plots prior to their screening in the winter of 1962. We are also confident that all plots were impermeable to mosquito larvae. This confidence is based on (1) visual inspection and constant maintenance of the plots during and between each flooding and at frequent intervals between seasons, (2) decreasing population sizes in the screened plots as compared to level or increasing populations in the open plots and the

TABLE 1.—Ecologic comparison of the four screened and four open plots, Spring, 1962.

	Screened Plots				Open Plots			
	1-A *	2-A	3-A	4-A	1-B *	2-B	3-B	4-B
Elevation (in feet above MSL)	418.8	418.8	418.8	419.0	418.8	418.8	418.8	419.0
Area (in sq. ft.)	96	96	96	96	96	96	96	96
Dominant Vegetation (descending order)	*Carex lupulina* *Polygonum hydropiperoides* *Ludwigia palustris*	*C. lupulina* *Juncus effusus* *P. hydropiperoides*	*Cynodon dactylon* *C. lupulina* *P. hydropiperoides*	*C. lupulina* *P. hydropiperoides* *Aster* sp.	*C. lupulina* *P. agrostoides* *P. hydropiperoides* *L. palustris*	*C. lupulina* *J. effusus* *Aster* sp.	*C. lupulina* *C. dactylon* *Aster* sp.	*C. lupulina* *C. dactylon* *R. crispus*
Other Vegetation	*Rumex crispus* *Ranunculus* sp.	*L. palustris* *R. crispus* *Panicum agrostoides*	*L. palustris* *R. crispus* *Ranunculus* sp. *P. agrostoides*	*R. crispus* *Rumex verticillatus* *Ranunculus* sp. *P. agrostoides*	*R. crispus* *Ranunculus* sp. *Aster* sp.	*L. palustris* *R. crispus* *Ranunculus* sp. *C. dactylon*	*J. effusus* *P. hydropiperoides* *R. crispus* *Ranunculus* sp.	*P. hydropiperoides* *L. palustris* *Ranunculus* sp. *P. agrostoides* *Aster* sp.
Floodwater Mosquito Eggs from 1 Square-Foot Soil Sample								
Ae. vexans	158	34	526	109	353	202	180	43
P. cyanescens	1	..	16	..	..	..	5	..
P. confinnis	..	..	6	3	3	2	..	..
P. discolor	..	..	1	..	..	..	4	..
P. ferox	..	..	..	..	..	..	1	..
Total Eggs, All Species	159	34	549	112	356	204	190	43

* 1-A is counterpart to 1-B; 2-A to 2-B; 3-A to 3-B; 4-A to 4-B.



* 1966 screened plots were open plots, 1962–65; 1966 open plots were screened plots, 1962–65.

FIG. 5.—Population size, larval floodwater mosquitoes in experimental field plots during twenty-eight broods produced over a five-season period, Florence, Alabama, 1962–1966.

matrix between plots, and (3) agreement between field observations and associated insectary and laboratory studies on partial hatching and extended dormancy in eggs, e.g., one study showed that the same batch of 500 eggs required subjection to 17 laboratory floodings and alternate periods of drying in the field before all eggs were hatched out (Breeland *et al.*, 1965).

The most positive assurance, however, came as a result of reversing the plots between the 1965 and 1966 seasons, i.e., the lids were removed from the four plots which had been screened for the four previous seasons, 1962–65, and placed on the open plots. Thus, the 1962–65 screened plots became open plots for the 1966 season, and the 1962–65 open plots became screened plots for the 1966 season. The results were impressive. Figure 5 shows that the population size in the original group of four screened plots had diminished to a relatively low level after May 1963 and continued low until the final flooding under the screen in September 1965. However, after the screens were removed for the 1966 season, the new open plots recovered to a population level almost equal to that at the time the plots were first screened (6.0 larvae per dip in 1966; 7.0 larvae per dip in 1962). Conversely, the plots which had been open from the start had consistently higher populations due presumably to added oviposition during 1962–65. However, when they were screened for the 1966 season, the population dipped to low levels after the initial large group of banked eggs had hatched during the June flooding, that is, the population divergence between the screened and open plots reversed itself when the plots were reversed.

