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TRANSMISSION INDICES OF *LOA LOA* IN THE CHAILLU MOUNTAINS, CONGO

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Abstract. A longitudinal entomological survey of the vectors of loiasis was conducted in the Missama area (Lekoumou region) in the Congo from September 1987 to August 1989. The principal catching site was a palm grove surrounded by forest 3 km from the village. Landing/biting densities of *Chrysops* were measured by standardized fly catches lasting 11 hr carried out twice a month. Vector landing densities were also assessed in the Bantu and Pygmy villages and in the fields. Populations of *Chrysops* from the palm grove were examined 6 times a month for infection with the infective stage of *Loa loa*. *Chrysops silacea* was the predominate vector except at the beginning of the rainy season, when *C. dimidiata* was the prevailing species. *Chrysops* were caught throughout rainy season, from October to June. The host-seeking activity of *C. silacea* was greatest in the middle of this season (February), but occurred sooner (October) for *C. dimidiata*. The following variables associated with transmission were calculated from our observations in the palm grove (the first figure corresponds to the first year of the study and the figure in parentheses corresponds to the second year). It was calculated that 2.658 (2.185) *C. silacea* and 1.412 (1.182) *C. dimidiata* could bite a person in the palm grove per year, including an average of 14.4 (12.7) infective *C. silacea* and 9.8 (7.2) infective *C. dimidiata*. The percentage of all dissected flies with third stage larvae in the head and the mean number of larvae in the head/infective fly were 0.57% and 10.1 ± 6.8 for *C. silacea* and 0.66% and 11.2 ± 6.5 for *C. dimidiata*, respectively. The estimated annual transmission potentials were 171.1 (102.9) for *C. silacea* and 116.1 (73.8) for *C. dimidiata*. In the palm grove, transmission was ensured by 2 effective vectors during the rainy season (October to May). Although the annual biting rate for both species was twice as low in the village as in the forest, our data suggest that effective transmission occurs there also.

Loiasis has long been neglected by epidemiologist due to the low pathogenicity of this filariasis compared with other tropical endemic diseases.[1] However, in hyperendemic regions of Central Africa, 95% of the population by the age of 2 years have antibodies reacting with *Loa loa* antigens and >90% of the adults present microfilaraemia or symptoms indicative of loiasis.[2–4] Until recently, diethylcarbamazine was the only drug found to be clearly effective against *L. loa*.[5] However, the occurrence of sometimes severe side effects has prevented mass utilization.[6] Recently, preliminary trials of ivermectin in patients infected with *L. loa* demonstrated the microfilaricidal action of this drug without notable side-effects and with an improvement in symptoms (J. Prod'hon, ORSTOM, Paris, France, personal communication).[7] If these results are confirmed, it may be possible to carry out mass treatment of an exposed population in the near future. In addition to the clinical improvements and the lack of side effects of the treatment, it would be useful to determine the impact of ivermectin on the transmission of loiasis by measuring entomological indices. Apart from the work of Duke in Cameroon, no data on the transmission of *L. loa* is available.[8] However, it has been estimated that during the rainy season at Kumba (Cameroon), all individuals were likely to be bitten by an infected *Chrysops* once every 5 days.[9]

In the Chaillu Mountains in the Congo, the endemicity of loiasis is high. Indeed, 18.9% of the Bantus are microfilaraemic and >50% of the adults report subconjunctival migration of an adult worm.[10] We carried out a field study of filarial infection over 2 annual cycles to define entomological indices of transmission in an hyperendemic zone.

MATERIALS AND METHODS

The Chaillu Mountains (altitude 400–600 m) are situated in the Southwest of the Congo and

