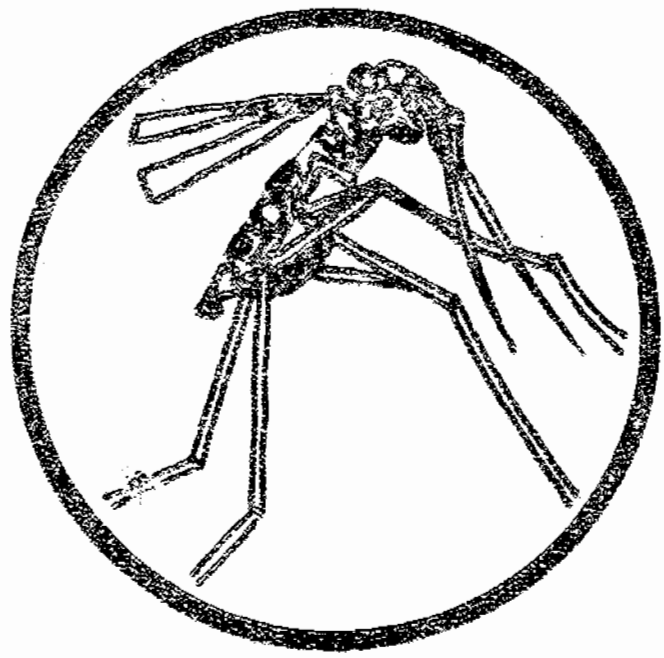
DENGUE FEVER CONTROL

IN TAHITI



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DENGUE CONTROL IN TAHITI IN 1975

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I - INTRODUCTION

In 1971-1972, the South Pacific was hit by a pandemia of type II dengue (1, 2, 3) differing from the preceeding epidemics (31, 32) by an increased frequency of haemorrhagic syndromes of much severity, sometimes causing death.

On the other hand, contrarily to before (4), the endemic *Aedes (Stegomyia)*, of the *Scutellaris* group, only appear to have been implicated in the transmission to a very weak extent (5, 6) rather than *Aedes aegypti*, which urban development favorises.

Finally, the arrival of tourists from various territories increases the risks of seeing a new type of virus introduced, and; by increasing the ratio between non immunized subjects and immunized subjects, allows the virus to continue to circulate during the decline of the epidemy (7).

This is an alarming situation as it reproduces, with a certain time lag, the situation in South East Asia, where dengue, which was rife in the endemic state under a mild form, changed into a serious haemorrhagic syndrome about twenty years ago.

If the theoretical problem of etiology of haemorrhagic forms remains a factor to be counted with (8, 9), luckly the same can no longer be said in regards to prevention (10, 11, 12). Where no vaccin or specific treatment is available, one must prevent or interrupt the transmission by controling the main vector, *Aedes aegypti*. This is essentially an anthropophilic mosquito, reproducing in artificial breeding sites and being able to fly over short distances only. In theory,it is therefore possible to eradicate it : all one has to do is eliminate all potential breeding sites in the neighbourhood of inhabited areas. Because of the number, diversity and small size of these sites, anti-larvae control requires the active and continuous support of the population in its whole. In a free country, such collective self-discipline is difficult to obtain and it would not be prudent to prejudge its efficiency. That is why it is necessary, in case the risk of an explosive epidemy becomes apparent in spite of anti-larvae control, to intensify this effort and the same time to fight against adults in order to prevent a too rapid circulation of the virus (16, 17).Recent research carried out

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in South Asia (13, 14, 15) has proven that the choicest method for this type of situation is the ultra low volume (ULV) procedure, which consists in nebulizing a cold concentrated insecticide.

The 1971-1972 pandemia amploy proved the extent to which the Pacific Territories are unarmed against such an arbo-virus epidemy, this being considered and put up with as a fatality rather than being really fought against. By inference, no one considers himself as responsible. It was therefore necessary to reach a certain number of conclusions for the future on the local (16) as well as the international level (17).

The main lesson learned, on both level, was the lack of coordination, indispensable to carry out such large type operations. To fix this on a local level, a Dengue Control Committee was set up in 1971 in Tahiti which grouped, under the presidency of the Government Councillor in charge of Health, all authorities and technicians who, closely or from afar, had a role to play in the campaign, either in upholding it or those who might hinder it. The second point was the lack of motivation to start intensive control against the *Aedes aegypti*, due to a lack of information at all levels. Lastly, from a technical point of view, a serological laboratory was to be set up, as this was necessary in order to track down suspect cases and to keep abreast of an eventual evolution of the epidemy and to obtain the nebulization material and products required for an eventual imagocide campaign.

2 - STRATEGY AND PRACTICAL ORGANIZATION FOR CONTROL

2.1. EVALUATION OF THE RISK FACTOR

On March the Ist, 1975, when a type I explosive dengue outbreak was announced as having made its appearance in Fiji, Tahiti was, as in 1971, the most exposed country (17). If it has not already taken place, the introduction of the virus is forthcoming, if one takes into account the frequent air links

between the Fiji Islands and Tahiti. One can find no comfort in the nearness of the dry season as this is very relative in Tahiti and this to such and extent that it remains compatible with such densities of mosquitoes as to render transmission possible : In 1971, the height of the epidemy took place in July-August, which are considered as the driest months(5).On the other hand, the type II virus is still in circulation three years after the epidemy(18). Although an important fraction of the population has been immunized, conditions are therefore greatly favorable to the birth of a type I outbreak which has not taken place since 1944, and against which the greater part of the population is not immunized(19). Lastly, many cases of flu are noted at the same time and they may mask the development of a new dengue epidemy.

2.2. MEETING OF THE DENGUE CONTROL COMMITTEE

On March 4, 1975, this alarming situation was exposed to the members of the Dengue Control Committee by the Director of the Health Department and his technicians who presented the main action lines that were to be undertaken on the preventive level as well in the purchase of spraying equipment and insecticides. The Committee gave the green light. That very evening, a press conference and a televised program gave an account of the conclusions reached by the Committee and began an intensive information campaign to alert the public.

This meeting may have seemed to be of an administrative and protocol nature, but, in fact, it conditioned the smooth unfolding of the campaign, especially each time it became necessary to ask for the support and cooperation of a Government Department the attributions of which were not particularly in relationship with problems of Public Health.

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2.3. SET-UP OF A TECHNICAL UNIT

The Director of the Public Health Department grouped together eight technicians of the Territory who were directly concerned in dengue control, their branches covering the organization of the campaign, epidemiology, sero-virology, Health Education and anti-mosquito control. They belonged to various departments or organisms : the Health Department, the Sanitarian Department, the Endemics Department, ORSTOM (Bureau for Overseas Scientific and Technical Research) and the "Louis Malardé" Medical Research Institute. Each of its members was conscious that this technical unit would be the cornerstone of the anti-dengue control campaign and felt directly responsible for the evolution of the situation. The Committee met daily at the beginning of the campaign, thence on a weekly or bi-weekly basis.

2.4. STRATEGY AND GOALS

The strategy adopted mainly covered the urban and nearly zones of Tahiti, where human densities and vectorial densities were compatible with an important epidemy(5).Above all, it consisted in putting the prevention action to the forefront. The level of the *Aedes aegypti* population had to be brought down to a sub-epidemic level and only anti-larvae control could allow one to obtain durable results.

