

# Why aircraft disinsection?

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A serious problem is posed by the inadvertent transport of live mosquitoes aboard aircraft arriving from tropical countries where vector-borne diseases are endemic. Surveys at international airports have found many instances of live insects, particularly mosquitoes, aboard aircraft arriving from countries where malaria and arboviruses are endemic. In some instances mosquito species have been established in countries in which they have not previously been reported. A serious consequence of the transport of infected mosquitoes aboard aircraft has been the numerous cases of "airport malaria" reported from Europe, North America and elsewhere. There is an important on-going need for the disinsection of aircraft coming from airports in tropical disease endemic areas into nonendemic areas. The methods and materials available for use in aircraft disinsection and the WHO recommendations for their use are described.

**Keywords:** mosquito control, methods; malaria, transmission; aircraft; insect vectors; insecticides, administration and dosage.

Voir page 1001 le résumé en français. En la página 1002 figura un resumen en español.

## Introduction

Since the inception of international air traffic there has been concern that mosquito vectors and the diseases they transmit might be introduced by aircraft into countries where they were not previously found (1, 2). Thus, consideration was already being given in the early 1930s as to how aircraft might be disinsected so as to prevent this from happening.

In conjunction with its Collaborating Centres, WHO conducted field trials on various materials and methods for the disinsection of aircraft and developed recommendations on this basis. Foremost among the recommended methods is "blocks away" disinsection, in which an insecticide aerosol spray is applied to the interior of aircraft just before they begin taxiing for take off (3, 4).

Many countries insist that arriving aircraft be disinsected, especially if they have come from areas where vector-borne diseases are endemic. It is common for an arriving aircraft to be sprayed by the health services of the country of destination if there is any doubt as to whether treatment has been applied earlier in the flight. Moreover, there have been instances in which the suspension of landing rights has been proposed unless evidence of disinsection was provided by the crews of arriving aircraft.

Concern has been expressed about possible adverse effects on passengers and crews of the

application of pyrethroid aerosol sprays for the disinsection of aircraft. A detailed review conducted by WHO led to the conclusion that no toxicological hazard was attributable to any of the materials or methods recommended for use in aircraft disinsection and that they were safe to use in the presence of passengers and crew (5).

There have been reports that the "blocks away" method and other types of aerosol disinsection used with passengers on board, such as the "top of descent" method (6), are of limited effectiveness and that live mosquitoes have arrived in aircraft following blocks away disinsection (7). Mosquitoes can conceivably survive if treatments are not properly effected and if aerosols do not reach all areas where the vectors rest, for instance in overhead baggage racks. There is a need to improve disinsection methods (8).

## Vectors introduced by aircraft

There have been frequent instances of insects of public health importance being introduced from one country to another, with occasional dire consequences. Until the advent of passenger aircraft in the 1920s such occurrences were mainly associated with ships. For example, *Anopheles gambiae*, a major vector of malaria, was probably introduced into Brazil in 1930 from Senegal by a French naval vessel, although the possibility that an aircraft was responsible cannot be excluded. This mosquito was first observed in a flooded field 2.5 km from the port of Natal and subsequently spread rapidly to other parts of Brazil. As a result, there was a great increase in the transmission of malaria and a sharp increase in mortality from the disease in the country. The importation and subsequent establishment of this

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highly efficient vector led to an epidemic of malaria involving ca. 300 000 cases and 16 000 deaths. A costly campaign was successfully conducted to eradicate the vector from Brazil (9).

The Government of Brazil was concerned about the possibility of *A. gambiae* being re-introduced into the country. After eradication was achieved, therefore, aircraft arriving in Brazil from Africa continued to be inspected. Over a nine-month period in 1941–42 the vector was found on seven occasions on such aircraft. During the inspections, 132 mosquitoes and two live tsetse flies were found. This led the government to insist that all aircraft arriving from Africa be disinfected by means of pyrethrum spray before the passengers disembarked.