Additional evidence of the effectiveness of the plot barriers is offered by soil sampling for eggs. Table 2 shows results of three such samplings. Here it is seen that in March 1962, prior to the first flooding, samples from the screened plots had a total of 854 eggs as compared to 793 from the open plots. Four years later (after 23 floodings), similar sampling showed only 94 eggs in the screened plots as compared to 1,104 in the open plots. After the reversal, the previously screened plots (1962–65), now open for only one year, showed 1,222 eggs. Conversely, the previously open plots (1962–65), now screened for only one year, showed no eggs.

TABLE 2.—Number of floodwater mosquito eggs removed from soil samples* from screened and open plots on three occasions, 1962–1966.

Plot No.	March 30, 1962	March 2, 1966	October 21, 1966
	Date of Sample		
	Screened	Screened	Open
1-A	159	0	239
2-A	34	8	412
3-A	549	0	74
4-A	112	86	497
Total	854	94	1,222
	Open	Open	Screened
1-B	356	185	0
2-B	204	821	0
3-B	190	98	0
4-B	43	0	0
Total	793	1,104	0

* Each sample consisted of two units of soil (6" x 6") removed to a depth of 2–3 inches.

Notwithstanding the demonstrated effectiveness of the screens in providing a closed mosquito habitat, it is recognized that the possibility of a degree of autogeny or freakish oviposition through the screens should be considered. However, the probability of such occurrences seems slight and in our judgment would not be of sufficient importance to affect the general principles involved.

The foregoing is presented to lend credence to the validity of results yet to be discussed.

BROOD STUDIES AND SPECIES COMPOSITION. Figures 6 and 7 summarize results obtained from the 23 floodings in the screened and open plots, respectively, from 1962–65. Figure 8 shows results obtained after the plots were reversed for the 1966 season. Perusal of these data will reveal much about dormancy, viability, and

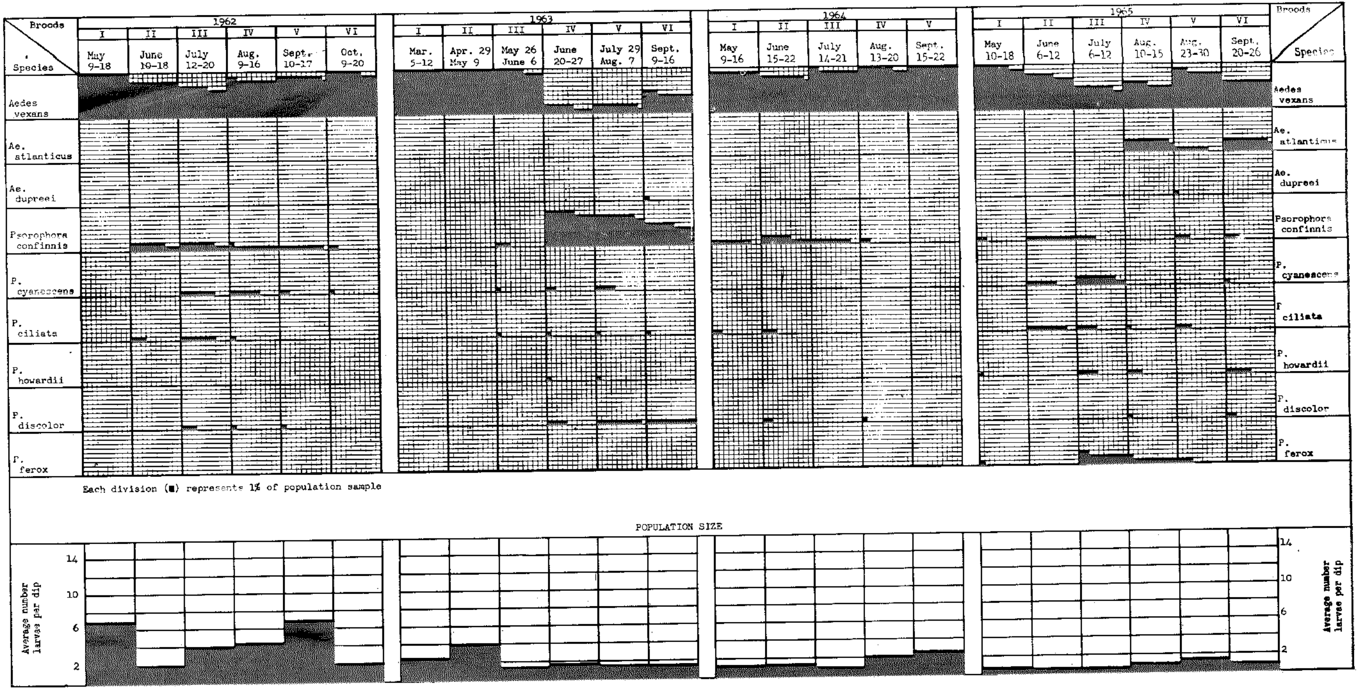


FIG. 6.—Species distribution of larval floodwater mosquitoes in experimental screened * field plots during twenty-three broods produced over a four-season period, Florence, Alabama, 1962–65.

