SERO-EPIEMIOLOGICAL EVIDENCE OF ERADICATION OF MALARIA FROM MAURITIUS

by

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1. Introduction

Malaria was virtually unknown on the island of Mauritius (Fig. 1) before 1866. Introduced from other parts of the world with immigrant labour and transmitted by Anopheles gambiae and A. funestus brought by ships from the mainland of Africa, malaria caused in 1867-1868 a severe epidemic with 43 000 deaths. It became endemic on the island and caused recurrent epidemics with much loss of life and untold economic losses.

Sir Ronald Ross visited Mauritius in 1907 and in his famous report (1908) assessed the malaria situation and recommended the main lines for the control of malaria by source reduction and the use of larvicides. During the next 40 years these methods were used mainly in urban areas and contributed to a considerable decrease of the disease, which was confined largely to the rural areas of the low-lying coastal belt, although small outbreaks of great intensity occurred periodically in the higher areas. About 3000 deaths every year were attributed to malaria.

A survey carried out by Sippe & Twining (1946) showed that in the areas of high malaria endemicity the spleen rate of children was of the order of 50-60% with a parasite rate of 36%. Plasmodium falciparum constituted about 44% of all infections, P. vivax 43%, and the remainder was due to P. malariae with an occasional P. ovale infection.

In 1949 a malaria eradication pilot scheme was set up by Dowling (1951) under the auspices of the United Kingdom Colonial Office. The object of this was the eradication of A. gambiae and A. funestus (the latter being the main vector) by residual spraying of DDT and HCH. The results of antimalaria operations showed a fall of the number of cases of malaria from 46 000 in 1948 to 6000 in 1950, a corresponding decrease of the spleen rate from 35% to 2.5% and of the parasite rate from 9.5% to 0.1%. There was also a dramatic decrease of the crude death rate and of the infant mortality rate. A. funestus practically disappeared but A. gambiae, while greatly reduced in numbers, remained still in evidence. Breeding places of this mosquito are plentiful in Mauritius; they are either natural, as a result of the abundant rainfall, or man-made, such as the numerous irrigation canals of sugar cane plantations. An attempt to eliminate A. gambiae by a vigorous larvicidal campaign was not successful (Dowling, 1953).

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Although the results of this project were satisfactory, small outbreaks of malaria con-
tinued during the 1950s with the annual number of reported cases between 100 and 200. During
the period 1957-1959 mass blood surveys totalling 182 000 samples revealed only 95 cases, but
active case detection resulted in finding 249 cases of malaria (Verdrager et al., 1964).

Total coverage by DDT insecticide spraying ceased in 1958; intensive malaria surveillance
was introduced in 1960, using active and passive case detection, and this revealed that cases
of malaria were more common than previously estimated. However, the relatively large number
of cases (1179) detected in 1960 decreased to 955 in 1961 and to 226 in 1962 (Verdrager et al.,
1964). Most of these were found in the districts of Black River and Grand Port; during the
period 1960-1962 not less than 60% of all cases of malaria were reported from these two areas
(Fig. 2). Hence it was confirmed that transmission of malaria continued on a small scale in
some coastal areas. Residual DDT spraying of malarious foci was reintroduced in these areas
in 1960-1964 and improved surveillance measures resulted in the further fall of the number of
cases of malaria to 30 in 1963, 20 in 1964, 14 in 1965 and 12 in 1966.

In 1960-1961 P. vivax and P. falciparum were the two malaria parasites commonly found,
the former in 62% and the latter in 37% of all cases, while P. malariae was rare. However,
during 1964-1966 P. vivax decreased to very low numbers and P. falciparum and P. malariae
were the main species detected, the latter mainly due to relapses or related to blood trans-
fusion. The fact that P. falciparum disappeared from Mauritius after the elimination of
P. vivax is of epidemiological interest as pointed out by Verdrager (1964).