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are largely covered with dense forest. Apart from a few groups of Pygmies, the population is sedentary, living in villages along the thoroughfares. Missama village (3°36'S, 13°18'E) was used as the base for the study. Stretching along a track for 1,200 m, the Bantu village comprises 500 inhabitants living by farming, hunting, and fishing. The Pygmies have set up permanent camp at the southern end of the village, which they leave for several months of the year to go hunting expeditions. The village is surrounded by a 200 m wide banana plantation, beyond which shrub savannah is established with a few patches of secondary forest and a few coffee and cocoa plantations. Part of the savannah is cultivated as manioc and ground nut fields. The dense rain forest begins ~1.5 km from the village. Rainfall and average temperature in Missama village were measured each month during the sampling period and are presented in Figure 1. Thick blood films prepared from long-term residents of Missama were examined for the presence and density of *L. loa* microfilariae and case histories of subconjunctival migration adult worms were noted. The procedures used have been described.[10] Prevalence and intensity of loiasis at Missama are summarized in Table 1. The 4 locations selected for the field studies were the center of the Bantu village, the Pygmy village, a manioc field on the forest edge, and a palm grove within the forest. Using human bait, we carried out fortnightly catches of *Chrysops* at the first 3 locations for 12 consecutive months (September 1988–August 1989) and at the 4th location for 24 consecutive months (September 1987—August 1989). In order to assess the landing/biting densities of *Chrysops* at the 4 locations, we chose a standard catch of 11 hr (0700–1800 hours)/day during which two 2-member teams, with 1 person serving as bait and the other as the collector, were used to catch the flies. The teams carried out their collections while sitting next to wood fires. The teams changed sites at each capture period. The results of these catches were expressed as potential bites/ man-day (B/MD) and the individual annual biting rates (ABR) were calculated for both species of *Chrysops* in the 4 locations.[11] In addition, 6 catches a month were carried out by 2 catchers in the palm grove. These flies were then transported to the laboratory and dissected for parity.[12] The abdomen, thorax, and head of parous females were examined for the presence of infective larvae.[7]

TABLE 1
Prevalence and intensity of loiasis in Missama

	Bantus	Pygmies
Residents examined	302	134
Microfilariae carriers (%)	25.2	13.4
DMf 50*	26	45
Adults reporting history of eyeworm (%)	60.3	ND†

* DMf 50 = median microfilarial density/20 μl blood.
† Not determined.

Transmission relates to the frequency of L3 found in the heads of flies and the biting density of both vectors.[11] The product of these 2 factors per unit of time is the infective biting rate (IBR) and represents the number of infective flies seeking a bloodmeal.[13] The product of infective biting density and the arithmetic mean of L3 present in the head/infective fly determines the transmission potential.[13] Monthly and annual transmission indices were calculated for each vector species in the palm grove. Annual transmission indices (ABR, AIBR, and ATP) were calculated as described for onchocerciasis.[11]

RESULTS

Two species of anthropophilic *Chrysops*, *Chrysops silacea* and *C. dimidiata*, were collected in the 4 sites. Species composition and annual biting rates are shown in Table 2. Landing density of both *Chrysops* species varied according to the site, but *C. silacea* was found to be the primary vector at all sites. The host-seeking activity of the vectors decreased with distance from the forest, from 2, 185 bites/man/year in the palm grove to <1,700 bites/man/year in the other 3 sites for *C. silacea*. Differences between sites were most pronounced for *C. dimidiata*, for which the ABR ranged from 1,182 at the palm grove to 61 at the Pygmy village. This species accounted for >35% of the biting tabanid population at the palm grove and <24% of the tabanids collected at the 3 other sites ($P < 0.0001$).

The highest seasonal density of landing *Chrysops* was observed during the rainy season. For *C. silacea*, the seasonal patterns of landing density were similar at all 4 sites. This species was observed from October to June; density was highest in February, with >10 B/MD at all catching sites (Fig. 2). Landing densities of *C. dimidiata* were greatest in the palm grove and usually greater in the fields than in the village (Fig. 3).

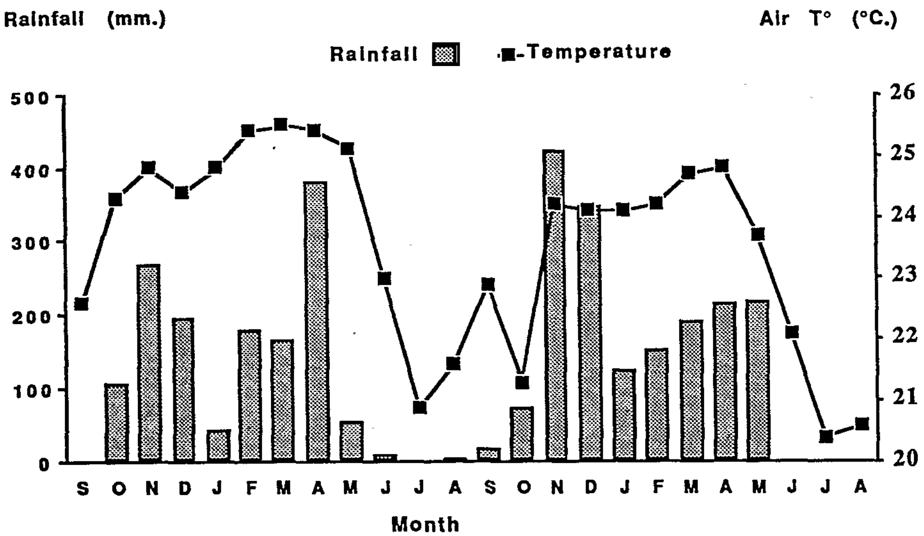

FIGURE 1. Climatic conditions during the sampling period (September 1987–August 1989) in Missama village.

