While it seems likely that dengue fever (DF) has existed in French Guiana for at least one century, data on outbreaks are sketchy before temporary eradication of the dengue vector mosquito Aedes aegypti and its reestablishment in the early 1960s. Dengue cases were serologically confirmed for the first time in 1965, and since then dengue epidemics have occurred at two to six year intervals, the most important occurring in 1968–1969, 1970, 1972, 1976, 1982, 1986, and 1992. Three of the four dengue virus serotypes (dengue-1, dengue-2, and dengue-4) have been implicated in these outbreaks.

During the 1992 epidemic, which appears to have begun in 1991 and extended into 1993, cases of dengue hemorrhagic fever (DHF) were confirmed for the first time. In all, at least 40 DHF cases and several deaths were associated with this epidemic. This development has raised considerable concern about the public health threat posed by DHF in French Guiana. Such concern is only heightened by the fact that while vector control is the sole means of preventing or combating dengue outbreaks, it has proved difficult to maintain vector populations at low levels with the control measures currently employed.

Dengue fever (DF), with its related potentially fatal conditions dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS), is a viral disease (1) transmitted to humans by mosquitoes of the Aedes genus. The known history of dengue in the Americas began several hundred years ago. It is widely presumed that the most important dengue vector in the Americas, the mosquito Aedes aegypti (2), entered the Americas from Africa with the slave trade. According to Eymeri (3), however, there is reason to suspect that Ae. aegypti has also been present in the Americas for at least 600 years, considerably before discovery of the Americas by Columbus. Coury (4) reports on an epidemic of hemorrhagic fever (most probably yellow fever, another Ae. aegypti-borne disease) described in old Mayan inscriptions dating from around 1350 in Central America. The first "modern" description of an epidemic of dengue-like fever did not come until much later, following an apparent outbreak of the disease in Philadelphia in 1780 (5). Since then, dengue outbreaks of varying intensity have occurred in many parts of the Americas.

Over the past three decades the four dengue virus serotypes (dengue-1, dengue-2, dengue-3, and dengue-4) have been isolated from various parts of the Americas (6). The first disease cases reported as being dengue hemorrhagic fever (DHF) occurred in Curacao in 1968, but these cases did not satisfy the case-defining WHO criteria required for DHF confirmation (7). Over a decade later, in 1981, a major DF/DHF outbreak occurred in Cuba that produced some 344,203 DF cases, 10,312 DHF cases, and 159 deaths.
Another large outbreak took place in Venezuela in 1989-1990, resulting in 5,990 reported DHF cases and 73 deaths (9). Moreover, throughout the 1981-1991 period in the Americas, "with the exception of 1983, confirmed cases of DHF that meet the WHO case definition have been reported" (6).

THE LOCAL BACKGROUND (1900-1950)

French Guiana, a department of France east of Suriname and north of Brazil, has experienced epidemics of dengue-like fever since the beginning of the 20th century. Within French Guiana, where Aedes aegypti is the only known dengue vector, three dengue serotypes (dengue-1, dengue-2, and dengue-4) have been isolated. The first recognized case of DHF occurred in 1992 (10).

Situated on the Caribbean along the northern fringe of the Amazon River Basin, French Guiana (83,500 km²) forms part of the Guianas Plateau just north of Brazil (Figure 1). The country consists mostly of equatorial rain forest, except along the Caribbean coast, where 90% of its 114,000 inhabitants live. Within the rain forest area a typical rainy season (from December through June with a short March remission) sees a total precipitation of around 4,000 mm. The dry season lasts from July through November.

Between 1900 and 1950 several epidemics of dengue-like disease (including one outbreak just after World War II) have occurred in French Guiana (11). Some of these may not have been DF outbreaks, but in most cases the clinical records agree well with dengue pathologies. Furthermore, the presence of Aedes aegypti in this half-century is well documented. Neveu-Lemaire recorded its presence in Cayenne in 1902 (12), making it the first mosquito species reported in French Guiana. Thereafter, in 1903, 1918, 1922, and 1937 it was reported in entomologic studies carried out by Laveran (13), Léger (14), Dyar (15), and Senevet (16). It is noteworthy that Senevet found Aedes aegypti to be abundant in Cayenne, Kourou, Saint-Elie, Matoury, and other localities.

During the 1940s, chemical control measures using DDT and dieldrin eradicated Aedes aegypti. On 16 September 1950 (the date of the last treatment), the species was officially declared eradicated from French Guiana (11). Subsequently, a few sporadic and temporary Aedes aegypti reintroductions, from the western part of the country along the Suriname border, were reported (11). However, they did not result in the species' reestablishment in French Guiana for 13 years.

