Papua New Guinea Med J 30:291-300, 1987

# Malaria, Splenomegaly and Filariasis in the Ok Tedi Area of the Star Mountains, Papua New Guinea, Three Years After Residual DDT Spraying

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## SUMMARY

**In 1983 Cattani et al. conducted a baseline malariometric survey in the Star Mountains Wopkaimin villages. The investigators reported a malaria parasite rate of 64.9% in children aged 2 to 9 years, 79% palpable splenomegaly in adults and children aged 2 years and over, and 34% positivity for microfilaraemia in night blood films. After three years of vector control using residual DDT spraying in accessible Wopkaimin villages the rates decreased to 18.4%, 47% and 25%, respectively. The infant parasite rate for malaria dropped from 54.8% to 2.2%, a reduction of 96%. Two Ningerum-speaking villages in the immediate area were included in the spraying program in 1984. This paper discusses some of the problems experienced in the vector control program and a possible strategy of filariasis control using minimal diethylcarbamazine in conjunction with vector control.**

## INTRODUCTION

A malariometric survey of the Star Mountains Wopkaimin people in early 1983 (1) reported a 64.9% parasite rate for malaria in children aged 2 to 9 years and 19.5% in adults 15 years and older. The parasite formula was 75.2% *Plasmodium falciparum (Pf)*, 17.4% *P. vivax (Pv)* and 7.4% *P. malariae (Pm)*. Palpable splenomegaly occurred in 79.2% of the adults and children over 2 years of age. Over 50% of the spleens were grade 3 (Hackett) or greater. Microfilaraemia (*Wuchereria bancrofti*) was detected in 34.3% of the night blood films collected. These results established a baseline against which change might be measured with the development of the Ok Tedi project in the area.

The Star Mountains census division of the North Fly Region, Western Province had less than 800 people at the time of the 1980 National Census. The above survey examined 611 Wopkaimin people, 76% of the total population, as part of a longitudinal health and nutrition study (2,3). The Wopkaimin are a genetically homogeneous group of people who have remained virtually isolated from the outside world until 1963, when mining exploration began in the area. Austen was probably the first to describe the Wopkaimin during his magisterial patrols up the Ok Tedi (Alice) River in 1920 and 1922 (4). The Wopkaimin are a small portion of the 25,000 'Mountain Ok' or Min people of the upland ranges. 'Ok' is a local word for river. The Ningerum-speaking people, commonly referred to as the 'Lowland Ok', dwell along the southern fringes and lowland plains of the Star Mountains. The Ningerum number about 3,000, one-quarter living on the Irian Jaya side of the border. The Ningerum villages at higher elevation, with less than 100 people, have shown a decline in population over the past 10-15 years (5). The general health of these people is considered poor; malaria, acute respiratory conditions, gastroenteritis, malnutrition and filariasis are common (6).

The Wopkaimin and the Faiwolmin have the highest rate of employment in the Ok Tedi workforce; but the Ningerum, Awin and Yonggom people are also well represented.

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Tabubil and neighbouring villages have become a haven for many of these people since full-scale exploration began in the late 1960s and construction work on the mine and its infrastructure in mid-1981.

An intensive vector control program was initiated by Ok Tedi Mining Limited (OTML) in March 1982 at Tabubil, associated construction sites and camps. Activities at the village level did not commence until early 1983, as the villages became more accessible. Commencement of the village residual spraying program coincided with the malariometric surveys described and the beginning of the government spraying program in the Kiunga area.

In early 1985, two years after the first DDT spray round, a second blood survey was carried out and favourable results were noted. A third malariometric survey was conducted in March 1986 to confirm the effectiveness of the control program and revise strategies if required. Night blood surveys were conducted o see if a significant change had occurred in he prevalence of microfilaraemia. This paper hows that classic malaria control activities still work if village cooperation is maintained through health awareness and concern.

## METHODS AND MATERIALS

### Residual Spraying Activities

Village houses were sprayed twice per year with 5% DDT applied at a rate of 2gm/m$^2$. Mesto Resistent model 3610 compression sprayers with a standard fan nozzle were used to apply the insecticide. A 25% DDT emulsion concentrate (EC) stock was used during 1983 and 1984, and 75% DDT wet-dispersible powder (WDP) obtained from the Papua New Guinea Malaria Control Programme was used in 1985. The climate of the Star Mountains is aseasonal, with annual rainfalls exceeding 10 metres in some areas. Spray rounds were designated for the months of March-April and October-November, before the wet and drier-wet periods, supported by seasonal changes noted in the local flora.