The observation of suspect cases lets one to suppose that the sub-epidemic level had not been reached and that it is necessary to undertake an anti-adult campaign to prevent the immediate propagation of the virus(16,17). This action was to be harmonized with the number and the spreading of suspect cases : if one had to deal with an isolated case, or groups within the same neighbourhood, or again spread out over the whole urban zone, one would use portative pulverization equipment, set up on trucks or again nebulization by aircraft.

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The goals to meet could be divided into three main categories :

- an attempt to have a day to day knowledge of the situation, regrouping insofar as possible all epidemiological, sero-virological and entomological parameters, in order to decide on steps to be taken and then to evaluate their efficiency.
- inform the population and promote their participation in anti-larvae control.
- set up means for anti-adult control adapted to local conditions.

2.5. SURVEILLANCE

2.5.1. EPIDEMIOLOGICAL SURVEILLANCE

The success of the strategy adopted was essentially based on a rapid and as complete as possible knowledge of the number of suspect cases and their localisation. It was therefore necessary to obtain the collaboration of the private and Government doctors in the Territory. To this effect, the Director of the Public Health Department invited all doctors to a meeting during which the technical unit was presented to them, the steps planned on were explained and a proposal was made for a declaration form which would contain various clinical and epidemiological information. 10 000 copies of the form were distributed to all doctors and a Social Assistant was named to pick them up on a regular basis, and eventually to bring in suspicious cases for the second sample when a sero-virological analysis was requested. The results of such tests were given free of cost. As soon as the cards were received, the suspicious cases were carded and immediately pointed out to the Sanitation Department which was in charge of disinsectization. Results on type-taking require several months, the presumption of type I virus being based on the proportion of suspicious cases : those present in 1971/New arrivals which are all the more high to the extent the type I virus predominates.

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During the entire campaign, the Director of the Health Department wrote to the doctors on a regular basis to maintain contact and keep them informed on the progress of the situation.

2.5.2. *SERO-VIROLOGIC SURVEILLANCE*

A system of watchmen, made up of volunteers chosen among young recruits who had recently arrived and who had always lived in a zone free from dengue was set up in early 1974 (18). Serological tests run every two months allowed a detection of any abnormal propagation of the virus.

In regards to suspicious cases for which a serological test was asked for, the pairs of serum were treated locally in inhibiting hemagglutination. Serums which seemed to be the nearest thing were sent to Honolulu for isolation (20) and typing the virus by Complement-fixation technique.

25.3. *ENTOMOLOGICAL SURVEILLANCE*

40 standard WHO ovitraps, visited on a weekly basis, were set up in 1970 all around the island. They were mainly for *Aedes polynesiensis* (81,5% of all eggs identified). After the 1971 epidemy, 44 other ovitraps appliances were set up in the urban area and these were mainly for surveillance of *Aedes aegypti* (96% of the eggs identified). Since the beginning of the campaign, four teams of catchers make a series of captures, every two weeks in general, in the urban zone in order to evaluate the agressivity rate of *Aedes aegypti* per man and per hour. This collection work takes place between 6 and 9 a.m. and between 3 and 6 p.m. The density of larvae breeding sites is calculated using the Breteau index : number of positive *Aedes aegypti* larvae sites per 100 homes visited.

The results of the various surveillance systems are regularly compared and appropriate decisions made.

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3 - PSYCHOLOGICAL ACTION : SANITARY EDUCATION

The elimination of all collections of water favorable to the development of *Aedes aegypti* ia a goal as difficult to attain as easy to describe, for it requires the active, efficient and lengthy participation of the population in its whole. When the filariasis endemy was very prevalent, Tahiti had been the setting for an intense large scale anti-larvae control program against the *Aedes polynesiensis* (21). The spectacular decrease , obtained by D.E.C.* mass-treatment, and the socio-economic changes which have occurred over the past twenty years have entailed an almost complete abandon.

3.1. INFORMATION

Most of the breeding sites stemming from ignorance, it was necessary to inform the population of the dengue cycle, the biological aspects of the carrying mosquito, etc... in order to encourage them to apply the anti-larvae control instructions. This information had to be intensive, but varied enough to not cause lassitude (22).

On the other hand, as there is little hope of modifying in any durable way adult behaviour, an in-depth action must be carried out with children through the assistance of the schools. In this light, a brochure was published in 1974 for the information of teachers entitled "The Mosquito, our enemy" (23) and the mosquito biology has been introduced into the normal teaching cycle for primary schools in Tahiti. Therefore at the school level, a special effort is being made. In March-April, a vast campaign was done through the media, radio-T.V. (spots, slogans, group discussions, questions from listeners, etc...) and the written press, which published on a regular basis, often on the front page, various articles on dengue. At the same time, tracts in two languages, stickers and posters were widely distributed. Talks with slide shows, mosquito stands in various communities, in schools, or before several religious groups also took place.

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* diethylcarbamazine

On Saturdays (Mahana ma'a : in Tahitian, the day to prepare the meal) which is traditionally reserved for household duties, a "mosquito day" was proclaimed , with the radio reminding the population of anti-larvae control instructions, and recommending the elimination, every Saturday, of all potential breeding sites in a radius of thirty metres around one's home. This reduced distance was intentionally chosen so that the control efforts would not appear to be out of proportion, and that the greater number of people would carry them through.

In various communes, anti-dengue committees were set up which organized cleanliness campaigns.

In the initial stages, at the risk of shocking the purists of sanitary education, the fear which arose from the alarming information coming from Fiji, largely diffused in the local press, strongly encouraged the population to undertake larvae control. Nevertheless, and perhaps for fortuitious reasons, this phase of the campaign corresponded with a spectacular decrease in the amount of mosquitoes, along with a less spectacular decrease, but of far more importance, in the number of declarations of suspicious cases, and this phenomenon was felt by many people as proof of the efficiency of steps taken which they had previously thought to be an illusion.

This intensive information campaign, spread out over five weeks, was essentially handled by the technical team and by the Government Councillor in charge of Public Health, but various personal initiatives must be mentioned : several mayors personally visited each house and distributed cleanliness certificates, a local orchestra composed a song about dengue, etc....

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3.2. CREATION OF THE CLAM (Comité de lutte Anti-Moustique)

After the technicians, it was advisable that animation of the campaign be continued by an organization stemming from the public, as this would be more persuasive. The meeting of various group leaders decided on April the 11th to set up a Mosquito Control Commission in which the members of the technical unit would occupy the position of technical advisers. Reciprocally CLAM chairman will attend meetings about technical unit. The creation of the CLAM gave us the occasion to obtain the participation of the Chinese Community which, through an appeal on television and tracts in Chinese, encouraged Chinese businessmen to clear up any potential mosquito breeding sites in the backyards of their shops. It was also an occasion for various well known persons to take position in public for the anti-dengue campaign.

However, five weeks after the campaign had begun, the decrease in the number of mosquitoes and declarations of suspicious cases entailed, as could be expected, a let-down in watchfulness. CLAM decided to organize "action days" hoping that their spectacular aspect would renew the interest of the population.

3.3. "ACTION DAYS"

3.3.1. The first action day, set up in collaboration with the pedagogic Bureau, consisted in distributing in all classes of the primary level a packet of *Aedes aegypti* eggs, along with an instruction sheet, which allowed all the pupils to simultaneously watch the mosquito's development. The comments by teachers, and talks animated by Health Department Agents, encouraged children to intensive anti-larvae control actions in their homes on Saturday May 17, during which day the CLAM leaders went all around

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the island with cars equipped with speakers, giving advice in Tahitian with a musical background, as well as in French and Chinese and distributing tracts. The children also sent in stories and drawings about the dengue control program, the best of which were published in the local papers and broadcasted on radio and television.

