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Malaria and urbanization in Central Africa: the example of Brazzaville.

Part IV. Parasitological and serological surveys in urban and surrounding rural areas

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Summary

Five schools were chosen in different districts of Brazzaville where the intensity of malaria transmission, determined in a previous study, is representative of the very varied conditions observed in this town in relation to urbanization. The parasitological and serological results found in schoolchildren are analysed according to the level of transmission to which they are exposed, and compared with the results of a longitudinal survey carried out in the rural area of the Brazzaville region.

In the urban area malaria prevalences in schoolchildren aged from 5 to 9 years and from 10 to 14 years vary considerably according to the districts. They are, respectively, 78·9% and 84% in Massina, 58·8% and 71·7% in Talangai, 32·3% and 46·9% in Bacongo and 5·6% and 12·6% in Moungali. In Poto-Poto, no positive thick films were found in a representative sample of 62 schoolchildren aged 6 and 7 years who have always lived in this district, and the malaria prevalence is only 6·9% in schoolchildren aged 14 and 15. In the rural area, the malaria prevalence is 76·4% in schoolchildren aged 5 to 9 and 82% in those aged from 10 to 14. According to standard immunofluorescent technique, 63% of children aged 6 and 7 years living since birth in the central part of the Poto-Poto and Moungali districts have no detectable antibodies. In the rural area, all children over 4 years of age are seropositive.

These results show that the decrease in vectorial density which accompanies urbanization has considerable parasitological repercussions. All levels of malaria endemicity are found in Brazzaville despite the presence of a very high malaria stability index. The presence of a constant maximum plasmodic index in the 10 to 14 years age group is discussed. This seemingly paradoxical observation is attributed to the growing use of antimalarial drugs, self-medication representing now one of the essential aspects in urban areas as well as in developed rural areas.

Introduction

Urban development in Brazzaville is accompanied by an important decrease in malaria transmission intensity in many districts of this town. According to their place of residence, inhabitants are exposed to a number of infective bites varying from less than one infective bite per person every three years, to over 100 infective bites per person per year (TRAPE & ZOULANI, see pp. 10-18). In order to establish the parasitological and serological repercussions of the lowering of the level of transmission which accompanies urbanization, a survey of the prevalence, parasite density and fluorescent antibodies was carried out in five schools in Brazzaville. The results are analysed in conjunction with those of another study carried out in a village near Brazzaville, where the entomological conditions, about 250 infective bites per person per year, are representative of those habitually observed in rural areas of this part of the Congo.

Material and Methods

In a previous entomological study, we drew up a map of malaria transmission intensity in Brazzaville, where four areas were marked (TRAPE & ZOULANI, see pp. 19-25.): (i) very low transmission: less than one infective bite per person per half-year, (ii) low transmission: from one infective bite per person per half-year to one infective bite per person per month, (iii) moderate transmission: from one infective bite per person per month to one infective bite per person per week, (iv) high transmission: at least one infective bite per person per week.

Parasitological Surveys

In each of these areas a school was chosen and a representative sample of schoolchildren aged from 5 to 9 years and from 10 to 14 years was selected at random. These schools were the Martyrs School in Moungali for the very low transmission area, the 19th September 1965 School in Bacongo for the low transmission area, the Liberté School in Talangai for the moderate transmission area, and the Ngaliema A School in Massina for the high transmission area.

In the very low transmission area, a second school was chosen (Unité Africaine School in Poto-Poto) where the random selection of schoolchildren was carried out only among the children aged 6 and 7 years and 14 and 15 years who have lived in this area since their birth.

The parasitological surveys in rural areas which serve as references were carried out in Linzolo, a village situated 25 km to the south-west of Brazzaville. The results presented here are those of two surveys concerning adults and preschool children, and seven surveys of schoolchildren.

The parasitological methods used for these surveys have already been described in a previous article (TRAPE, 1985). 200 oil-immersion fields on thick blood films (about 0·5 μl of blood) were systematically examined by the author. The parasite density was estimated with relation to the leucocytes, on the basis of 8,000 leucocytes per μl of blood, and classed into 5 categories with limiting values of 50, 500, 5,000 and 50,000 parasites per μl.

