past five years has been carrying on an educational program. Each year a list of recommended insecticides is published and distributed to all municipalities which are carrying on insect control programs or which are interested. Also a series of meetings have been held in the spring of each year. Unfortunately, the majority of these meetings have been poorly attended.

At the present time encephalitis is the only mosquito-borne disease in Nebraska. Although we have for years considered St. Louis encephalitis as endemic in eastern Nebraska, recently we have been able to demonstrate serologically that St. Louis encephalitis occurs throughout the state. Since *Culex pipiens* is of minor importance it is thought that *Culex tarsalis* is the principal vector in Nebraska.—WILLIAM F. RAPP, JR., Entomologist, State Department of Health, Lincoln, Nebraska.

# THE MOSQUITOES OF THE INTERNATIONAL AIRPORT, ISLA VERDE, PUERTO RICO, AS SHOWN BY LIGHT TRAPS

IRVING FOX [1]

School of Medicine—School of Tropical Medicine, University of Puerto Rico, San Juan, P. R.

The Puerto Rico International Airport is among the most important in the world, accommodating almost a million passengers a year (Gotay Montalvo, 1957). It is located about seven miles to the east of the Old City of San Juan on the north coast, in an area of great natural beauty and of high recreational value, where new housing developments and luxurious hotels are being constructed at a rapid rate. But this is a region of largely undeveloped land including many acres of saltmarsh which breed mosquitoes and sand flies in enormous numbers. The airport cost $16,000,000 to construct and property values in the environs and equipment, including that of an important Air National Guard base, would give a figure several times this amount as the total value of the area; nevertheless no significant part of the huge sums spent for construction go for insect control, despite the magnitude of the mosquito problem there. Since inauguration on May 22, 1955, popular clamor has been great that something be done about the mosquitoes and sand flies, but repeated attempts to secure an adequate appropriation by legislative action have so far been unsuccessful.

Despite the handicaps of an inadequate budget, it was possible to accomplish certain aspects of the survey work which is essential to control by limited use of personnel and equipment of the various interested agencies; in particular the gathering of data by light traps was feasible. Several of these were in operation by the U. S. Public Health Service before this project began. Others were added and the collections carefully studied with the following objectives: (1) To find out what species occur in the area and their relative abundance; (2) to ascertain any consistent seasonal variation of the pest species; (3) to obtain population data which may be used to gauge the effectiveness of control measures should they ever be instituted in the future; and (4) to obtain information on disease hazards.

[1] In cooperation with Félix C. García and Manuel Pérez Torres, Puerto Rico Department of Health; Dr. Marvin S. Cashion, U. S. Public Health Service; and O. L. Sands, Puerto Rico Ports Authority. Portions of this study were supported by the Puerto Rico Department of Health. Other portions were supported by Research Grant E-1225, from the National Institute of Allergy and Infectious Diseases, Public Health Service.