C. dimidiata reached peak activity in the early rainy season (October–November) and was then the predominant species. Catches of >4 landing *C. dimidiata*/day were only common in the palm grove. In the village, catches never exceeded 2 B/MD. Independently of the catching site, host-seeking by both species occurred at a very low level during the dry season (July–September) and no flies were captured in August.

Monthly variations in the infective rate, biting rate, and transmission potentials of vectors at the Missama palm grove are presented in Tables 3 and 4. Seasonal fluctuations in transmission, expressed as infective biting density, were observed (Fig. 4). Transmission occurred during the rainy season (October–May), with a range of 0.5 to 5.5 infective bites/month for both species. The frequency of third stage *L. loa* larvae in *C. silacea* and *C. dimidiata* and the estimated transmission indices for the palm grove are summarized by year in Table 5. There were no significant differences in the percentage of tabanids with L3 in the head or in the average number of larvae/infective *Chrysops* between the 2 species for the 2 years. The rates of infectivity (percentage of all dissected flies with L3 in the head) and the mean number of L3 in the head/infective fly were 0.57% and 10.1 ± 6.8 for *C. silacea* and 0.66% and 11.2 ± 6.5 for *C. dimidiata*, respectively. The infective biting density and the transmission potential of the 2 species of *Chrysops* varied substantially.

DISCUSSION

In the Chaillu Mountains, the landing density of *C. silacea* and *C. dimidiata* varies according to the season and can be related to the seasonal distribution of rainfall. Although there appears to be a general seasonal pattern, some variability between the species occurs as a result of differences in emergence conditions. The general pattern is characterized by a high population density during the rainy season and a low or zero density throughout the dry season. Reduction in populations of *Chrysops* was observed during the drier and cooler months of the year.[14] For both species, the host-seeking activity was sustained over an 8–9 month period, but seasonal fluctuations in population density were different. A regular decline in host-seeking activity occurred from

TABLE 2

Annual landing density (expressed as potential annual biting rate or ABR) and distribution for C. silacea *and* C. dimidiata *at 4 sites in the Missama area (September 1988–August 1989)*

	Palm grove		Field		Bantu village		Pygmy village	
	C. silacea	*C. dimidiata*	*C. silacea*	*C. dimidiata*	*C. silacea*	*C. dimidiata*	*C. silacea*	*C. dimidiata*
ABR	2,185	1,182	1,546	485	1,637	152	1,687	61
Percent each species	64.9	35.1	76.1	23.9	91.5	8.5	96.5	3.5

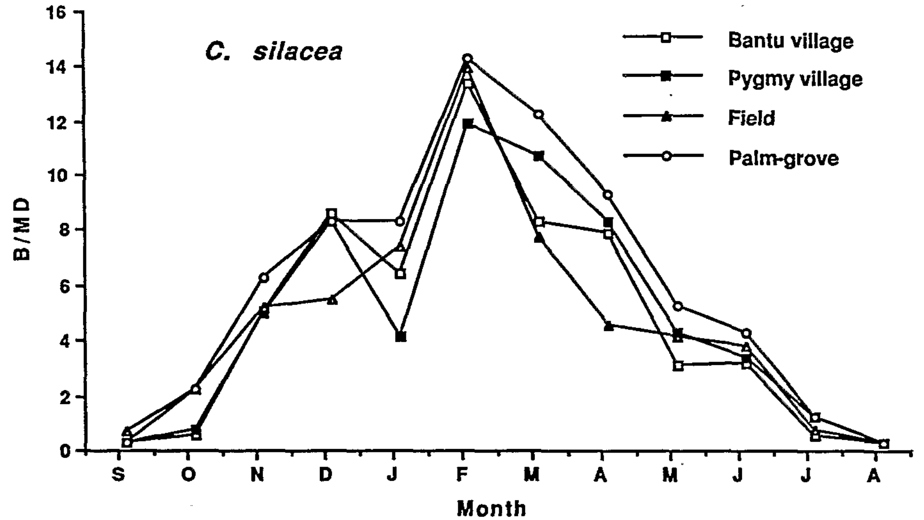

FIGURE 2. Monthly landing density of *C. silacea* at 4 sites in the Missama area from September 1988 to August 1989 expressed as mean B/MD.