3.3.2. The second operation was a most spectacular one. A month before the rainy season began, it consisted in distributing to the 13.000 or more pupils of the primary schools an ovitrap containing Abate, that they were to set up in their own yards after having attempted to destroy all potential breeding sites. The psychological success of this operation was made possible thanks to the participation of the local FR3 and television stations which launched an important "10.000 bottles" promotional campaign so that, in one day's time, enough plastic bottles could be recuperated to make the ovitraps. The bottles were spray painted in black, cut transversally, equipped with a wooden stick and a piece of blotting paper impregnated with Abate. Each trap was handed out along with instructions in both languages, which insisted on the priority to be given to the elimination of all potential breeding sites. The 13.200 traps were distributed in the schools by the City Halls on Friday October 3rd. The same evening, a film on television was shown several times on how to set up the trap and to control larvae.

The next day, on which the traps were to be set, CLAM organized a new information day with the help of several vehicles equipped with speakers, which were in contact with the local radio station.

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3.3.3. The last CLAM operation took place in December, when the increase in rainfall entailed an alarming fresh outbreak in *Aedes* mosquitoes and dengue declarations.

A CLAM delegation, in the presence of newsmen, paid a visit to all the Mayors of the Island to ask them what steps they had taken to protect their electorate against dengue (cleaning up of trash, clearing of ditches, etc....). Several communities organized cleanliness campaigns for the occasion.

3.4. SUPPORT FOR THE CAMPAIGN AGAINST ADULT MOSQUITOES

At the time, the number of declarations and of mosquitoes gave birth to fear that the anti-larvae control program would be insufficient to prevent the epidemy from reaching serious proportions, all the more so as the proximity of the end of the year festivites, as in July, entailed a great amount of movements amongst the population. Calling upon nebulization by aircraft therefore became necessary, but the idea had to be acceptable to the population and the authorities, highly sensibilized by the various campaigns against insecticides, some of which even came from International organisms (24). The technical team put out a mathematical report (25) which showed, taking account of the densities of the vectors, the "risk factor" that could reasonably be forseen. Several articles were published on the pros and cons of insecticides, and on the epidemiological situation which made their large scale use advisable. When the O.K. to overfly was given for low altitudes, the press used this occasion to remind the population of anti-mosquito instructions which had become more necessary than ever before (the use of Abate was intentionally not mentioned) in order to make this spectacular operation more lasting in effects.

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4 - TECHNICAL ACTION

When the alert was given, the anti-larvae staff of the Sanitation Department was only 14 strong. This was an insufficient number to supervize and animate an anti-larvae campaign : the inspection of all houses in the urban zone would require more than two years.

The Sanitation Department was therefore reduced to chemical control. The Dengue Control Committee authorized it to unfreeze funds to get itself urgently equipped in U.L.V. nebulization material and insecticide products.

4.1. NEBULIZATION PRODUCTS AND EQUIPMENT

4.1.1. PRODUCTS

The insecticides chosen were Malathion (OMS 1) and Abate (OMS 786) because of their lack of toxicity for man, their proven worthiness, and the need for non pollution of the precarious island environment. The tests carried out by the WHO Reference Laboratory on insecticides in Bondy (ORSTOM) indicated that local *Aedes aegypti* strains are affected by these products. Moreoever, they exist in ULV formulae : Malathion ULV (96% technical Malathion) and Abate 500E (50% technical Abate). The most developped urban zone, which came foremost on the list of protection zones, was evaluated on the whole at 40 square kilometres and a stock of 4 tons of Malathion and I ton of Abate was requested. Their rapid arrival from France was assured by military aircraft.

4.1.2. U.L.V. EQUIPMENT

No ULV equipment was available in the Territory so the Sanitation Department ordered the following equipment :

- Five MICRO-GEN portable nebulizers, for disinsectising the homes of suspicious cases.

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- a LECO nebulizer, truck-mounted, for neighbourhood desinsectisation. For aerial nebulization, the use of mono-prop planes is not advisable if the surface to be covered is over 10 square kilometres. The only type of bi-prop plane available with sufficient loading possibilities and which could respect the necessity for good stability at low speeds and low altitudes was the Britten Norman II Islander, a bi-prop-plane used for inter-island transport in many territories of the South Pacific.

To limit the danger of breakdowns (the consequences of which could have been catastrophic in a crisis period) the criterium used to choose the principle of nebulization was that of its simplicity, even if a more sophisticated arrangement could have furnished better results. This criterium has been amply met by tests, in particular in Languedoc at the Entente Interdépartementale de Démoustication with an equipment described for spreading Ortho-Dibrom ULV (26) : the pressure required is furnished by a bottle of compressed air rather than by an electric pump, and a "Tee Jet" ramp is prefered to a rotative diffuser, of the Micronair type.

This arrangement was set up locally by DCAN (27) and CIP, by attempting to make the most of the capacity, load factor, and other characteristics of the BN II Islander. Bureau Veritas ensured classification formalities. The installation weighed 235 kgs and was made up of :

- 3 insecticide tanks with a total capacity of 390 litres and a useful capacity of 330 litres
- 1 compressed azote tank (30 kg/cm2)
- 1 fast draining system
- 1 pulverization ramp, 12,7 metres overall, with 22 TEE JET pulverisers, ref 8001, at a pressure of 3,5 kg/cm2(50 PSI) their total theoretic debit being 9,33 litres of water per minute (2,46 U.S. Gallons/min) or 8,02 1 (2,12 US Gallons) for a product having the viscosity of Malathion ULV.

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The spreading speed is set at 120 km/h (80 mph), the width of the band treated being therefore in the order of 65 metres, if an attempt is made to use a dose of 0,584 l/ha (8 fl Oz./acre) composed of 3/4 Malathion and one quart of Abate 500 E.

4.2. EQUIPMENT TESTS

4.2.1. THE MICRO GEN PORTABLE SETS, were preferred to the FONTAN sets because the users of the latter model had pointed out that they had frequent breakdowns (13). In the long run, the MICRO-GEN sets presented the same inconvenience.

4.2.2. LECO SET

The width of the band to be treated was determined with the help of tetraedric cages, laid out perpendicular to the passage of a truck. The results confirmed those of the builders : a very high efficiency over a width of one hundred metres (28).

Theoretically, by estimating the efficient band at 65 metres, an average spreading speed of 15 km/h would enable 97,5 ha to be treated in an hour.

On a pratical level, in view of the many manoeuvers the truck had to do,the surface treated in an hour is in the order of 11 ha, without taking into account the time spent on maintenance, repairs and filling of tank.

To treat a 40 km2 zone, this type of apparatus would require 364 hours or more than three months if climatical conditions are favorable enough for it to work 30 hours a week. During the rainy season, the period required for treatment must be multiplied by 2 or 3. The cost price per hectare is in the order of 780 francs CP (i.e. 2,5 U.S. dollars per acre).

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4.2.3. AERIAL ULV APPLIANCES

4.2.3.1. Preliminary tests (28) took place on April 12th above the runway at the Faaa airport and on the island nearby. Only Malathion was used. The efficiency and the quality of the nebulization was evaluated by 50 tetraedric or cubic cages each containing 50 female *Aedes aegypti* and filter-papers impregnated with Rhodamine B.