* Four natural river-bottom plots, 96 square feet each, delimited by sandbox-type frames 8 feet by 12 feet and covered with mosquito-proof aluminum screen wire tops to prevent oviposition. A closed mosquito habitat.

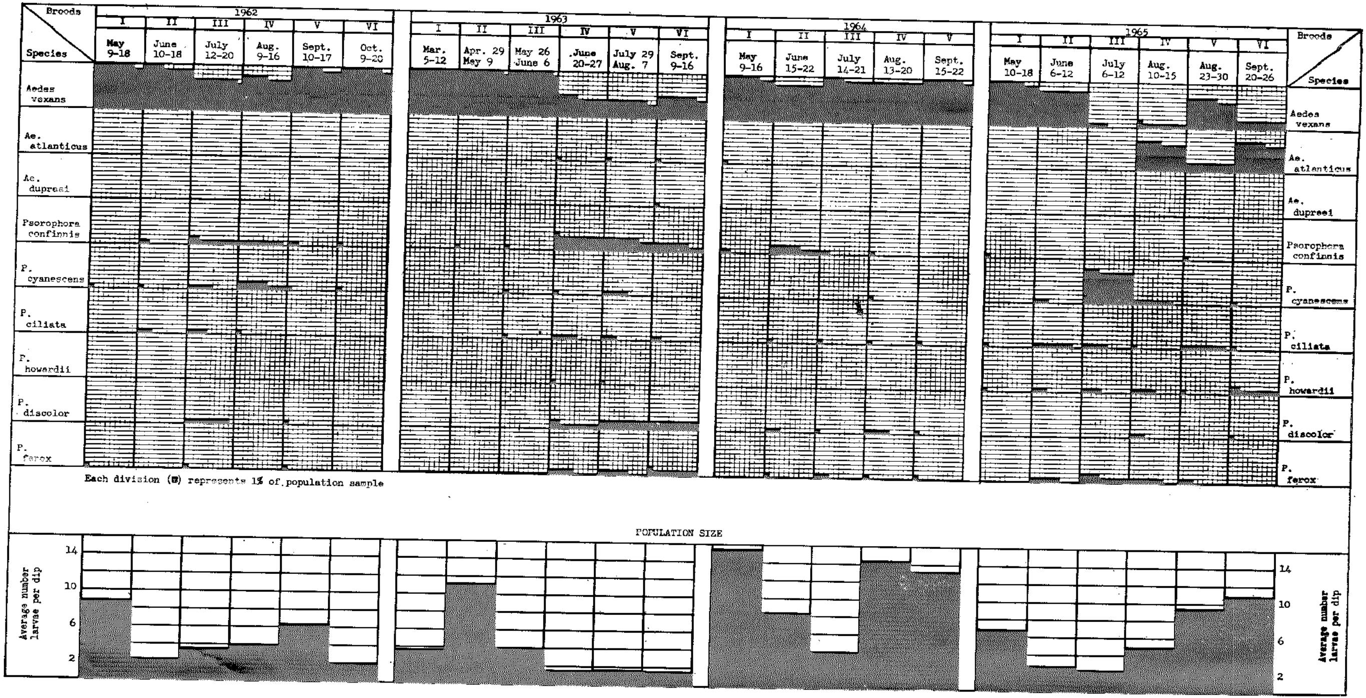


FIG. 7.—Species distribution of larval floodwater mosquitoes in experimental open * field plots during twenty-three broods produced over a four-season period, Florence, Alabama, 1962–65.

* Four natural river-bottom plots, 96 square feet each, delimited by sandbox-type frames 8 feet by 12 feet without covers. An open mosquito habitat.