In 1966 the spraying operations ceased except for occasional focal spraying, and the
island was divided into a central area in the maintenance phase of malaria eradication
(population 322 000) and peripheral areas in the consolidation phase (population 440 000).
Surveillance and vigilance have been carried out unremittingly during the past few years.
During the period 1963-1971 of the total number of 148 cases of malaria only 11 were due to
local transmission (Table 1). The last case of malaria due to local transmission occurred
in 1968, when the whole island entered into the maintenance phase of malaria eradication, but
this case was later classified as cryptic. According to the criteria of the World Health
Organization (1964) one of the fundamental requirements of the confirmation of malaria
eradication is the absence of indigenous cases of malaria during three years providing that
there is an adequate surveillance system (Black, 1968).

Of the adequacy of the malaria surveillance system there can be no doubt. The total
population, which had reached 822 350 in mid-1971, is under passive case detection operated
by 85 malaria detection posts. Amongst some 160 000 households under active case detection
at one- to three-monthly intervals, about 391 000 visits were made in 1971. The surveillance
measures for all persons arriving from malarious countries into Mauritius are strictly carried
out (Ministry of Health, Mauritius, 1967-1971). Most of the infections detected in the
course of the investigation of such persons have been due to P. falciparum. Appropriate
measures have prevented any introduction of malaria from outside.

In the final phases of malaria eradication the surveillance system depends on epidemi-
ological follow-up and treatment of detected cases of malaria, but the criterion of the infection
is still the microscopic examination of the blood for the presence of plasmodia. Technical
and statistical problems related to some unavoidable shortcomings of this traditional method
are well known (Pampena, 1969) and recently much attention has been given to the application
of serological techniques (WHO, 1968). The general consensus of opinion is that some of
these methods are useful for epidemiological surveys and particularly for the assessment of
the progress of a malaria eradication campaign. The present paper describes one of the first
attempts at using the immunofluorescent antibody (IFA) test for this purpose.
2. Objectives and methods

The rationale for the use of antibody surveys in malaria epidemiology has recently been discussed by several authors (Draper & Voller, 1972; Collins & Skinner, 1972). Antibodies can persist for many years, particularly if antimalaria treatment has been delayed or inadequate, and they can therefore be used to measure the incidence of the infection in the past. If the ages of the subjects tested are known this can be estimated for different periods.

The objectives of the survey in Mauritius were as follows:

(1) to look for antibodies in a large sample of the younger children in order to confirm or disprove the belief (based solely on negative parasitological findings) that transmission has been stopped for several years. Their presence in young children might reveal any undetected foci of transmission missed by the standard surveillance method of taking blood films from suspected cases;

(2) to determine the prevalence and amount of antibodies in different age-groups of the population exposed to infection in parts of the island where malaria transmission was particularly high in the past. This might give an indication of the trend of decrease of functional immunity, which is relevant to the risk of reimportation of malaria.

In April-May 1972, following a series of preliminary discussions with the medical authorities of Mauritius and the World Health Organization, two of the authors (C. C. Draper and P. Konfortion) proceeded with the collection of blood samples. Rather than take a large number of small population samples over a wide area, it was decided to concentrate on the Black River district in the south-west part of the island, this being the district where the most intense malaria transmission has occurred in former times and where it persisted longest. Thus during the period 1960-1962 out of the total number of 2360 cases of malaria on the island 788 (or 33%) were reported from this district; 668 of these were due to P. falciparum, and 91 to P. vivax (Fig. 2). Moreover in the Black River district numerous A. gambiae could still be found and, because of a scattered population, the surveillance system was thought to be weakest. Hence, if there was any residual transmission occurring in the island, this was the most likely place for detecting it by sensitive immunological methods.

Another small survey was done at Beau Bassin, half way up to the plateau and in Plaines Wilhems district, around an imported case of P. vivax malaria that was discovered at the time of the survey. Although there were only a few vector mosquitoes in this area it was thought to be of interest to do a serological survey since this might find some undetected secondary cases. In addition, a small survey was done at a school at Curepipe, on the central plateau in Plaines Wilhems district, where there has almost certainly been no transmission for 10 years, as a comparison with Black River, where some transmission is known to have occurred after this time.

