not give any apparent reduction of *A. taeniorhynchus.*

Plot 2 and Control—Moderate densities of larvae and pupae of *A. taeniorhynchus* were present in water-filled cracks in the earth and in small pools. Five percent DDT in fuel oil applied at the rate of 2 lbs. DDT per acre as a pre-hatching treatment gave an estimated 50 percent reduction of *A. taeniorhynchus.*

Plot 3 and Control—Breeding of *A. taeniorhynchus* was light except for one small ditch in the test plot where larvae were present in moderate numbers. No apparent reduction was obtained when 5 percent DDT in fuel oil was used at the rate of 2 lbs. DDT per acre as a pre-hatching treatment.

Plot 4 and Control—Breeding of *A. taeniorhynchus* was light in both the test and control plots. No apparent reduction was obtained when 10 percent DDT dust was used at the rate of 2 lbs. DDT per acre as a pre-hatching treatment.

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GROUND SPACE SPRAYING OF *MANSONIA* AND OTHER MOSQUITOES IN LEESBURG, FLORIDA *

MAURICE W. PROVOST [1]

I. INTRODUCTION

Since the advent of DDT, a voluminous literature has appeared on the technique of adulticiding. Although hundreds of adulticiding techniques have appeared to be successful, there has been virtually no scientific appraisal of programs employing them. The 1948–1949 studies of the Florida State Board of Health in Leesburg were essentially an attempt to evaluate a program in which the mosquitoes were primarily *Mansonia,* and the method of control was to be the use of DDT thermal aerosols and mists.

Leesburg, a city of some 9,500 population, is in the lake and rolling hill region of central Florida. It occupies an isthmus separating lakes which have large sections of their shorelines in swamp or marsh (Fig. 1). Several of these embayments penetrate the city limits. They are typically peat or muck bays supporting extensive sawgrass *(Mariscus jamaicensis)* marshes and cypress *(Taxodium distichum)* swamps. The deep organic soils of both marshes and swamps hold extensive shrubby growths of willow *(Salix nigra),* buttonbush *(Cephalanthus occidentalis),* and water willow *(Decodon*

* A contribution from the Division of Entomology, Florida State Board of Health, and the Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Ga. The field work was done largely by Messrs. D. B. Lieux, and W. B. Braddock, of the Public Health Service.

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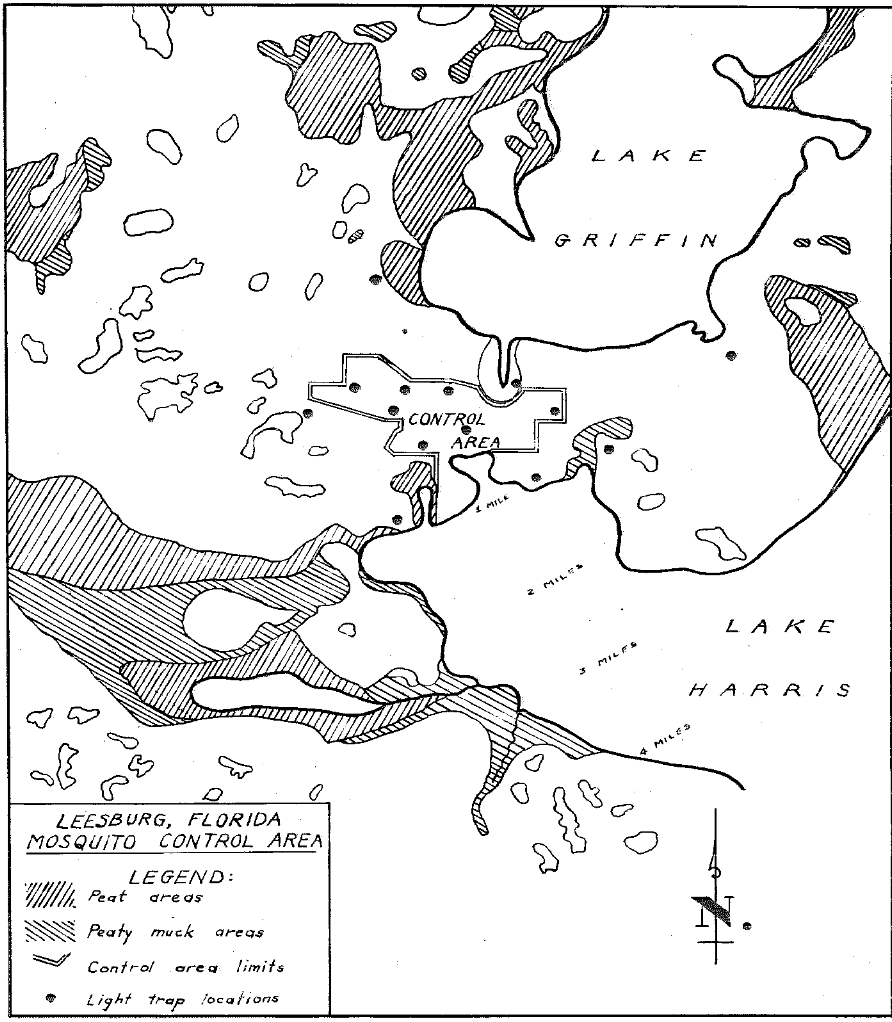