Serological Surveys

Serological surveys in Brazzaville concerned two samples of 60 schoolchildren of 6 to 7 years and 14 to 15 years from Poto-Poto and Moungali schools chosen

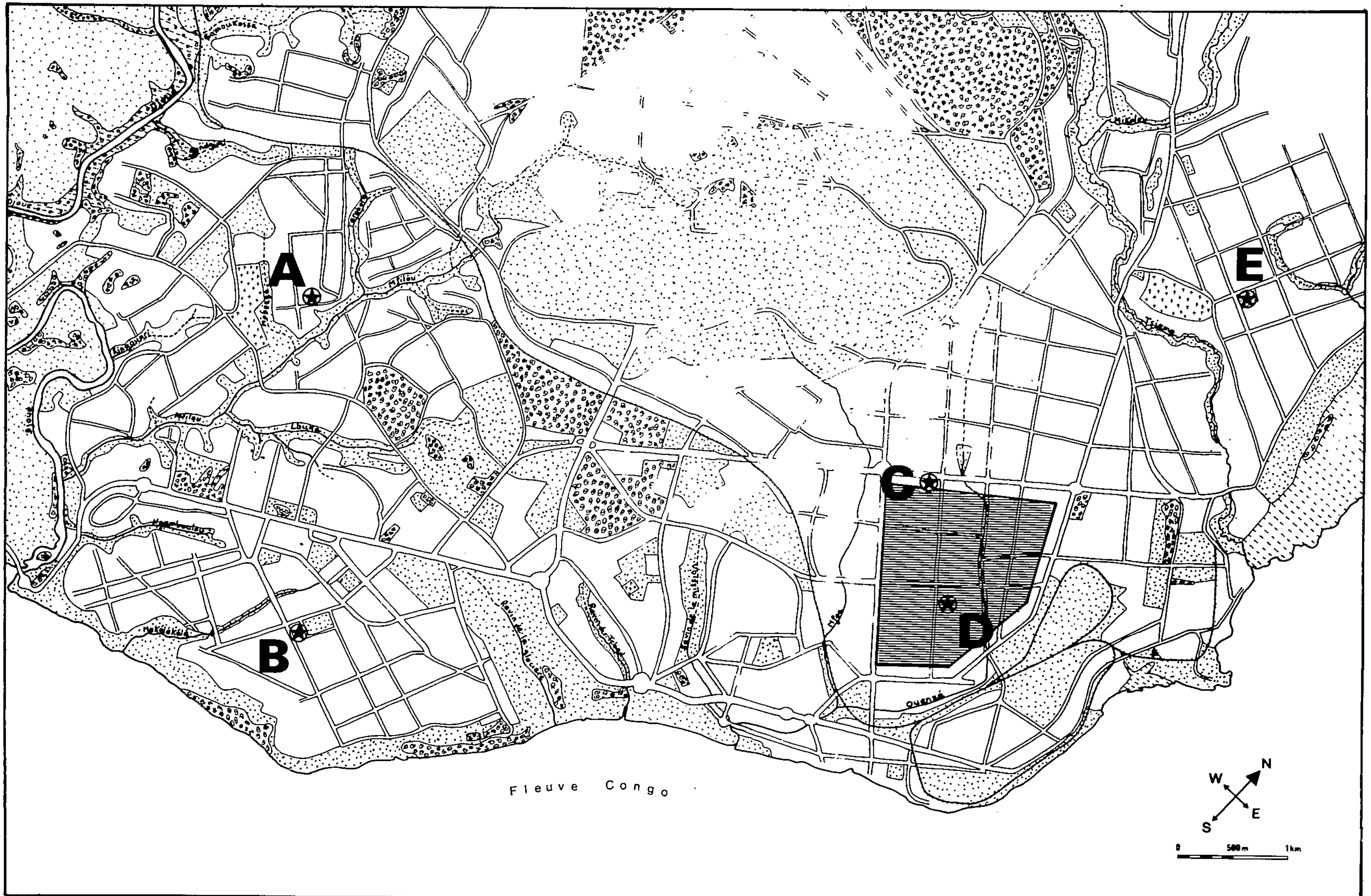

Fig. 1. Map of Brazzaville with localization of the schools investigated: A: Ngaliema A School in Massina; B: 19 Septembre 1965 School in Bacongo; C: Martyrs School in Moungali; D: Unité Africaine School in Poto-Poto; E: Liberté School in Talangaï. The shaded area indicates the place of residence of the Poto-Poto and Moungali schoolchildren selected for serological surveys.

at random among those living since birth in the central part of these districts. In Linzolo, 506 subjects of all ages were tested.