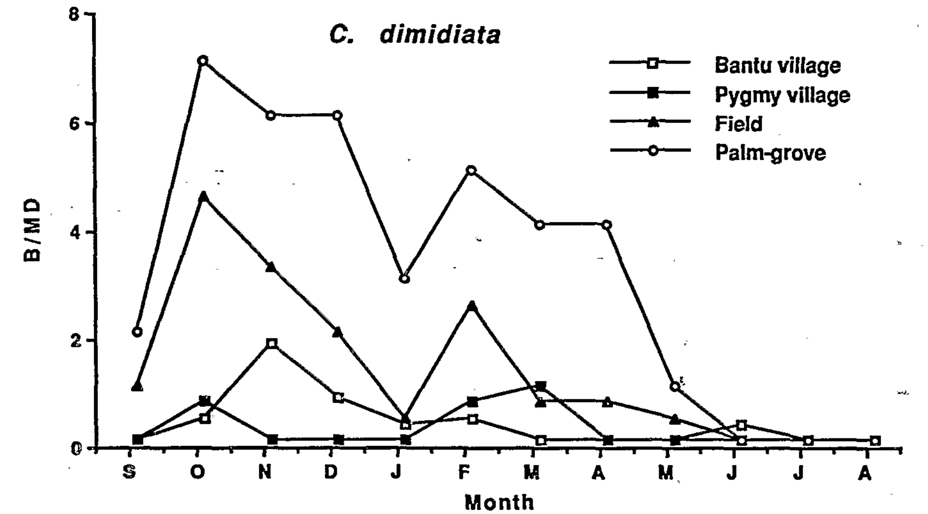

FIGURE 3. Monthly landing density of *C. dimidiata* at 4 sites in the Missama area from September 1988 to August 1989 expressed as mean B/MD.

TABLE 3

Capture and dissection results of C. silacea *at Missama palm grove: monthly biting rate (MBR), number of dissected flies, number of infective flies, estimated monthly infective biting rates (MIBR), and monthly transmission potentials (MTP)*

Year	Month	MBR	No. dissected	Infective flies (L3)	No. with L3 in head	Percent with L3 in head	Total L3 in head	MIBR	MTP
1987	Sep	15	11	0	0	0	0	0	0
	Oct	155	265	4	1	0.4	4	0.6	2.3
	Nov	255	706	5	2	0.3	10	0.7	3.6
	Dec	295	473	2	1	0.2	9	0.6	5.6
1988	Jan	326	855	8	7	0.8	57	2.7	21.7
	Feb	421	1,797	15	9	0.5	141	2.1	33
	Mar	403	1,041	11	9	0.9	113	3.5	43.7
	Apr	390	845	9	6	0.7	111	2.8	51.2
	May	295	416	5	2	0.5	14	1.4	9.9
	Jun	105	101	1	0	0	0	0	0
	Jul	0	5	1	0	0	0	0	0
	Aug	0	1	0	0	0	0	0	0
	Sep	15	7	0	0	0	0	0	0
	Oct	78	184	3	3	1.6	38	1.3	16
	Nov	195	453	6	5	1.1	35	2.2	15.1
	Dec	264	620	4	4	0.6	44	1.7	18.7
1989	Jan	248	1,285	6	5	0.4	36	1	6.9
	Feb	406	1,501	9	7	0.5	38	1.9	10.3
	Mar	388	839	3	3	0.4	21	1.4	9.7
	Apr	270	1,039	7	6	0.6	51	1.6	13.3
	May	155	492	6	4	0.8	27	1.3	8.5
	Jun	135	244	1	1	0.4	8	0.6	4.4
	Jul	31	15	0	0	0	0	0	0
	Aug	0	0	0	0	0	0	0	0