DDT emulsion was initially used to improve public cooperation, since it leaves less of a residue behind, and because of ease of mixing in the field. The emulsion was also compatible with the smooth surface areas sprayed in the villages. Villagers were quick to make use of construction waste material, i.e., timber crates, plywood, metal roofing and siding off-cuts, to replace less permanent traditional bush building materials. The villages around the mine and Tabubil took on the appearance of squatter settlements as a result of this. Attempts to use DDT WDP during 1985 resulted in a number of complaints and refusals during the second spray cycle for the year. DDT EC was used again in 1986.

Source reduction of breeding sites and larviciding with Abate were occasionally carried out in some of the local villages to highlight the numerous control measures required to prevent mosquito-borne illness and stimulate some community participation. Wangbin II village, established in 1980 on the plateau adjacent to OTML facilities and the Tabubil township, benefited most. Wangbin was not sprayed with residual DDT until early 1983 but did directly benefit from ultra-low-volume (ULV) fogging, source reduction and larviciding activities on the plateau since March 1982. The malaria control activities in relation to the development of the Ok Tedi Project have been described in a separate paper (7).

The Wopkaimin villages sprayed since early 1983 were Wangbin II, Bultem II, and Finalbin. Migalsimbip was first sprayed in early 1984. Two Ningerum-speaking villages have also been sprayed, Ok Tidetau since late 1984 and OM 11 (or Asikomban, yet to be properly named) since late 1985; both of these villages are west of Tabubil along the Ok Ma road (Figure 1).

### Malariometric Surveys

Thick and thin blood smears were prepared on the same slide and stained with Giemsa, and 100 high-power fields (x1000 magnification) microscopically examined according to conventional techniques for malaria diagnosis (8). All day-time thick smears collected were scanned (x100 magnification) for microfilariae. Separate night blood films, collected after 2200 hours, were made with a standard 40µl volume of blood using a 20µl micropipette for the quantitative enumeration of