Blood samples were taken by fingerprick using heparinized microhaematocrit tubes. After separation, the plasma was stored at −20°C until it was tested for antibody according to standard immunofluorescent technique using *P. falciparum* antigen.

Results

Parasitological Surveys

The village of Linzolo

The over-all results of parasitological surveys carried out in this village between November 1980 and March 1982 are presented in Table I. The detailed results and analyses of these surveys, those of the period 1982-1984, and those of six other villages in the Brazzaville region will be presented in a subsequent article (TRAPE, in press). We observed that malaria prevalence was at its maximum in the 10 to 14 age group where it reached 82%. Malaria prevalence is also very high in the one to four and five to nine age groups, where it reaches respectively 78·4% and 76·4%. From the age of 15 onwards. it decreases progressively to 36·3% in adults over 40 years of age.

In children and adolescents, we noticed significant differences between malaria prevalence in the 5 to 9 and 10 to 14 age groups on the one hand, and the 10 to 14 and 15 to 19 age groups, which confirms the unusual form of the graph of plasmodic index variations according to age with a maximum between 10 and 14 years.

On the other hand, we observe a regular decrease in parasite density with age : 24·5% of children aged from one to four years have a parasitaemia of class 4 or 5, compared with only 20·4% of those aged between 5 and 9 years, 14·3% of those aged between 10 and 14 years and 5·2% of those aged between 15 and 19 years. In persons over 20 years of age a high parasite density is no longer observed.

Plasmodium falciparum was found on almost all the positive slides. *P. malariae,* usually associated with *P. falciparum,* was found in 15·7% of children under 15 and 10·4% of adults. *P. ovale* was found in 5·2% of children aged to 5 to 9 years, 3·1% of children aged from 10 to 14 years and was only exceptionally found in adults. Parasite density never reached class 4 for *P. malariae* or class 5 for *P. ovale.* In the case of associated species, the parasite density for these species was generally lower than for *P. falciparum.*

The gametocyte rate of *P. falciparum* was 24·5% between one and four years, 21·6% between 5 and 9 years, 21·4% between 10 and 14 years, 18·3% between 15 and 19 years and 8·8% in adults.

Massina (Ngaliema A School)

This district of Brazzaville is among those where intensity of malaria transmission is highest. The children attending this school are exposed to about three infective bites per person per week during nine months of the year (October to June), the transmission intensity decreasing considerably from July to September (TRAPE & ZOULANI, see pp. 10-18). The survey took place in February 1984.

Out of 126 schoolchildren selected at random, 102 (80·95%) had positive thick blood films. The malaria prevalence was higher in schoolchildren aged from 10 to 14 years than those aged from 5 to 9 years : 84% (42 out of 50) instead of 78·95% (60 out of 76) were positive.

P. falciparum was found on all the positive slides except in one case where only *P. ovale* was present. 12 cases (9·52%) of associated *P. falciparum–P. malariae* were found, and seven cases (5·56%) of associated *P. falciparum–P. ovale. P. falciparum* gametocytes were seen in 24 cases (19·05%).

Table II shows the results of the study of parasite density. 15·87% of the schoolchildren had a class 1 parasitaemia, 23·02% class 2, 29·36% class 3 and 12·70% class 4. No class 5 infections were found. The parasite density of *P. malariae* infections was generally low (class one : 9 cases, class 2 : one case, class 3 : 2 cases) as well as that of *P. ovale* infections (class one : 5 cases, class 2 : 3 cases). In cases of species associations, the parasite density of *P. falciparum* was always the highest, except in one case where the parasite density of *P. malariae* was slightly higher.