Fig. 1. Location of Leesburg with respect to water, swamps, and marshes. Both peat and peaty-muck soils support a great abundance of host plants for *Mansonia* spp. Map adapted from soil map of Lake County (U. S. Dept. Agric., Bureau of Soils; 1923).

verticillatus). The common emergent aquatics, particularly in the sawgrass, are arrowhead *(Sagittaria lancifolia)*, pickerelweed *(Pontederia cordata)*, cattail *(Typha latifolia)*, and lizard's-tail *(Saururus cernuus)*. Water hyacinth *(Piaropus crassipes)* is well distributed throughout. Water lettuce *(Pistia stratiotes)* is not as common as the hyacinth close to the city, but considerable communities of it occur in the cypress swamps. By contrast to these swamps and marshes, the northwestern sector of the Leesburg area is dotted with ponds, most of which are sand-bottomed, open, and grown to maiden-cane *(Panicum hemitomum)*, spatterdock *(Nuphar advena)*, and pickerelweed. This terrain produces *Anopheles crucians, Psorophora confinnis,* and *Culex* species, while the swamps and marshes described earlier produce the more important *Anopheles quadrimaculatus,* and, most especially, *Mansonia indubitans* and *Mansonia perturbans.*

From April through October in Leesburg, the maximum temperatures are in the nineties and the minima in the sixties. April and May are normally dry, but from June to October, expected rainfall would be six to seven inches per month. In the mosquito season, the relative humidity averages 60% at noon, 75% at 8:00 p.m., 98% at 3:00 a.m., and 85% at 8:00 a.m. In the evening hours, temperature inversions at ground levels seldom occurred over paved surfaces even as late as 10:30 p.m. Over vegetated surfaces, inversion conditions were attained usually by 8:30 p.m. An inversion difference of 1° C. between the one-foot and six-foot levels was attained once as early as 7:15 p.m., but on several occasions did not occur until after 10:30 p.m. The best hours for aerosol retention at ground levels, therefore, came normally after 10:00 p.m.

II. The Problem

A glance at Table 1 will reveal the very serious mosquito problem in this city. Its anopheline mosquitoes alone constitute a menace. Three species are common and nearly equally so: *Anopheles quadrimaculatus, A. crucians,* and *A. walkeri.* The domestic mosquitoes, *Culex quinquefasciatus,* are an ever-present nuisance. The glades mosquito, *Psorophora confinnis,* plagues the city after very heavy rains in summer and fall. But over and above all, Leesburg is harassed by *M. indubitans* and *M. perturbans.* This paper will deal primarily with comparisons of *M. indubitans, M. perturbans,* and *A. quadrimaculatus.* "All biting species" indicates exclusion of *Culex (Melanoconion)* spp. and *Uranotaenia* spp.

Mansonia indubitans: Extensive larval studies, using the Bidlingmayer trap (Bidlingmayer, 1950), failed to uncover breeding on any host plant in this area but water lettuce. Both mosquito and host occur here at the northern limits of their distribution, and being tropical species, are very sensitive to low temperatures. From 1944 to 1947, the winters were cold, and *M. indubitans* occurred as a relatively small brood in the fall. The subsequent two winters were mild, and the species occurred in both 1948 and 1949 as large broods every 90 to 100 days. Larval investigations showed clearly the development of these generations (Provost, 1950). These were the years of adult control herewith discussed. The winter of 1949–50 was colder, and the subsequent spring brood of *indubitans* was very small. There followed in 1950 the first abnormally low water levels in the swamps of the Leesburg area since 1941, which all but eliminated further breeding of *indubitans.*

Mansonia perturbans: Larval studies in Leesburg (Bidlingmayer, 1950) uncovered breeding of *M. perturbans* on a great variety of host plants. It was predominant, however, on water lettuce, water willow, sawgrass, lizard's-tail, and arrowhead. Adult and larval collections showed but one generation a year; in 1948 and 1949, the big emergences came in April and May (Provost, 1950). Following an extremely mild winter, there was an un-

TABLE 1.—Monthly Average Collections of Mosquitoes Outside the Control Area in Leesburg, Florida, in 1949. Only the 2 light traps which operated throughout the year are included; 20 species affecting man are included in the totals.

