Tropical Medicine and International Health

VOLUME 3 NO 9 PP 700–705 SEPTEMBER 1998

Origin and prevention of airport malaria in France

P. Guillet[1], M. C. Germain[2], T Giacomini[3], F. Chandre[1], M. Akogbeto[4], O. Faye[5], A. Kone[6], L. Manga[7] & J. Mouchet[8]

1 ORSTOM-LIN, Montpellier, France
2 DDASS Seine St Denis, Contrôle Sanitaire aux Frontières, France
3 Centre Hospitalier Robert Balanger, Aulnay-sous-Bois, France
4 Centre de Recherches Entomologiques, Cotonou, Benin
5 Laboratoire de Paludologie, Université de Dakar, Senegal
6 Institut National d'Hygiène Publique, Abidjan, Côte d'Ivoire
7 OCEAC Yaoundé Laboratoire de Lutte Antivectorielle, Cameroun
8 ORSTOM, Paris, France

Summary Since 1969, 63 cases of airport malaria have been reported in Western Europe, 24 of which occurred in France. Most were due to *Plasmodium falciparum*. In 1994, 7 cases occurred in and around Roissy Charles de Gaulle airport (CDG), showing 4 types of contamination: among employees working on airstrips or opening containers, among residents living near the airport, among people living at some distance from the airport after a secondary transport of vectors, and by vectors transported in luggage. In-flight or stop-over infection is not considered as airport malaria. The infective anophelines originated from airports where malaria transmission occurs, mostly in subsaharan Africa. A tentative list is given taking into account aerial traffic with France. Surveys in the airports of Dakar (Senegal), Cotonou (Benin), Abidjan (Cote d'Ivoire) and Yaoundé (Cameroun) found potential vectors in all of these from July to September. After 1994, the Contrôle Sanitaire aux Frontières (CSF) in charge at CDG concentrated its efforts on the flights at risk, as well as information and sensitization of airline companies, which resulted in 73% and 87% of the flights at risk being properly disinsected in 1995 and 1996. Despite pyrethroid resistance in *Anopheles gambiae s.s.* in West Africa, the efficacy of aircraft spraying with permethrin aerosols is still acceptable. However, surveillance of resistance should be improved and search for nonpyrethroid insecticides suitable for aircraft strongly encouraged.

keywords Airport malaria, *Plasmodium falciparum*, pyrethroids, sub-Saharan Africa

correspondence: Dr P Guillet, ORSTOM-LIN, BP 5045, 34032 Montpellier Cedex 1, France

Introduction

The first cases of airport malaria in France were retrospectively diagnosed in 1969 in Le Bourget Airport, 6 km north of Paris (Doby & Guiguen 1981). Since then, 24 cases were recorded in France and 41 in the rest of western Europe (Belgium, Italy, the Netherlands, Spain, Switzerland and United Kingdom). A list of these cases was compiled by Giacomini *et al.* (1995), updated in 1996 by Dr P. Carnevale (unpublished observations) and in 1997 by our team. All cases were due to *Plasmodium falciparum* except one case of *P. malariae* in Switzerland (Giacomini *et al.* 1995) and one doubtful case of *P. vivax* in France (Larcan *et al.* 1978). Most cases were recorded during the summer and only 3 occurred during the winter and were luggage malaria.

In 1994, 7 cases of *P. falciparum* malaria were recorded among non-travelling people in and around Roissy-Charles-de-Gaulle (CDG), the main airport serving tropical Africa. An immediate epidemiological survey with an entomological component confirmed that they were airport malaria. Further research in 1995 established the possible origin of infective vectors (anopheline mosquitoes), assessed the efficacy of aircraft disinfection procedures and controlled their application by airline companies. The overall objective was to propose practical measures to prevent airport malaria.

Sites and ways of contamination

The first step was to make sure that there were no vectors in the vicinity of the airport able to transmit *P. falciparum*. Indigenous anophelines in and around airports of western Europe – *Anopheles messae, A. atroparvus and A. labranchiae* (the latter occurs only in Italy) – were shown to be refractory to *P. falciparum* (Ramsdale & Coluzzi 1975). Another common species, *A. claviger*, has never been associated with malaria.