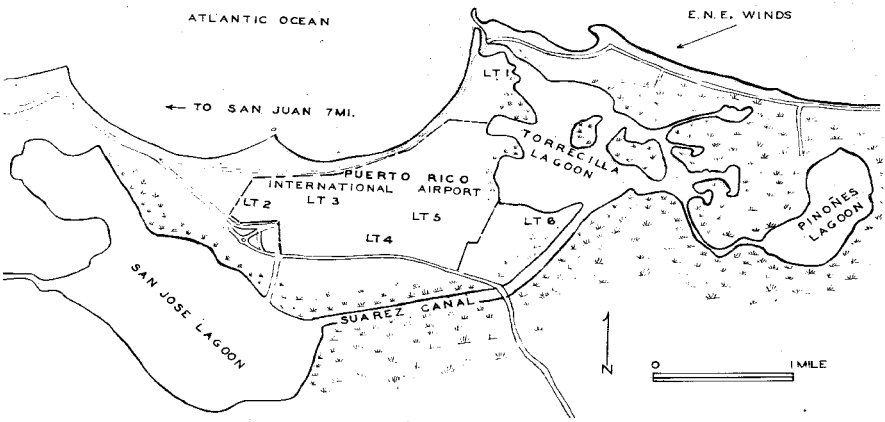


FIG. 1

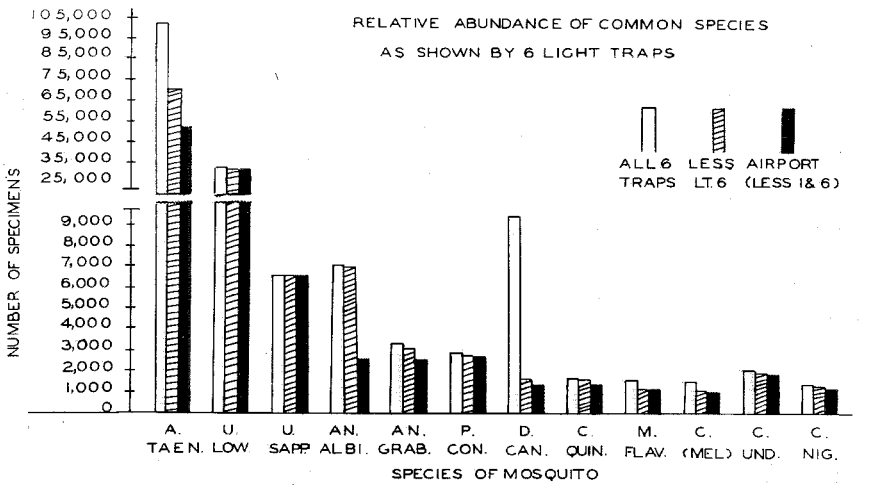


FIG. 2

FIG. 1.—Map of the International Airport and vicinity, Isla Verde, Puerto Rico.

FIG. 2.—Relative abundance of *Aedes taeniorhynchus, Uranotaenia lowii, Uranotaenia sapphirina, Anopheles albimanus, Anopheles grabhamii, Psorophora confinnis, Deinocerites cancer, Culex quinquefasciatus, Mansonia flaveola, Culex* (*Melanoconion*) species, *Culex* undetermined species, and *Culex nigripalpus* as shown by six light traps in 2,733 trap-nights during the period January 1, 1956 to December 30, 1957 at the International Airport and vicinity, Isla Verde, P. R.

Six New Jersey type light traps were operated, using 40 watt light bulbs. Four of the traps were within the fenced grounds of the airport proper (about 1200 acres) and two in the near vicinity; their locations are indicated on the map, Figure 1. The light traps were designated as follows: Lt. 1, Yacht Club (about a mile to the northeast of the airport limits at Boca de Cangrejos); Lt. 2, Maintenance Area (inside the fenced area of the airport proper but some distance to the west of the main buildings); Lt. 3, Terminal (airport proper); Lt. 4, Transformer (airport proper); Lt. 5, Water Tank (airport proper); and Lt. 6, International Park (a recreation area about a mile to the east of the airport on the shores of Torrecilla Lagoon). Various difficulties prevented the operation of one or the other of the traps at various times; however, from January 1, 1956 through December 30, 1957 the traps were run for a total of 2,733 trap nights. Except for Light Trap 6, the traps were operated more or less regularly during the two year period and the trap nights they functioned during each month are shown in Table 1.

A total of 176,053 mosquitoes were captured and identified. *Culex* males were all determined on the basis of the male terminalia, but most of the *Culex* females had to be counted either as "*Culex* undetermined" or "*Culex* (*Melanoconion*) species." The members of the other genera were determined using external characteristics. *Uranotaenia* and *Deinocerites* were not separated into males and females. In all, 26 species were encountered or about three-fourths of those known to occur in Puerto Rico and more than have ever been taken in light traps at any other place in the Island (Tulloch, 1937; Pritchard and Pratt, 1944; Fox, 1953; Fox and Maldonado-Capriles, 1953). The species captured in order of abundance of specimens are

