A comparison of Freon- and water-based insecticidal aerosols for aircraft disinsection *

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In Miami, USA, passenger compartments of wide-bodied jet aircraft were disinfected at "blocks away" or while parked. The application of 2% Freon- and water-based formulations of (+)-phenothrin at about 35 g/100 m³ was highly effective against mosquitos and flies in all instances. More basic research is needed on water-based aerosols.

Over the past several years, as the possible dissemination of insect vectors of disease by aircraft has become increasingly important, the US Department of Agriculture, in cooperation with the World Health Organization, has developed improved materials and methods for disinsecting aircraft (1–4).

In 1977, the Committee on International Surveillance of Communicable Diseases and the Thirtieth World Health Assembly (5) approved a 2% aerosol formulation of (+)-phenothrin in Freon 11+12 (1:1 ratio), to be applied at 35.3 g/100 m³ at "blocks away", for inclusion in the International Health Regulations (1969) as a method of disinsecting aircraft.

To reduce the risk to the ozone layer, the US Environmental Protection Agency has issued proposed rules that will eliminate almost all manufacturing, processing, and commercial distribution of fully halogenated chlorofluorocarbons used as aerosol propellants (6). The use of these propellants in formulations for space-spraying of aircraft against flying insects is exempt from the ban, but this may not always be the case.

Therefore, during the past year, water-based, hydrocarbon-propelled systems have been compared with the usual Freon system at the Beltsville Research Center, MD, USA (7). A typical patent on water-based systems was taken out by S. C. Johnson & Son in 1964, a and Takashi et al. (8) recently reviewed the literature on water-based aerosols.

MATERIALS AND METHODS

The 6- to 8-day-old insects tested were: mosquitos (Aedes taeniorhynchus and Anopheles quadrimaculatus); houseflies (Musca domestica); and Caribbean fruit flies (Anastrepha suspensa). Prior to each flight, cylindrical (5.5×7 mesh/cm) wire screen cages 20.3 cm long and 6.4 cm in diameter containing either mosquitos or houseflies and cages containing Caribbean fruit flies (made by replacing both ends of 1-pint (9 cm long×8.6 cm diameter cardboard cartons with 5.5×6.29 mesh/cm nylon screen) were removed from sealed plastic bags and placed in the aircraft on a forward seat, under a middle seat, and on top of a rear coat rack.

The trials were conducted in aircraft of Eastern Airlines at the International Airport, Miami, FL, USA on 9–10 May 1977, during several pilot training

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a US Patent No. 3 159 535.
Table 1. A comparison of the effectiveness of Freon- and water-based aerosol formulations of 2% (+)-phenothrin against four insect species in Lockheed 1011 aircraft

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Temperature (°C)</th>
<th>Aerosol tested</th>
<th>Dose (g/100m²)</th>
<th>Location of test insects in aircraft</th>
<th>Insect knockdown in 15 min (%)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Musca domestica a</td>
<td>Anastrepha suspensa</td>
<td>Aedes taeniorhynchus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4 h)</td>
<td>(24 h)</td>
<td>(4 h)</td>
</tr>
<tr>
<td>1.</td>
<td>23</td>
<td>Water-based b</td>
<td>31.4</td>
<td>On seat (forward)</td>
<td>81 (38)</td>
<td>67 (15)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Under seat (middle)</td>
<td>100 (29)</td>
<td>33 (9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Top of coat rack (rear)</td>
<td>75 (20)</td>
<td>56 (9)</td>
</tr>
<tr>
<td>2.</td>
<td>22</td>
<td>Freon-based d</td>
<td>32.5</td>
<td>On seat</td>
<td>71 (56)</td>
<td>13 (100)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Under seat</td>
<td>70 (37)</td>
<td>5 (100)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Top of coat rack</td>
<td>100 (72)</td>
<td>90 (100)</td>
</tr>
<tr>
<td>3.</td>
<td>21</td>
<td>Water-based</td>
<td>33.5</td>
<td>On seat</td>
<td>60 (47)</td>
<td>0 (128)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Under seat</td>
<td>100 (67)</td>
<td>16 (124)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Top of coat rack</td>
<td>100 (53)</td>
<td>90 (98)</td>
</tr>
<tr>
<td>4.</td>
<td>21</td>
<td>Freon-based</td>
<td>32.5</td>
<td>On seat</td>
<td>75 (48)</td>
<td>13 (111)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Under seat</td>
<td>42 (65)</td>
<td>17 (65)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Top of coat rack</td>
<td>100 (45)</td>
<td>96 (48)</td>
</tr>
</tbody>
</table>

Aerosol applied at "blocks away"