However, as the 1994 summer was very hot, it was hypothesized that imported tropical anophelines such as *A. gambiae s.l.* could temporary breed in local water pools. Examination of potential breeding sites in the vicinity of reported cases gave no proof supporting this hypothesis. Obviously cases in and around the airport were transmitted by infective anophelines imported by aircraft. Once infective mosquitoes arrive in an airport, they can disseminate the parasite in different ways.

Transmission inside the airport

Ground personnel working on airstrips are at risk when the cabin and cargo hold doors are opened. Also, those who manipulate and open containers in warehouses, stores or the post office are exposed to bites of the vectors which have travelled in containers. In 1994, three cases were recorded among airstrip personnel and two among container manipulators, including a mailman (Giacomini *et al.* 1995).

Transmission among the airport nearby residents

Nearby residents are also exposed to bites of mosquitoes coming from the airport. Two cases in 1969 and one in 1995 were reported near Le Bourget airport, and three cases near CDG in 1976, 1977 and 1987 (Giacomini *et al.* 1977, 1988).

Transmission after a second transport of the vector

Two cases occurred among people living in an urban area located 7 km away from the airport, who had no contact with any airport and never travelled to endemic areas. However, a number of airport employees lived in the immediate vicinity. The only reasonable explanation was that anophelines were brought by car by airline employees. Interviews with the employees revealed that at the time they were on night shift and their cars were parked near airstrips. The CO_2 emitted by the engine when a car is starting can attract mosquitoes.

Similar cases of secondary transport over several kilometres were reported in England (Whitfield *et al.* 1984) and Italy (Rosci *et al.* 1987).

Luggage malaria

Luggage has often been suspected of harbouring mosquitoes, possibly causing infections when opened at arrival. Such cases were reported in Italy in 1989 (luggage loaded in Benin) (Rizzo *et al.* 1989) and France in 1995 (luggage loaded in Haiti) (Dr T. Giacomini, unpublished observation).

In-flight infection

There is evidence of a passenger having been infected during a flight from Johannesburg to Paris which stopped over at Abidjan airport, where the aircraft doors were left open (Conlon *et al.* 1990). As there is no malaria in Johannesburg, the infected anophelines evidently got on board at Abidjan. Another case was a serviceman supposedly infected during a night stop-over at Banjul, The Gambia. These cases do not meet the definition of airport malaria.

Possible origin of infective anophelines

Tentative list of airports at risk

To focus the activities of sanitary control on flights at risk of introducing infective vectors, we tried to establish a list of airports where infective mosquitoes are likely to get on board. About 100 countries are considered malarious by the WHO (1995), but only a limited number of airports are at risk, i.e. located within an area where *P. falciparum* is actively transmitted. A flight is considered at risk when it lands at one of these airports

Most international airports of Asia and the Americas are located in areas where there is no *P. falciparum* transmission even if the country is classified as malarious. This is the case in Hanoi and Ho Chi Minh in Vietnam; Phnom Penh in Cambodia; Bangkok in Thailand; Sao Paulo, Rio de Janeiro and Brasilia in Brazil, for example. Moreover, some airports implemented effective vector control measures as recommended by international legislation.