TABLE 1.—Months of operation and trap-nights for each light trap at the International Airport and vicinity, Isla Verde, Puerto Rico, in 1956 and 1957

| Month | Lt. 1 | Lt. 2 | Lt. 3 | Lt. 4 | Lt. 5 | Lt. 6 | Total |
|---|---|---|---|---|---|---|---|
| 1956: | | | | | | | |
| January | 31 | 0 | 0 | 0 | 0 | 0 | 31 |
| February | 14 | 20 | 27 | 11 | 16 | 0 | 88 |
| March | 24 | 29 | 27 | 10 | 30 | 0 | 120 |
| April | 32 | 32 | 18 | 31 | 31 | 0 | 144 |
| May | 24 | 31 | 0 | 31 | 31 | 0 | 117 |
| June | 27 | 30 | 0 | 30 | 30 | 0 | 117 |
| July | 30 | 23 | 0 | 21 | 26 | 18 | 118 |
| August | 27 | 27 | 0 | 32 | 17 | 0 | 103 |
| September | 29 | 22 | 0 | 29 | 29 | 0 | 109 |
| October | 28 | 32 | 0 | 29 | 29 | 0 | 118 |
| November | 23 | 26 | 0 | 8 | 30 | 0 | 87 |
| December | 29 | 28 | 0 | 17 | 28 | 0 | 102 |
| 1957: | | | | | | | |
| January | 33 | 30 | 30 | 33 | 32 | 0 | 158 |
| February | 28 | 25 | 28 | 28 | 25 | 0 | 134 |
| March | 30 | 30 | 21 | 30 | 23 | 0 | 134 |
| April | 31 | 31 | 31 | 31 | 5 | 22 | 151 |
| May | 31 | 32 | 32 | 32 | 0 | 32 | 159 |
| June | 24 | 24 | 24 | 24 | 0 | 24 | 120 |
| July | 37 | 37 | 35 | 35 | 0 | 0 | 144 |
| August | 34 | 26 | 29 | 29 | 0 | 0 | 118 |
| September | 18 | 22 | 22 | 22 | 0 | 0 | 84 |
| October | 33 | 11 | 36 | 33 | 0 | 0 | 113 |
| November | 22 | 0 | 30 | 30 | 0 | 0 | 82 |
| December | 27 | 0 | 26 | 29 | 0 | 0 | 82 |
| Total | 666 | 568 | 416 | 605 | 382 | 96 | 2,733 |

TABLE 2.—Relative abundance of mosquitoes taken in light traps at the International Airport and vicinity, Isla Verde, Puerto Rico, in 1956 and 1957

| Species | Females | Males | Total |
|---|---|---|---|
| *Aedes taeniorhynchus* (Wied.) | 100,698 | 3,099 | 103,797 |
| *Uranotaenia lowii* Theob. | | | 32,740 |
| *Deinocerites cancer* Theob. | | | 9,649 |
| *Anopheles albimanus* Wied. | 6,786 | 183 | 6,969 |
| *Uranotaenia sapphirina* (O.S.) | | | 6,689 |
| *Anopheles grabhamii* Theob. | 2,740 | 648 | 3,388 |
| *Psorophora confinnis* (L.A.) | 2,194 | 605 | 2,799 |
| *Culex* undetermined | 1,896 | | 1,896 |
| *Culex quinquefasciatus* Say | 892 | 713 | 1,605 |
| *Mansonia flaveola* (Coq.) | 878 | 603 | 1,481 |
| *Culex* (*Melanoconion*) species | 1,398 | | 1,398 |
| *Culex nigripalpus* Theob. | 717 | 549 | 1,266 |
| *Culex atratus* Theob. | 14 | 839 | 853 |
| *Aedes tortilis* (Theob.) | 312 | 38 | 350 |
| *Anopheles vestitipennis* D. & K. | 277 | 70 | 347 |
| *Aedes sollicitans* (Walk.) | 280 | 12 | 292 |
| *Culex opisthopus* Komp | 56 | 125 | 181 |
| *Culex erraticus* (D. & K.) | | 155 | 155 |
| *Culex habilitator* D. & K. | 4 | 61 | 65 |
| *Culex iolambdis* Dyar | | 64 | 64 |
| *Culex sardinerae* Fox | | 15 | 15 |
| *Uranotaenia cooki* Root | | | 14 |
| *Culex chidesteri* Dyar | | 13 | 13 |
| *Psorophora pygmaea* (Theob.) | 13 | | 13 |
| *Aedes aegypti* (Linn.) | 4 | 3 | 7 |
| *Culex bahamensis* D. & K. | | 4 | 4 |
| *Culex pilosus* (D. & K.) | | 2 | 2 |
| *Culex americanus* (N.-L.) | | 1 | 1 |
| *Aedes mediovittatus* (Coq.) | | | 0 |