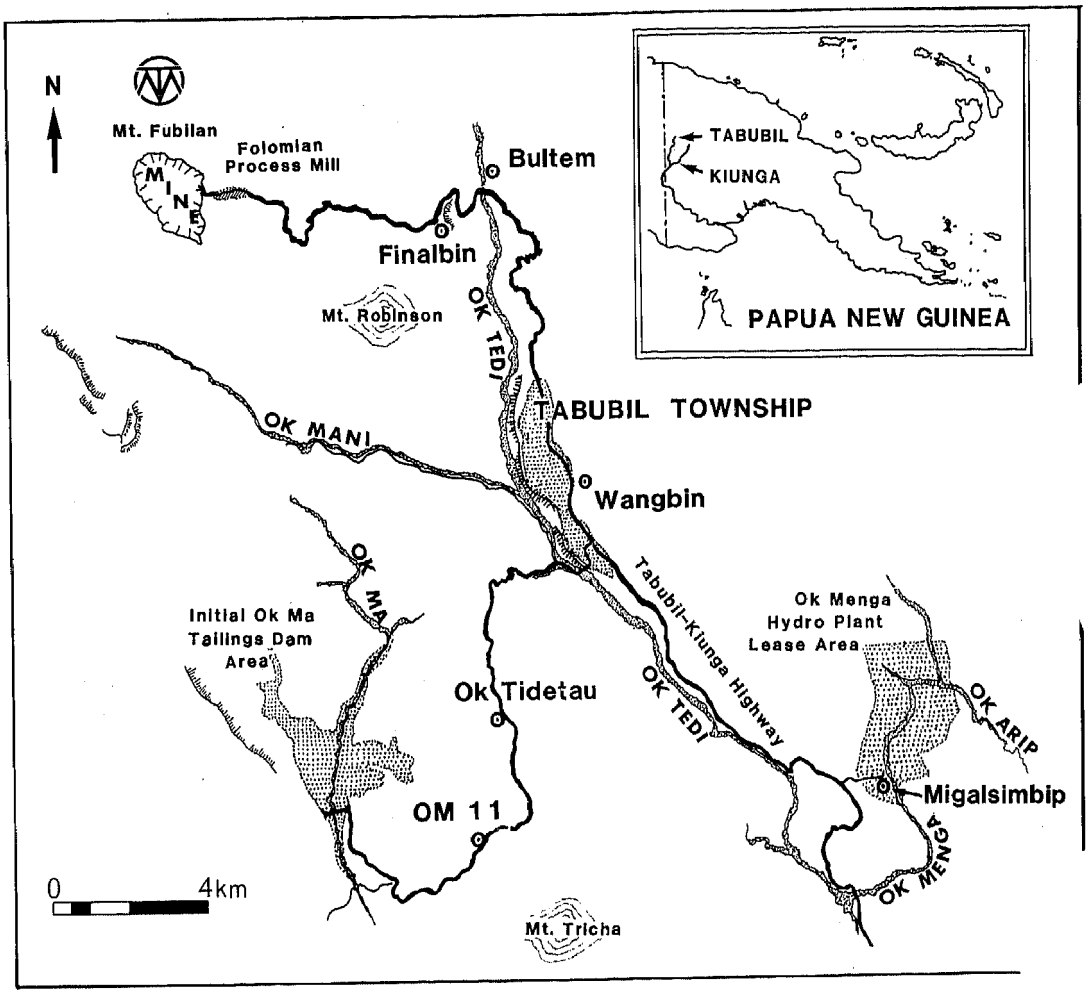


Figure 1. The Star Mountains Ok Tedi vector control area.

detectable parasites. Positive blood slides were confirmed by a second technician and all negative smears re-examined. Spleens were palpated and graded according to Hackett's classification by the same health extension officer on each occasion. Surveys were carried out in all sprayed villages during 1985 and 1986. Tabubil Community School was also surveyed annually since 1982.

Entomological surveys were carried out in late June 1986 to identify possible vectors in the area. Night-biting catches were carried out between 1800 and 0200 hours for 40 minutes per hour using human bait. Five collectors were used and surveys carried out for two nights in each of the following villages regardless of weather: Bultem, Migalsimbip, Ok Tidetau, and OM 11. The mosquitoes caught were identified, midguts and salivary glands examined for infection, and parity of the ovaries determined.

### Diethylcarbamazine in Filariasis Control

In June 1986, 685 people were treated with 6mg/kg diethylcarbamazine (DEC). Individuals under 20kg bodyweight, pregnant females, the ill and the very old were excluded. The occasional side-effects noted with DEC and the release of foreign protein into the blood from dead microfilariae were subdued by

administering an antihistamine with DEC treatment. Injectable cortisone and oxygen were on hand for hypersensitivity or anaphylactic shock. Villagers were monitored for 2-3 hours after treatment. The villages will receive treatment semi-annually in conjunction with the residual spraying program and minimal larviciding. A standard DEC dose of 6mg/kg will be administered on each occasion. Preliminary results will be made available in early 1988.

## RESULTS

### The Wopkaimin Villages

Tables 1 and 2 present parasite and spleen rates for the different age groups in the Wopkaimin villages surveyed since 1983. The malaria parasite rate was reduced from 36.8% to 9.8% for all age groups. The parasite rate in children under 10 years of age was correspondingly reduced from 66.9% to 14.1%. The infant parasite rate of 2.2% (1/46) in 1986 clearly indicates that transmission of malaria had been interrupted compared to the 1983 figure of 54.8% (23/42). The parasite formula for each of the three surveys conducted to date are as follows:

| | Pf: | Pv: | Pm | |
|---|---|---|---|---|
| 1983 | 87 | 7 | 6 | % |
| 1985 | 42 | 45 | 13 | % |
| 1986 | 49 | 39 | 12 | % |

The spleen rate for adults and children 2 years old and over during the 1983 Wopkaimin village survey was 79%; this was reduced to 47% in 1986 with a 2.4 average enlarged spleen (AES) size and 46% of the spleens reported grade 3 and above. Microfilaraemia was detected in 25% (54/215) of the adult night blood films examined with a mean density (MFD) of 65 per 20µl and a range of <1 to 507 per 20µl. The rate at Wangbin was 14% (5/36), Bultem 22% (22/100), Finalbin 38% (14/37) and Migalsimbip 31% (13/42).