The first reported occurrence of insects in an aircraft was in 1928 when a quarantine inspector boarded the dirigible *Graf Zeppelin* on its arrival in the USA: 10 species of insects were discovered on plants (10).

Inspections of 102 aircraft arriving at Miami during 1931 from various airports in the West Indies and Central America after flights lasting a day yielded 28 live *Culex quinquefasciatus* and one live *Aedes aegypti* (1).

In the 1930s the Government of India drew up recommendations for preventing mosquito vectors of yellow fever from being imported on aircraft arriving in the country. The recommendations included measures to disinsect aircraft by spraying them on arrival before the doors were opened. It was also recommended that all aircraft flying to India be provided with hand sprayers and pyrethrum so that they could be sprayed during long flights (2).

The results of surveys of insects found in aircraft are summarized in Table 1. There have been additional reports of vectors that probably became established in countries through being introduced by international air or sea transportation (19); however, since these do not include reports of finding vectors on aircraft, they are not included here.

Among more than 20 000 insects found in aircraft during a 13-year survey conducted by the US Public Health Service (16) were 92 species of mosquito, 51 of which were not known to occur in mainland USA, Hawaii, or Puerto Rico.

In 1960–61, baggage compartments and cabins were inspected in 210 aircraft at New Orleans airport, 1183 at Miami international airport, and 89 in Honolulu. A total of 81 mosquitoes were recovered in New Orleans, 32 in Honolulu, and 100 in Miami. The species found in Miami and Honolulu were generally not native to the USA and the insects appeared to have been attracted more to the illuminated cabins than to the baggage compartments (12).

The usual rate of malaria infection of anopheline vectors in Africa is 2%. Only a minority of mosquitoes on aircraft find a host and favourable conditions for survival on arrival from Africa. It was estimated that 2000–5000 anopheline mosquitoes were imported into France during a three-week period in 1994 when six cases of airport malaria

occurred at Roissy (29). During this period, 250–300 aircraft arrived from areas of Africa where malaria is endemic, and it was estimated that 8–20 anopheline mosquitoes were imported on each flight. This does not take account of the common potential vector mosquitoes that were probably also on the aircraft.

Mosquitoes are not always transported in passenger cabins. For example, *A. aegypti* eggs were found in surveillance ovitraps in Bermuda airport during 1982 and were subsequently discovered to be breeding in the freight shed. The species was probably reintroduced in infested airfreight containers (27), which may become a more common vehicle as volume of traffic increases. At Forbes Air Base in Kansas, 16 live larvae of *A. aegypti* and *Culex cinerellus* were found in May 1968 in water on a tarpaulin that had been stored in the open in Liberia before being placed on a US military aircraft. The aircraft had left Charleston, SC, on 28 April and had made stops in Suriname, Liberia and the Azores (22).

Cockroaches are frequently found in the galleys of passenger aircraft, and their introduction into countries where they have not previously been found may be attributable to this source (30).

## Consequences of the importation of mosquito vectors

The public health consequences of the importation of mosquito vectors from countries where certain diseases are endemic into countries where they are not, are as follows:

- if the mosquitoes are infected they may transmit disease in the country of arrival, e.g. airport malaria;
- the importation of an infected vector may result in the establishment of autochthonous transmission by a local vector;
- introduced mosquitoes may become established in the countries into which they have been imported, especially in tropical or semitropical areas;
- the introduction and establishment of an imported vector may necessitate a costly control programme, as occurred with *Anopheles gambiae* in Brazil and Egypt and recently with *Aedes albopictus* in the USA and Italy.