Aircraft on ground

| 5.       | 24              | Freon-based    | 35.3           | On seat                              | 75 (28)                     | 50 (10)        | 20 (15)        | 100          | 100          | 100          |
|          |                 |                |                | Under seat                           | 69 (28)                     | 17 (11)        | 20 (5)         | 100          | 100          | 100          |
|          |                 |                |                | Top of coat rack                     | 100 (25)                    | 83 (8)         | 71 (14)        | 100          | 100          | 100          |
| 6.       |                 | Control (1 and 5) e | 0 (71)         | 0                          | 0                          | 0                          | 10                          | 0                          | 0                          |
| 7.       |                 | Control (2, 3, and 4) f | 0 (152)        | 0 (372)                      | 0 (16)                     | 0 (152)        | 9                          | 1                          | 6                          | 14                          |

a Multiple resistant to insecticides.
b 2.03 % (+)-phenothrin (98.5%), 0.87 % Span 80, 0.03 % Tween 60, 30.00 % propellants (80 % isobutane, 20 % propane), 67.07 % deionized water.
c The figures in parentheses indicate the number of insects exposed.
d 2.09 % (+)-phenothrin (95.8%), 97.91 % propellants (Freon 11:12) (1:1).
e Controls for tests on 9 May 1977.
f Controls for tests on 10 May 1977.
flights aboard Lockheed 1011 wide-bodied aircraft (cabin volume 498 m\(^3\)). In four tests, an aerosol was sprayed at "blocks away" (as the aircraft taxied for take-off). This is a period during which air exchange occurs every 3–4 min, i.e., about 5% more often than when the aircraft is in normal flight (the airflow was from the front to the rear of the aircraft). Also, in one test, the aircraft was on the ground with no ventilation except that from an open door in the forward part of the aircraft.

The water-based aerosol was supplied by S. C. Johnson & Son, Racine, WI, USA and the Freon-based aerosol was prepared at the Beltsville Agricultural Research Center. The (+)-phenothrin was obtained from Sumitomo Chemical Co., Osaka, Japan. The rate of release of the Freon-based aerosol was about 1.1 g/s; the water-based aerosol had a similar initial rate of release, but the rate decreased as the contents of the can decreased. The volume mean diameter of both aerosols had been determined in previous studies to be about 8 \(\mu\)m (7).

During taxiing prior to take-off, the desired dosage (35.3 g aerosol/100 m\(^3\)) was obtained by timing the release as the operator walked down one aisle and returned along the parallel aisle at a normal pace, spraying the aerosol from side to side just above eye level at a slightly upward angle. The exact dosage was determined by weighing the aerosol can before and after each application. Fifteen minutes after treatment, the insects were observed and the percentage knockdown was recorded. This exposure period was selected since previous studies (4) had demonstrated that 90% of the aerosol was removed by the air-conditioning system in a 10-min period. After exposure, the containers were placed in plastic bags, which were then sealed and removed to a constant temperature laboratory (25°C) after the flight. There the insects were fed sugar-water. Mortality of the mosquitoes and the houseflies was determined after 4 h; that of the fruit flies was determined after 24 h. Similar counts were made of control insects held in sealed plastic bags aboard the aircraft during the test flight.

RESULTS AND CONCLUSIONS

The basic data and the data on insect knockdown and mortality for each test flight are given in Table 1. The water- and Freon-based formulations with 2% (+)-phenothrin were equally effective against adult \(A.\) quadrirnaculatus, \(A.\) taeniorhynchus, \(M.\) domestica, and \(A.\) suspensa at doses of 31.4–35.3 g/100 m\(^3\). The results were similar whether the aircraft was disinfected at "blocks away" or while stationary on the ground. In all instances, the treatments were satisfactory for quarantine purposes. However, disinfestation at "blocks away" is recommended (7).

Although knockdown of the insects could be enhanced by the addition of a pyrethroid with faster knockdown qualities, e.g., bioresmethrin (trans-(+)-resmethrin), the dose of 31.4–35.3 g/100 m\(^3\) of 2% (+)-phenothrin in Freon 11+12 (ratio 1:1) gave excellent kill of houseflies and Caribbean fruit flies. The 17.6 g/100 m\(^3\) dose used in earlier tests did not give satisfactory quarantine control (9). The Caribbean fruit fly was included because it is the most difficult of the subtropical fruit flies to kill. The water-based aerosol gave similar results.

With the ever-increasing world population, it becomes more important to develop a safe and non-offensive insecticidal formulation for disinfesting aircraft that is effective against insects of agricultural importance and also insect vectors of disease. We believe that the Freon-based 2% (+)-phenothrin formulation at 35.3 g/100 m\(^3\) is a step in the right direction. Moreover, the water-based aerosol appeared promising for disinfesting aircraft, although the cans required shaking before use. More research is needed on water-based aerosols to ensure that:

1. There are no deleterious effects of any components of the formulation on the internal structure or components of aircraft.

2. There is no possibility of a fire hazard from the propane and isobutane propellants used in water-based aerosols. Faulty seams or valves, corrosion or rusting of cans in storage, and discharge of the contents without shaking are important in this respect.

3. Extremely high quality control can be maintained in the manufacture of water-based aerosols. This is necessary to achieve the efficacy needed for quarantine purposes, and such quality control might not always be attainable.

4. Water-based aerosols are effective against a wide spectrum of agricultural insects. This must be determined before such formulations are submitted for registration.
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REFERENCES