listed in Table 2. Included therein is *Aedes mediovittatus,* previously captured by other workers (Pritchard and Pratt, 1944), bringing the total taken by light traps operated in the airport and vicinity to 27 species. Ten species: *Ae. taeniorhynchus, U. lowii, D. cancer, Anopheles albimanus, U. sapphirina, An. grabhamii, Psorophora confinnis, C. quinquefasciatus, Mansonia flaveola* and *C. nigripalpus,* provided more than 95 percent of all the specimens taken. Light traps 1 and 6 were located outside the fenced area of the airport proper and Figure 2 shows graphically the relative abundance of the common species counting and not counting the results from these two light traps; when these two traps are eliminated the difference in relative abundance is significant only as regards *An. albimanus* and *D. cancer.* Light trap 6 was located nearest to the main breeding places of *Ae. taeniorhynchus* in the swamps to the east of the airport, and many more mosquitoes would have been collected had it been possible to operate this light trap as regularly as the others. As it was, in only 96 trap-nights, this light trap yielded about 30 percent of all the specimens of *Ae. taeniorhynchus* collected. The counts were as follows: July, 1956, 2,133 specimens; April, 1957, 501; May, 1957, 7,604;

FIG. 3.—Monthly average of *Aedes taeniorhynchus* per light trap-night for four light traps (Light traps 1, 2, 4, and 5), shown in solid lines, and the monthly rainfall in inches, shown in broken lines, 1956 and 1957, International Airport and vicinity, Isla Verde, Puerto Rico.

FIG. 4.—Monthly average of *Anopheles albimanus* per light trap-night for four light traps (Light traps 1, 2, 4, and 5), shown in solid lines, and the monthly rainfall in inches, shown in broken lines, 1956 and 1957, International Airport and vicinity, Isla Verde, Puerto Rico.

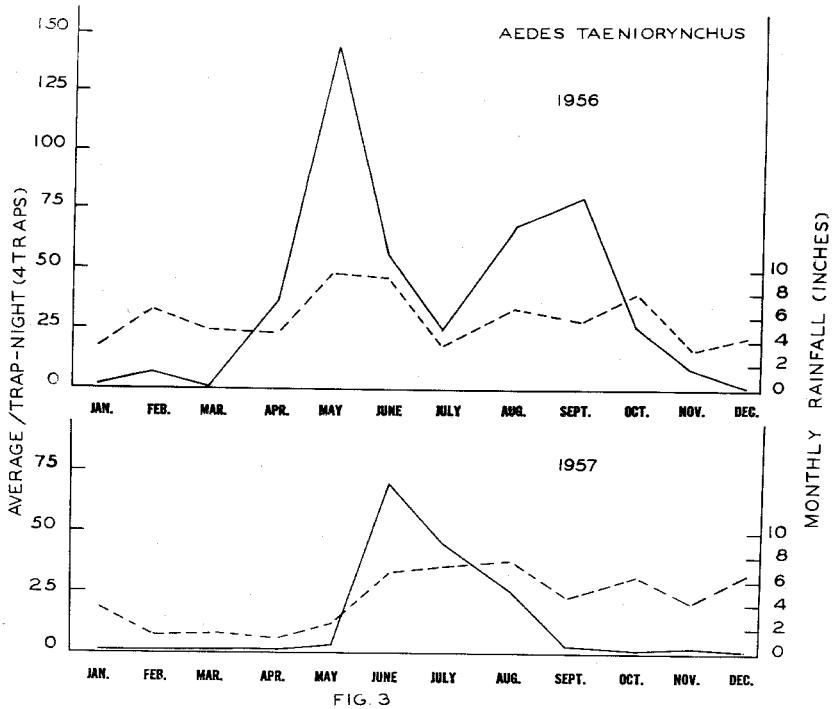
AEDES TAENIORYNCHUS
1956
1957
AVERAGE / TRAP-NIGHT (4 TRAPS)
MONTHLY RAINFALL (INCHES)
150
125
100
75
50
25
0
10
8
6
4
2
0
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