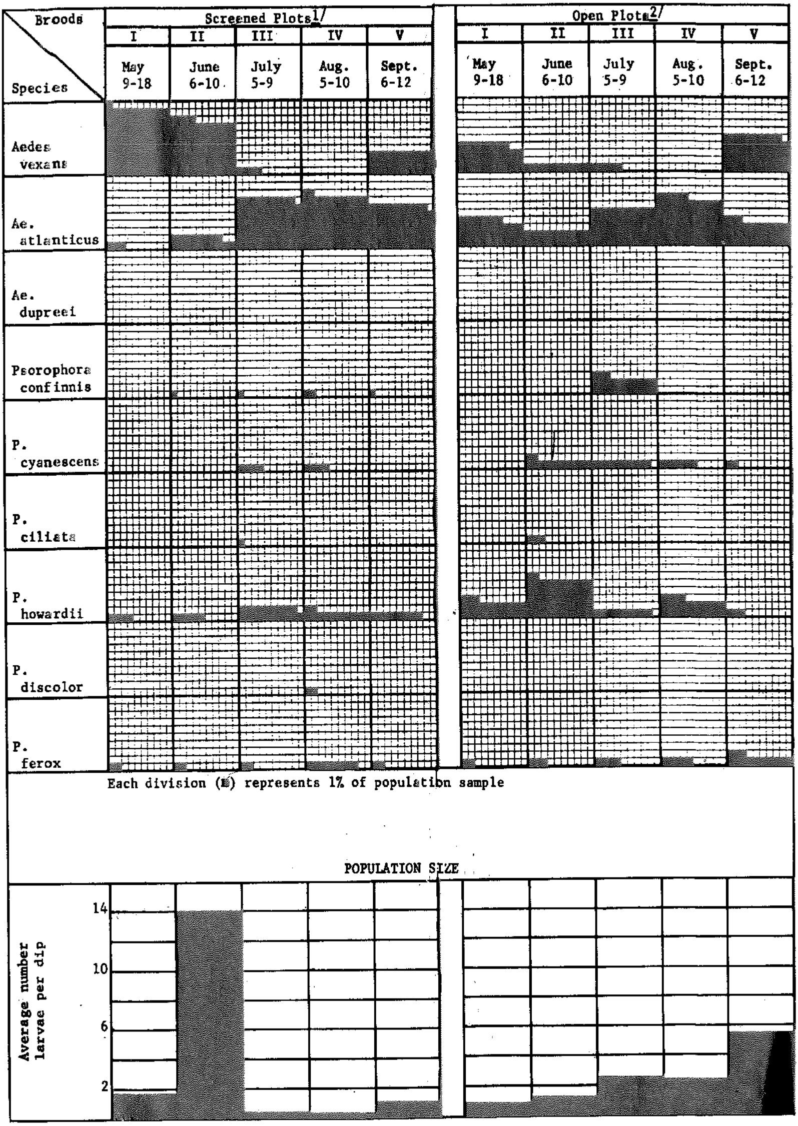


FIG. 8.—Species distribution of larval floodwater mosquitoes in reversed* experimental field plots during five broods produced in Florence, Alabama—1966.

* 1966 screened plots were open plots, 1962–65; 1966 open plots were screened, 1962–65.

1 Four natural river-bottom plots, 96 square feet each, delimited by sandbox-type frames 8 feet by 12 feet and covered with mosquito-proof aluminum screen wire tops to prevent oviposition. A closed mosquito habitat.

2 Four natural river-bottom plots, counterparts to the above, but without covers. An open mosquito habitat.

hatching of individual species of floodwater mosquitoes; brood patterns of a mixed population; and, when used in conjunction with other data, adaptation and population changes in relation to ecologic changes brought about by repeated inundations. Some significant findings follow.

The population was composed of nine species of mosquitoes (*Aedes vexans, Ae. atlanticus, Ae. dupreei, Psorophora confinnis, P. cyanescens, P. ciliata, P. howardii, P. discolor,* and *P. ferox*)—all of the multivoltine type. Five of these species (*Ae. vexans, Ae. atlanticus, P. confinnis, P. cyanescens,* and *P. howardii*) dominated one or more broods during the 5-year period; however, *Ae. vexans* was by far the most persistent species, almost completely dominating 19 of the 28 broods. Typically (Figs. 6–8), spring populations (March–early June) were almost exclusively *Ae. vexans. Psorophora* species began to show in mid-June, peaked out in July and August, and receded somewhat in September when *Ae. vexans* usually showed a recovery toward spring numbers (Fig. 6). Occasionally, *Psorophora* would actually dominate one or more broods, e.g., *P. confinnis* in 1963 (Fig. 6), *P. cyanescens* in 1965 (Fig. 7), *P. howardii* in 1966 (Fig. 8), and a mixture of species in 1963 (Fig. 7). It is interesting that this pattern was consistent for the first four years of the study; however, toward the end of 1965, *Ae. atlanticus* began to compete with *Ae. vexans* for dominance (Figs. 6 and 7). This carried over into 1966, and Figure 8 shows that the mid-season competition to *Ae. vexans* came largely from *Ae. atlanticus* with some help from several *Psorophora* species, primarily *P. ferox* and *P. howardii.*