SPECIES	FEMALES PER TRAP NIGHT											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
M. indubitans	3.44	38.86	129.61	207.59	146.93	138.43	171.26	172.68	310.86	248.48	107.94	14.88
M. perturbans		1.14	47.46	170.18	245.19	53.42	11.06	14.68	12.21	11.75	.13	
C. (Culex) spp.*	5.50	9.50	10.35	10.25	11.39	14.15	46.49	36.86	129.66	21.61	21.00	40.07
An. crucians	7.75	32.43	22.02	11.72	10.82	8.80	13.75	13.98	18.52	6.89	5.44	15.47
An. walkeri	5.13	18.50	42.00	16.61	7.19	14.97	23.04	20.00	9.57	3.05	5.00	17.59
An. quadrimac.	1.81	8.64	21.81	12.28	7.46	9.22	12.55	9.57	10.16	3.48	6.88	5.71
P. confinnis				.18	.08	.40	4.75	6.98	8.14	2.12		
A. mitchellae	.25	.21	.42	.30			.04	.34	.42	.02		
A. infirmatus						.02	.02	.18	.21	.05		
A. taeniorhynchus		.14			.03	.15	.20	1.29	.04	.19		
A. sollicitans						.05			.07			
A. vexans						.02	.21					
TOTAL	24.50	108.71	274.27	428.91	428.85	240.30	287.62	277.63	501.34	298.69	146.88	94.12

* *Culex quinquefasciatus, Culex salinarius,* and *Culex nigripalpus.*

usually severe annoyance in the spring of 1949; the cold spring of 1950 was followed by an abnormally small emergence. Larval studies demonstrated one dominant generation per year, a fact corroborated by adult collections throughout Florida over an 8-year period. A slight resurgence of numbers in the fall was also noted. McNeel (1932) reported two "definite peaks in abundance during the summer" in Zellwood, which the biology of the species indicates as possible. But this is the exception rather than the rule in Florida.

Anopheles quadrimaculatus: The malaria mosquito is abundant in this area. Among the many malaria-control projects in Florida during World War II, the one in Leesburg was among the least successful in maintaining low levels of the vector. There was a great abundance of *A. quadrimaculatus* prior to initiation of adult control in 1948, and they remain numerous outside the control area. They originate in very much the same semi-swamp areas which produce the *Mansonia* hordes.

Since the effectiveness of an insecticidal fog is proportional to the *duration* of contact between fog and mosquito, it is just as important to fog when the mosquitoes are most vulnerable to the spray as it is to fog when the aerosol is most likely to hug the ground. In 1949, light traps outside of Leesburg (Station 11) were arranged to make three collections per night, 7:00 to 10:30, 10:30 to 2:00, and 2:00 to 6:00. They were operated in this fashion 14 nights in May, 21 in July, and 21 in September. All species except *A. walkeri* were shown to be most active in the evening and least active at dawn. This was particularly true of the *Mansonias*. With *M. indubitans,* the percentage of nights' collections entering the trap before 10:30 was 68 in May, 61 in July, and 67 in September, or 65.0% (11,467 out of 17,634) for the 56 trap nights. (For substantiation, cf. Bradley and McNeel, 1935, and King et al., 1937). If mosquito kill were proportional to activity, it would appear that the mortality of these mosquitoes per hour would be four times as great before 10 o'clock as after. Unfortunately, it is not until after that hour that the aerosol operates at its best in hugging the ground.

III. Techniques Used

In 1948, the space spraying was done with a Tifa fog machine putting out a 5% or 10% solution of DDT in fuel oil. In 1949, the same Tifa used a 5% or 7½% DDT-oil solution. Late in 1949, a Buffalo Turbine was used also to put out a 1% DDT emulsion. The Tifa was set to discharge 40 gallons per hour and the turbine 80 gallons per hour. Both of these machines were arranged for one-man operation, i.e., one man drove the truck and operated the machine. The treatments were always made at night, usually beginning at dark and continuing until midnight in 1948 and until 2:00 or 3:00 a.m. in 1949. The Tifa covered the 1030-acre area in four nights in 1948 and in two or three nights in 1949. The turbine was never used alone to cover the whole area. Operating each in separate sections, the Tifa and the turbine together covered the area in two nights. The applications were made at intervals of from three days to three weeks, depending largely on the mosquito population. Since no larval control at all was done, the problem of reinfiltration was preeminent both in timing operations and in evaluating them. Data were kept on all operations, to include quantity of formulation used, miles traveled, hours of operating, etc. A considerable amount of weather data was gathered, although correlations with control results are too voluminous and not significant enough to warrant discussion in this paper.