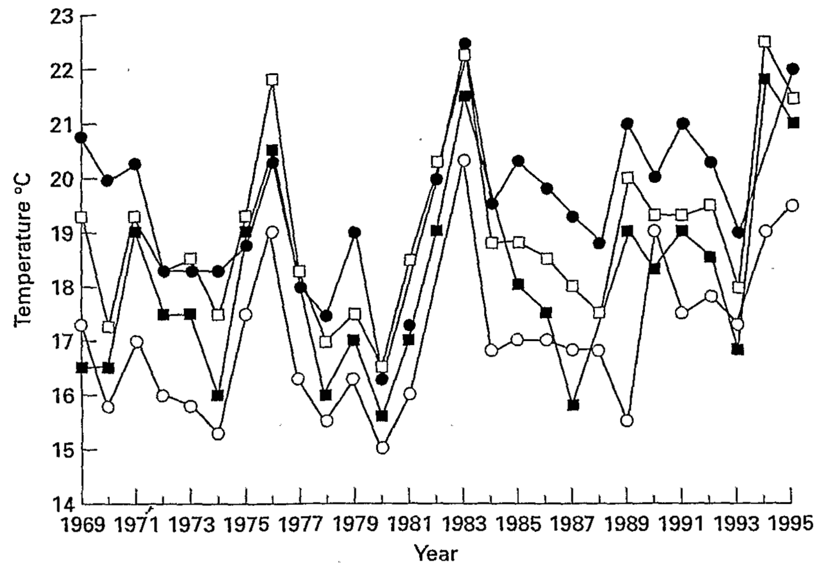
In establishing a list of airports at risk, we have not considered countries without direct connections with France (e.g. Papua-New Guinea), and for a more complete list, the increasing number of charters, military and cargo flights need to be considered also.

So far, most cases were recorded in summer (July usually being the warmest month in western Europe) and predominantly in very warm years (Figure 1). Apart from the warm temperatures which favour anopheline activity, European summertime corresponds to the rainy season in tropical countries of northern hemisphere, the peak of mosquito production and malaria transmission. According to these criteria and taking into account the traffic in French airports, we propose a tentative list of airports at risk, which should be periodically updated and completed.

West Africa

Benin (Cotonou), Burkina-Faso (Ouagadougou), Côte d'Ivoire (Abidjan), Guinea (Conakry), Mali (Bamako), Niger (Niamey), Nigeria (Lagos, Kaduna, Kano), Senegal (Dakar), Togo (Lome). At the moment, there are no direct flights to France from Guinea Bissau, The Gambia, Ghana, Liberia and Sierra Leone.

Figure 1 Average July temperature in 4 western European airports. □ Paris; ■ Brussels; ● Geneva; ○ London.



Central, East and Southern Africa

Cameroun (Douala, Yaoundé), Chad (Ndjamena), Djibouti, Central African Republic (Bangui), Gabon (Libreville), the Congo (Brazzaville), Congo DM (Kinshasa), Kenya (not Nairobi but charters from Mombasa), Sudan (Khartoum), Uganda (Entebbe), Angola (Luanda), Comoro Islands (Moroni), Zambia (Lusaka), Mozambique (Maputo), Madagascar (not Antananarivo but charters from Nosy-Be).

Americas

Haiti (Port-au-Prince).

In France, most flights at risk arrive at CDG, Paris, and to a much lesser extent at Marseille, Nice, Lyon, Bordeaux and Toulouse. Charters and private flights land at Le Bourget and Orly. Military airfields such as Frejus, Istres and Villacoublay should also be considered. European airports with many connections to Africa had the greatest number of malaria cases: France (24 cases), Belgium (16), Switzerland (10), UK (4), whereas those with fewer links recorded fewer cases: Italy (4), Germany (2), The Netherlands (2), Spain (1).

Entomological research studies in airports of tropical Africa

To support our hypothesis of an African origin of infective mosquitoes, entomological surveys were carried out in the airports of Dakar (Senegal), Abidjan (Côte d'Ivoire), Cotonou (Benin) and Yaoundé (Cameroun) from July to September 1995. In the last three countries where four seasons occur, rainfall is high in July but decreases in August and September (minor dry season) along with anopheline densities. However, transmission is almost perennial. The results (Tables 1 and 2) were as follows:

In Dakar, two people did one-night collections every two weeks from July to November, both inside and outside the airport. *Anopheles arabiensis* was found only in August (2) and September (5). Five *A. pharoensis* and 2720 *Culex quinquefasciatus* were harvested.

In Abidjan, 12 night/man collections (4 per month) harvested 54 *A. gambiae s.s.*, 38 in July, 15 in August, 1 in September. Twenty-nine were caught on the airstrip (near the aircraft) and 25 in the luggage container-loading area.