For the survey in Black River it was decided to concentrate particularly on children under five years old as an index of any malaria transmission that might have occurred in recent years. However, samples were also taken from older children and adults in order to study the general antibody profile of the population. In order to cover the pre-school child population, adolescents, and adults, house-to-house visits were made by teams of health workers. This work was greatly facilitated by their unique local knowledge guided by house maps and population registers. Some visits were made to infant welfare clinics. To cover older children extensive use was made of schools in the Black River district, each of which was visited.
For the collection of blood samples the absorbent paper method was used since laboratory
tests have shown its reliability. Two samples of blood, each of not less than 50 µl, were
taken from the finger of each individual onto pieces of Whatman No. 3 chromatography paper.
These were about 13 cm x 9 cm in size, so that five sets of drops can be put on each.
Assistants were instructed to allow the drops to dry as much as possible and this was completed
by collecting the papers at the end of each day and placing them in a desiccator overnight.
They were then sealed into polythene bags and stored in a refrigerator at about 4°C before
being sent by air to London, where they were stored at -20°C until testing. The maximum
period of storage at 4°C was not more than three weeks, during which no deterioration of
properly dried samples would have occurred.

At the same time that blood samples were collected, individual record forms were filled
in for each person with information on place, age, sex, ethnic group, period of residence in
this and other districts, and travel overseas. Data were also obtained about history of
fever and illness but these were not considered sufficiently accurate to be used for sub-
sequent analysis.

All IFA tests were carried out at the sero-epidemiology laboratory of the Ross Institute
by one of us (C. C. Draper). For testing, a disc of paper equivalent to 50 µl of blood was
cut from each drop and eluted in 0.4 ml of phosphate buffered saline of pH 7.2 to give an
approximate 1/16 dilution of serum.

The IFA test using unfixed thick films of human malaria parasites from infected owl
monkeys was employed (Bruce-Chwatt et al., 1972). The first 1000 samples were tested using
both P. falciparum and P. vivax as antigens. However, as all positive specimens reacted
with both antigens, P. falciparum alone was used as the screening antigen in subsequent tests.
All specimens were screened against this at an initial dilution of 1/16 of serum, and any
positive samples, showing a titre of 1/16 or higher, were then titrated against P. falciparum,
P. vivax and P. malariae.

3. Results

The numbers of subjects examined in different age-groups and the proportion whose sera
reacted with P. falciparum, P. vivax and P. malariae are given in Table 2, together with the
geometric mean reciprocal titres (GMT) of the positively reacting sera, while the proportions
reacting with any of the three antigens are given in Table 3. Many sera reacted with more
than one antigen but these are counted as single reactions in Table 3.

The total population of Black River district in June 1970 is given as 22 342. Using the
estimated age distribution by percentages of the total population of Mauritius in 1970, the
figures in each group in Black River district compared with the numbers examined (in
parentheses) are: under five years 3039 (1081), 5-19 years 8892 (4137), 30-44 years 6792 (540),
over 45 years 3619 (56). Thus from one-third to one-half of the pre-school and school-age
population of Black River district was examined and only small proportions of the older age-
groups. The proportions examined in the different ethnic groups were very similar to their
overall proportions on the island as a whole.

The results of the serological tests are also shown graphically in Figs 2, 3 and 4. It
can be seen that there is a very low proportion of positive sera in those under 20 years of
age who were born since the inception of intensive malaria control activities in the island
in 1949. By contrast much higher proportions of those in the older age-groups, particularly
those over 35 years, show antibodies. The highest proportions of reactions were with the
P. falciparum antigen which confirms the known fact that this was the predominant parasite in
the island. Some of the reactions with P. vivax and P. malariae may be cross reactions,
which commonly occur in the IFA test. The former predominance of P. falciparum is also
confirmed by a comparison of the GMTs of the positively reacting sera (Fig. 4). Table 2 and
Fig. 4 also confirm the common experience that P. malariae transmission is the first to be
stopped by control measures in that they show that there are very few antibodies to this parasite in people under 25 years old, while antibodies to *P. falciparum* and *P. vivax* are found up to the 5–9 years age-groups.