The amount of control achieved was gauged by New Jersey light traps operating every night from April to November. Seven of these were run within the area of control. On the outside, as checks, there were never less than three traps in operaation, and during most of 1949, there were many more. These traps all burned 60-watt frosted white bulbs. Biting rates were taken early in the experiment. They were soon discarded because the data secured were numerically too small for satisfactory statistical analysis and because the considerable man-power requirements were not available. That biting rates would have yielded substantially the same information as the light traps is very likely (cf. Young, 1948). In evaluating techniques, caged mosquitoes may have been preferable, but again the man-power was not available, and furthermore, the caged mosquito results alone would have been valueless in evaluating the program. Actually, *any* evaluation of adult mosquito control in the field is bound to be statistically on very shaky ground because (1) all sampling methods known are selective, and because (2) we know virtually nothing of mosquitoes' behavior during 95% of their adult lives, a few anophelines and *Aedes aegypti* being notable exceptions. The unfortunate result is that the mosquitoes themselves can cause more variation among adulticiding results than all the variables of technique, equipment, and material we can array against them.

The method of computing reductions after treatments received careful attention and considerable research in itself. The outcome of these statistical tests can be summed up in the following points: (1) The "before" figure was an average of three nights previous to the treatment. (2) The "after" figures were expressed as percent increase or decrease from the "before" figure and were given separately for each of seven days following the treatment. (3) Whenever several traps or several treatments were averaged, the result was based not on averaging percentages of increase or decrease (Table 3), but on total mosquitoes involved (Table 2, Figs. 2 and 3). (4) The resulting reduction figures were not corrected for population trend assumed from trap collections on the outside of the control area since it was

TABLE 2.—Changes in densities of all biting female mosquitoes after ground fog and spray applications of DDT in Leesburg, Florida, in 1948 and 1949, based on the operation of seven light traps within the control area. Average densities for each of seven days following the treatments are compared with a three day average density previous to treatments and the results are expressed as percent deviations.

Species	Average Density Before Treatment	% reduction without ( ), % increase with ( ); days following treatment: 1	2	3	4	5	6	7
				TIFA 1948 16 treatments				
M. indubitans	20.08	60.0	70.4	62.8	35.9	12.1	(1.5)	6.0
M. perturbans	21.54	24.1	22.3	27.6	56.0	39.3	17.4	(44.5)
An. quad.	2.12	78.8	71.1	66.9	69.4	33.5	(6.4)	(21.6)
All biting spp.	58.56	44.5	51.5	46.0	39.7	24.2	16.8	14.3
				TIFA 1949 23 treatments				
M. indubitans	18.00	49.2	61.3	38.0	(16.5)	(29.7)	(16.3)	(18.8)
M. perturbans	25.72	33.6	33.6	26.0	2.6	23.1	8.8	26.9
An. quad.	1.40	65.4	80.2	58.4	33.8	23.0	26.2	1.1
All biting spp.	61.75	45.3	53.6	37.2	1.6	(7.9)	1.6	4.9
				BUFFALO 1949 10 treatments				
M. indubitans	24.20	48.6	41.6	25.3	(6.9)	(15.1)	(38.6)	(55.0)
M. perturbans *								
An. quad.	1.04	77.6	62.3	55.5	(4.4)	(2.8)	(48.8)	(50.5)
All biting spp.	65.62	47.0	52.3	42.4	31.5	2.0	19.0	(14.3)

* The Buffalo Turbine was not in operation during the *perturbans* season.

questionable whether results, thus corrected, would have been more valid.