Moungali (Martyrs School)

This school is situated in one of the districts of

Table I—Village of Linzolo. Malaria prevalence and parasite density according to age

Parasite Density (Classes)	Age							
	<1	1-4	5-9	10-14	15-19	20-39	⩾40	Total
0	12 (57·1%)	22 (21·6%)	118 (23·6%)	111 (18%)	41 (29·9%)	20 (44·4%)	65 (63·7%)	389
1	1 (4·8%)	18 (17·6%)	88 (17·6%)	109 (17·7%)	27 (19·7%)	12 (26·7%)	21 (20·6%)	276
2	4 (19%)	20 (19·6%)	78 (15·6%)	159 (25·8%)	39 (28·5%)	11 (24·4%)	15 (14·7%)	326
3	3 (14·3%)	17 (16·7%)	114 (22·8%)	149 (24·2%)	23 (16·8%)	2 (4·5%)	1 (1%)	309
4	1 (4·8%)	19 (18·6%)	90 (18%)	86 (14%)	6 (4·4%)			202
5		6 (5·9%)	12 (2·4%)	2 (0·3%)	1 (0·7%)			21
Total Positive	9 (42·86%)	80 (78·43%)	382 (76·40%)	505 (81·98%)	96 (70·07%)	25 (55·56%)	37 (36·27%)	1134
Total	21	102	500	616	137	45	102	1523

Table II—Massina (Ngaliema A School). Malaria prevalence and parasite density in 126 schoolchildren selected at random

Parasite density (Classes)	Age		
	5-9	10-14	Total
0	16 (21·05%)	8 (16%)	24 (19·05%)
1	12 (15·79%)	8 (16%)	20 (15·87%)
2	17 (22·37%)	12 (24%)	29 (23·02%)
3	21 (27·63%)	16 (32%)	37 (29·36%)
4	10 (13·16%)	6 (12%)	16 (12·70%)
5	0	0	0
Total positives	60 (78·95%)	42 (84%)	102 (80·95%)
Total	76	50	126

Table III—Moungali (Martyrs School). Malaria prevalence and parasite density in 192 schoolchildren selected at random

Parasite density (Classes)	Age		
	5-9	10-14	Total
0	84 (94·38%)	90 (87·38%)	174 (90·63%)
1	3 (3·37%)	1 (0·97%)	4 (2·08%)
2	2 (2·25%)	4 (3·88%)	6 (3·12%)
3	0	7 (6·80%)	7 (3·65%)
4	0	1 (0·97%)	1 (0·52%)
5	0	0	0
Total positives	5 (5·62%)	13 (12·62%)	18 (9·38%)
Total	89	103	192

Table IV—Talangai (Liberté School). Malaria prevalence and parasite density in 111 schoolchildren selected at random

Parasite density (Classes)	Age		
	5-9	10-14	Total
0	21 (41·18%)	17 (28·33%)	38 (34·23%)
1	8 (15·69%)	10 (16·67%)	18 (16·21%)
2	10 (19·61%)	17 (28·33%)	27 (24·32%)
3	5 (9·80%)	13 (21·66%)	18 (16·21%)
4	6 (11·76%)	3 (5%)	9 (8·11%)
5	1 (1·96%)	0	1 (0·90%)
Total positives	30 (58·82%)	43 (71·67%)	73 (65·77%)
Total	51	60	111

Brazzaville where malaria transmission is lowest. About half of the children attending this school are exposed to one to three infective bites per year, and the other half receive less than one infective bite per year. The survey took place in February 1984.

Of 192 schoolchildren selected at random, 18 (9·38%) had positive thick blood films. The malaria prevalence of schoolchildren aged from 5 to 9 years was 5·62% (5/89) whereas that of schoolchildren aged from 10 to 14 years reached 12·62% (13/103).

P. falciparum was found on all the positive slides, alone in 16 cases and associated with *P. malariae* in two cases. The presence of *P. falciparum* gametocytes was observed in 6 cases (3·13%). Table III shows the results concerning parasite density. Only classes one and 2 infections were found in schoolchildren under 10 years old but classes one to 4 were found after the age of 10. The parasite density of *P. malariae* infections was of classes one and 2, associated respectively with densities of classes 4 and 3 for *P. falciparum*.

Talangai (Liberté School)

The children attending this school are exposed to about one or two infective bites per person per month. The survey took place in May 1984.