FIG. 3

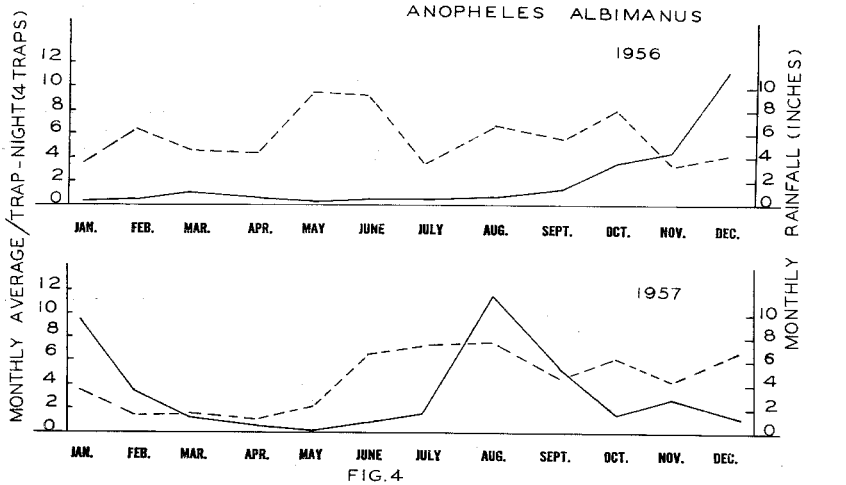
ANOPHELES ALBIMANUS
1956
1957
MONTHLY AVERAGE / TRAP-NIGHT (4 TRAPS)
MONTHLY RAINFALL (INCHES)
12
10
8
6
4
2
0
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