IV. Evaluation of Techniques

The results of Tifa treatments for 1948 and 1949 are given in Table 2 and shown in Fig. 2. The reduction in all biting mosquitoes for both years averaged slightly over 50%. When this reduction is divided among the several mosquito species, however, important variations are evident. *Anopheles quadrimaculatus* was consistently reduced more than any other species, averaging a little over 80% for the two years. Since the main biological factor affecting the reduction rates was probably re-infiltration of the fogged area, it would be expected that the mosquito with the least flight range would show the best control, and this would be *A. quadrimaculatus*. Should this be the true explanation for the good results with that species, the same reasoning would indicate the *Mansonias* to have the greatest flight range of the important mosquitoes in Leesburg. As between *perturbans* and *indubitans*, the poorest results were obtained with *perturbans* in both years, and aside from the possibility of flight range effect, the reason may also be that *perturbans* breeding is more widely distributed and closer in than the *indubitans* breeding.

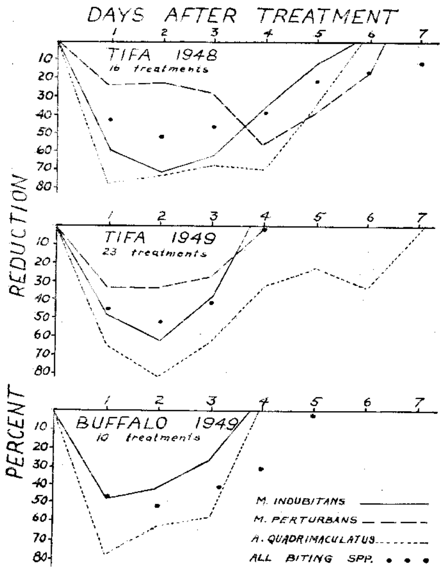

FIG. 2. Reductions in densities of female mosquitoes following ground spray and fog applications of DDT in Leesburg. Based on seven light traps in the control area. The horizontal lines represent average densities for three days previous to treatment.

Reductions following Buffalo Turbine treatments in 1949 compare favorably with fogging results in 1948 and 1949. As with the Tifa, the best reductions were obtained with *A. quadrimaculatus*. Because the turbine was not used early in the season, results with *M. perturbans* are not available. In the case of *M. indubitans*, a reduction of about 50% was achieved, the same figure as for all biting species combined.

If it were possible to delete from our figures the infiltration factor, the resulting reduction would be somewhere between the 50% for all species and the 80% for *A. quadrimaculatus*. In an investigation of 25 Tifa foggings in Illinois, each covering an area similar in size to Leesburg, Clarke (1948) reported an actual kill of 69% of the caged adult mosquitoes. The Leesburg data suggest an actual kill of about the same order.

Under the conditions prevailing in Leesburg in both 1948 and 1949, adulticide treatments resulted in substantial reductions for three to four days. In other words, it took that many days for an area of about 1100 acres, surrounded by unchecked breeding, to become reinfested with mosquitoes. When mosquitoes were emerging in large numbers, either *Mansonia* or *Psorophora*, there was frequently no significant reduction in adult numbers following treatments. At such times even semi-weekly treatments gave poor results. During lulls in mosquito emergence, treatments two weeks apart appeared adequate. It was obvious, both from the reductions obtained and from population trends on the outside of the control area, that a rigid routine of treatments, whether weekly or semi-weekly, would have been either inadequate during periods of maximum emergence or wasteful during lulls in mosquito production.

Under Leesburg conditions, the dosage of DDT was best presented in pounds per mile of itinerary. In 1949, the Tifa discharged on an average 5.2 pounds per mile and the turbine 2.0 pounds per mile. The best approximation would be, respectively, 0.29 and 0.11 pound per acre. Using the Tifa data, because it was more abundant and representative, it is seen that at dosages of less than 5.0 pounds per mile or roughly 0.3 pound per acre, the results were erratic; above these dosages they were consistently satisfactory. With the turbine, the dosages used were never great enough to bring out a point above which consistently good results were obtained. The overall results demonstrated that even in a wide open Tifa, driven at five miles per hour, a 5% DDT solution is inadequate; while in a turbine discharging 80 gallons an hour at the same speed, a 1% emulsion is not adequate. The Leesburg studies indicate that a Buffalo turbine should be operated at a vehicle speed of five miles per hour, discharging 125 gallons per hour of a 2½% DDT emulsion. If the itinerary is so planned that there are 12 acres treated for every mile of front, the theoretical dosage (i.e., computed as discharge) will be .44 pound of DDT per acre.