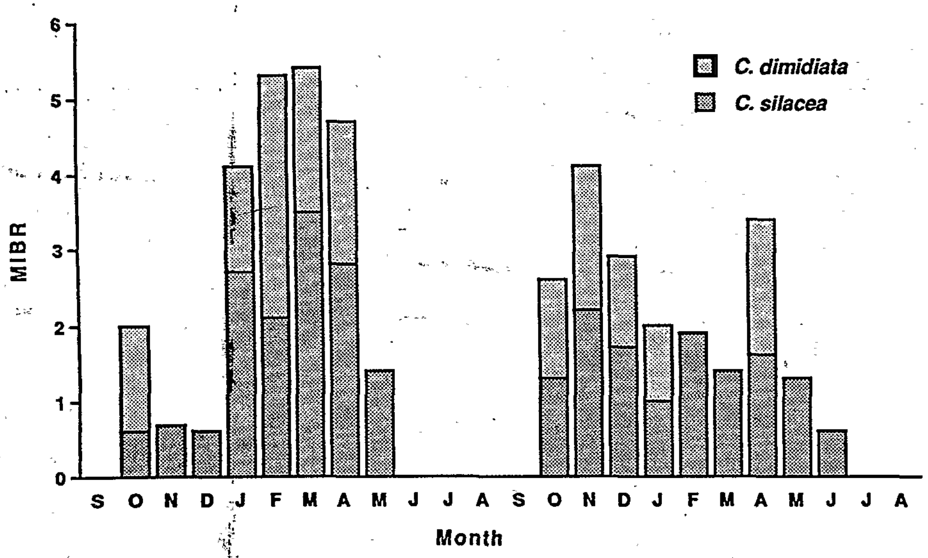

FIGURE 4. Monthly *Chrysops* infective biting rate at Missama palm grove from September 1987 to August 1989.

TABLE 4

Capture and dissection results of C. dimidiata *at Missama palm grove: monthly biting rate (MBR), number of dissected flies, number of infective flies, estimated monthly infective biting rates (MIBR), and monthly transmission potentials (MTP)*

Year	Month	MBR	No. dissected	Infective flies (L3)	No. with L3 in head	Percent with L3 in head	Total L3 in head	MIBR	MTP
1987	Sep	90	34	0	0	0	0	0	0
	Oct	217	318	12	2	0.6	20	1.4	13.6
	Nov	150	274	4	0	0	0	0	0
	Dec	155	286	2	0	0	0	0	0
1988	Jan	140	202	2	2	1	18	1.4	12.4
	Feb	218	270	6	4	1.5	24	3.2	19.3
	Mar	202	208	4	2	1	28	1.9	27.1
	Apr	180	190	8	2	1.1	46	1.9	43.6
	May	47	22	0	0	0	0	0	0
	Jun	15	2	0	0	0	0	0	0
	Jul	0	0	0	0	0	0	0	0
	Aug	0	0	0	0	0	0	0	0
	Sep	60	72	0	0	0	0	0	0
	Oct	217	322	2	2	0.6	44	1.3	29.7
	Nov	195	208	2	2	1	16	1.9	15
	Dec	186	312	2	2	0.6	20	1.2	11.9
1989	Jan	93	190	2	2	1.1	24	1	11.7
	Feb	140	140	0	0	0	0	0	0
	Mar	124	142	0	0	0	0	0	0
	Apr	105	116	2	2	1.7	6	1.8	5.4
	May	47	42	0	0	0	0	0	0
	Jun	15	0	0	0	0	0	0	0
	Jul	0	0	0	0	0	0	0	0
	Aug	0	0	0	0	0	0	0	0

March for *C. silacea*; for *C. dimidiata*, the decline began earlier in the rainy season (October). For *C. silacea*, the seasonal density patterns in the 4 sampling locations tended to be similar, whereas marked differences were noted for *C. dimidiata*. The greater abundance of *C. dimidiata* in the forest seems to be related to its ecological dependence on the natural vegetation and its inability to thrive on cultivated land or in the village.[15] For the most part, the seasonal pattern of host-seeking activity for *C. silacea* and *C. dimidiata* in southern Cameroon resembled the general pattern, except that the biting densities were not so high and presented a more marked peak.[8]

The vectorial ability of *Chrysops* is related to vector-human contact. Preliminary studies have shown that both species feed primarily on humans in this region and that humans are the sole effective reservoir host for *L. loa*.[16,17] In the palm grove, the average infective rate, based on the presence of L3 in the head and the mean number of L3/infective fly, were similar for *C. silacea*

TABLE 5

Comparative annual transmission indices of C. silacea *and* C. dimidiata *at Missama palm grove*