MATERIALS AND METHODS FOR DENGUE STUDIES

Studies of dengue outbreaks—including case recognition, virus isolation, and Aedes aegypti prevalences—have been made
by two laboratories of the Pasteur Institute of French Guiana, the Arbovirology Laboratory and the Medical Entomology Laboratory. The Pasteur Institute, with its Medical Entomology Laboratory, was created in 1940. The Institute was in charge of vector control activities from 1940 until 1984, though the Medical Entomology Laboratory closed in 1974 and did not reopen until 1993.

The Arbovirology Laboratory, created in 1967, carried out dengue virus identification and isolation (17). The techniques used for this purpose, described in detail in the annual reports of the Pasteur Institute, have been summarized by Reynes et al. (10). Initially, flavivirus infections were detected by hemagglutination inhibition (18), and viruses were isolated by inoculation into suckling mice (19). After 1977, dengue viruses were isolated by means of other techniques—human sera being inoculated either intra-thoracically into mosquitoes and/or into cell cultures and the viruses being identified with an immunofluorescence assay (10). The latter technique, unlike the former, was able to distinguish recent dengue infections from those occasioned by prior outbreaks or exposures.

After 1984, the medical and research activities were separated from the vector surveillance and control activities. A departmental vector control agency named the Departmental Disinfection Service (Service Départemental de Désinfection—SDD) was created and became responsible for control and surveillance of disease vectors and other pests.

The entomologic surveillance methods used to assess Ae. aegypti prevalences have been described in detail in the annual reports of the Pasteur Institute and the Departmental Disinfection Service. These methods, based primarily on examination of domestic containers for Ae. aegypti larvae, involved regular estimation of the house index (the percentage of houses found positive for Ae. aegypti), the container index (the percentage of breeding containers found positive for Ae. aegypti), and the Breteau index (the number of breeding containers found positive for Ae. aegypti per 100 houses visited).

**AE. AEGYPTI REINFESTATION AND DENGUE EPIDEMICS (1963–1971)**

The first Ae. aegypti resistant to DDT and Dieldrin were found initially in Cayenne, in October 1963 (11), and later in Saint-Laurent-du-Maroni near the Suriname border (see Figure 1). The reinfestation was quick and intense. As Ae. aegypti populations grew, the house index in Cayenne rose from 3.3 in October 1963 to 62 in April 1964 (20). French Guiana's first new reported cases of dengue-like fever also occurred in 1964 (11).

One year later, in 1965, the country experienced its first new outbreak of epidemic dengue. The nature of the epidemic was elucidated by serologic tests carried out by the Trinidad Regional Virus Laboratory (Rockefeller Foundation) on the sera of 85 people presenting with clinical dengue symptoms who had never been outside French Guiana. Upon HI testing for several flaviviruses (dengue-2, Ilheus, St. Louis encephalitis, and yellow fever) 30 of the 85 sera (35%) were found positive for dengue-2 (11). All but one of these positive sera came from residents of Cayenne. However, it was not possible to determine whether any specific positive response was the result of a current or prior dengue infection.

Since then, as Figure 2 shows, a number of dengue outbreaks have occurred in French Guiana. In each instance, the number of reported cases has not necessarily reflected the actual situation, partly due to shortages of information gathered and reported by local health au-
Figure 2. Suspected and laboratory-diagnosed dengue cases in French Guiana, 1965–1993, showing both early laboratory data (for 1965–1972) that did not distinguish between recent and prior dengue cases, and later data (for 1980–1993) that identified recent cases. The "suspected dengue cases" were reported cases in subjects presenting clinical dengue symptoms; the "recent dengue cases" were found in subjects whose blood samples were positive for recent infection by a flavivirus, most probably dengue; and the "recent and old dengue cases" were found in subjects whose blood samples were positive for either recent or prior infection by a flavivirus, most probably dengue. The blood tests screened for a group of four flaviviruses (dengue, yellow fever, Ilheus, and St. Louis encephalitis). However, the yellow fever virus has not been isolated in French Guiana for 50 years; the Ilheus virus was isolated about 10 times in the last 30 years; and the St. Louis encephalitis virus has only been isolated once. None of the cases shown are confirmed dengue cases.

Authorities and partly because many dengue cases typically go unreported (1).

No dengue-like epidemics were reported in 1966 or 1967 (21), and in 1967 *Ae. aegypti* control was reorganized and the *Ae. aegypti* house index in Cayenne again dropped below 1% (21).