Out of 111 schoolchildren selected at random, 73 (65·77%) had positive thick blood films. The malaria prevalence was 71·67% (43/60) in schoolchildren aged from 10 to 14 years whereas it was only 58·82% (30/51) in those aged from 5 to 9 years. *P. falciparum* was found alone in 69 cases, *P. malariae* in 2 cases, and *P. ovale* in one case: One case of *P. falciparum–P. malariae* association was also observed. The presence of *P. falciparum* gametocytes was observed in 11 cases (9·91%).

Table IV shows the results of the study of parasite density for each of the two age-groups. We found that 16·21% of all the schoolchildren had a class one parasitaemia, 24·32% class 2, 16·21% class 3, 8·11% class 4 and 0·90% class 5. The parasite density of *P. malariae* infections was of class 3 (one case) or class 2 (2 cases, of which one was associated with a class 3 *P. falciparum* infection). The only case of *P. ovale* infection observed had a class 1 parasite density.

The 111 children taking part in this study were questioned to find out if they usually slept under a mosquito net. 26 of them (23·4%) were affirmative. The proportion of positive thick blood films was 65·4% in these children, and 65·9% in those who did not use a mosquito net.

Bacongo (19th September 1965 School)

This school is situated in a district which has a particularly heterogeneous malaria transmission intensity. Numerous *A. gambiae* breeding places are found in the Makelekele stream and adjacent vegetable gardens. The residents in the immediate vicinity are thus exposed to malaria transmission of high intensity, more than one infective bite per week. However, this decreases rapidly as one moves away from the gardens : at a few hundred metres distance it is less than one infective bite per half-year. The children attending this school are therefore exposed to very different transmission intensities according to where they live. However, most of them are exposed to less than one infective bite every three months.

The survey took place in May 1984. Of 126 schoolchildren selected at random, 50 (39·68%) had positive thick blood films. The malaria prevalence was 32·26% (20/62) in schoolchildren from 5 to 9 years and 46·88% (30/64) in schoolchildren from 10 to 14 years. *P. falciparum* was found on all the positive slides, except one case of an association *P. malariae*-*P. ovale*. Three cases of *P. falciparum*-*P. malariae* association and one case of *P. falciparum*-*P. ovale* association were also observed. The presence of *P. falciparum* gametocytes was observed in 10 cases (7·94%).

Table V shows the results relating to the parasite density. 12·70% of the schoolchildren had a class one parasitaemia, 9·52% class 2, 11·11% class 3, 5·56% class 4 and 0·79% class 5. Half of the four *P. malariae* infections were of class one and the other half class 3, and the two *P. ovale* infections were of class one and class 2.

Of 126 children taking part in this survey, 28 (22·2%) said that they usually slept under a mosquito net. The proportion of positive thick blood films was 35·7% in these children and 40·8% in those who did not use a mosquito net.

Table V—Bacongo (19 septembre 1965 School). Malaria prevalence and parasite density in 126 schoolchildren selected at random

Parasite density (Classes)	Age		
	5-9	10-14	Total
0	42 (67·74%)	34 (53·12%)	76 (60·32%)
1	7 (11·29%)	9 (14·06%)	16 (12·70%)
2	5 (8·07%)	7 (10·94%)	12 (9·52%)
3	3 (4·84%)	11 (17·19%)	14 (11·11%)
4	4 (6·45%)	3 (4·69%)	7 (5·56%)
5	1 (1·61%)	0	1 (0·79%)
Total positives	20 (32·26%)	30 (46·88%)	50 (39·68%)
Total	62	64	126

Poto-Poto (Unité Africaine School)

This school is situated in the oldest district of Brazzaville, which is also the district with the lowest anopheline density. The schoolchildren who were selected at random for the survey were among those between 6 and 7 years and 14 and 15 years who had always lived within a perimetre of about 200 hectares, shown in Fig. 1, where no anopheles were captured during the entomological survey (TRAPE & ZOULANI, see pp. 10-18). The survey took place in May 1985.

Of 61 thick blood films of schoolchildren between 6 and 7 years, none was positive; out of 58 thick blood films of schoolchildren between 14 and 15 years, 4 (6·98%) were positive. These were 4 *P. falciparum* infections, of which the parasite density was in one case class 4 and the other three cases class 3. In these last three infections, the presence of gametocytes was also observed.