Of the children under five years old 16 positive reactions with either *P. falciparum* or *P. vivax*, all at low titre, were found during the first run of tests. With the cooperation of the health services it was possible to find these children again after six months and to get additional blood samples, together with an exhaustive history. On retesting, seven of these children still gave a reaction at low titre with one or both of the above antigens (Tables 2 and 3). Some of their mothers had antibodies but these were of low titre so that persistence of congenitally transmitted antibodies is an unlikely explanation for these reactions. No history suggestive of malaria was obtained for any of these children and it is assumed that these reactions were non-specific.

The small survey at Beau Bassin (Table 3) did not suggest any increased prevalence of antibodies, although its extent was very limited. There was, surprisingly, a low prevalence of antibodies (6% of 542 children examined in the age-group 5–14 years) at Curepipe School, suggesting that a few of these children may have had malaria in the past, perhaps during sojourns in the coastal areas while there was still some transmission there.

Only six individuals of all those tested gave a history of having lived in another country, so it was impossible to assess on this small sample the malaria risks from living abroad. Other analyses of the data showed no significant differences in the prevalence of antibodies between ethnic groups, between the sexes, nor between those who had lived in Black River district all their lives and those who had spent some time in another district.

4. **Discussion**

The interpretation of the results of this survey is conditioned by two factors: the size of the sample of population examined and the sensitivity and specificity of the tests.

Within the limitations of the sample size it can be stated that on the serological findings it is unlikely that there has been any malaria transmission in Black River district in the last five years, as no specific antibodies were detected in children born during this period. It should be pointed out that even if no positives are found in a sample of 1000 the 95% confidence intervals for the prevalence of antibodies in the universe from which that sample is drawn are from 0 to 0.37%. It is not impossible, therefore, that if a larger sample of children under five years old had been examined a true positive might have been discovered.

A sensitive test was purposely employed so as not to miss any low titre antibodies but with the risk that some of the positive reactions detected might be non-specific. However, this was done with the knowledge that the local health organization existed to follow up and verify if necessary any presumed case of malaria amongst the important group of children under five years of age.

As already stated, there is a high prevalence of antibodies in subjects over 20 years old, born before effective malaria control was started in Mauritius, and a lower prevalence in those aged five to 19 years, born in the period when malaria control was becoming increasingly effective and approaching the point of complete cessation of transmission. This is emphasized in Fig. 5, in which the percentage prevalence of antibodies by age-groups is plotted on a reverse logarithmic scale. The slope of the line for those over 20 years old corresponds to a former inoculation rate of about 5% per annum, while that for those aged five to 19 years corresponds to about 1% per annum, using the method of calculation of Draper & Vollr (1972). This assumes that there has been no loss of immunofluorescent antibodies in the older subjects in the absence of transmission. Some of our earlier studies on populations previously exposed to malaria and removed from the endemic areas confirm the
relatively long persistence of immunofluorescent antibodies (Bruce-Chwatt et al., 1972) and, taking this into account, it seems that our estimates of the inoculation rates are reasonably accurate.

Although many of the adult population show antibodies in the IFA tests it is impossible to know what proportion of these are functional protective antibodies. It is probable that only a proportion are such, as the IFA titres recorded were generally low. Similarly it is impossible to state how long such antibodies could persist in such a population with their history of malaria. It would be instructive to perform another serological survey in Mauritius in a few years' time on a sample of the same population, including as far as possible the same individuals.