For a Tifa operating at five miles per hour and discharging 40 gallons per hour, an 8% DDT solution would seem indicated. At this discharge rate, Tifas usually produce a fog with particles of about optimum size for aerosol control of adult mosquitoes. Because of the unpredictable dispersion of aerosols out of doors and also because of the variation in block dimensions in cities, swath-width means precious little with this technique. Instead, an effort should be made to plan the itinerary so that every mile of travel will cover 12 acres of terrain. At a speed of 5 m.p.h., this should represent a discharge of .44 pound of DDT to the acre. This dosage is not as heavy as it appears when it is remembered that only 1.4% of the discharged insecticide will be deposited for every 100 feet of swath width (Yeomans, 1950). Clarke (1948), after extensive tests with Tifas, decided that an 8% solution of DDT in oil at the rate of .3 pound of DDT per acre was minimum for consistently good results,—which is essentially like our findings in Leesburg. The Bureau of Entomology and Plant Quarantine (Yeomans, 1950) recommends 500-foot swaths and ½ pound of DDT discharged per 100 feet of travel. This is the theoretical equivalent of .44 pound per acre. Although approaches to the problem may differ, we are substantially in agreement with Yeomans (1950), with Clarke (1948), and with our own findings in Leesburg when we suggest for Tifas:

(1) 65 lbs. DDT per 100 gals. oil (approximately 8%)

(2) 40 gals. per hour discharge (approximately 20-micron m.m.d.)

(3) 5 miles per hour speed

(4) 1 mile of front per 12 acres treated (approximately .44 lb. DDT/acre)

The last requisite could be met in any number of ways, e.g., by fogging one or two sides of a block, by doubling or tripling traverses, by skipping half-blocks, etc., etc. And of course, requisites (1) and (3) could also be varied to affect (4). Requisite (2), however, should be varied only under extremely well-considered circumstances.

V. EVALUATION OF PROGRAM

The experience of two years in Leesburg has amply demonstrated how very difficult it is to obtain an accurate measurement of space-spraying control results. Except in those rare cases of phenomenal reduction of mosquitoes from phenomenal numbers, public reaction is an exceedingly poor criterion of control achieved. In view of the fact that laymen in Leesburg expressed general satisfaction with the control program of 1948 and 1949, it becomes doubly interesting to consider the demonstrated, objective facts in the case. We find that the results varied greatly in three directions: with species of mosquito, with locations, and with treatments.

(1) *Species variation.* Reductions were far better with *A. quadrimaculatus* and other anophelines than with *Mansonia* and other culicines. They were much more satisfactory with *M. indubitans* than with *M. perturbans.* All analyses of species differences led to the same conclusion, viz., reductions were more satisfactory the more sedentary the species. (2) *Location variation.* There was no consistent pattern to the differences in reductions among the seven light-trap locations. The differences among these stations are clearly evident in Fig. 3. The mosquito species is seen to be the controlling factor. For *A. quadrimaculatus,* there were striking differences between stations only after the third day, for *M. indubitans* only the first day was without significant differences, while *M. perturbans* showed enormous differences throughout the post-treatment period. As

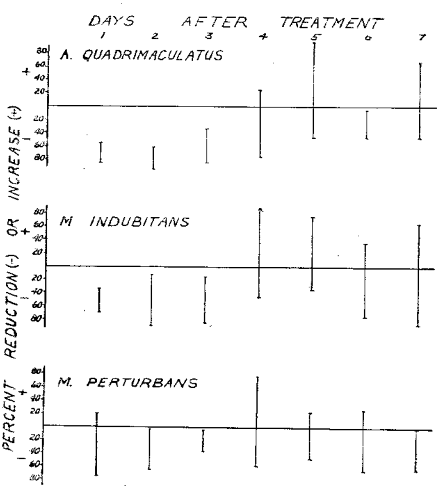

FIG. 3. Daily ranges of percent deviations in female mosquito densities for seven light traps in the control area. As in Fig. 2, the deviations are from three-day averages previous to treatment. Data based on twenty-three foggings in 1949.

with species variation mentioned earlier, this demonstrates the adaptability of space control methods to sedentary species and their erratic results with migratory species. (3) *Treatment variation.* This third variant was the greatest of them all. Consistent results were obtained only with anophelines. As stated earlier, all averages in this paper are for traps taken together and treatments taken together as though there had been but one trap and one treatment. Variations among trap locations and treatments were such that there was no alternative. It is readily seen in Table 3 that very few significant averages can be obtained from series of individual treatment results. So great is the variation in results among treatments that one treatment alone yields no significant information while even averaging ten treatments yields dubious information. The second day after treatment gave most of the significant averages; beyond the third day, significant averages were rare.

This variation in three dimensions has been reiterated to emphasize the necessity of evaluating a control program in terms of averages which consider all variables. An effective technique alone cannot guarantee a successful program.