FIG. 4

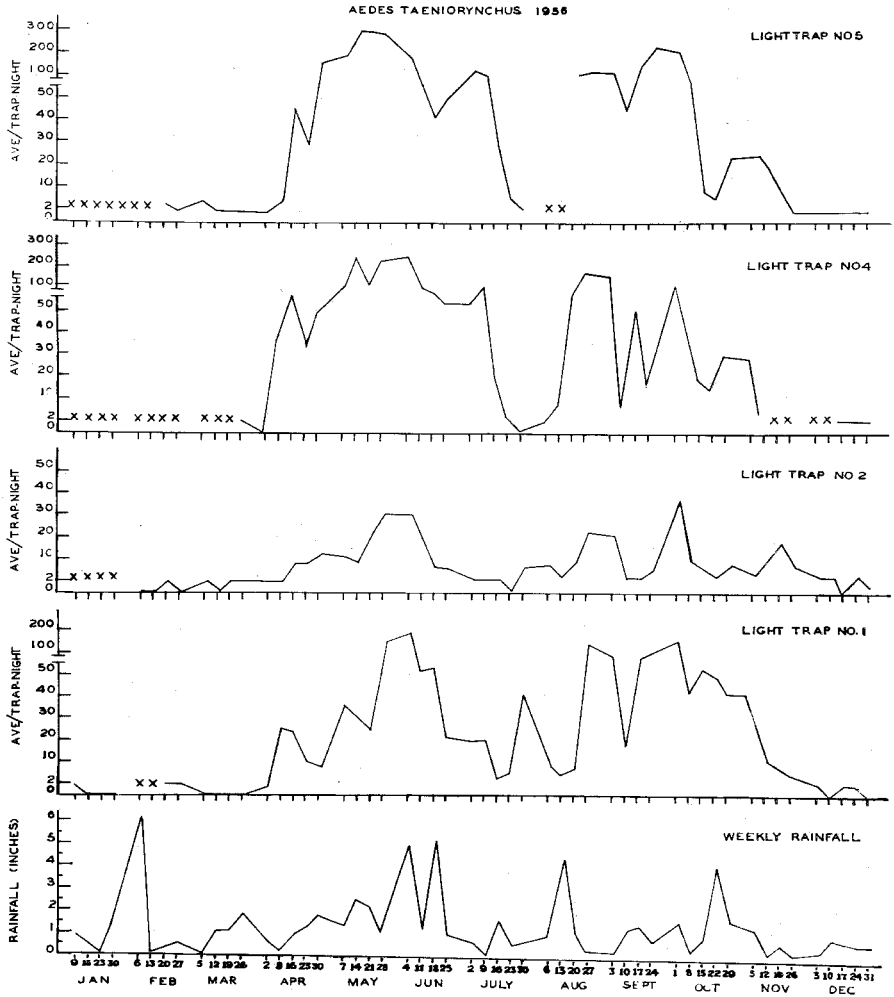


FIG. 5

FIG. 5.—Weekly average per light trap-night of *Aedes taeniorhynchus* for each of four light traps (for 2 read "2 or less"; and the letter "x" indicates that the light trap did not operate), compared with the weekly rainfall in inches at the International Airport and vicinity, Isla Verde, Puerto Rico, in 1956.

June, 1957, 24,102 (for the trap-nights see Table 1). On the other hand, light trap 2 was located farthest to the west away from the main breeding places and in the whole two year period in a total of 568 trap-nights only 3,051 specimens were taken. The light traps were eminently successful in providing worthwhile population data on *Ae. taeniorhynchus,* undoubtedly the main pest mosquito; but they failed entirely to give an indication of the abundance of *Ae. sollicitans* which occurred in very few numbers in the traps, although biting viciously in their vicinity. Nor is the data reliable as regards *C. quinquefasciatus,* which is probably much more abundant than indicated by the light traps.

The north coast of Puerto Rico has a very mild climate usually with temperatures from 70° to 90° and rainfall from 50 to 70 inches annually. Monthly rainfall may be quite variable from year to year, yet typically there are two rainy seasons with peaks in late spring or summer and again in the fall. During 1956 precipitation was heavy with 69.61 inches recorded at the airport; peak rainfall of about 9 inches occurring in the months of May, June, and October. In 1957 there was much less rainfall, 53.01 inches for the year, with very dry weather from February through May. The monthly average of *Ae. taeniorhynchus* for four light traps (light traps 1, 2, 4, and 5) was calculated and the results are shown graphically in Figure 3. Many more specimens were taken in the year of greater rainfall, 1956 than the one of lesser rainfall, 1957. In 1956 *Ae. taeniorhynchus* showed peaks and recessions of abundance which seemed to follow the monthly rainfall, but in 1957 it was abundant in the light traps only in the summer months, and there was no increase in mosquitoes corresponding to the second peak of rainfall in the late fall. From these data we may conclude that the abundance of *Ae. taeniorhynchus* will vary from year to year depending upon the rainfall and that it is most abundant from April to October of each year. The 1956 weekly average per trap-night was calculated for these same light traps and the results are shown graphically in Figure 5. The light traps are consistent in showing periods of abundance and scarcity even though certain traps yielded many more mosquitoes than others, indicating that the phenomenon is general. Comparison with the weekly rainfall seems to indicate that a sudden heavy precipitation does not influence the mosquito counts, rather it is high levels of rainfall over relatively long periods of time which result in an increase in the mosquitoes. Rainfall is of great importance, but undoubtedly other factors influence the seasonal variation of *Ae. taeniorhynchus.* The monthly average per trap-night of *An. albimanus* for the same light traps was also compared with the monthly rainfall and the results are given graphically in Figure 4. This species did not show any consistent seasonal variation or relationship to rainfall from year to year.