Treatment took place at a speed of 120 km/h (80 mph) at the height of 60 metres (200 ft) ; in open ground the mortality rate was 100 percent over a width of 250 metres.

Moreover, the penetration of the insecticide fog was judged to be satisfactory after the results were obtained from cages placed inside hangars or in the leaves of trees.

Lastly, the use of colored paper indicated that the nebulization was fine enough and homogeneous.

4.2.3.2. Real tests took place in December when it seemed that an explosive epidemy of dengue fever was near. The meteorological conditions at the time were quite unfavorable, as it rained fairly often, even in the morning, and the wind was often above 10 mph.

The fine calibrating of the appliance took place, by using a mixture of 3/4 Malathion ULV-1/4 Abate 500E, which was to cover 0,584 1/ha (8 fl. oz/acre). A debit of 9,5 1/mn was obtained which brought the distance between two passages to 75 m and to 16,3 ha the surface treated within a minute. The loading of tanks for such an operation corresponded to a 200 litres drum of mixture, which allowed coverage of a surface of 342,5 ha for a 21 minute actual spreading time, without landing, or, given the nature of the ground to be covered, between 35 to 60 minutes flying time. In good weather conditions nebulization must be carried out in the early morning, to avoid ascending winds. It is therefore impossible to do more than two treatments per day. In poor weather, the time factor is not important, one must make good use of calm periods.

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By counting two flights a day, which was almost always possible, it would take the aircraft six days to cover a surface of 40 square kilometres.

4.2.3.3. Efficiency

To evaluate the efficiency of the treatment, 15 houses were chosen at random in part of the urban zone. In each house, on the outside, under cover, and inside, a tetraedric cage containing 50 female *Aedes aegypti* is set up, a bowl containing about forty larvae in the third stage, and kromekote paper. The material is picked up once again about an hour after the plane has flown over. Almost immediate death is noted in the larvae placed outside and under cover. 24 hours later, the mortality rate is total in the bowls, and reaches 60% for those placed inside the houses. Adults do not die immediately, but all cages mortality reaches 100% within twenty four hours. No mortality was observed in controls. The Kromekote paper is powdered with Rhodamine B which colorates the drops of insecticide and shows a satisfying level of homogenity and finess in the nebulization.

Moreover, for each of the fifteen houses, an evaluation of the natural population of mosquitoes is carried out by net captures inside the houses ; by captures from man outside and under cover. In spite of the poor climatological conditions (heavy rain fell just a few hours after the nebulization), the results (table n° 1) were satisfactory. They were confirmed by routine captures carried out in the urban zone as a whole.

Overflying allowed the evaluation of the "high risk" zone with a good deal of precision as only the sufficiently inhabited areas were treated. This zone is made up of 20 km2 (as well as Taravao and Uturoa). The most densely populated area, about 4 km2, was treated once again six days after the first passage. The cost of the aerial treatment was 2,0 U.S. dollars per acre, i.e. 25% less than the ground treatment.

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4.2.3.4. Other consequences

This operation was in the whole well accepted. A certain number of deaths took place in the honey hives in the urban zone amongst the gathering bees. Concerning aquatic fauna the only victims appear to have been the *Neomyxus* sp. or mullet fry who live in the dead ends of the lagoon. No deaths were pointed out amongst other species as well as amongst carps and fresh water shrimps. Even though Abate ULV is considered as being even more corrosive than Malathion, no complaint was heard about the painting on cars.

5 - RESULTS

5.1. DECLARATIONS

Overall, the situation in 1975 was not at all like that which can be noted when a dengue epidemy "follows its free course" as this was the case in Tahiti in 1971. The incidence was never high enough to perceptibly slow the activities of the Territory. On the other hand, even some haemorrhagic symptomes were noted, none were sufficiently serious enough to necessitate hospitalization, which tends to indicate that if the speed of circulation is maintained at a low level, this hinders the exacerbation of viral virulence.

Figure N° 1 shows the progress of weekly declarations since the beginning of the alert. From the third week onwards, which corresponds with the setting up of the declaration cards, this table brings to light three phases :

A) From the beginning to the 12th week, one observes a regular decrease, the number of daily declarations dropping from 50 to 8.

B) From the 13th to the 26th week, the number of cases regularly climbs upwards to reach a peak of 68 declarations during the 24th week. It then decreases rapidly till the 28th week (24 declarations) and then continues decreasing at a slower rate. Probably the observed drop at the 20th week is only apparent, because of the "July" feasts.

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c) From the 37th week onwards, the number of declarations increases sharply till the 41st week (142 declarations) and then drops suddenly.

Even though desinsectization in homes favorises the declaration of suspect cases, the number of declarations is certainly inferior to the actual number of cases concerned.

The ratio between freshly arrived Europeans and the natives ought to be, if one takes account that a fraction of the latter were immunized by the type 1 epidemy of 1944, in the order of 1 to 4, whereas the actual ratio registered was 1 for 1. This seems to highlight the fact that new arrivals have a tendancy to freely consult a doctor whereas locals do not to the extent the illness is, in general, not serious.

Except for the beginning of the campaign where it is probable that almost all suspect cases were reported, one can estimate that afterwards, for one declared case, five to ten went undeclared. A verbal investigation has been undertaken to check this estimation out in retrospective.

5.2. SEROLOGICAL CONFIRMATION

Serological analyses allow one to estimate the proportion of suspect cases who really came down with dengue fever. This proportion varies in a sigmoid manner through time :

- during phase A, on the decrease, it is only 28%, which can be explained by the presence of an epidemy of flu at the same time.
- during the first month of phase B, the proportion increases sharply and reaches 52%.
- the frequency of confirmation of suspect cases remains stationnary at about 69% during the end of phase B and phase C.

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5.3. VIROLOGICAL CONFIRMATION

To date, 34 viruses have been identified by the Pacific Research Section in Honolulu (figure 2d).

During phase A, 19 corresponded with type II and 3 with type I, the first of which made its appearance around mid March, three weeks after the beginning of the campaign.

For the ten viruses isolated in the upgoing part of phase B, only type I were isolated. It is therefore probable that all cases confirmed serologically from then on were essentially, if not fully, of type I.

5.4. BRIEF CLINICAL STUDY

According to a rapid analysis of clinical information shown on the declaration standard forms of cases serologically confirmed, it is apparent that the clinical symptoms noted are those that have been classically described. A brutal onset, pain, hyperthermia are almost always at the forefront of the clinical description. The fever frequently takes the classical aspect in V (3 days of high fever followed by a drop on the fourth day and than a resumption on the 5 th and 6th days).

The morbilliform type eruption was not very frequent. It appeared most often when fever rose again, sometimes however a bit earlier. Its prurigeneous characteristic was noted but with variable intensity. The prurit localized in the palms of the hands, though quite inconstant, proved to be a specific sign.

We did not register any serious haemorrhagic forms. However a slight haemorrhagic tendancy (epistaxis, gum bleeding) took place fairly often (approximately 15% of cases).

Among the other less classical signs, one notes the frequency of digestive troubles (nausea, anorexia, marked changes in taste and smell which made food and cigarettes taqte badly) as well as the presence of rhino-pharyngitis signs and this is important to know in order to not eliminate the diagnostic of dengue fever when in their presence. These signs never came to the forefront however and remained at the level of irritants (dry cough).

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On the hematological level, leucopenia and classical thrombocytopenia were observed in most cases.