Serological Surveys

The village of Linzolo

The percentage of subjects with a positive titre was 65·5% in infants (out of 55), 85·9% in children aged one to 4 years (out of 78), 100% in children aged five to nine years (out of 110) and 100% in subjects over 9 years of age (out of 263). Antibody levels rose steadily throughout childhood and adult life.

The central part of Poto-Poto, Moungali and Ouenze districts

All children concerned in this study were selected at random among those living since birth in the area shown in Fig. 1 where the anopheline density is the lowest in Brazzaville. Half were selected in Moungali school and the other half in Poto-Poto school.

Out of 60 schoolchildren aged six to seven years, only 22 (36·7%) had detectable antibodies and out of 60 schoolchildren aged 14 to 15 years, 50 (83·3%) had detectable antibodies. Very low titres were observed in nine of 22 seropositive children aged six to seven years.

Discussion

In a previous study, we observed the existence of major variations in intensity of malaria transmission in the different districts of Brazzaville, which suggested the existence of important differences in malaria prevalence in the residents of these districts. The comparison of the results of Poto-Poto, Moungali, Bacongo, Talangai and Massina shows a very close relationship between the level of malaria transmission and malaria prevalence : for the different districts studied, the higher the intensity of malaria transmission, the higher the malaria prevalence observed. Above all, the differences observed in malaria prevalence are considerable : according to the usual classifications of malaria endemicity (METSELAAR & VAN THIEL, 1959; WHO, 1964), malaria is holoendemic in Massina, hyperendemic in Talangai, mesoendemic in Bacongo and hypoendemic in Moungali and Poto-Poto. The whole range of endemic levels is thus observed in Brazzaville, despite the presence of a very high malaria stability index, over five (TRAPE & ZOULANI, see pp. 10-18). Such an observation is remarkable since it is classically accepted that malaria is always highly endemic when the stability index is high and transmission not limited by temperature factors (MACDONALD, 1952 and 1957; SPENCER, 1963). Thus the specificity of the epidemiological conditions in the urban area is clearly apparent.

Another peculiarity observed in this study, independent of the level of endemicity and in both the rural and the urban area, is the presence of a malaria prevalence higher in the 10 to 14 age group than in the younger age groups.

This observation seems at first paradoxical : it is a well-established fact that maximum prevalence is usually reached fairly quickly during childhood—before the age of two years in holoendemic areas, between two and four years in hyperendemic areas and between five and nine years in mesoendemic and hypoendemic areas (BOYD, 1949; SCHWETZ, 1949). The malaria prevalence then progressively decreases after a stable phase, thus indicating that immunity is acquired. The only acknowledged exception is epidemic malaria where, classically, all age groups are uniformly affected. Even in this case, it is not rare to find a higher prevalence in children (SWELLENGREBEL, 1950).

The analysis of the results of Linzolo and Massina gives an explanation for the apparent paradox of a maximum malaria prevalence in the 10 to 14 year age group. All the previous studies in Central Africa, as well as in other regions where malaria is holoendemic, showed that the malaria prevalence for this age group was considerably lower than that of younger age groups. Even when the malaria prevalence in children from 10 to 14 years was less than 80%, the malaria prevalence in the one to four and five to nine year age groups was often over 90% (CHRISTOPHERS, 1924; BARBER & OLINGER, 1931; FARINAUD & PROST, 1939; ARCHIBALD, 1956; MUIRHEAD-THOMSON, 1954). In fact, a direct relationship between transmission intensity and prevalence only exists for low or moderate transmission levels. The parasitaemia tends to become permanent rapidly, as shown by various authors in children of populations where anti-malarial drugs were not regularly used and where thick blood films were carefully examined (PUTNAM, 1931; WILSON, 1936; WILSON *et al.*, 1950; SCHWETZ, 1938; DAVIDSON & DRAPER, 1953; MUIRHEAD-THOMSON, 1954). The fact that parasite density decreases much more rapidly with age than does prevalence suggests that the parasitaemia remains permanent in adults despite a high level of acquired immunity. This is also suggested by the observations of DOWLING & SHUTE (1965).