In 1968–1969, however, the mean house index in Cayenne increased drastically over a two-month period, rising from 0.31% in November 1968 (21) to 18.69% in January 1969 (21). This was followed by a new dengue epidemic in which the peak numbers of reported cases occurred in January–March 1969. However, the number of detected cases was small, the time period limited, and so this peak does not show up well in Figure 2. As in the 1965 epidemic, most cases were found in the city of Cayenne and its surroundings. Virus serotypes dengue-2 and dengue-3 were suspected of being responsible for this outbreak, but the very few serologic tests that were done produced no reliable results (18).

In response to these developments, mosquito control activities directed against *Ae. aegypti* larvae and adults were maintained and strengthened. Average *Ae. aegypti* house indexes in other cities of French Guiana remained below 1%. Very few dengue cases were reported in the
last quarter of 1969, and by the end of that year the mean house index in Cayenne had dropped to 1.54% (19).

However, a new resurgence followed on the heels of this decline. By February 1970 the mean *Ae. aegypti* house index in Cayenne had increased again, this time to 9.46%; and another epidemic followed, with the peak numbers of cases (shown by a very small peak in Figure 2) occurring in April–June 1970. As Figure 3 shows, three strains of dengue-2 virus were isolated in this period, these being the first dengue strains isolated in French Guiana (17). (An epidemic caused by dengue-2 was also reported in Jamaica during the same period.)

Few dengue cases were reported in 1971, as shown by a slight decline in Figure 2, though a dengue-2 strain was again isolated in March of that year (19).

It is noteworthy that from 1968 to 1971 control of *Ae. aegypti* was attempted with the insecticides malathion and Abate. New chemical products were used in 1971, when Ortho-Dibrom 14 fogging was implemented. In general, however, these control measures did not yield the degree of success expected.

**Figure 3.** The numbers and types of dengue virus strains isolated in French Guiana from 1970 through 1993.

![Graph showing dengue virus strains isolated from 1970 to 1993.]

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**DENGUE EPIDEMICS OF 1972–1979**

A new dengue epidemic occurred in 1972, as reflected by a small peak in Figure 2. While 129 of 245 sera tested were found positive for dengue-2, it was not possible to distinguish current from prior infections. This epidemic did not follow any clear changes in the mean annual *Ae. aegypti* house index in Cayenne, which declined from 5.27% in 1971 to 2.51% in 1972 (22).

During the 1973–1976 period, annual reports on the dengue situation contain little information. No dengue cases were reported in 1973–1975 (see Figure 2) (23). An epidemic was recorded in 1976 and two dengue-2 strains were isolated (23). However, only 6 out of 359 sera tested by HI were found positive for recent dengue infection. It thus seems plausible that another dengue-like disease was occurring the same year, even while some dengue virus was still circulating. The mean annual *Ae. aegypti* house index in Cayenne ranged from 8% to 10% in this period.

In 1977 a dengue pandemic swept through many countries of the Caribbean and northern South America (24). That year 645 sera were tested for dengue antibodies in French Guiana, but the results were not suitable for interpretation (25). Some dengue cases were reported, mostly in the city of Cayenne, from January to July 1977, with the peak number occurring in March (26). However, the exact number of cases was not reported, and so this number is not included in Figure 2. The *Ae. aegypti* house indexes ranged from 10% to 15% in January–March and from 5% to 7% in April–July.

Also, a total of 19 strains of dengue-2 were isolated in 1977, 15 of these from human subjects, three from pooled collections of *Ae. aegypti*, and one from a pooled collection of the mosquito *Cqul-

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Footnote:

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Zettidia venezuelensis (26). This last isolation could point to the latter mosquito species as a dengue vector, but it appears very probable that one of the tested mosquitoes was engorged with viremic blood, and for this reason the pool was found positive for dengue viruses.

Sporadic dengue cases were reported until February 1978 (25), but numerical data were not provided and could not be reported in Figure 2. From then through the end of 1979 very little information about dengue cases is available, but no outbreaks were reported. However, a single strain of dengue-1 virus was isolated in March 1978, and six more were isolated later that year (27). This was the first time that dengue-1 was observed in French Guiana.

DENGUE EPIDEMICS OF 1980–1989

Data on Ae. aegypti population fluctuations in French Guiana during the 1980s are fragmentary. However, dengue continued to circulate in French Guiana during the 1980s, with major outbreaks occurring in 1982 and 1986 (see Figure 2).

Three confirmed dengue cases were reported in 1980 and 1981, confirmation consisting of dengue strain isolation from a patient’s blood sample. Two strains of dengue-1 were isolated in 1980 and one in 1981 (25, 28); but even though Ae. aegypti was found regularly in virtually all urban and semiurban settings, the dengue situation was not considered epidemic. However, dengue-2 did spark a major Cuban epidemic in 1981, as noted above, producing over 10 000 reported DHF cases and 159 deaths (29).