The present study, the first to be used for confirmation of the interpretation of transmission and of the subsequent achievement of malaria eradication in a country in the African Region of the World Health Organization, indicates the growing potential for the application of modern immunological methods as an epidemiological tool (Sulzer et al., 1969; Voller, 1971). During the past five years among various methods used for this purpose in the field the IFA test has proved its reliability, though in order to appreciate its potentialities and limitations one must be aware of the variables involved and have a good knowledge of the local epidemiology of malaria (Voller & Bruce-Chwatt, 1968; Bruce-Chwatt, 1970; Draper & Voller, 1972). The particular value of IFA tests for detection of a source of infection in small malarious foci in eradication programmes in or approaching the consolidation phase has been emphasized by Lepeš (1972).

Although reasonably good results may be obtained using various non-human plasmodia such as P. fieldi and P. cynomolgi, as shown for example by Ambroise-Thomas et al. (1971, 1972) and Meuwissen (1966), it is preferable to employ, for epidemiological purposes the most sensitive homologous antigens available (Collins & Skinner, 1972; Bruce-Chwatt et al., 1972; Draper et al., 1972). This is particularly important when the amount of malaria is low as in the final stages of a malaria eradication programme. It has been pointed out on page 5 how the use of the human parasites as antigens showed that P. malariae transmission was interrupted before that of P. vivax and P. falciparum.

The screening by the IFA test of large numbers of blood samples collected in the field can be done as rapidly as by the traditional methods of examination of blood films but with greater relevance to the previous events. With much help in the field the blood samples from over 6000 people were collected in about three weeks and an equal number of months were spent in testing them in a semi-automated laboratory with the full-time services of one technician.

ACKNOWLEDGEMENTS

Many thanks are due for the unstinting courtesy and cooperation of the following people in Mauritius: the Minister and the Permanent Secretary, Ministry of Health; Dr A. Y. Wong, Principal Medical Officer (Preventive); Dr S. Ramphul, School Medical Service, and her School Health Nurses; Mr R. Rose, Zone Supervisor, Mr Moutia, Chief Health Inspector, and the Health Workers of the Rose Hill Health Office.

The IFA tests were carried out by Mr Sherali Thaver, the coding and computer analysis of the results by Mrs J. Thiedeman, and the graphs prepared by Miss A. Caisley, of the London School of Hygiene and Tropical Medicine.
RESUME

La transmission du paludisme, maladie qui semble avoir été introduite à Maurice vers 1866, a été interrompue en 1963 à la suite de plusieurs années d'efforts de lutte et d'éradication. Au cours des dix dernières années, les activités de surveillance ont permis de découvrir de temps à autre des cas occultés de paludisme à malaïrie mais aucun cas indigène de paludisme à falciparum ou de paludisme à vivax n'a été mis en évidence. Cette situation a permis d'utiliser des techniques sérologiques pour évaluer les progrès réalisés par une campagne d'éradication du paludisme.

Quelque 6000 échantillons sériques ont été recueillis, principalement dans la région jadis très impaludée de la rivière Noire, au sud-ouest de l'île, où la transmission s'est poursuivie jusqu'en 1963, ainsi qu'à Beau Bassin, à mi-hauteur du plateau, et à Plaines Wilhems où un cas importé à P. vivax a été découvert à l'époque de l'enquête. Ces échantillons ont été recueillis afin de déterminer la prévalence et la quantité des anticorps par l'épreuve indirecte d'immuno-fluorescence, a) dans un échantillon important de jeunes enfants, de manière à confirmer ou à infirmer les constatations parasitologiques négatives sur lesquelles on s'était fondé pour déclarer que la transmission était interrompue et b) dans différents groupes d'âge de la population précédemment exposés à l'infection et susceptibles de fournir une indication sur la diminution du titre d'anticorps.