It appears that habitat changes resulting from frequent inundations and gradual change from a field to wooded area (development of a canopy cover by ash, hackberry, osage-orange, and maple) have created a habitat more favorable to woodland species, e.g., *Ae. atlanticus, P. ferox,* and *P. howardii.* Perhaps these species now are more suited to the existing habitat than is *Ae. vexans.* Results from the last three broods of 1965 (Figs. 6 and 7) and the entire 1966 season (Fig. 8), along with observations of habitat changes, would substantiate such an explanation.

Of the four species that showed no tendency toward dominance, *Ae. dupreei* was rare and showed up only in spots during the study; *P. ciliata* was consistently present but in relatively low numbers; the distribution of *P. discolor* was similar to that of *P. confinnis* but at a lower population level; and *P. ferox* came on strong as the habitat developed from field type to canopy as previously mentioned.

The importance of sequential floodings of the same habitat in revealing population dynamics is seen in retrospect. For example, Figure 6 shows that in the screened plots one flooding (May 1962) would have detected only one species; two floodings, three species; and after a full season of six floodings, information would have been available on only five species. It was only after 11 floodings that a sufficient number of *P. discolor* became available for life history observations; 11 floodings preceded the finding of the first *Ae. dupreei;* and 17 and 20 floodings (4 years) preceded the finding of the first *P. ferox* and *Ae. atlanticus,* respectively. Two seasons were required to discover all nine species in the open plots (Fig. 7).

The need for corollary observations on the adult and larval phases of a population was vividly pointed out by these studies, e.g., adult biting alone would have been quite misleading. In many cases where the larval population was known to be almost completely dominated by *Ae. vexans* (e.g., 1962 August brood), biting collections were dominated by *P. confinnis, P. cyanescens,* and *P. ciliata.* The combined use of light traps, Malaise traps, and biting collections for adults and larval dipping gave a rather accurate appraisal of the population.

ECOLOGIC OBSERVATIONS. 1. SPECIES

Fig. 9(a).—Plot 3-B at beginning of the study, May 1962.

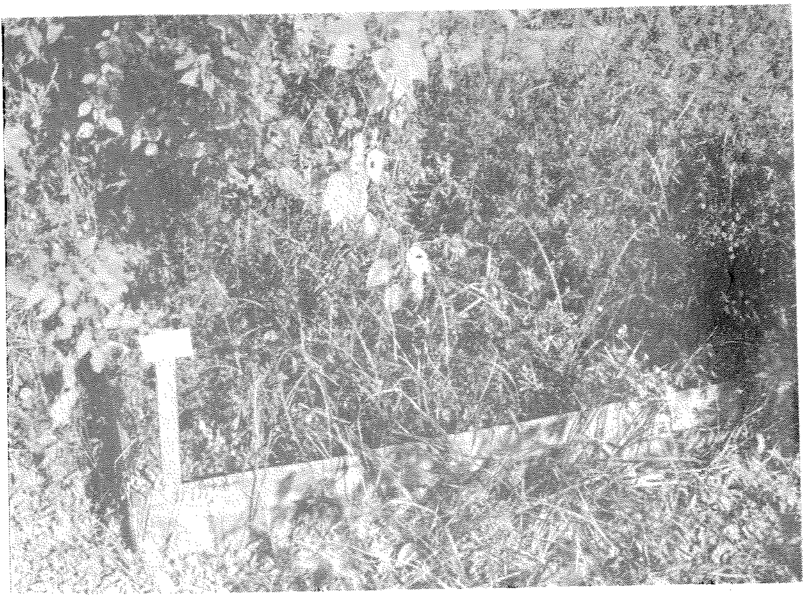


Fig. 9(b).—Plot 3-B, 4 seasons later, October 1965. Note increased canopy and leafy ground cover.