**TABLE 1**

MALARIA PARASITE RATES BY AGE GROUP FOR THE WOPKAIMIN VILLAGES IN THE OK TEDI AREA

| Age group (years) | Survey year | Total examined | Total positive | Malaria parasite rate % | % Pf |
|---|---|---|---|---|---|
| 0 – <2 | 1983* | 42 | 23 | 54.8 | 82.6 |
| | 1985 | 76 | 10 | 13.2 | 30.0 |
| | 1986 | 83 | 3 | 3.6 | 0 |
| 2 – 9 | 1983 | 106 | 76 | 71.7 | 88.2 |
| | 1985 | 148 | 34 | 23.0 | 35.3 |
| | 1986 | 201 | 37 | 18.4 | 54.0 |
| 10 – 14 | 1983 | 24 | 7 | 29.2 | 85.7 |
| | 1985 | 42 | 4 | 9.5 | 75.0 |
| | 1986 | 73 | 6 | 8.2 | 66.7 |
| 15+ | 1983 | 233 | 43 | 18.5 | 86.0 |
| | 1985 | 118 | 5 | 4.2 | 80.0 |
| | 1986 | 225 | 11 | 4.9 | 36.4 |
| **Total** | 1983 | 405 | 149 | 36.8 | 86.6 |
| | 1985 | 384 | 53 | 13.8 | 39.6 |
| | 1986 | 582 | 57 | 9.8 | 49.1 |

* 1983 breakdown results courtesy of Jacqueline Cattani (1).

TABLE 2

SPLEEN RATES BY AGE GROUP FOR THE WOPKAIMIN VILLAGES IN THE OK TEDI AREA

| Age group (years) | Survey year | Total examined | Total spleens enlarged* | % enlarged spleens |
|---|---|---|---|---|
| 0 – <2 | 1983** | 49 | 12 | 24.5 |
| | 1986 | 83 | 3 | 3.6 |
| 2 – 9 | 1983 | 154 | 135 | 87.7 |
| | 1986 | 201 | 81 | 40.3 |
| 10 – 14 | 1983 | 43 | 33 | 76.7 |
| | 1986 | 73 | 43 | 58.9 |
| 15+ | 1983 | 365 | 277 | 75.9 |
| | 1986 | 223 | 112 | 50.2 |
| | 1983 | 611 | 457 | 74.8 |
| **Total** | 1986 | 580 | 239 | 41.2 |

* ⩾ Grade 1 (Hackett Scale)
** Cattani et al. (1)

Figure 2 shows the malaria parasite rate decline for each village since spraying commenced in early 1983.

### The Ningerum Villages

The malaria parasite rate, for all age groups, was 32.7% (36/110) in the two Ningerum-speaking villages of Ok Tidetau and OM 11. The parasite rate in children under 10 years was 54.7% (29/53); the parasite formula was 41% Pf, 17% Pv and 42% Pm. The Ningerums showed the highest prevalence of splenomegaly with a rate of 71% (32/45) in children 2-9 years and AES of 2.4. Adults and children 2 years of age and older displayed a spleen rate of 62% (63/101), AES 2.6 and 49% of the spleens grade 3 and above. Microfilaraemia was detected in 61% (27/44) of the night-time adult blood films examined, with an MFD of 106 per 20 µl ranging from <1 to 455 per 20 µl. The rate of detectable microfilaraemia at Ok Tidetau was 69% (18/26) and 50% (9/18) at OM 11. Two villagers at Ok Tidetau were noted with clinical manifestations of filariasis (elephantiasis of the leg in one, the scrotum in the other) and one at OM 11 (elephantiasis of the scrotum) but did not present for blood examination.

### The Community Schools

Figure 3 shows a steady rate of decline for malaria in local area children at Tabubil Community School since 1982. The parasite rate in children under 10 years of age had declined from 30% (14/47) in February 1982 to 10% (5/49) in April 1986. Spleens were examined in 297 students at Tabubil Community School, including those from all other parts of the country. The spleen rate for all students examined was 30% (89/297), AES 2.4 and 46% of the spleens grade 3 and above. The spleen rate for children under 10 years was 24% (39/160). Local children, including those from other areas within the North Fly region, made up 40% of students examined at the school. The spleen rate amongst the local group was 57%, AES 2.6 and 53% of the spleens grade 3 and above. Local area children examined at the school in 1984 showed a spleen rate of 63% (119/190), AES 2.9 and 54% of the spleens grade 3 or above at the time.