Ces épreuves indirectes ont été effectuées à Londres sur des étalements épais non fixés de parasites du paludisme humain provenant de nyctéthiques infectés. Tous les spécimens ont d'abord été soumis à une recherche de P. falciparum en partant de la dilution 1/16 et les échantillons positifs au titre supérieur ou égal à 1/16 ont ensuite été titrés avec P. falciparum, P. vivax et P. malaïrie.

Chez les moins de 20 ans, nés après l'adoption de mesures de lutte antipaludique intensive dans l'île en 1949, la proportion des sérums positifs est très faible. En revanche, une part beaucoup plus grande des sérums prélevés dans les groupes plus âgés, notamment chez les plus de 35 ans, contient des anticorps. Les plus fortes proportions de réactions s'observent avec P. falciparum, ce qui confirme bien la prédominance de ce parasite dans l'île.

Au cours de la première série d'épreuves, 16 réactions positives avec P. falciparum ou P. vivax, toutes de faible titre, ont été observées chez les enfants de moins de cinq ans. Grâce à la collaboration des services de santé, il a été possible de retrouver ces enfants six mois plus tard et de procéder à une deuxième prise de sang tout en recueillant sur eux des renseignements détaillés. Lors de la deuxième épreuve, on relevait encore sept cas de réactions positives faibles à l'un des antigènes précités ou aux deux. Aucun indice de paludisme antérieur n'ayant été recueilli sur ces enfants, on a supposé que ces réactions n'étaient pas spécifiques.

Malgré la taille de l'échantillon étudié, les résultats de l'enquête sérologique permettent de conclure qu'il est fort peu probable que le paludisme se soit transmis dans le district de la rivière Noire au cours des dix dernières années, étant donné qu'aucun anticorps spécifique n'a été décelé chez les enfants nés pendant cette période.

La recherche des antigènes par l'épreuve indirecte d'immuno-fluorescence pratiquée sur un grand nombre d'échantillons de sang recueillis sur place peut s'effectuer aussi rapidement que par les méthodes traditionnelles d'examen des étalements de sang, tout en permettant de tenir davantage compte des antécédents. Grâce à l'aide importante fournie pour la collecte, les échantillons de plus de 6000 personnes ont été réunis en trois semaines environ et il a fallu trois mois pour procéder aux épreuves dans un laboratoire semi-automatisé occupant un technicien à plein temps.
TABLE 1. CASES OF MALARIA RECORDED IN MAURITIUS DURING THE PERIOD 1944-1971

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of cases</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1944</td>
<td>59 107</td>
<td></td>
</tr>
<tr>
<td>1945</td>
<td>47 667</td>
<td></td>
</tr>
<tr>
<td>1946</td>
<td>50 990</td>
<td></td>
</tr>
<tr>
<td>1947</td>
<td>41 228</td>
<td></td>
</tr>
<tr>
<td>1948</td>
<td>46 395</td>
<td>Dowling (1953)</td>
</tr>
<tr>
<td>1949</td>
<td>23 746</td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>6 021</td>
<td></td>
</tr>
<tr>
<td>1951</td>
<td>1 255</td>
<td></td>
</tr>
<tr>
<td>1952</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>1957*</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>1958</td>
<td>88</td>
<td>WHO (1960)</td>
</tr>
<tr>
<td>1959</td>
<td>161</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>1 179</td>
<td></td>
</tr>
<tr>
<td>1961</td>
<td>955</td>
<td>Verdrager et al. (1964)</td>
</tr>
<tr>
<td>1962</td>
<td>226</td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td>30 (8)**</td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>17 (1)</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>14 (2)</td>
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<td>1966</td>
<td>12 (0)</td>
<td>Annual Reports, Ministry of Health, Mauritius</td>
</tr>
<tr>
<td>1967</td>
<td>15 (0)</td>
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<td>1968</td>
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<td>1970</td>
<td>11 (0)</td>
<td></td>
</tr>
<tr>
<td>1971</td>
<td>18 (0)</td>
<td></td>
</tr>
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</table>