## Transmission of disease by mosquitoes imported on aircraft

**Airport malaria.** The most direct evidence of transmission of disease by mosquitoes imported on aircraft is the occurrence of airport malaria, i.e. cases of malaria in and near international airports, among persons who have not recently travelled to areas where the disease is endemic or who have not recently received blood transfusions. Airport malaria should be distinguished from imported malaria

Table 1. Reports of mosquitoes in aircraft

Date	Place	Origin	Species found	Reference
1931	Miami	Caribbean	<i>Culex quinquefasciatus</i> <i>Aedes aegypti</i>	1
1933	Kisumu, Kenya	Juba, Sudan	<i>Anopheles gambiae</i> s. l.	11
1936–41	Hawaii	California	<i>Culex quinquefasciatus</i> <i>Anopheles pseudopunctipennis</i> <i>Culiseta incidens</i>	12
1939	Marseilles	West Africa	<i>Anopheles gambiae</i>	13
1938–41	Darwin, Australia	<i>Anopheles</i>	<i>Aedes</i> <i>Culex</i> <i>Mansonia</i>	14
1941–42	Brazil	West Africa	<i>Anopheles gambiae</i> s.l.	11
1942–45	Brazil	West Africa	<i>Anopheles gambiae</i> s.l.	15
1946–60	USA Brownsville Honolulu Houston New York Miami	Asia Americas	<i>Anopheles grabhami</i> <i>Anopheles neomaculipennis</i> <i>Anopheles vestipennis</i>	16
1950	Cyprus	Portugal	<i>Anopheles superpictus</i>	5
1950	Auckland, New Zealand	Fiji Sydney	<i>Aedes aegypti</i> <i>Culex annulirostris</i>	17
1952	Auckland	Fiji	<i>Culex annulirostris</i>	18
1955–59	Bombay, India New Orleans	? ?	<i>Culex</i> spp.	19
1960–61	Honolulu Miami		220 mosquitos including 6 species not found in the USA	20
1964–68	Manila	?	52 live and 482 dead mosquitos	21
1968	Kansas, USA	Liberia	Live larvae of <i>Aedes aegypti</i> and <i>Culex cinerellus</i>	22
1968	Nairobi	Africa	153 mosquitos	11
1968–69	Nairobi	Europe	356 mosquitos including 2 species from Europe	11
1970–74	New Zealand	Fiji Fiji Hong Kong Hawaii Hong Kong	<i>Aedes vexans</i> <i>Culex bitaeniorhynchus</i> <i>Culex quinquefasciatus</i> <i>Culex</i> sp.	23
1972–73	Tokyo	?	<i>Aedes aegypti</i> <i>Anopheles subpictus</i> <i>Culex gelidus</i> <i>Culex sitiens</i> group	24
1974	Darwin	Bali	<i>Anopheles sundaicus</i>	25
1975	Australia	Indonesia Darwin	<i>Anopheles subpictus</i> ? 5517 insects	14 14
1974–79	Brisbane Perth Sydney		including 686 mosquitos	
1975–81	Tokyo		3 species of mosquito not found in Japan	26
1983	Bermuda	?	<i>Aedes aegypti</i>	27
1983	Trinidad	?	967 insects including <i>Aedes aegypti</i> and <i>Anopheles albimanus</i>	28

among persons who contract the infection during a stay in an area of endemicity and subsequently fall ill.

The occurrence of airport malaria indicates the need to disinsect aircraft arriving from areas where vector-borne diseases are endemic. Each case of

airport malaria represents an importation of infected *Anopheles* mosquito aboard an aircraft. Arboviral diseases, e.g. dengue fever, may be transmitted by imported mosquitoes carrying the infection. Since the symptoms of arboviruses are usually non-

specific, however, diagnosis is difficult and single cases may not be detected. Nevertheless, a case of airport dengue fever has apparently occurred among German travellers (31). Transmission of leishmaniasis by sandflies in Tajikistan has occurred as a result of the importation of these insects from Afghanistan on helicopters (32).

Airport malaria is particularly dangerous in that physicians generally have little reason to suspect it. This is especially true if there has been no recent travel to areas where malaria is endemic. Diagnosis may, therefore, be protracted and death may occur before a correct diagnosis is made and adequate treatment provided, particularly in cases of *Plasmodium falciparum* malaria (33).

Several summaries of the known cases of airport malaria have been prepared (34–39). Table 2 presents an updated version of information (38) on countries in which confirmed or probable cases of airport malaria have been reported.