TABLE 3.—Habitat change as reflected by vegetation in Plot 3-A (screened) and Plot 3-B (open) between May 1962 and October 1965.

Plot	May 1962	October 1965
	Dominant (descending order)	*Dominant* (descending order)
3-A	1. *Cynodon dactylon*	1. *P. agrostoides*
	2. *Carex lupulina*	2. *C. lupulina*
	3. *Polygonum hydropiperoides*	3. *Aster* sp.
	Also:	Also:
	4. *Ludwigia palustris*	*4. *Fraxinus* (ash) cover
	5. *Rumex crispus*	5. *Campsis radicans*
	6. *Ranunculus* sp.	6. *Celtis* (hackberry) seedling
	7. *Panicum agrostoides*	
		Absent from 1962: 1, 4, 5, 6
	Dominant	*Dominant*
3-B	1. *C. lupulina*	1. *Aster* sp.
	2. *C. dactylon*	2. *C. lupulina*
	3. *Aster* sp.	*3. *Maclura* (osage-orange)
		4. *Fraxinus* (ash)
	Also:	Also:
	4. *Juncus effusus*	5. *Celtis* (hackberry) seedling
	5. *P. hydropiperoides*	6. *C. radicans*
	6. *R. crispus*	
	7. *Ranunculus* sp.	
		Absent from 1962: 2, 4, 5, 6, 7

* Tree species were outside of plots and are listed in terms of their influence on the plot.

ADAPTATION TO CHANGING HABITATS. When these studies were initiated in the spring of 1962, the experimental depression was a rather typical lowland pasture with a ground cover of pasture grasses, primarily Bermuda. In fact, the land had been pastured to cows for a number of years until 1959. Being subjected to occasional flooding, the usual semiaquatic vegetation was present (Table 1), but only a few very young seedlings of forest tree species (ash, hackberry, and osage-orange) existed with practically no leaf cover except over a portion of plots 3-A (screened) and 3-B (open). As flooding progressed, cover vegetation changed and the seedlings grew and became canopy-size trees, contributing leaf litter to the floor of several plots. Thus, certain plots gradually became woodland rather than pasture habitats. Figure 9 gives an example of this change in the vicinity of plots 3-A and 3-B, and Table 3 tabulates specific changes in these plots. Change affected species composition as already noted by offering increasingly better habitats to such canopy species as *Ae. atlanticus, P. ferox,* and *P. howardii.* A chronological review of these species in Figures 7 and 8 will will demonstrate the change in species composition with habitat. Also, during earlier broods before the habitat changes were pronounced, what few *Ae. atlanticus, P. ferox,* and *P. howardii* that had been recovered were from the canopied plots. Thus, as the woodland habitat developed, woodland species moved in to dominate.

2. DELAYED HATCHING. Of substantial survival value to a species is the ability to delay egg hatching until a favorable time. This phenomenon was much in evidence in this study. Consider that *Ae. atlanticus* had 20 opportunities over a 3½ year period to hatch in the screened plots before doing so (Fig. 6); *Ae. dupreei,* 11 opportunities; *P. howardii,* 9 opportunities; and *P. ferox,* 17 opportunities. No significant conclusions can be drawn for

Ae. dupreei in this respect; however, the three canopy species previously mentioned (*Ae. atlanticus, P. howardii,* and *P. ferox*) appear to offer good examples of delayed hatching until a favorable time. Early in these studies, even though some eggs of these species were obviously present in both screened and open plots, conditions for their hatching, survival, and habitat infiltration were not present; however, as conditions changed in their favor, hatching resulted and they very successfully integrated the habitat.

3. INSTALLMENT HATCHING. That floodwater mosquitoes exhibit installment hatching is no longer questionable (Gjullin *et al.,* 1950; Mallack *et al.,* 1964; Breeland *et al.,* 1965). This phenomenon is of significant survival value to a species. In this study this is best illustrated by the hatching patterns of *Ae. vexans.*

In the screened plots (Figs. 6 and 8) the initial egg population of *Ae. vexans* hatched in installments spread out over 23 broods in four seasons. Although the population level was considerably reduced after 1963 in the screened plots, the egg supply did not exhaust itself to hatching. In another study (Breeland *et al.,* 1965), installment hatching of 500 *Ae. vexans* eggs required 17 alternate periods of laboratory flooding and field drying to reach an end point. This group of eggs, representing only one brood, implies considerable variation when differences between broods and seasons are involved.