5.5. PROGRESS OF DENSITY VECTOR AND WEEKLY INCIDENCE

Figure 2 represents the progress from the start of the campaign :

a) of monthly rainfall readings in the urban zone (Faaa)
b) of the agressivity rate of the *Aedes aegypti* in urban areas, given in the number of females captured per man and per hour.
c) the number of weekly cases presumed to be positive, calculated in accordance with the rate of confirmation of suspect cases analysed.
d) isolated and typed virus.

5.5.1. VECTORIAL DENSITY

From the start of the campaign, a rapid decrease in stegomyian density was noted, the agressivity rate dropping from 5,1 to 1,0 and the Breteau index from 30-100 to 4-12 in only three weeks. Vectorial density then stabilizes itself around 1 for 8 full months. In particular, it does not seem to be affected by the nebulizations done from a truck in August. From early November onwards it starts up again sharply to reach a maximum at about mid December. After two weeks of treatment by trucks, it drops back down to 2,1. The spreading of product by air improves this result and density then falls to 0,2. It begins climbing on again the rate reaching 2,4 at the end of January, with a Breteau index of 11-23.

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5.5.2. *WEEKLY INCIDENCE*

On the whole, this varies in parallel with vectorial density. The sharp stegomyian decrease is accompanied by a slower but regular decrease of incidence (phase A). Moreover, the vectorial "peak" in December corresponds with an epidemic outburst (phase C). However, phase B, observed during July and August, and which set off the first anti-adult campaign, corresponds with a period during which stegomyian density was weak and apparently stationnary.

5.5.3. *PROGRESS COMPARISON AND INTERPRETATION*

The identity and the proportion of viruses present allows one to interpret that vectorial densities of the same order, during phases A and C, could have had radically different consequences on incidence.

At the beginning of phase A, the incidence was weak because it was essentially due to type II, which continues to subsist in view of the great number of vectors, and which ought to disappear if the latter decreased sufficiently. Such a regression has taken place, but it is partly hidden, attenuated by the appearance and the multiplication of virus I, which can develop in spite of a weak vectorial density because the greater part of the population is not immune to it.

A mathematical model will back up this interpretation. Vectorial density being practically constant during the major part of phase A and phase B, one can consider that the incidence due to type I is multiplied over the successive weeks by a constant factor. The upgoing part of phase II, during which only type I was isolated, allows one to estimate this factor at 1,218 and to extrapolate on incidences due to type I during phase A. The incidences due to type II are then obtained by the difference : they also seem to follow an exponential curve, the factor being 0,749.

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Even though being determinist, this model correctly reproduces the data observed (fig. 3). In particular, it points out well the results obtained in virus identification : the expected number of isolations of virus II is 20,1 on a total of 24 during phase A instead of 21, and 1,9 on 10 during phase B instead of 0.

It is probable that the dry period from July to September reduced the average life span of the vector population, which should have had repercussions on the transmission of the virus. But it appears that this phenomenon was counter-balanced by the July "Fetes" which are of some importance in Tahiti and which, while causing a drop in anti-larvae awareness, also entailed important group mouvements amongst the population.

It is therefore possible that transmission remained at the same rate in spite of a weaker absolute number of mosquitoes infected, taking into account the feeding habits of the female *Aedes aegypti* who takes its meals over several persons and who, during that period, had many more hosts at their disposal.

Regulation phenomenons, which are quite important among the *Stegomyia* subgenus (29) allow an interpretation of the paradoxal action of the first nebulization campaign, which seems to have caused a drop in transmission without a significant decrease in the vectorial population. It is therefore possible that these disinsectisations caused a good number of infectious or infected mosquitoes to die, but, because of density dependent factors, these are quickly replaced by a younger population, e.g., containing a less important fraction of mosquitoes susceptible of allowing viral incubation, all the more so that this is spread out during the cooler period. The relative dryness which lasted till mid-October maintened this tendancy, entailing a stationary or slightly decreasing transmission.

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Many of the breeding sites having been put back into water with the coming of the rainy season, this entailed an increase in vectorial density, accompanied with an epidemic outburst which corresponded with phase C. Even though climatical conditions favorised mosquito pullulation, the second anti-adult campaign on the ground had a more discernable action than the first one on vectorial density (regulation factors intervened to a weaker extent), and air treatment consolidates this result, keeping the virus from circulating in an explosive manner.

6- DISCUSSION : EFFICIENCY OF CONTROL

Three main questions can be asked :

1°) Is the public better informed and more motivated for anti mosquito campaign ?

2°) Can one be sure that the epidemy was of small importance ?

3°) If affirmative, is this due to fortuitious causes or to the efficiency of control measures ?

6.1. IMPACT OF THE CAMPAIGN ON THE PUBLIC

Polls carried out during the course and decline of the intensive sanitary education campaign as well as the overall feeling of the technical unit showed that the majority of the population now understands the role of the mosquito in transmission, its life span and the main things to do to control larvae. Everyone has more or less been made aware of the problem.

Even if a certain amount of lassitude is unfortunately inevitable, in general public feeling, at least the public now knows about the situation. The massive participation of the public without which no durable results could have been obtained in dengue control, cannot be hoped for.

This is a long term enterprise and if it is apparent that the unprecedented effort in this domain is to be continued, this must be carried out amongst the children who are the only one who can ensure future success.

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6.2. INTENSITY OF VIRAL PROPAGATION

The first point has already been brought up. If one can be sure that the number of declarations only represents part of the actual number of cases, one can also be certain that, on the whole, the epidemy of 1975 in Tahiti was in no way similar to those described in other territories or on this same island during preceeding epidemics : no deaths, no serious haemorrhagic syndromes were reported ; absence from work due to none serious froms was never important enough to cause a notable restriction on the island's activities.

While awaiting the results of the retrospective oral investigation actually underway, two arguments indicate the poor propagation of the virus.

The first is due to a poll carried out by antifilariasis agents, who were charged with counting the number of suspect cases encountered during the week during their visits to homes.

This investigation was carried out from the Ist to the 26th of September, during phase B, a period during which 24 to 35 declarations were registered each week. On 3.405 persons questioned, 3 suffered from sickness which reminded one of dengue, and had been hit during the two weeks prior to the investigation, two of them had been declared. The incidence from this poll is only 2,3 times higher than the incidence estimated on the basis of the declarations.

The use of watchmen subjects (18) also allows an evaluation of the intensity of propagation of the virus. Figure 4 indicates the proportion of non immunized subjects who presented a sero-conversion during the last two months. One notices that this rate was fairly important in 1974 and in the beginning of 1975 before the date type I virus was probably introduced. The absence of sero-conversion during phase A confirms the weak viral propagation which followed the onset of the campaign. The increase observed thereafter, and which is in the main imputable to type I, is of the same order as that observed in 1974.

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It can therefore be confirmed that in spite of the immunological conditions which were favorable to an important epidemic outbreak of type I, the virus had the same behaviour as a virus which has maintained itself for over three years at the endemic stage.