It is very obvious from Fig. 4 that every treatment made a dent in the mosquito population. The average dent represents a 68% reduction from peak to lowest subsequent point and lasted three days. This evaluation thus parallels that already made for the technique, but the graph shows what the latter evaluation did not, viz., the significance of these reductions in the overall mosquito-density picture. It has long been judged that light-trap catches greater than 24 females per night indicate an annoyance. The State of New Jersey has even contemplated a lower figure. Using the arbitrary figure 24, it is seen that the Leesburg area was out of control virtually the entire season. The 1948 data are, incidentally, almost identical to the 1949 data depicted. The simple conclusion is that the dents in the mosquito population resulting from fogging were neither deep enough nor broad enough.

TABLE 3.—Average reductions in light trap collections of female mosquitoes. Results of individual treatments (i.e., % increase or decrease) are averaged rather than total samples as in Table 2. Only significant averages are given, with standard errors.

Species	Per cent reduction after treatment: 1st day		2nd day		3rd day	
	TIFA 1948 16 treatments					
M. indubitans	44.4	±10.03	57.4	± 9.42	51.9	± 9.94
M. perturbans						
An. quad.	80.7	± 4.29	75.6	± 5.64	74.1	± 4.88
All biting spp.	46.4	± 3.65	52.4	± 6.91	46.5	± 8.41
	TIFA 1949 23 treatments					
M. indubitans			44.0	±13.62		
M. perturbans			41.5	±10.17		
An. quad.	64.3	± 8.99	87.7	± 3.53	64.5	± 8.43
All biting spp.	41.4	± 6.23	56.7	± 5.04	32.7	± 8.34
	BUFFALO 1949 10 treatments					
M. indubitans						
M. perturbans						
An. quad.			87.5	± 6.00		
All biting spp.						

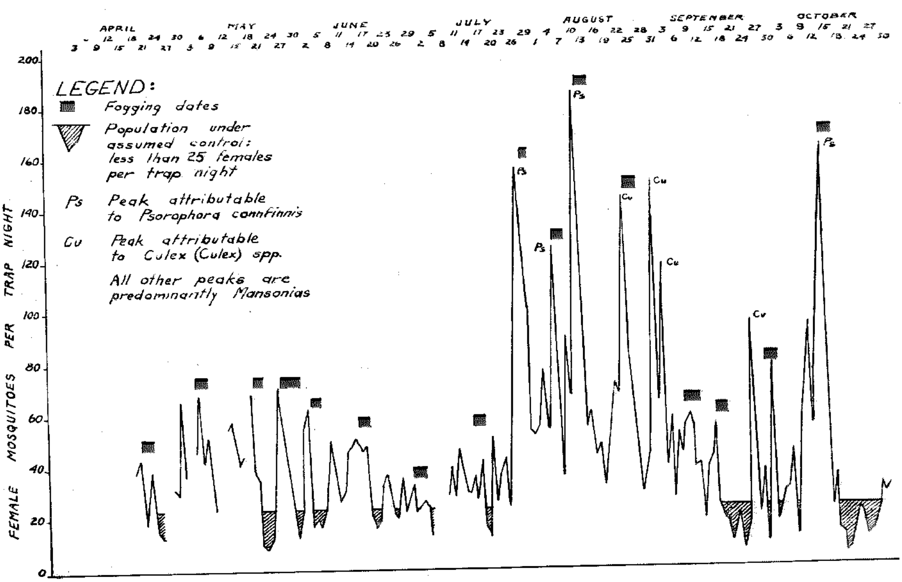

FIG. 4. Daily average collections, all biting female mosquitoes, for seven light traps in Leesburg control area in 1948. Showing relation to aerosol adulticiding program.

Statistical analysis of the voluminous Leesburg data bring out these further considerations: (1) The traps outside the control area showed the same number of reversals in density trend as those inside; connecting the peaks in Fig. 4 would, therefore, not present what the situation would have been without control. (2) Mean percentage deviation in outside and inside traps did not significantly differ; in other words, natural fluctuations in mosquito density were as great as fluctuations produced by control. (3) The percentage of collections with less than 25 mosquitoes in 1947, without control, did not differ significantly from the 1948 and 1949 figures. Even assuming greater mosquito production in 1948 and 1949, it is difficult to demonstrate how the fogging in these two years materially affected the seasonal mosquito-prevalence picture. All the satisfaction left is in the dubious conclusion that an average fogging reduced the mosquito hordes by some 50% for three or four days.

