ever, in 1949 it required three men to make 17 applications which produced no results. In 1950 it took the three men only four days to make the application of chlordane emulsion, this time with very favorable results.

In conclusion, chlordane has proved to be more effective than DDT in this particular control problem. The cost has been about the same as DDT but the labor costs have been considerably less. Because of the scarcity of DDT and its prohibitive cost, chlordane larvicide is being adopted in Nassau County for the coming year as the basic larvicide. It is planned to continue experimenting with it and to test its effectiveness in controlling *Mansonia perturbans.*

MOSQUITO CONTROL WORK IN PORTLAND, OREGON AND VICINITY IN 1950

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The first serious attempt at mosquito control in the Portland vicinity came in the middle 30's. In 1934, a study was made by the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, with Entomologist H. H. Stage in charge. Results showed that the *Aedes,* or floodwater mosquitoes, were much more than a nuisance. Their presence caused losses running into thousands of dollars through decrease in milk production in dairy herds, inability to hire or keep labor in the truck crop area, and loss of tourist trade.

There are 34 species of mosquitoes known to occur in Oregon. They belong to 5 genera; *Aedes, Anopheles, Culiseta, Culex,* and *Mansonia.* Out of 34, we have nine species that are plentiful enough to warrant control. They are:

A. 1. *Aedes vexans* Meig
2. *Aedes sticticus* Meig (formerly known in this area as *lateralis* Meig)
3. *Aedes increpitus* Dyar
4. *Aedes dorsalis* Meig.

These species are found in the overflow areas along the Columbia and Willamette Rivers.

B. 5. *Culex tarsalis* Coq.
6. *Culex pipiens* Linn.
7. *Culiseta incidens* Thompson.

These species are found in semi-permanent and impounded bodies of water.

C. 8. *Anopheles punctipennis* Say
9. *Anopheles freeborni* Aitk.

These species are found in spring-fed lakes in both Multnomah and Clackamas County.

With Federal aid, extensive brush clearing of the mosquito breeding areas was done in 1935. When the floodwaters passed over these areas, oiling crews sprayed diesel oil on water where larvae were hatched. Since this work was done by rowboat or on foot, it was impossible to treat all the hatching areas. Indeed, only an estimated 25,000 out of a possible 80,000 acres were treated.

The work was continued until 1938, when Federal aid was withdrawn. By that time residents of Portland and Multnomah County had become aware of the advantages of mosquito control and protested its discontinuance. So the City of Portland and Multnomah County consulted to see what they could do, and be-

tween them, they budgeted $10,000 per annum for the continuance of the work, and the same sort of control program was carried on, but without brush clearing and otherwise in a more limited way. During the war years, however, mosquito control bogged down owing to the limited budget and rising costs.

In 1944, a dump truck and a power pump were acquired for use in control work. The following year, Mayor Lee initiated steps to establish the Bureau of Insect Control with mosquito control as its major problem.

In 1946, three flights were made with an Army bomber, experimenting with the dispersal of insecticide from aircraft. One thousand two hundred gallons of 25 per cent DDT concentrate cut to 5 per cent in diesel oil were used and a total of 3,000 acres was covered in 3½ hours of flight time. The results obtained were practically 100 per cent control for this area. It would have taken ten men 22 days using the usual method of spraying by hand from knapsack sprayers.

The City of Portland, therefore, went ahead with plans to use this type of control in the future, and early in 1947 purchased two surplus trainer planes and equipped them with thermal exhaust aerosol units and spray booms from plans developed by the Tennessee Valley Authority and the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

During the past four years, through the use of aircraft and other improvements, the mosquito problem in Portland and Multnomah County has become sufficiently well controlled to result in fewer and fewer reports of the presence of mosquitoes, particularly of the *Aedes* species.