	Chrysops silacea		*Chrysops dimidiata*	
	Year 1	Year 2	Year 1	Year 2
No. flies dissected	6,156	6,679	1,806	1,544
No. parous (%)	ND*	1,576 (23.6)	ND*	369 (23.9)
No. infective (%)	61 (0.94)	45 (0.67)	38 (2.1)	10 (0.65)
No. with L3 in head (%)	37 (0.57)	38 (0.57)	12 (0.67)	10 (0.65)
Mean No. L3 in head/infective fly	12.4	7.8	11.3	11
Annual biting rate	2,658	2,185	1,412	1,182
Annual infective biting rate	14.4	12.7	9.8	7.2
Annual transmission potential	171.1	102.9	116.1	73.8

* Not determined.

and *C. dimidiata*. Thus, the respective role played by both species of *Chrysops* in the transmission of *L. loa* filariasis is directly related to the landing density. *C. silacea* was the dominant vector in the palm grove. Its density was higher during the entire transmission season and thus accounted for 60–64% of the AIBR for both species combined. Since the study of transmission parameters was limited to the forest site, it is not possible to determine precisely the transmission in the village. However, it is known that *C. silacea* accounts for >90% of the flies caught and the ABR for both species is twice as low as in forest. The infective rates of the vectors were significantly higher in the village than in the forest. Our data suggest that effective transmission occurs in both sites.[15]

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CONTROL OF MORBIDITY DUE TO *SCHISTOSOMA HAEMATOBIUM* ON PEMBA ISLAND: EGG EXCRETION AND HEMATURIA AS INDICATORS OF INFECTION

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Abstract. The variability of *Schistosoma haematobium* egg excretion using a quantitative syringe filtration technique and the variability of hematuria detected visually and by reagent strips were studied in a population of 520 subjects from the village of Pujini (Pemba Island, Zanzibar, Tanzania) for 6 consecutive days. A high degree of day-to-day variability of egg excretion within subjects was found both in the whole population and in the 5–19 year age group. Subjects with 1 urinary egg count of ≥50 eggs/10 ml urine were not similarly classified in 36–61% of the other 5 examinations and 4–16% of their other examinations were negative. Gross hematuria had a specificity of almost 100%, when related to a positive filtration on any day, and was closely related to egg counts of ≥50 eggs/10 ml urine. The finding of a strongly positive reaction for hematuria on a given single day was closely associated with the subject having a high egg count (≥50 eggs/10 ml urine) on at least one of the 6 days of the study. At the primary health care level, single highly positive semiquantitative values for hematuria were a more useful diagnostic indicator than a single egg count to select patients with heavy infections for selective population chemotherapy.

Quantitative diagnostic techniques for epidemiological studies and the control of schistosomiasis have been repeatedly advocated during the past 20 years by the World Health Organization.[1]

In the most widely used treatment approach, selective population chemotherapy (SPC), detection of *Schistosoma haematobium* eggs is required to select people for treatment. Counting the number of parasite eggs in the urine enables one to estimate the intensity of infection with *S. haematobium*.[1] However, since the 1950s, even before urine filtration techniques were introduced, it was reported that the total number of eggs excreted each day varies and that there is also a fluctuation within the daily output. The circadian fluctuation, with a peak of egg excretion around noon, was originally reported to be more predictable than the day-to-day variation.[2] A consistent circadian variation was confirmed in several subsequent studies,[3,4] but the day-to-day variation in excretion of *S. haematobium* eggs has been reported as being either high[2,5–8] or, more recently, low.[4,9]

On Pemba, we suspected that there was a greater day-to-day fluctuation of egg excretion but a more stable excretion of blood in subjects with *S. haematobium* infection because schoolchildren positive for microhematuria but negative at a single urine filtration were found to be cured by a single treatment with praziquantel (40 mg/kg body weight).[10,11] A similar observation was recently made in Zimbabwe.[12]

The variability of both quantitative egg excretion in standard field conditions (detected by consecutive daily filtrations of 10 ml urine per random sample) and semiquantitative values of hematuria (detected by visual examination and urinalysis with reagent strips) were evaluated in a large cohort.

MATERIALS AND METHODS

Pemba Island, Zanzibar, Tanzania has been described elsewhere.[10] In the village of Pujini, Chake district, no previous survey or chemotherapy control campaign had ever been performed and no treatment for schistosomiasis was yet available in the local dispensary.

In July 1988, daily urine samples from 879 people were examined in the village for 6 con-