* Note: Figures for 1953-1956 not available.
** Figures in brackets = number of indigenous cases.
| Age-groups | No. examined | Titres of sera x P. falciparum | | | Titres of sera x P. vivax | | | Titres of sera x P. malariae | |
|------------|-------------|-------------------------------|---|---|---|---|---|---|---|---|
|            |             | <16 | 16 | 64 | 256 | 1024 | per cent. positive at ≥16 | GMT | <16 | 16 | 64 | 256 | 1024 | per cent. positive at ≥16 | GMT | <16 | 16 | 64 | 256 | 1024 | per cent. positive at ≥16 | GMT |
| 0-11 months | 171         | 170 | 1  | 0.6 | 16.0 | 170  | 1  | 0.6 | 16.0 | 171 | 0  | 0  |     |     |     |     |     |     |     |     |     |     |     |
| 12-23 "    | 169         | 169 | 1  | 0.6 | 64.0 | 169  | 0  | 0   | 169 | 0  | 0  | 0   |     |     |     |     |     |     |     |     |     |     |     |
| 2-4 years  | 741         | 738 | 3  | 0.4 | 16.0 | 737  | 4  | 0.5 | 16.0 | 741 | 0  | 0  |     |     |     |     |     |     |     |     |     |     |
| Total under 5 | 1 081   | 1 077 | 4  | 1  | 0.5 | 21.1 | 1 076 | 5  | 0.5 | 16.0 | 1 081 | 0  | 0  |     |     |     |     |     |     |     |     |     |     |
| 5-9 years  | 2 494       | 2 313 | 149 | 30 | 2  | 7.3  | 20.7 | 2 386 | 102 | 6  | 4.3  | 17.3 | 2 488 | 6  | 0.2 | 16.0 |     |     |     |     |     |     |     |     |
| 10-14 "    | 1 164       | 1 044 | 95 | 23 | 2  | 10.3 | 21.8 | 1 113 | 43 | 7  | 4.4  | 20.4 | 1 160 | 4  | 0.3 | 16.0 |     |     |     |     |     |     |     |     |
| 15-19 "    | 479         | 410 | 53 | 14 | 2  | 14.4 | 22.9 | 446  | 29 | 4  | 6.9  | 18.9 | 477  | 1  | 0.4 | 32.0 |     |     |     |     |     |     |     |     |
| Total 5-19 years | 4 137    | 3 767 | 297 | 67 | 6  | 8.9  | 21.5 | 3 945 | 174 | 17 | 1  | 4.6  | 18.2 | 4 125 | 11 | 0.3 | 17.9 |     |     |     |     |     |     |     |     |
| 20-24 years | 304         | 249 | 42 | 11 | 2  | 18.1 | 23.3 | 276  | 23 | 5  | 9.2  | 20.5 | 295  | 3  | 3.0 | 34.6 |     |     |     |     |     |     |     |     |
| 25-34 "    | 167         | 102 | 32 | 24 | 9  | 38.9 | 39.2 | 125  | 35 | 7  | 25.1 | 20.1 | 150  | 7  | 10.2 | 33.3 |     |     |     |     |     |     |     |     |
| 35-44 "    | 69          | 23  | 19 | 18 | 8  | 66.7 | 48.8 | 36   | 23 | 9 | 47.8 | 25.4 | 49   | 5  | 1  | 29.0 | 32.0 |     |     |     |     |     |     |     |     |
| Total 20-44 years | 540    | 374 | 93 | 53 | 19 | 30.7 | 35.1 | 437  | 81 | 21 | 19.1 | 21.7 | 494  | 15 | 3  | 8.5  | 33.0 |     |     |     |     |     |     |     |     |
| 45-54 years | 30          | 6   | 6  | 12 | 5  | 1  | 80.0 | 67.8 | 10  | 14 | 5 | 1  | 66.7 | 25.9 | 20  | 5  | 33.3 | 32.0 |     |     |     |     |     |     |     |     |
| Over 55 years | 26     | 7   | 4  | 6  | 8  | 1  | 73.1 | 99.1 | 12  | 8  | 5 | 1  | 53.8 | 31.8 | 17  | 6  | 34.6 | 25.4 |     |     |     |     |     |     |     |     |
| Total over 45 | 56     | 13  | 10 | 18 | 2  | 76.8 | 80.2 | 22  | 22 | 10 | 2  | 60.7 | 28.3 | 37  | 11 | 8  | 33.9 | 28.8 |     |     |     |     |     |     |     |     |