The areas under mosquito control extend over a total of approximately 150 square miles covering not only Multnomah County, but other counties which contract with the City for control. In 1950, these counties were Clackamas in Oregon and Clark in Washington. Control is carried on not only in all areas affected by the spring and summer run-off of the Columbia and Willamette Rivers, but also impounded water areas, drainage ditches, artificial water bodies such as duck ponds and water hazards on golf courses. In the 1950 season, 78,000 acres were controlled by aircraft and 2,360 acres with ground equipment.

This year, it was necessary to carry on active *Aedes* control operations for a longer period than in prior years as the flood condition of the Columbia and Willamette Rivers continued for a period of 68 days, compared to a normal period of 35 days. Seven complete coverages of the breeding areas in Multnomah County were required using 27,180 gallons of oil and solvents and 16,121 pounds of chemicals. The Bureau aircraft flew a total of 456 hours and 18 minutes.

Due to the longer summer season, *Culex* and *Culiseta* mosquitoes were found in greater numbers than in prior years, indicating that climatic conditions play a large part in control operations. Because of the international situation which might cause a critical shortage in some of the necessary chemicals needed in control work, we deviated from our normal operations and carried on an experimental project under the supervision of C. M. Gjullin, Research Entomologist attached to the U. S. Bureau of Entomology and Plant Quarantine stationed at Corvallis, Oregon. In an attempt to find a non-critical insecticide which could be used for mosquito control, it was found that Nopco 1216 mixed at the rate of one gallon of Nopco to ten gallons diesel oil applied at the rate of two gallons per acre by aircraft gave excellent control.

The principal chemicals used were DDT and pyrethrum extract. These were blended in aromatic solvent 42, diesel oil and black oil, not exceeding 5 per cent DDT and 1½ per cent pyrethrum, dispersed at the rate of two quarts per acre. This combination gave a truly surprising control, both as a larvicide and adulticide. Complete toxicological data given by the manufacturers show that pyrethrum can be used in combination with DDT in these percentages without any added toxic

hazard to human beings or warm blooded animals. The diesel oil used meets Federal Specification V-K-211A, having a specific gravity between 0.824 and 0.795 at 60° F. The black oil used is a pure petroleum product free from fatty oils, fatty acids, resins, soaps or other non-hydrocarbons, sediments, and sludge. Aromatic solvent 42 is methylated naphthalene, specifications for which can be obtained from U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

The Bureau of Insect Control owns and operates a North American AT-6 equipped with a 600 h.p. Pratt and Whitney engine, which has been converted to a spray plane. Controls and instrument panels were removed from the rear cockpit and a 96 gallon tank fabricated and placed in position directly in back of the pilot's seat in the front cockpit and resting one inch beyond center of C/G line. A 12-volt electric driven pump was constructed and mounted on fuselage members directly beneath the tank. The boom is 42 feet long, mounted nine inches below the wing surface. It is attached 3½ inches behind the leading edge at the wing tip diagonally to a point directly beneath the fuselage at the trailing edge of the wing. Nozzles are spaced 12 inches apart, using Chicago Spraying Systems diaphragm T-jets with No. 6510 tips. T-jet diaphragm valves open at five pounds PSI. The operating pressure of the system is 40 pounds with a dispersal rate of 18 gallons per minute at 133 miles per hour, applying two quarts to the acre at 50 to 75 foot levels. This plane was operated the entire season of 1950 without mishap or breakdown in the spray system and has proved to be a very satisfactory airplane for the type of area that we control here.

We also had a Boeing PT 17 equipped with a 220 h.p. engine with an exhaust stack five inches in diameter installed lengthwise of the fuselage. A 2½ inch venturi is attached to the end of the 17-foot stack with two Monarch .0015 spray nozzles projecting into the venturi throat with a distributing rate of 5.5 gallons per minute at 70 miles per hour. A 70 gallon insecticide tank of tear drop design is mounted on bomb shackles beneath the fuselage of the plane with a wind-driven Overdorfer bronze gear pump mounted on the under-carriage. This airplane, while being very efficient in small, level areas, has been very high on maintenance. A breakdown on operational costs between the Boeing and North American, this past season, showed that while the North American used much more gasoline, it did three times the amount of work that the Boeing did. We disposed of the Boeing and have recently purchased a Douglas A-25, which is an all-metal airplane of approximately the same design as the North American and will be equipped with the same type of dispersal system.