In 1997 a mother and daughter who had recently travelled from Luxembourg to Iceland, and who had never been in an area of endemicity, became affected with malaria. They lived in a village 1–2 km east of Luxembourg's airport. In 1999 a husband and wife travelled by air from Luxembourg to Scotland via Brussels on 30 May and returned to Luxembourg on 18 June. The woman fell ill in late July and *P. falciparum* was confirmed by blood smear. A blood smear taken from the husband was also positive. A third patient, who had not travelled by air, lived in a village 3–4 km east of Luxembourg airport. All five cases occurred during periods of high summer temperatures, which may have allowed imported mosquitoes to survive. Severe thrombocytopenia was a common feature in these patients (40).

**Baggage malaria.** Table 2 includes cases of "baggage malaria" in which infected vectors were evidently brought in baggage to sites, sometimes at a considerable distance from the airport of arrival, and transmitted the disease on escaping (41–43). Extensive investigations revealed no indigenous vectors

and no evidence of local transmission in any reported instance of baggage malaria.

**Runway malaria.** Three documented cases of "runway malaria" have occurred in which the infection was transmitted to passengers who had not left their aircraft during a transit stop in a country where malaria was endemic. Two of the cases occurred at Abidjan Airport and one in Banjul, Gambia. These cases occurred in the course of travel between countries where the disease was not endemic. In addition, two passengers and a crew member on a Middle East Airlines flight from Lebanon to Brazil developed malaria after arrival at their destination. *P. falciparum* was diagnosed about two weeks after the flight and the patients were treated in hospitals in São Paulo. No other passengers among the 360 on board the aircraft gave positive reactions. Investigation showed that they had not been infected in Brazil and it is probable that they were infected during a stop in Côte d'Ivoire. During the two-hour stop at Abidjan Airport the doors of the aircraft were open and this presumably permitted an infected mosquito to enter (44).

One of the cases involving Abidjan Airport was that of a 37-year-old British woman who lived in Cape Town and had travelled to the United Kingdom; 14 days after her arrival she developed fever and malaise; was treated at home with antibiotics. Three days later her fever rose to 40 °C, she became unconscious, and she was taken to hospital with convulsions and thrombocytopenia. *P. falciparum* was identified, appropriate treatment was given, and she recovered after a prolonged illness. The patient had never been to an area where malaria was endemic. Her flight from Johannesburg to Europe landed in Abidjan for about an hour. She did not leave her seat but noted that the doors of the aircraft remained open. The aircraft was not sprayed before departure. All travellers in transit through an area where malaria is endemic were advised to obtain prophylaxis, and it was suggested that airlines should spray aircraft in transit with insecticides (45).

In another case associated with Abidjan Airport, a 63-year-old British woman who lived in Johannesburg travelled to the United Kingdom in July 1989. Nine days after arrival in the United Kingdom she developed fever and malaise and was treated on an ambulatory basis for gastroenteritis. Five days later she developed jaundice and rigors and was admitted to hospital for suspected hepatitis. She was deeply jaundiced, semiconscious, and had a temperature of 40 °C. Examination of blood samples revealed the presence of *P. falciparum*. She was treated with intravenous quinine and made a good recovery. Her flight had stopped at Abidjan for an hour. She had not left her seat but the doors had remained open. The aircraft was sprayed before take off. It was surmised that she had acquired malaria on the flight between areas where the disease was not endemic after being bitten by an infected anopheline mosquito while the aircraft was standing at Abidjan, perhaps before spraying was carried out (46).

Table 2. Countries in which confirmed or probable cases of airport malaria have been reported, 1969–August 1999

Country	Period					Total
	1969–77	1978–86	1987–95	1996–98	1999	
France	9	3	11	3	–	26
Belgium	0	9	7	1	–	17
Switzerland	3	0	5	1	–	9
United Kingdom	4	3	0	7	–	14
Italy	0	1	3	0	–	4
USA	0	0	3	1	–	4
Luxembourg	–	–	–	2	3	5
Germany	0	0	2	1	1	4
Netherlands	0	2	0	0	–	2
Spain	0	1	1	0	–	0
Israel	0	0	0	1	–	1
Australia	0	0	0	1	–	1
<b>Total</b>						<b>89</b>

Two cases of malaria transmission occurred on an Ethiopian Airlines flight from Heathrow to Rome (47, 48); both possibly resulted from the same infected mosquito biting twice.