6.3. EVALUATION OF THE ACTIONS CARRIED OUT

For obvious ethical, psychological and practical reasons, it was impossible to obtain a authentic "control test" which would have allowed the evaluation of the share due to fortuitious circumstances or the campaign itself on results obtained. At the beginning of the campaign, the density of larvae breeding sites was of the same order as that registered during the 1971 epidemy. The Sanitary educative campaign entailed a reduction of 75 to 90 percent. An indirect indication is also furnished by our ovitrap arrangements, which have been used since 1971. The number of eggs for the same trap shows important fluctuations, but on the average a comparative study indicates that this number has a tendancy to increase with the number of mosquitoes captured nearby. The set-up of 40 egg-traps around the island is mainly for *Aedes polynesiensis* (81,5% of eggs identified), whereas the 44 egg-traps set up in town essentially represent *Aedes aegypti* (96% of eggs identified). The ecology of these two species allows one to believe that climatic conditions, in particular the rainfall index, have a comparable action ; however, the spread of *Aedes polynesiensis* and the frequency of natural breeding sites which are often inaccessible make it far less sensitive than *Aedes aegypti* to the control campaign which has been undertaken.

Figure 5 compares the number of weekly eggs registered in 1975 respectively around the island and in the urban zone, given in percentage of the corresponding average value obtained during the same period for each of the two devices during the 1971-1974.

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One notices that the series of samples around the island are always superior to the average of the previous years which suggests that, with the exception of August and September, the climatical conditions in 1975 were not unfavorable to the development of *Stegomyia* ; this has, in fact, been confirmed by routine captures of *Aedes polynesiensis* made in the context of the filariasis research. However, the curve of *Aedes* layings in the urban zone clearly shows a tendancy to the contrary, as it remains constantly inferior to the averages of previous years. The results of the tour of the island suggest that this sharp reduction can only difficultly be attributed to metereological particularly unfavorable conditions, and it therefore appears only logical to render the control campaign responsible to a large extent.

CONCLUSION

Identified in mid March, the type I virus did not provoke an explosive epidemy of dengue in Tahiti in 1975. Contrary to the type II virus, which arrived four years earlier during the same season, it caused no deaths, serious haemorrhagic forms, or perceptible slowdown in the island's activities. If one makes an exception of the weak epidemic outburst which coincided with the beginning of the rainy season, the new virus was kept at the endemic stage, although the major portion of the population was not immunized and that climatical conditions were, on the whole, favorable to the multiplication of vectors.

It is probable that this result can be imputed to the anti-vector campaign which was launched as soon as the announcement of a serious epidemy in Fiji was made in early March, which date most probably coincides with the introduction of the virus in Tahiti. This campaign, based essentially on the sanitary education dispensed in the beginning, was accompanied by a spectacular decrease in the density of *Aedes aegypti*, at a sufficient level to entail the virtual disappearance of the type II virus, which had been present at the endemic stage since 1971 ;

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but it was insufficient to prevent the implantation and relatively slow multiplication of the type I virus. It was necessary to make use twice of general nebulizations with Malathion and Abate, as soon as the number of declarations or the vectorial density reached alarming proportions. The two ground treatments made in August and December were able to cause a perceptible decrease in incidence but their range of action appears to be too weak to interrupt transmission, even in the dry season. The second ground treatment was greatly consolidated by the air spraying which entailed a reduction in the vector population of over 90%, in spite of very unfavorable metereological conditions.

The acquisition of immunity by an ever increasing number is progressively diminishing the risks of an explosive epidemy. However, acute surveillance must be maintained.

Another positive point to remember is : at the time, many people know how the disease : is transmitted as well as the main things to do as far as the anti-larvae control is concerned.

If the results obtained justify the strategy adopted, they also point out its limits. The intensive sanitary education campaign did not allow reaching the critical transmission level, which for this strain of virus is probably situated between 0,5 and 0,8 *Aedes aegypti* female per man and per hour. On the other hand, if another serious alert were to take place, such a campaign would have certainly less results because more difficult to carry on as intensively : a certain lassitude would certainly be felt. Efforts should be continued in the schools in order to give children anti-larvae reflexes but the effects of such efforts will only be felt in the long range.

The imagocide control plan which follows a gradual response allows a reduction of incidence when it is put into effect early enough, but it appears to be incapable of interrupting the transmission, once the virus has settled in nicely. In particular, the disinsectisation of homes with portable sets where suspect cases have been registered seems to be an illusion because of the "iceberg" phenomenon noted by HALSTEAD (30).

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This author proposes, rather, an offensive strategy : "when adequate quantities of insecticide and manpower are available, mosquito control can be started during the seasonal low population and sustained through the rainy season". In retrospective, one realizes that if a vast anti-adult campaign had been launched as soon as the type I virus was identified, e.g. at the end of phase A or the beginning of phase B, it is quite probable that the virus could not have maintained itself. But the attitude of the population and authorities at that time in regards to insecticides prohibited their intensive use, which did not seem justified by the weak incidence observed. On the other hand, the persistance of epidemic situations in Fiji and in the Tonga Islands exposed Tahiti to the risk of a reintroduction of the virus.

That is the reason why the future of dengue control in the South Pacific has to be based on a wider concertation between territories, in order to define in common a realistic strategy, which takes into account the imperatives and possibilities of one and all.