GMT = geometric mean reciprocal titre of positives only.
### Table 3: Mauritian Serological Survey 1972. Total numbers of people with sera reactive in malaria

**IFA test with P. falciparum, P. vivax or P. malariae**

<table>
<thead>
<tr>
<th>Age-groups</th>
<th>Black River district</th>
<th>Beau Bassin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. examined</td>
<td>No. positive</td>
</tr>
<tr>
<td>0-11 months</td>
<td>171</td>
<td>1</td>
</tr>
<tr>
<td>12-23 &quot;</td>
<td>169</td>
<td>1</td>
</tr>
<tr>
<td>2-4 years</td>
<td>741</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total under 5</strong></td>
<td>1,081</td>
<td>7</td>
</tr>
<tr>
<td>5-9 years</td>
<td>2,404</td>
<td>183</td>
</tr>
<tr>
<td>10-14 &quot;</td>
<td>1,164</td>
<td>123</td>
</tr>
<tr>
<td>15-19 &quot;</td>
<td>479</td>
<td>70</td>
</tr>
<tr>
<td><strong>Total 5-19 years</strong></td>
<td>4,137</td>
<td>376</td>
</tr>
<tr>
<td>20-24 years</td>
<td>304</td>
<td>56</td>
</tr>
<tr>
<td>25-34 &quot;</td>
<td>167</td>
<td>65</td>
</tr>
<tr>
<td>35-44 &quot;</td>
<td>69</td>
<td>46</td>
</tr>
<tr>
<td><strong>Total 20-44 years</strong></td>
<td>540</td>
<td>167</td>
</tr>
<tr>
<td>45-54 years</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>Over 55 &quot;</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td><strong>Total over 45</strong></td>
<td>56</td>
<td>43</td>
</tr>
</tbody>
</table>
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FIG. 1. THE ISLAND OF MAURITIUS
FIG. 2. INCIDENCE OF MALARIA PER 1000 POPULATION
REPORTED DURING 1960-1962 FROM VARIOUS
ADMINISTRATIVE DISTRICTS OF MAURITIUS

1. Port Louis  6. Savane
2. Pamplemousses  7. Black River
4. Flacq  9. Moka
5. Grand Port
FIG. 3. MAURITIUS SURVEY 1972. TOTAL MALARIA ANTIBODIES BY AGE-GROUP, BLACK RIVER DISTRICT. ARITHMETIC SCALE.

FIG. 4. MAURITIUS SURVEY 1972. GEOMETRIC MEAN RECIPROCAL TITRES (GMT) OF POSITIVE SERA WITH P. FALCIPARUM, P. VIVAX AND P. MALARIAE BY AGE-GROUP, BLACK RIVER DISTRICT. ARITHMETIC SCALE.
FIG. 5. MAURITIUS SURVEY 1972. TOTAL MALARIA ANTIBODIES BY AGE-GROUP, BLACK RIVER DISTRICT. REVERSE LOGARITHMIC SCALE.

(R = probability of being infected in one year)
The purpose of the WHO/MAL series of documents is threefold:

(a) to acquaint WHO staff, national institutes and individual research or public health workers with the changing trends of malaria research and the progress of malaria eradication by means of summaries of some relevant problems;

(b) to distribute to the groups mentioned above those field reports and other communications which are of particular interest but which would not normally be printed in any WHO publications;

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