The occurrence of a relatively large number of cases of airport malaria in Paris and Brussels reflects the large number of flights arriving from Central and West Africa. The majority of the cases were caused by *P. falciparum*. At least five deaths have resulted; all cases occurred among non-immune individuals, accounting for a relatively high mortality of 6%. Long delays in achieving correct diagnosis frequently resulted in patients developing severe or complicated malaria. In the five cases of airport malaria that occurred in Switzerland in 1990 it was estimated that it took as long as 7 days between the occurrence of the first symptoms and correct diagnosis of malaria. In at least one case, 31 days elapsed before a correct diagnosis was made (49).

Isaacson (11) believed that the published records of airport malaria represented only the more serious cases and that mild cases were either not considered worth publishing or that the patients recovered spontaneously and were not diagnosed as having malaria. It is possible that some cases of serious malaria were not correctly diagnosed, leading to the development of severe symptoms or death (50).

### **Autochthonous transmission of malaria resulting from importation of infected vectors**

A serious public health problem would arise if the introduction of infected vectors led to the transmission of malaria by local vectors, particularly if transmission were renewed in an area where the disease had previously been endemic. There are several known instances in which malaria transmission, albeit limited, has been reintroduced into countries from which it had been eradicated, e.g. Germany (51), Italy (52), and the USA (53–56). In most instances an infected traveller was responsible, although some outbreaks may have been caused by the importation of infected mosquitoes.

### **Exotic vectors introduced by aircraft**

A serious consequence of the importation of exotic mosquito species on aircraft is that they may establish themselves in the country into which they have been introduced. Although this would not be likely for tropical mosquitoes arriving in temperate countries, introduced species have established themselves in several islands of the South Pacific. These established populations are a source of great concern to health authorities in Australia and New Zealand, and have led to a requirement for efficient disinsection in aircraft arriving from areas from which vector mosquito species may be introduced and established (57, 58).

There are many instances of exotic vectors having been introduced into and established in countries where they had not previously been found. It is difficult to verify how a mosquito may have been

introduced unless the species is detected in or immediately around an international airport or seaport. Several species have been introduced into Pacific islands by aircraft, as evidenced by the finding in Guam of *Anopheles barbirostris*, a malaria vector in Viet Nam and elsewhere in South-East Asia (59). Both *Anopheles indefinitus* and *Culex fuscannus* were introduced into Guam and Saipan after the Second World War, probably by aircraft; *A. indefinitus*, a potent vector of malaria, undoubtedly caused outbreaks of the disease on Guam in 1966 and 1969 (60, 61).

*A. aegypti* and *Aedes albopictus* have been disseminated widely by international commerce, mainly as eggs laid in used tyres (62), although aircraft were probably responsible for the introduction of the species into Bermuda (27), Bolivia (63), and Trinidad and Tobago (64). Outbreaks of dengue fever followed the introduction of *A. albopictus* into the Solomon Islands and of *Aedes vigilax* into Fiji by aircraft (65). *A. albopictus* was introduced into Europe (66–68), Africa (69, 70) Brazil, and the USA (71, 72) as eggs in used tyre casings. *Aedes atropalpus*, an American species, was introduced into Italy in the same way (73).

*A. aegypti* has spread to most of the countries of South and Central America in which it previously occurred before attempts to eradicate it. Much of the spread is probably attributable to the importation of tyres or containers containing eggs of the species. In 1943, Bolivia was the first country in Latin America to succeed in eradicating *A. aegypti*. In 1980 the species was rediscovered in the city of Santa Cruz, both in the vicinity of the airport and near the railway station (74). It quickly spread, especially to the old section of the city where 25% of the houses were infested. *A. aegypti* was first found to be breeding in houses near Santa Cruz airport and it may have been brought in by aircraft from Cali, Colombia. It is now widely distributed throughout Bolivia, as is dengue fever. In South or Central America, except in Brazil, there appear to have been virtually no searches for mosquito vectors on aircraft.