Blood slides collected from 31 Ningerum-speaking students at the new Ok Ma Commun-

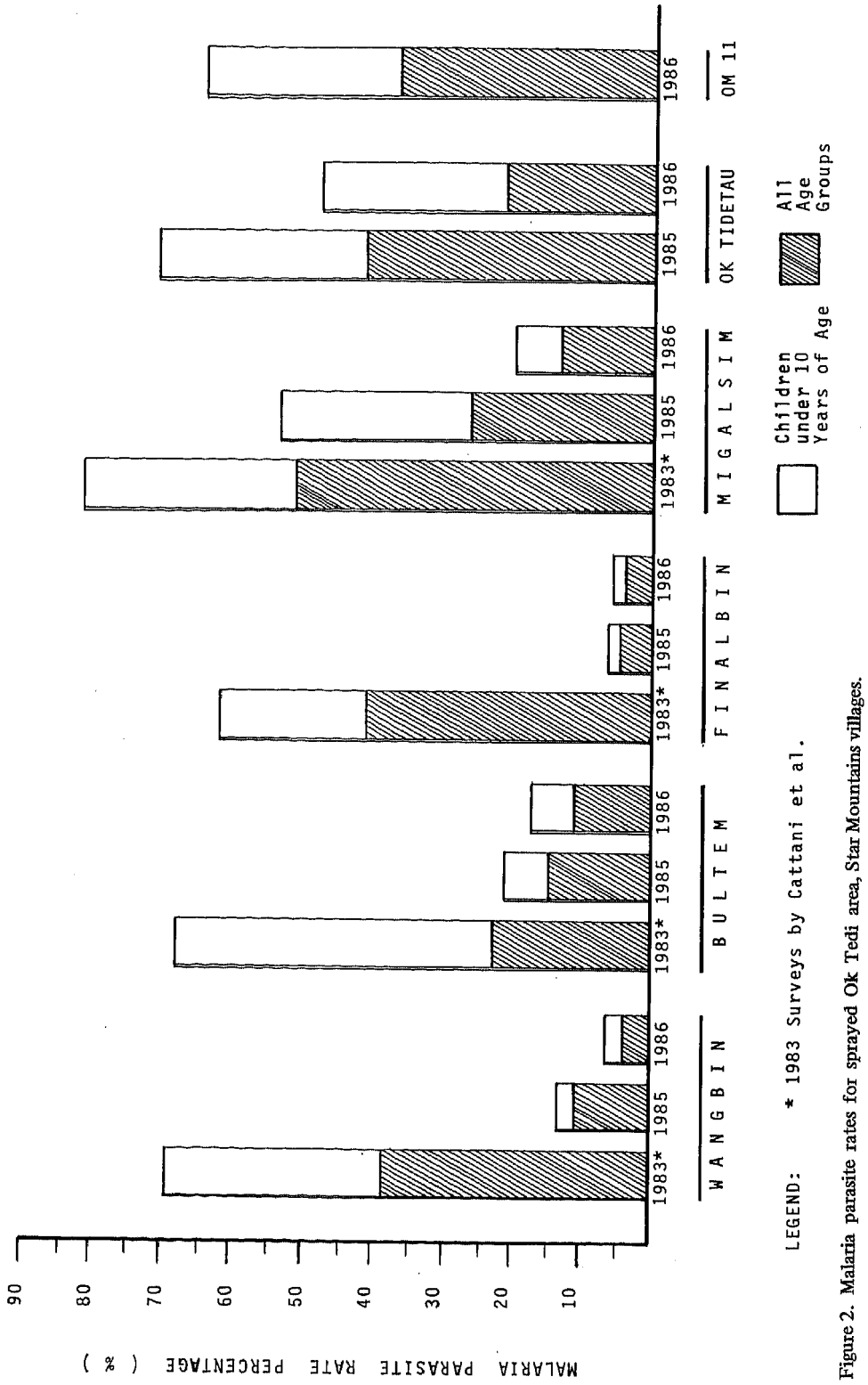


Figure 2. Malaria parasite rates for sprayed Ok Tedi area, Star Mountains villages.