As we are operating from a fixed base at the Portland-Troutdale airport, it became necessary for us to purchase a tank truck, which is a four-wheel drive truck with an 1,850 gallon tank. This is used to transport insecticide from our mixing plant to the airport. For our ground control work, we have a Lawrence Aero-Mist, a Hardy Sprayer, and a high-velocity Friend Duster.

We have found it advisable to obtain the following meteorological data before conducting spray flights:

1. *Relative Humidity,* which is determined by the use of a sling psychrometer.

2. *Wind Velocity,* which is determined with the aid of an anemometer, as aerial spraying cannot be done with wind velocity exceeding four miles an hour.

3. *Conversion and Inversion Temperature Conditions,* determined by placing one thermometer one foot above the ground and another thermometer six feet above the ground, a difference in temperature indicating whether the air is rising or falling. For airplane spray application, inversion temperatures are most desirable, as the settling rate of spray particles in still air is proportional to the square of particle radius, according to Stokes' law, which is applicable to spherical particles of less

than 300 microns diameter. However, in the wake of an airplane, there exists a pronounced downdraft which imparts to spray particles settling velocities which are greatly in excess of the velocities indicated by Stokes' law. A 50-micron droplet of 5 per cent DDT solution will settle in still air at about 17 feet per minute, while in the wake of an airplane it has a downdraft of 600 feet per minute. This factor is of greatest importance in the deposition of fine spray droplets. Satisfactory spray results with minimum dosages can be secured only under the proper meteorological conditions of still air existing at dawn and dusk, when breezes are at a minimum and inversion conditions exist.

Starting last year, ground markers were placed indicating areas and swaths so the pilot can locate areas and treat them with minimum loss of time. Radios have also been installed in the aircraft so that they can be in communication with the tower and also with a Bureau automobile which, too, is equipped with radio, eliminating the necessity of employing flagmen. This arrangement provides an increased measure of safety, as in an emergency the pilot can communicate directly with the Bureau and vice versa.

We have had a very successful mosquito control this past season and hope to achieve the same degree of control this coming year.

EQUIPMENT AND MATERIALS USED IN CONTROL OF GNATS IN CLEAR LAKE, CALIFORNIA

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The Clear Lake gnat, *Chaoborus asticotopus* D. & S., has been a source of annoyance to the residents near Clear Lake in California for many years. The gnats do not bite, but enormous numbers flying around lights and into houses on summer evenings cause distress and discomfort. Outdoor gatherings and activities are all but impossible.

Research by the Corvallis, Oreg., laboratory of the Bureau of Entomology and Plant Quarantine indicated that several of the chlorinated hydrocarbon insecticides were effective in killing gnat larvae. One of the compounds, TDE (dichlorodiphenyl dichloroethane) was selected as having exceptional promise because it was relatively nontoxic to fish. Tests in two small lakes (Lindquist and Roth, 1950) gave encouragement that a TDE emulsion could be used safely and that the gnat might be controlled in Clear Lake. The emulsion concentrate contained 30 grams of TDE, 10 ml. of Triton X-100, and 72 ml. of xylene.

The Board of Trustees of the Lake County Mosquito Abatement District were willing to proceed with a control project on Clear Lake. The County district financed the operation with assistance from the State of California through the Bureau of Vector Control. The writers worked out plans for applying 14,000 gallons of the insecticide over the lake.

Clear Lake covers an area of approximately 40,000 acres, and has a water depth up to about 65 feet in a few places. The shore line is about 150 miles and the greatest distance across is about 8 miles. Frequent storms creating heavy wave action had to be considered in making plans for size of boats and barges to be used.

Studies by the writers had shown pronounced subsurface currents running in a somewhat circular pattern in the large arm