The expanding distribution of *A. albopictus* has not been associated with increased transmission of arboviruses. The species was first found in Mexico in 1988 (75) and has since spread widely in this country; by 1995, wild male and female *A. albopictus* were found to be naturally infected with dengue virus (76). In 1994–95, both Potasi virus and Cache Valley virus were isolated from *A. albopictus* in Illinois, USA (77).

The filariasis vector, *Aedes polynesiensis*, is now established throughout French Polynesia and it is considered that air traffic was more important than maritime traffic in its dispersal (78). Many of the areas in which exotic mosquito species have been established are islands; communication among the widely separated Pacific islands is principally by air, and their climates and ecologies are similar; a species established on one island can therefore easily be spread and establish itself on another.

Many species of mosquito have arrived on aircraft in countries where they are not indigenous; in

most instances this has not led to their establishment. It is unlikely that a tropical mosquito such as *A. gambiae* would be successfully established in temperate parts of Europe or North America other than for the short period of the year when temperatures are suitable. Countries with warmer climates are at far greater risk of invasion by *A. gambiae*, as has happened in Brazil and Egypt. *A. albopictus*, on the other hand, has spread as far north as Minnesota in the USA; the strains introduced into both North America and Brazil originated from the northern range of the species and they are well adapted to surviving both winter and summer temperatures (79). The strain of *A. albopictus* established in Italy was probably imported from GA, USA, in used tyre casings (68). In the event of global warming, vectors and the diseases they transmit could extend well beyond their present ranges (80).

The substantial number of mosquito species introduced into countries in which they were not previously present indicates that such introductions are not unusual. Introductions may occur via all means of international transport. Clearly, however, aircraft can transfer mosquitoes from one place to another relatively rapidly, thus increasing the chance of their survival in receptive areas.

## Economic cost of introduced vectors and diseases

The introduction of malaria by whatever means into an area where the disease is not endemic can be costly in terms of treatment, hospitalization, epidemiological investigations, lost working time, human suffering and even mortality. A study of 142 patients with introduced malaria in the USA showed that 110, 21 and 11, respectively, had mild, moderate and severe infections; 2 deaths occurred. The mean cost of treating a case was US\$ 2743.51. For mild, moderate, and severe cases, the median costs of treatment per case were US\$ 467.54, US\$ 2701.16 and US\$ 12 515.52, respectively. For 42 of the patients at least one element of therapy was inconsistent with recommendations current at the time of the study; the remainder were treated in what was considered an appropriate manner (81).

An analysis in France of the costs related to 33 patients with imported malaria, four of whom had to be hospitalized in an intensive care unit and one of whom died during hospitalization; the cumulative cost for these cases was at least FF 660 000 (ca. US\$ 100 000) (82). This did not take into account the costs of lost working time or other expenses to the families of the patients nor the costs of death. In another study of malaria imported into France the overall cost of an uncomplicated case of malaria, involving medical expenses and an average sick leave of two weeks, was estimated at 6400 euros (ca. US\$ 5000) for inpatients and 1400 euros (ca. US\$ 1100) for outpatients (83).

If an introduced vector mosquito species becomes established the cost of eliminating it may be very substantial. Malaria was eradicated from the Indian Ocean island of Reunion in 1949; however, in 1988, 155 cases of imported malaria were detected on the island and 3 autochthonous cases occurred. The cost of dealing with these introduced cases and the ensuing local transmission was US\$ 3 350 000 per year (0.65% of the total health budget of the country), equivalent to US\$ 6.00 per inhabitant per year; 77% of the expenditure was on vector control (84).