Table 1 Number of malaria vectors and other mosquito species collected in 4 international airports in Africa, July September 1995

	Dakar			Abidjan			Cotonou			Yaoundé		
Month	Night/ man	Malaria vectors	Other species	Night/ man	Malaria vectors	Other species	Night/ man	Malaria vectors	Other species	Night/ man	Malaria vectors	Other species
July	2	0		2	18		8	5		2	15	
August	2	1		2	26		8	3		4	14	
September	2	10		2	11		8	0		4	8	
Total	6	11	2780	6	55	297	24	8	193	10	37	2

Table 2 Collection areas for adult malaria vectors in four international airports in Africa, July September 1995

	Collection area		
Airport	Tarmac	Luggage loading area	Inside luggage container
Dakar	4	7	Not inspected
Abidjan	29	26	Not inspected
Cotonou	3	5	2
Yaoundé	7	30	Not inspected

In Cotonou at 24 night/man collections around aircraft flying to Roissy, 8 *A. gambiae s.l* were collected together with 193 *C. quinquefasciatus*. In 24 luggage containers inspected, 2 *A. gambiae* were caught. Larval sites of *A. gambiae s.l.* were numerous in the area in July but dried out in August.

In Yaoundé, 5 *A. gambiae* s.s. (all in July), 2 *A. funestus and* 28 *A. moucheti* were collected in 10 night/man collections. The latter species, a very good vector in the area, is not rainfall-dependent because it breeds in rivers. No mosquitoes were found during night surveys in a Boeing 737 parked on the tarmac with open doors. It is important to note that in a village at the edge of the airport the sporozoitic index was 2.5% for *A. gambiae* s.s. and 1.7% for *A. moucheti* (Manga *et al.* 1995).

Most of the anophelines collected were dissected but no sporozoite was found in the salivary glands and the search for circumsporozoite antigen by ELISA was also negative. However, the number of dissected anophelines (< 50) was too low to draw any conclusion. Parous rates were over 50%, which is consistent with the possibility of transmission. It is interesting although not surprising that no anopheline was found in aircraft parked on the tarmac at night, because there was neither bait nor any attractant in the empty plane. It is likely that anophelines enter a plane with passengers or are attracted by the CO_2 emitted by the power units before take-off, when cabin and cargo hold are still open. Many flights take off after 10 p.m., which corresponds to the peak activity of *A. gambiae s. l.* The two *A. gambiae* females found inside containers in Cotonou were bloodfed, i.e. they were resting in the containers during their blood meal digestion.

Prevention of airport malaria

According to international sanitary regulations, the area of airports themselves and the perimeter of 400 m around the airport must be made free of *Aedes aegypti and* malaria vectors. However, vectors were found in all airports suspected to be at the origin of cases, whether they had mosquito control or not. Beside these measures, all aircraft coming from endemic areas must be disinsected before landing in nonendemic areas. The application of instructions varies from country to country. In France, emphasis is mainly on control of malaria, plague and – to a lesser extent – haemorrhagic fever vectors. Aircraft disinsection guidelines proposed by the WHO are based on the use of pyrethroids (either aerosols or residual treatment) and were recently reviewed (WHO 1985, 1995). The efficacy of these procedures was assessed within the framework of our study and will be published separately.

Organization of control in France

Airport controls are the responsibility of the Contrôle Sanitaire aux Frontières (CSF), a branch of the Direction Départementale des Affaires Sanitaires et Sociales (DDASS). Until 1994, all flights coming from endemic areas were eligible for control according to the list of malaria countries provided by WHO (103 countries). But due to the great number of flights involved, controls were random and on a small proportion of aircraft only. Immediately after the 1994 cases, we alerted the sanitary authorities to the necessity of more exhaustive controls of flights at risk.

Action at level of airline companies

The implementation of disinsection procedures recommended by WHO is the responsibility of airline companies. Aircraft are supposed to be disinsected before opening their doors upon arrival. In case of control by CSF, empty cans used in cabin and cargo (in case of aerosol disinfection) or a certificate of residual treatment must be presented by the cabin crew to the health officer.