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FIGURE 1

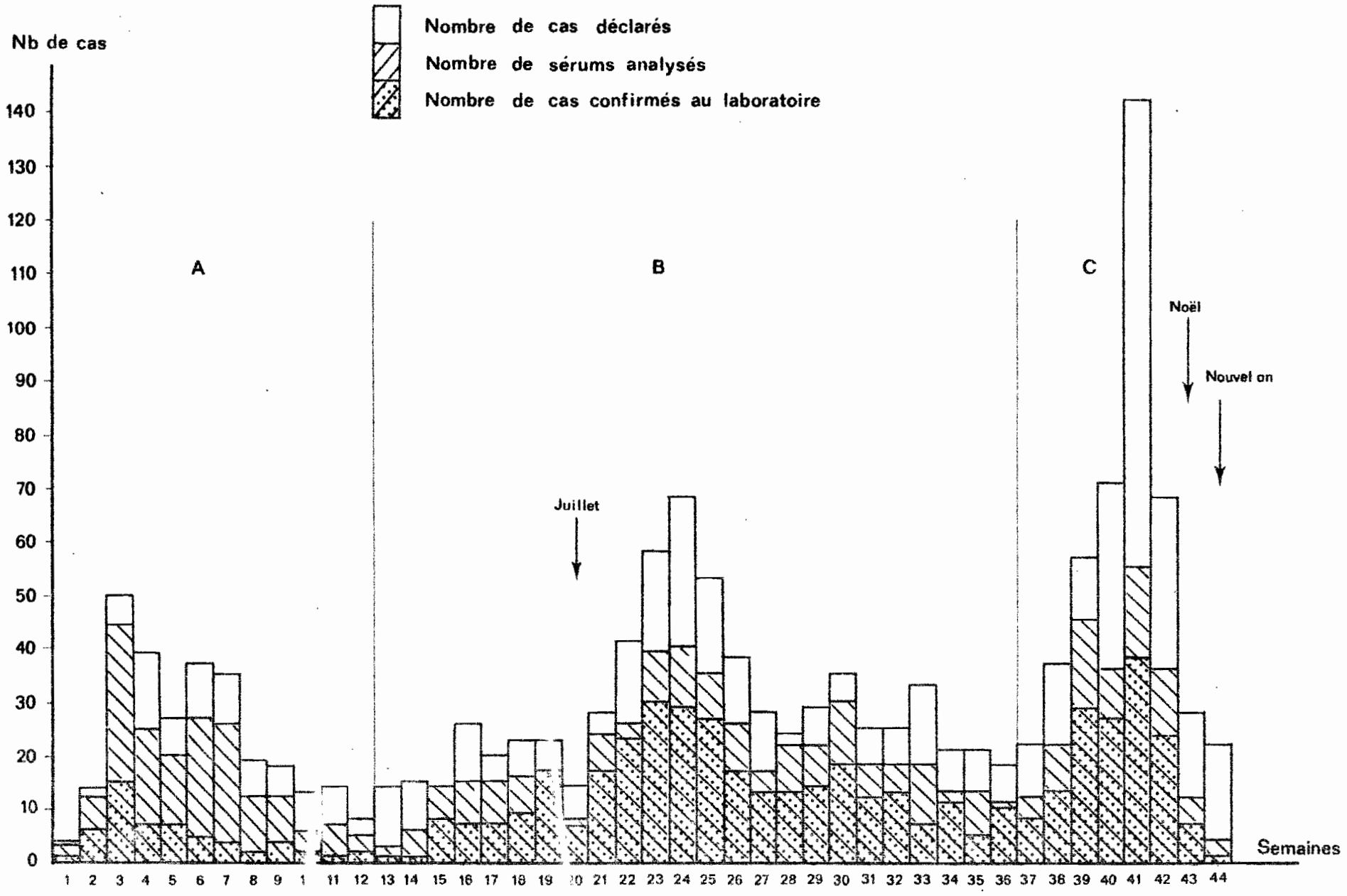

Nombre de cas déclarés
Nombre de sérums analysés
Nombre de cas confirmés au laboratoire
Nb de cas
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
A
B
C
Juillet
Noël
Nouvel an
Semaines
1 2 3 4 5 6 7 8 9 1 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44

FIGURE 2

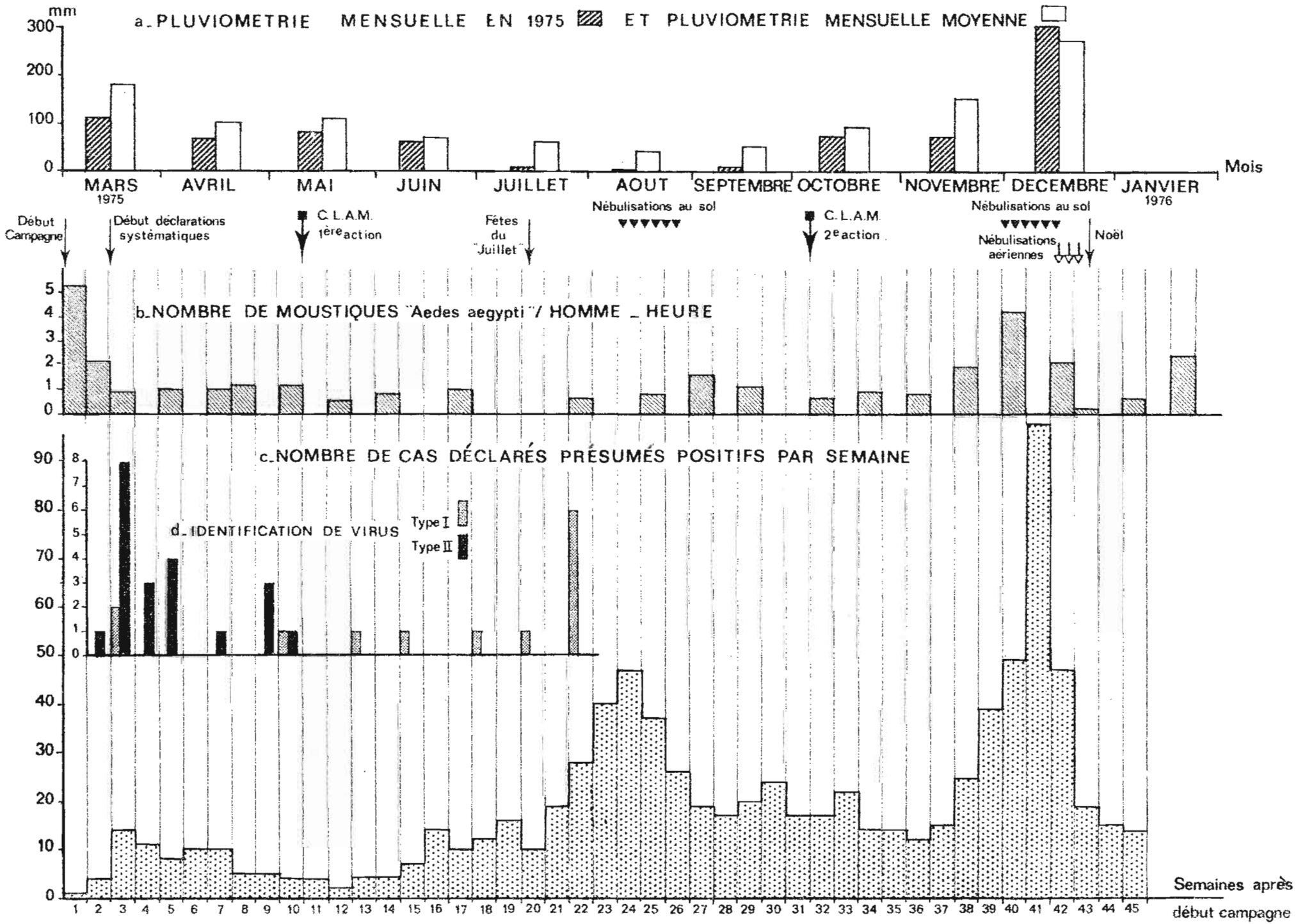
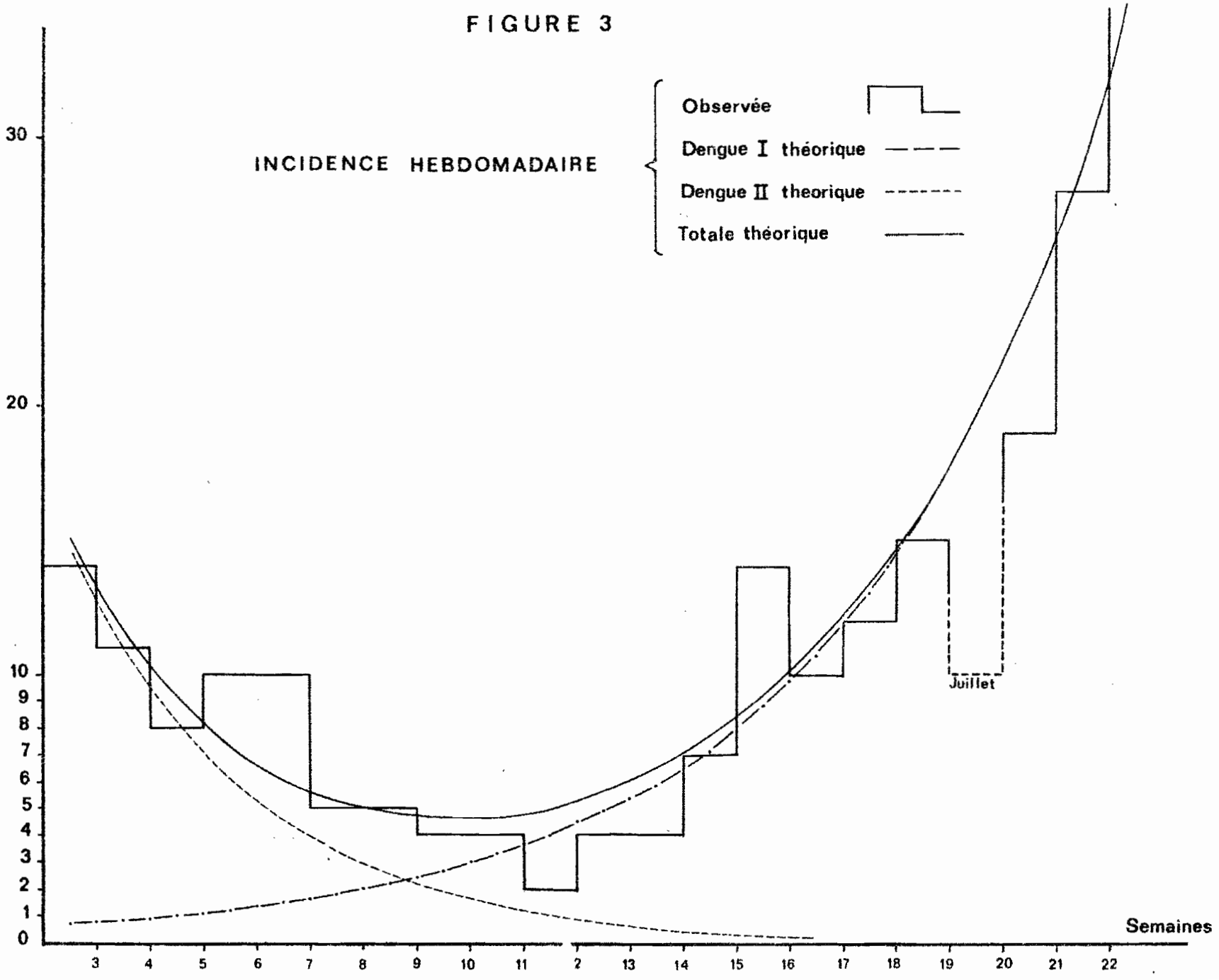