The following year, 1989, dengue viruses were still circulating in the country, with six dengue-2 strains and one dengue-1 strain being isolated (32). This was the same year that Venezuela experienced a major dengue-1 epidemic that caused over 5 000 reported DHF cases and 73 deaths (9).

DENGUE EPIDEMICS AND DHF IN 1990–1993

Ae. aegypti house, container, and Breteau indexes were reported during this period. However, the fluctuations in Ae. aegypti populations were not studied, and the data did not permit any relationship with the occurrence of dengue cases to be determined.

In 1990 dengue viruses were circulating in French Guiana (25) but not at an epidemic level. The number of reported cases was about the same as it had been in 1989. However, a major epidemic began in 1991 and continued into 1992, with the peak of laboratory-diagnosed cases estimated the occurrence of 5 000 to 6 000 dengue-4 cases.

During the 1983–1985 period the number of recent dengue cases was very low (see Figure 2), the minimum occurring in 1983. No dengue strains were isolated in these years (25, 31). However, another epidemic occurred in 1986, with the peak number of cases and isolation of five dengue-2 strains occurring in the April–May period. Another three dengue-2 strains were isolated later in the year (see Figure 3) (25).

This epidemic dissipated in 1987, a year when only 17 recent dengue cases were observed (25), compared to 218 in 1986. In 1988 the number of dengue cases increased again, but not dramatically. One dengue-2 strain was isolated in 1987 and two more were isolated in 1988 (25, 32), after which time the dengue-2 serotype was considered endemic in French Guiana.

The following year, 1989, dengue viruses were still circulating in the country, with six dengue-2 strains and one dengue-1 strain being isolated (32). This was the same year that Venezuela experienced a major dengue-1 epidemic that caused over 5 000 reported DHF cases and 73 deaths (9).
occurring from December 1991 to March 1992. This epidemic developed first and primarily in Cayenne, though other cities such as Saint-Laurent-du-Maroni and Kourou were involved later. The numbers of laboratory-diagnosed cases associated with the epidemic are shown in Figure 4.

This epidemic has been described in detail by Reynes et al. (10). For the first time in the history of French Guiana, recognized DHF cases were reported. The first DHF cases were found in August 1991; by the end of that year there were five recognized DHF cases meeting the WHO diagnostic criteria and three deaths. One of those killed was a boy 10 years of age with a DHF case meeting the WHO grade 2 criteria, while the other two (a man 41 years old and a girl of 8) presented dengue cases with hemorrhage that did not meet the WHO criteria for DHF. Another 40 DHF cases, an additional 128 dengue fever cases with hemorrhagic symptoms not meeting the WHO criteria for DHF, and two more deaths were reported by the end of 1992 (33). The epidemic declined toward the end of 1992; and though a fair number of laboratory-diagnosed DF cases and a few DHF cases occurred in 1993 (see Figure 4), no DHF cases were reported after March of the latter year.

Numerous dengue virus isolations have been made since 1990 (see Figure 3), owing partly to the epidemic dengue activity and partly to improved virus isolation techniques. Specifically, 2 dengue-1 strains were isolated in 1990; 1 dengue-1 strain and 17 dengue-2 strains were isolated in 1991; and 1 dengue-1 strain and 23 dengue-2 strains were isolated in 1992 (33, 34).

CONCLUDING REMARKS

At present, dengue fever is recognized as endemic in French Guiana, a situation that may have prevailed since 1964. Epidemics typically occur at two to six year intervals. While the numbers of confirmed cases most probably understate the true picture, the total numbers of suspected dengue fever cases have fluctuated and shown some peaks (see Figure 2). When these peaks coincide with relatively high numbers of dengue strain isolations (see Figure 3), as in 1976–1977,
1986, and 1991-1992, they can be taken to indicate an epidemic situation. The recent emergence of DHF is cause for great concern, since endemic occurrence of this severe and sometimes lethal form of dengue could pose a serious threat to the people of French Guiana.

Entomologic data on *Ae. aegypti*, the only recognized dengue vector in the country, are available for the period 1937-1972. After that the data are scarce and inappropriate for analysis of mosquito population fluctuations. However, the Pasteur Institute's newly reopened Laboratory of Medical Entomology has assigned priority to studying the distribution, infected status, and population fluctuations of dengue vector(s) in accordance with the occurrence of dengue around the country. This work should provide the baseline ecologic data needed to plan control measures aimed at reducing the vector population to a level where dengue transmission is no longer sustained.

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