At the end of 1994 and in 1995 the health authorities held meetings with airlines to make the companies aware of the danger of vector importation and to remind them of French disinsection rules. Most airlines responded favourably and were acquainted with the legislation although it was not always applied. Scientists attending the meeting drew attention to flights most at risk.

Results of aircraft control

The results of CSF controls of landing aircraft are summarized in Table 3. Priority was given to flights from West and Central Africa. The percentage of infractions significantly decreased from June to September 1995 (58–8%) following enforcement of controls of flights at risk. In 1996, overall infractions accounted for only 13% compared to 26% in 1995. No information about the situation of cargo or military aircraft was available.

Table 3 Control of aircraft landing at Roissy airport and observance of disinsection procedures by airline companies

	June	July	August	September	Total
1995					
Controls	38	81	69	50	238
Infractions	22 (58%)	22 (27%)	14 (20%)	4 (8%)	62 (26%)
1996					
Controls	43	58	39	22	162
Infractions	2 (4.7%)	12 (20.7%)	5 (12.8%)	4 (18.2%)	23 (14.2%)

The most common infraction was non-disinsection of cargo hold (48%) and cabin (13%), inadequate quantity of aerosols (18%) and incomplete forms (12%). This varied greatly according to airline companies, the highest proportion was recorded among small airlines operating only one or two aircraft.

There were no cases of airport malaria reported in CDG in 1995, 1996 and 1997 when sanitary controls focused on flights at risk and aircraft were better disinsected. One doubtful case of luggage malaria coming from Haiti was reported in 1995. A second case (Giacomini, personal observation) concerned a child infected in a house near Le Bourget airport, which receives only private flights. These are almost impossible to control efficiently because most flights are not scheduled. During the same period, 8 cases were recorded in Brussels.

Discussion and conclusion

In western Europe, the trends of average temperature in July are the same in all countries, but year-to-year differences can exceed 3 °C (Figure 1). From 1969 to 1996, airport malaria cases were reported in 20 years. It is almost impossible to correlate its occurrence with temperature because the number of cases is too small. However, no case was observed during the coolest years. In London, where the average temperature in July is lowest (Figure 1), four cases were reported in 1983 (Warhust *et al.* 1984), one of the warmest summers in the 27 years considered. Taking into account these figures, it is reasonable to infer that the risk of airport malaria as greater during warm years.

Epidemiological as well as entomological investigations have highlighted the role of containers in the transport of vectors. Possible cases of luggage malaria have been reported in Italy and suspected in France; however, further investigations are needed. For cases occurring far away from the airport, the probability of misdiagnosis is high. Whatever disinsection procedure is used, it is likely that vectors inside luggage escape treatment. Secondary transport of vectors from the airport should also be considered, although if the plane was properly disinsected this ought not to occur.

With the discovery of resistance to pyrethroids in *A. gambiae* s.s. from Côte d'Ivoire (Elissa *et al.* 1993), doubts arose about the efficacy of aircraft disinsection procedures with pyrethroids. We have found that, despite resistance, aerosol sprays were still acceptable (over 80% control compared to 100% with susceptible mosquitoes of this species) (Dr P. Guillet *et al.* unpublished observation). But the possibility for an increase of pyrethroid resistance exists which would make the current disinsection procedures useless. For example, it was observed that highly resistant *Culex quinquefasciatus* travels almost unharmed in treated aircraft. A surveillance program on the evolution of pyrethroid resistance among malaria and other disease vectors is necessary. As pyrethroids are the only insecticides currently available for aircraft disinsection, there is an urgent need to reactivate the search for an alternative.

After the 7 cases reported in 1994 in CDG, was proposed to classify flights with regard to risk of carrying infective malaria vectors. The malaria situation in endemic countries should be evaluated in the vicinity of the international airports and not at country level. With a precise and up-to-date classification of risks, disinsection can be effective, placing minimal constraints on airlines, cabin crew, passengers and sanitary services.