a_PLUVIOMETRIE MENSUELLE EN 1975 ET PLUVIOMETRIE MENSUELLE MOYENNE
mm
300
200
100
0
MARS 1975
AVRIL
MAI
JUIN
JUILLET
AOUT
SEPTEMBRE
OCTOBRE
NOVEMBRE
DECEMBRE
JANVIER 1976
Mois
Début Campagne
Début déclarations systématiques
C.L.A.M. 1ère action
Fêtes du "Juillet"
Nébulisations au sol
C.L.A.M. 2e action
Nébulisations au sol
Nébulisations aériennes
Noël
b_NOMBRE DE MOUSTIQUES "Aedes aegypti" / HOMME _ HEURE
c_NOMBRE DE CAS DÉCLARÉS PRÉSUMÉS POSITIFS PAR SEMAINE
d_IDENTIFICATION DE VIRUS
Type I
Type II
Semaines après début campagne

FIGURE 3


INCIDENCE HEBDOMADAIRE
Observée
Dengue I théorique
Dengue II theorique
Totale théorique
30
20
10
9
8
7
6
5
4
3
2
1
0
Juillet
Semaines
3
4
5
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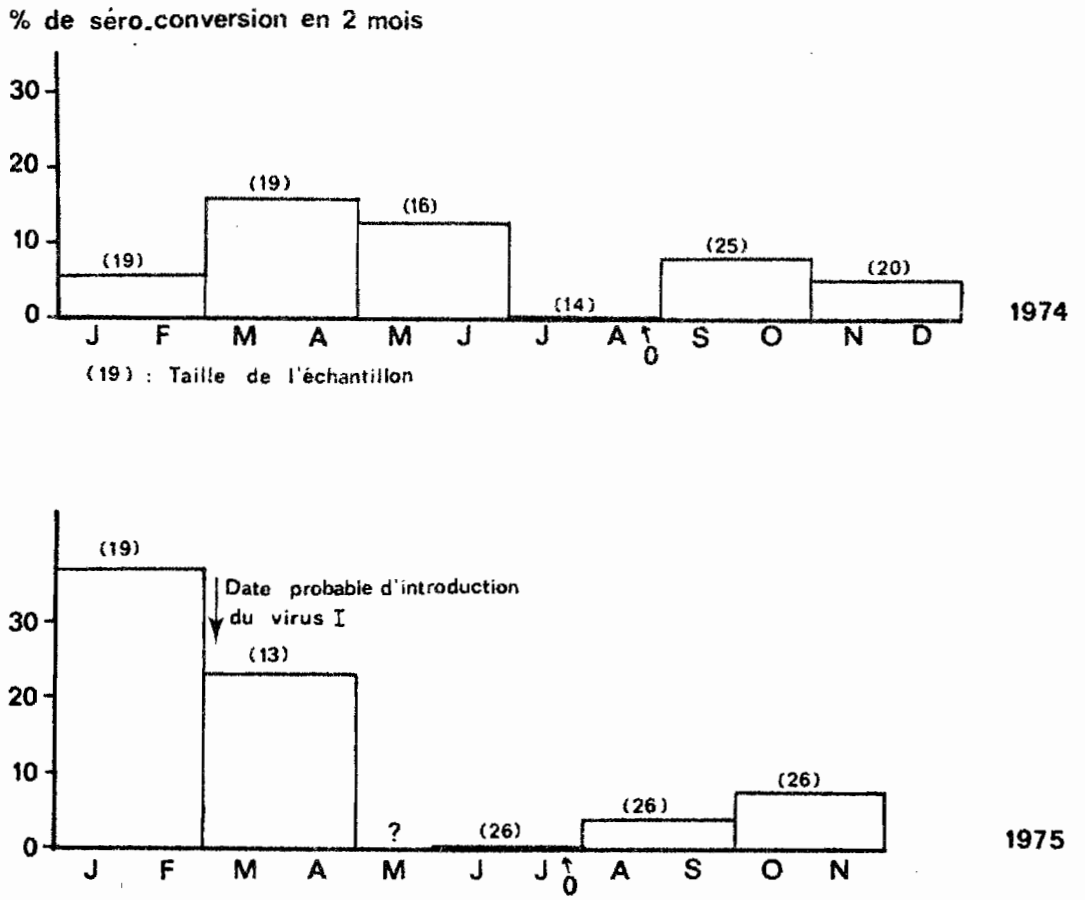

FIGURE 4 : POURCENTAGES DE SÉRO-CONVERSION DE SUJETS-SENTINELLES EN 1974 ET 1975, POUR DES PÉRIODES DE 2 mois

Tableau 1. Evaluation de l'efficacité des nébulisations aériennes U.L.V. sur les moustiques adultes, capturés sur homme à l'extérieur et capturés au filet à l'intérieur de 15 maisons de la zone urbaine.

DATE	Agressivité d'Ae. aegypti ♀ (par homme-heure)	Capture au filet par maison	
		Ae. aegypti ♀	C. p. fatigans ♀
1[illegible]-12-75	2, 1	3, 3	3, 2
16-12-75	1er traitement U. L. V.		
19-[illegible]2-75	0, 6	1, 7	2, 1
22-[illegible]2-75	0, 5	0, 7	0, 6
23-12-75	2è traitement U. L. V.		
2[illegible]-12-75	0, 1	0, 4	0, 4
3[illegible]-12-75	0, 3	2, 4	1, 6
[illegible]-1-76	0, 9	0, 5	0, 5
[illegible]-1-76	1, 0	0, 7	0, 6
[illegible]-1-76	1, 4	0, 9	0, 9