If mosquitoes are numerous enough to be an annoyance, surely an adequate control program should aim at something better than eliminating half of them some of the time. For the malaria mosquitoes in Leesburg, the average reduction was 80%, which is more in line with the expected and does speak very well for the technique in itself. If the other mosquitoes, representing the overwhelming majority, were either flying in or being produced in such numbers as to bring the average reduction down to only 50% for three or four days, it would seem that antimosquito measures other than adulticiding are indicated. In short, it is felt that the mosquito situation in Leesburg called for more than exclusive reliance on adulticiding.

There is some indication that these Leesburg findings may apply to any kind of space spraying under conditions of more or less continuous production of migratory mosquitoes. In Florida, the only serious mosquito pest which is always cyclical in production is the glades mosquito, *Psorophora confinnis*. Although the salt-marsh mosquitoes, *Aedes taeniorhynchus* and *Aedes sollicitans*, are normally produced in cycles or broods, there are many instances of continuous production over wide areas. For example, in Brevard County, salt-marsh mosquito broods succeeded one another so closely in 1948 that the vast breeding over the county's 50,000 acres of marsh could justly be called continuous. Aerial sprayings, with 5% DDT in oil at two quarts per acre, were three times as frequent as foggings in Leesburg. The average 24-hour reduction for 5 treatments, gauged by landing rates at 12 stations, was 45.9%. In Leesburg, 24-hour reductions, gauged by light traps, were 44.5%, 45.3%, and 47.0% respectively for Tifa foggings in 1948 and 1949 and Buffalo Turbine spraying in 1949 (Table 2). In both Brevard County and Leesburg, the reductions lasted three to four days. Experience in other sections of Florida (e.g., Lieux and Braddock, 1951) substantiates the evidence from these areas. It is thus concluded that where mosquito production in Florida is at all continuous and dominated by migratory species, exclusive reliance on adulticiding is unsatisfactory.

VI. Summary

A mosquito-control program in Leesburg, Florida, was evaluated in 1948 and 1949. The mosquitoes were predominantly *Mansonia* spp. The only control method employed was space spraying with DDT from the ground. The evaluation was made with New Jersey light traps. Reductions varied with mosquito species, with trap locations, and with individual sprayings. The overall conclusion was that the average spraying reduced the mosquito population by about one half, this reduction lasting three to four days. Exclusive reliance on adulticiding was judged unsatisfactory in any Florida mosquito control program where mosquito production is continuous and dominated by migratory species.

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MANSONIA INDUBITANS DYAR AND SHANNON IN PANAMA[1]

By STANLEY J. CARPENTER[2]

The females of *Mansonia indubitans* Dyar and Shannon are difficult to separate from those of *M. titillans* (Walker) unless the specimens are boiled in potassium hydroxide and the pattern of spines on the eighth abdominal tergite is examined under a microscope. Due to this tedious procedure necessary for accurate identification, *M. indubitans* has not generally been recognized in many areas in which it undoubtedly exists. Thus the distribution of *M. indubitans* and its relative abundance in relation to populations of *M. titillans* is not generally known.

Mansonia indubitans has been recorded in the literature from the following areas: BRAZIL—Several localities in central Brazil (Dyar and Shannon, 1925 and Shannon, 1934); PERU—Iquitos (Shannon, 1934); MEXICO—Mata Cabestra in Vera Cruz Province (Martini, 1935); BRITISH HONDURAS — Blue Creek and Rio Cacao (Martini, 1935); PUERTO RICO—Lake Cartegena (Tulloch, 1937), Fort Buchanon and Camp Tortuguero (Pratt, 1945); JAMAICA BWI—Clarendon Parish (Pratt, 1945); FLORIDA—Avon Park, Fort Pierce and Boca Raton (Chamberlain and Duffey, 1945), Boca Raton (Pratt, 1945); BOLIVIA—Several localities in the departments of Santa Cruz, Chuquisaca, Beni, Cochabamba, La Paz and the territory of Colonias (Cerqueira, 1943); PANAMA—Buena Vista, La Jolla 2, Cerro La Victoria and Juan Mina (Galindo *et al.*, 1950).

Galindo *et al.*, (1950) point out that the number of *M. indubitans* taken in connection with forest mosquito studies in Panama was undoubtedly much greater than is shown since time was generally not taken to separate them from *M. titillans*.

The localities that were trapped are as follows, with the number of *M. titillans* and *M. indubitans* captured in each. The types of traps are indicated by the symbols LT (light trap), HBT (horse-baited trap) and HC (hand catch).

La Jolla, Republic of Panama: *M*

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