According to WHO, the malaria situation is deteriorating throughout the world, but especially in Africa, with an increasing risk of infected vectors entering aircraft. Consequently, thorough information and sensitization of airline companies as well as effective sanitary controls in international airports are mandatory. Transport of malaria vectors is only one particular case of the more general problem of dissemination of vectors (Mouchet *et al.* 1995; Rhodain 1996) *and* agricultural pests together with the pathogens and resistance genes they carry. As most European countries are concerned, it would be desirable to harmonise at EC level policies both on aircraft disinsection and sanitary control.

References

Conlon CP, Berendt AK, Dawson K & Peto TEA (1990) Runway malaria. *Lancet* 335, 472–473.

Doby JM & Guiguen C (1981) A propos de deux cas 'bretons' de paludisme autochtone, en réalité premiers cas français de paludisme d'aérodrome. *Bulletin de La Societé de Pathologie Exotique* 74, 398–405.

Elissa N, Mouchet L, Rivière F, Meunier LY & Kra Y (1993) Resistance of *Anopheles gambiae s. l.* to pyrethroids. *Annales de La Societé Belge de Médecine Tropicale* 73, 291–294.

Giacomini T, Goudal H, Boudon P, Rennes C, Dumouchel P & Petithory LC (1977) A propos de deux cas de paludisme à *Plasmodium falciparum*. Responsabilité probable d'anophèles importés par voie aérienne. *Bulletin de La Societé de Pathologie Exotique* 70, 375–379.

Giacomini T, Mouchet L, Mathieu R & Petithory LC (1995) Etude de six cas de paludisme contractés près de Roissy-Charles-de-Gaulle en 1994. Mesures de prévention nécessaires dans les aéroports. *Bulletin de l'Académie Nat. de Médecine* 179, 335–353.

Giacomini T, Toledano D & Baledent F (1988) Gravité du paludisme des aéroports. *Bulletin de La Societé de Pathologie Exotique* 81, 345–350.

Larcan A, Laprevote Heully MC, Voydeville G & Bastos P (1978) Une nouvelle observation de paludisme autochtone avec contamination probable dans un aéroport international de la région parisienne. *Annales de Médecine Interne* 129, 411–412.

Manga L, Toto LC & Carnevale P (1995) Malaria vectors in an area deforested for a new international airport in southern Cameroon. *Annales de La Societé Belge de Médecine Tropicale* 75, 43–49.

Mouchet L, Giacomini T & Julvez J (1995) Diffusion anthropique des vecteurs de maladies dans le monde. *Cahiers Santé* 5, 239–238.

Ramsdale CD & Coluzzi M (1975) Studies on the infectivity of tropical African strains of *Plasmodium falciparum* to some southern European vectors of malaria. *Parasitologia* 17, 39–48.

Rhodain F (1996) Les insectes ne connaissent pas nos frontières. *Médecine des Maladies Infectieuses* 26, 408–414.

Rizzo F, Morandi N, Riccio G, Ghiazza G & Garavelli P (1989) Unusual transmission of falciparum malaria in Italy. *Lancet* 333, 555–556.

Rosci MA, Paglia MG, de Felici A *et al.* (1987) A case of falciparum malaria acquired in Italy. *Tropical Geographical Medicine* 39, 77–79.

Warhust DC, Curtis CF & White GB (1984) A commuter mosquito's second bites? *Lancet* 1(8389), 1303.

Whitfield D, Curtis CF, White GB, Targett GAT Warhurst DC & Bradley DJ (1984) Two cases of falciparum malaria acquired in Britain. *British Medical Journal* 289, 1607–1609.

WHO (1985) Recommendations on the disinsecting of aircraft. *Weekly Epidemiological Record* 7, 45–47.

WHO (1995) *Report of the informal consultation on aircraft disinsection. WHO/PCS/95.* 51

A European Journal

Tropical Medicine & International Health

Volume 3

Bernhard Nocht Institute for Tropical Medicine Hamburg

ISSN 1360-2276

1998, Vol-3, nº 9