## Diagnosing imported malaria

Cases of malaria diagnosed in persons who have neither recently returned from travel to an area of endemicity nor have a history of blood transfusions or intravenous drug abuse are usually categorized as airport malaria. Such cases have, for the most part, occurred in the vicinity of international airports at which flights carrying infected vectors have arrived. However, infected mosquitoes can be transported by vehicle or wind for considerable distances from such airports. This undoubtedly happened in two cases of severe *P. falciparum* malaria at locations 10 km and 15 km from Gatwick Airport in 1983 (85) and in two cases that occurred 7.5 km from Roissy Airport near Paris (37). At such distances from an airport there may be little suspicion that a patient's illness is caused by malaria. Consequent failures or delays in diagnosis may result in inappropriate treatment or death.

## Discussion and conclusions

There is abundant evidence that disease vectors, particularly mosquitoes, are being imported into countries on aircraft, and there is evidence that this can and does lead to the transmission of disease. Many instances of airport malaria, several of them fatal, have been recorded. Other cases have probably escaped diagnosis. Exotic vectors can and do establish themselves in areas where they were not previously found and this can have serious consequences for the transmission of mosquito-borne disease.

The costs of periodic treatments of aircraft with a residual spray and/or the application of a space spray before take off from an area of high endemicity are small in comparison with those associated with the hospitalization, loss of working time, and mortality that may be caused by mosquito vectors.

It is therefore important to prevent importations of vectors on aircraft and the risk of introduced disease transmission. Furthermore, appropriate measures would diminish the possibility of vectors becoming established in countries where they have been introduced and in which they have not previously been present.

That this can be achieved has been demonstrated in Paris. The largest number of cases of airport malaria in Europe has been in France

(Table 2), primarily because of the many direct flights arriving from areas of Africa where the disease is endemic. In order to tackle this problem the health authorities at Charles de Gaulle Airport concentrated their efforts on the flights at risk and provided information and sensitization to the airline companies operating out of airports near which malaria was common. This resulted in 73% and 87% of the flights at risk being properly disinfected in 1995 and 1996, respectively. Despite pyrethroid resistance in *A. gambiae* s.l. in West Africa, the degree of efficacy of aircraft spraying with permethrin aerosols is still acceptable (39).

The most recent WHO recommendations for aircraft disinsection were published in 1995 (5) and 1998 (86). The following methods are in use.

- The blocks away method, as described above.
- Pre-flight and top-of-descent spraying are similar to the blocks away method, except that aircraft are sprayed on the ground before passengers board. This allows overhead lockers, wardrobes and toilets to be opened and properly sprayed with an insecticidal aerosol containing permethrin. Further in-flight treatment with a quick-acting knockdown spray is applied.
- Residual spraying involves the regular application of a residual insecticide to internal surfaces of aircraft except in food preparation areas, at intervals based on the duration of effectiveness. In addition, spot applications are made to surfaces that are frequently cleaned.

The aerosol method may not be completely effective because it is often not carried out correctly. Alternative methods or approaches have been proposed that may be more effective than either the blocks away or the top-of-descent methods. Periodic residual applications of permethrin or

another safe and effective insecticide to passenger cabins, coupled with the use of an aerosol spray before boarding takes place, should provide a safe and effective alternative to the methods now used or recommended for aircraft leaving areas where mosquito-borne diseases are endemic.

Passenger aircraft are regularly treated with insecticides for the control of cockroaches and other insect pests in the galley and toilet areas. Some of the insecticides applied, both as residuals and ultra-low-volume aerosols, are the same as those used for controlling insects of public health importance. Pest control treatments are carried out once a month or immediately on the return of aircraft to their base if cockroaches or biting insects have been seen by crew members. Most treatments are aimed at the control of cockroach infestations, which are not rare in the galley areas. When galleys and toilets are being treated with a residual application of permethrin, the passenger cabins could be treated with the same product for the control of mosquitoes. The treatments could be applied by the same operators, and the additional cost of treating passenger cabins would not be excessive. Highly qualified and licensed pest control operators in Europe and the Americas only use insecticides that have been approved for application on aircraft. No information is available on what pest control operations are carried out or what pesticides are used other than in Europe and North America.