In these conditions, the decrease in malaria prevalence with age is only apparent and only expresses the growing proportion of very low parasite densities whose detection is impossible or depends on the conditions and methods of the parasitological examination (TRAPE, 1985). The results observed in Massina and Linzolo in the 10 to 14 age group show that the method we adopted was highly sensitive and that much higher prevalences, of about 95%, should have been observed in the younger age groups. It must be remembered that prevalences between 90% and 100% before the age of 10 were continually reported from Brazzaville and the surrounding area during previous surveys by the Institut Pasteur (1937, 1944, 1945) and that similar prevalences have frequently been reported in Zaire in regions bordering on the Congo (SCHWETZ, 1938, RUPPOL, 1942; PEEL & VAN HOOF, 1948; LEJEUNE, 1958).

We attribute this difference to the growing use of antimalarial drugs. For a long time, these drugs were little used, and only in a few populations grouped around important administrative posts and religious missions or employed in modern sectors (mines, plantations, transport, various work sites...). At present, various factors favour the general extension of the use of these drugs, the most important according to us being education (total schooling in the Congo since 1960) (COURADE & BRUNEAU, 1983), the creation of dispensaries in rural areas and the increasing use of transistor radios. It must be pointed out that similar observations were made in Tanzania by DRAPER *et al.* (1972) and MATOLA & MAGAYUKA (1981). It was also in older schoolchildren that SEXTON *et al.* (1984) observed the highest prevalences in Kinshasa.

The increasing use of antimalarial drugs has developed in various ways, of which the most classical chemoprophylaxis is only of secondary importance at the present time. The mass chemoprophylactic campaigns for children have been abandoned everywhere, but a relatively large (but difficult to estimate) proportion of infants still receives more or less regularly some chemoprophylaxis, either after visits to the dispensary or mother and child welfare centres, or on the initiative of the parents themselves. Above all, the systematic use of antimalarial drugs to treat all febrile attacks in children has become generalized with the multiplication of dispensaries and small health centres. Whereas at the beginning this systematic treatment was the prerogative of nurses and health workers, we now observe that the initial treatment of a febrile child has generally been taken over by the parents, with the systematic use of chloroquine or amodiaquine. Only in cases of serious symptoms or where this first treatment has failed is the child brought to the dispensary, where he is usually given an injection of quinine.

Thus, children receive antimalarial drugs on numerous occasions, especially in early childhood when febrile syndromes of all aetiologies are particularly frequent. This was particularly brought out in the study we effected in Linzolo (TRAPE *et al.*, 1987). We calculated that for each survey carried out in this village, an average of 12·2% of schoolchildren aged from five to six years and 5·9% of children aged from 11 to 13 years had received in one form or another an antimalarial drug during the previous week. In most cases treatment was given at home by the parents.

Just as in advanced societies parents give aspirin or an equivalent antipyretic to their febrile child before deciding to consult a doctor, we are now witnessing the general extension of a similar approach in the Congo, with chloroquine or amodiaquine. At first limited to certain classes of the population and essentially observed in urban environments, this attitude is now frequent in rural areas. It is made possible by the low cost of 4-amino-quinolines.

Our previous observations on the decrease in intensity of malaria transmission which accompanies urbanization and the low prevalence of malaria parasites and antibodies in schoolchildren from Moungali and Poto-Poto, show that Brazzaville and probably many large cities in tropical Africa become enclaves of hypoendemicity within a naturally holendemic region. The observations of FASAN (1969) in Lagos, BIGGAR *et al.* (1980) and GARDINER *et al.* (1984) in Accra, NGIMBI *et al.* (1982) and SEXTON *et al.* (1984) in Kinshasa also point to this. This is a new situation since it is difficult to compare with the previous situation observed in urban areas during intensive antimalarial campaigns. The considerable decrease in malaria prevalence which was then observed was as much the consequence of mass chemoprophylactic campaigns as of a decrease in vectorial density (MERLE & MAILLOT, 1955). Moreover, even in the case of intensive antivectorial campaigns (WALTON, 1947 and 1949; LIVADAS *et al.*, 1958; HARVERSON *et al.*, 1968), the extent of urbanization was insufficient to prevent the recurrence of a high anopheline density as soon as the antivectorial measures were relaxed. The present evolution presents us with various major questions, particularly concerning clinical epidemiology, because of the emergence of a large population without immunological protection during childhood, usually rarely exposed to malaria but necessarily exposed to high conditions of transmission from time to time.

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