In Puerto Rico at the present time active transmission of pathogenic organisms by mosquitoes is not a serious problem with the possible exception of filaria. The main vector of filaria, *C. quinquefasciatus* is common, and in view of the rapid growth of housing developments in the vicinity of the airport with concomitant flood water and sewage disposal problems, this species will become as serious a pest here as it is throughout the Island. However, filariasis is a disease which is most prevalent inside institutions such as prisons and asylums where more or less permanent sources of infection exist (Maldonado, *et al.,* 1948). Malaria was formerly a disease of great public health importance in Puerto Rico, but it is now eradicated from the Island, although a few cases occur each year from transients (Puerto Rico Bureau of Malaria and Insect Control, 1955). The vector, *An. albimanus* is sufficiently abundant near the airport at certain times to cause an outbreak of the disease if the mosquitoes became infected. Yellow fever has not occurred on the Island for more than 50 years, although *Ae. aegypti* has

been fairly common. An eradication program began in 1950 by the Department of Health is in progress, but because of an inadequate budget it is not completely effective and considerable strengthening is required (Fehn and Hayes, 1956). In 1956 a recrudescence in population of this species occurred in the San Juan area and breeding places were found in the airport. Therefore, there is a hazard based on the possibility of the disease being introduced by an airplane passenger. There is little hazard from dengue, also transmitted by *Ae. aegypti,* for the last outbreak took place several decades ago (King, 1917) and the disease does not appear to occur in Puerto Rico today. The danger from mosquito-borne virus encephalitides is not known, as this group of diseases has not been reported from the mainland of Puerto Rico although it has been found on nearby islands. From a practical point of view the mosquitoes of the airport are of more importance as pests than as vectors of disease and in many persons their bites cause allergic reactions of varying severity. This is a more serious problem than is generally realized, and investigations are under way to ascertain the extent and intensity of the reactions, their specificity and immunological characteristics.

SUMMARY AND CONCLUSIONS. In 1956 and 1957 six New Jersey type light traps were operated at the International Airport and vicinity, Isla Verde, Puerto Rico, and in the course of 2,733 trap-nights, 176,053 mosquitoes were collected and classified. Of the 26 species of mosquitoes encountered in the light traps, *Ae. taeniorhynchus* was the most abundant. A consistent seasonal variation in abundance of this species favoring the summertime and apparently related to the rainfall was demonstrated by the light traps, and the population data obtained when correlated with climatic conditions should prove useful in measuring the effectiveness of control efforts when they are instituted. However, the light traps failed to give an indication of the true abundance of *Ae. sollicitans* and probably *C. quinquefasciatus.* Light trap counts of *An. albimanus* did not show any consistent seasonal variation from year to year. Only seven specimens of *Ae. aegypti* were taken in the two year period, but this was considered an important finding as it led to the discovery of breeding places in the airport. The hazards from mosquito-borne diseases are discussed and it is concluded that the mosquitoes of the airport are of more importance as pests and producers of allergic reactions than as vectors.

ACKNOWLEDGMENTS. Thanks are expressed to Dr. E. H. Hinman, Dean of the School of Medicine and Dr. Pablo Morales Otero of the Puerto Rico Legislature for their continuous encouragement in the work; to Dr. Alan Stone of the U. S. Department of Agriculture for checking the determinations of the species of mosquitoes, and to Mr. Víctor Medina, Mr. Francisco Romero Alemán and Mr. Víctor Villanueva for their assistance.

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