Aircraft occasionally have to be fumigated by highly trained, licensed operators if rodents are present or if there is a very severe cockroach infestation. This requires the aircraft to be taken out of service for 7–15 hours. The airport health authorities and aircraft management are informed of any fumigations being carried out. ■

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## Résumé

### Désinsectisation des aéronefs

On a souvent trouvé des insectes potentiellement dangereux pour la santé publique, notamment des moustiques, à bord d'aéronefs arrivant dans des pays où ces insectes n'existent pas. Les nombreux cas de « paludisme aéroportuaire » signalés dans des pays non impaludés sont la preuve indirecte de ce type de transfert. Les cas surviennent lorsque des anophèles parasités s'introduisent à bord des appareils dans les pays tropicaux d'endémie et s'en échappent au point d'arrivée. Il est probable que des moustiques contaminés par des arbovirus comme celui de la dengue ont été aéroportés de la même façon. Dans les pays non impaludés, le diagnostic est souvent tardif, et le malade décède parfois, car les médecins locaux ne soupçonnent pas le paludisme chez quelqu'un qui n'a pas séjourné sous les tropiques. Il arrive aussi que des espèces exotiques de moustiques forment des populations dans des pays où elles ont été importées. Elles constituent

alors une menace en raison du risque de transmission de maladies.

Pour éviter que des vecteurs d'espèces exotiques ne soient fortuitement aéroportés, l'OMS, en concertation avec ses centres collaborateurs dans plusieurs pays, a mis au point des méthodes et des matériels pour la désinsectisation des aéronefs en provenance de pays où les maladies transmises par les moustiques sont endémiques. Les essais sur le terrain ont montré que ces méthodes étaient efficaces. Les insecticides recommandés (perméthrine et d-phénothrine) sont sans danger pour les passagers et pour l'équipage de l'appareil. La désinsectisation des aéronefs en provenance de pays d'endémie et l'intensification de la lutte antivectorielle dans les aéroports internationaux et les zones environnantes réduiront le risque d'importation de vecteurs et de transmission des maladies dont ils sont porteurs.

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## Resumen

### Desinsectación de aviones

Son numerosos los casos de insectos, en particular mosquitos, que han sido transportados a bordo de aviones hasta países que no constituyen su hábitat natural, lo que puede llegar a representar una grave amenaza para la salud pública. Los numerosos casos de «paludismo de aeropuerto» registrados en países sin paludismo endémico evidencian indirectamente ese fenómeno. Estos casos ocurren cuando mosquitos anofelinos infectados por el paludismo son transportados inadvertidamente en aviones procedentes de países tropicales de endemicidad palúdica y logran huir del aparato. Es probable que también hayan viajado así mosquitos infectados por arbovirus, como el virus del dengue. A menudo se tarda en diagnosticar el paludismo en los países no endémicos, a veces con resultados mortales, debido a que en esas circunstancias los médicos no suelen pensar en la enfermedad cuando el paciente no ha viajado a regiones tropicales. También se han dado casos de especies exóticas de mosquitos que han fundado poblaciones en los países a los que han

llegado y representan un peligro a causa de su habilidad para transmitir enfermedades.

Para prevenir el transporte de especies exóticas de mosquitos vectores a bordo de aviones, la OMS, junto con varios de sus centros colaboradores en diferentes países, ha desarrollado métodos y productos para desinsectar los aparatos procedentes de países con endemicidad de enfermedades transmitidas por mosquitos. Los ensayos sobre el terreno han demostrado la eficacia de esos procedimientos de desinsectación. Los insecticidas recomendados para la desinsectación (permetrina y d-fenotrina) no suponen ningún peligro para los pasajeros ni para la tripulación. La desinsectación de los aviones procedentes de países con endemicidad de enfermedades transmitidas por mosquitos y la mejora del control de las poblaciones de vectores tanto en los aeropuertos internacionales como en sus alrededores disminuirán la amenaza de introducción de vectores y de las enfermedades de que pueden ser portadores.

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