The combination of delayed hatching and installment hatching would seem to be of considerable survival value to a species.

4. DORMANCY. There are a number of reports of dormancy among floodwater mosquitoes in the literature, e.g., Gjullin *et al.,* 1950; Borg and Horsfall, 1953; Clements, 1963. However, the extent of dormancy in terms of longevity is still questionable. The present study indicates that eggs of all nine species with which we dealt remained dormant and viable under field conditions for a period of at least 4 years (Fig. 6). Population size diminished considerably after the second year, but small numbers remained. This agrees with results of Gjullin *et al.* (1950) obtained in a different manner. On July 29, 1966, laboratory egg batches which had been held for approximately 3 years on filter paper in small plastic containers at 40° F. were warmed to room temperature and flooded with corn broth solution for hatching. One group of *P. cyanescens* and six groups of *P. ciliata* yielded larvae. No special care was taken to preserve these eggs, and it is believed that special effort would produce even longer records of dormancy and viability.

5. THE ADULT POPULATION. We have previously pointed out (Breeland and Pickard, 1963) developmental time for several species. In the August 1962 brood at an average temperature of 80° F. (range 72°–89°), adult emergence in *Ae. vexans* began in 172 hours (7 days) after flooding; *P. confinnis* in 140 hours (<6 days); *P. cyanescens* in 132 hours (5½ days); and *P. ciliata* in 130 hours (5½ days). Blood feeding by these species began at 186 hours, 152 hours, 144 hours, and 144 hours, respectively. It is significant that, invariably, a specimen taking a blood meal in the field had previously mated. Thus, mating obviously occurred within hours after adult emergence.

Several species were observed feeding on flower heads at or near the site of emergence. In the May 1962 brood both males and females of *Ae. vexans, P. cyanescens, P. ciliata,* and *P. confinnis* fed profusely on the flower heads of *Rumex verticillatus.* In the September brood of the same season several *Ae. vexans* of both sexes and a single male *Ae. atlanticus* were collected feeding on *Solidago* sp. Again in the 1963 May brood, heavy feeding by *Ae. vexans* was observed on *R. verticillatus.* In the 1963 September brood, *Ae. vexans* adults were collected while feeding on *Eupatorium* sp. and *Vernonia altissima.* The feeding was dominated by newly emerged specimens.

We had previously reported flower feeding from *Solidago* and *Eupatorium*, but not from *Rumex* and *Vernonia* (Breeland and Pickard, 1961). We had not previously observed flower feeding by *Ae. atlanticus* or *P. confinnis.*

Although records are scarce, dispersal from the breeding area was rapid. This is evidenced by the few adults collected by any method only a few days after peak emergence.

Summary and Conclusions

A river bottom experimental pool (Florence, Alabama) harboring large numbers of floodwater mosquito eggs of several species was subjected to controlled floodings by pumping water from the adjacent Tennessee River on 28 occasions during five mosquito breeding seasons, 1962–66. The resulting broods of mosquitoes were observed from eclosion to adult emergence and dispersal. Eight plots (96 square feet each), four of which were screened to prevent oviposition, allowed close observations on such behavior as species composition, seasonal distribution, brood development, dormancy, delayed hatching, and installment hatching.

Nine species (*Ae. vexans, Ae. altanticus, Ae. dupreei, P. confinnis, P. cyanescens, P. ciliata, P. howardii, P. discolor,* and *P. ferox*) were represented in the population. Five of these (*Ae. vexans, Ae. atlanticus, P. confinnis, P. cyanescens,* and *P. howardii*) dominated one or more broods. *Ae. vexans* was the most persistent species (dominated 19 broods) and was most abundant in the spring and fall, while *Psorophora* species became abundant in mid and later summer. All nine species were of the multivoltine type and all exhibited the *ability to delay hatching* until a favorable time, even though many opportunities were previously available. *Installment hatching* was quite the rule as some hatching was still occurring in the screened plots after 4 years in a closed habitat. *Adaptation to changing habitat* was well illustrated by *Ae. atlanticus, P. ferox,* and *P. howardii* which were relatively rare in the beginning when the habitat was largely open but became abundant after part of the area gradually changed to a more woodland type habitat. Adults of all species mated within hours after emergence, and dispersal of the inseminated females from the breeding area was rapid. All adults taking blood meals from collectors at the breeding site had previously mated, and flower feeding was not uncommon.

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