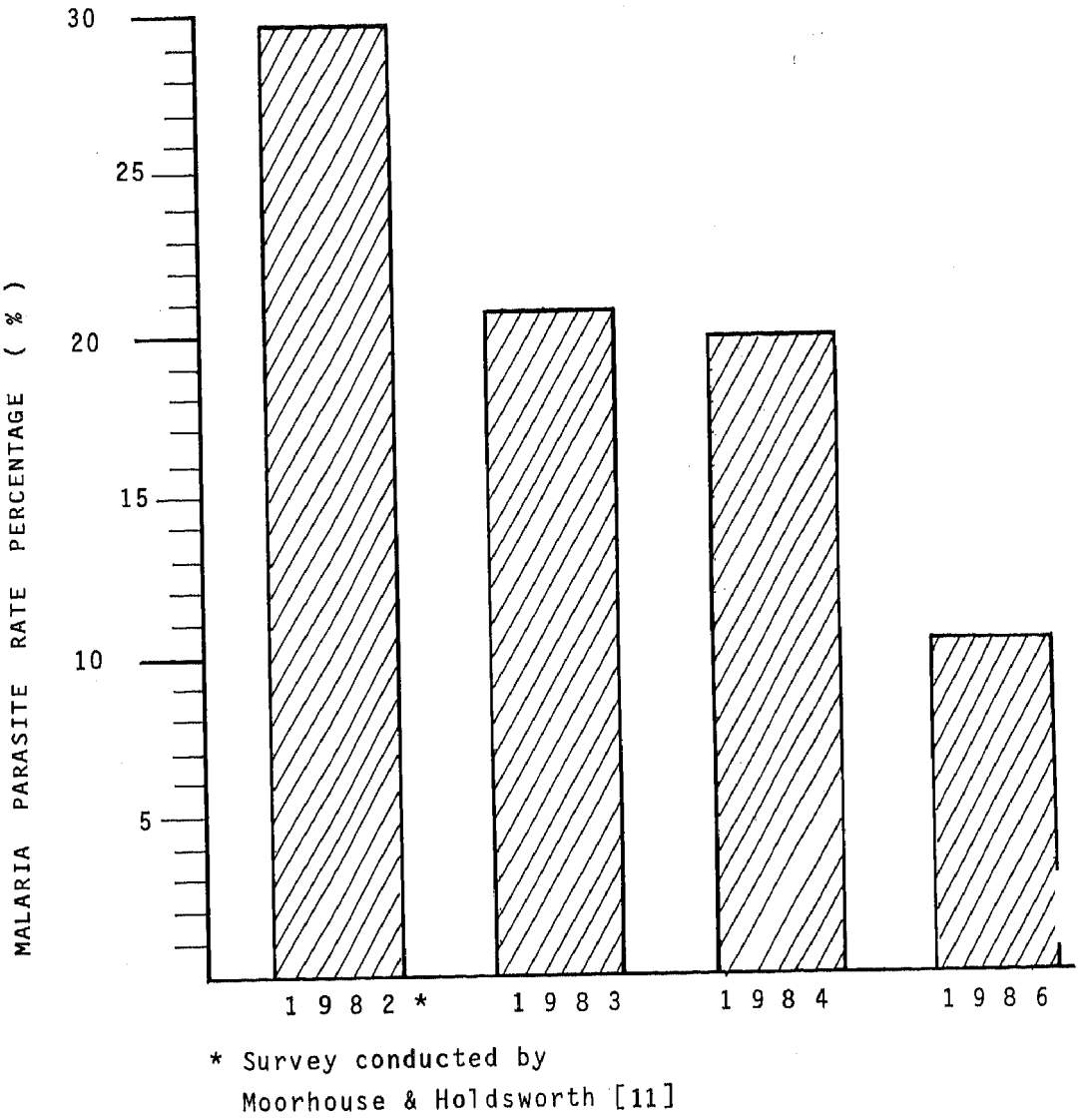


Figure 3. Malaria parasite rate in local children under 10 years of age attending Tabubil Community School.

ity School showed a 45% malaria parasite rate, the parasite formula being 43% Pf, 36% Pv and 21% Pm.

All students and the majority of villagers confirmed positive for malaria during the annual surveys were treated with a 3-day standard dose regimen of chloroquine or amodiaquine; a single dose primaquine treatment was provided if gametocytes of *P. falciparum* were detected. Patients detected with microfilaraemia during passive case detection (PCD) at Tabubil Hospital were offered treatment with 12 monthly doses of 6mg/kg diethylcarbamazine to initiate a radical cure. Villagers at nearby Wangbin when found positive during the 1986 survey were put on a similar treatment program through the hospital.

## Entomology

The anopheline vector breakdown for mosquitoes identified during the June 1986 entomological survey was 79% *Anopheles*

*punctulatus,* 19% *An. farauti* and 2% *An. koliensis.* The only mosquito biting at Bultem was *Culex (fatigans)* sp. with a consistent hourly man-biting rate of 1. *Anopheles punctulatus* was identified at Ok Tidetau and OM 11 with respective hourly man-biting rates of 0.2 and 0.12, the peak biting period being around 2200 hours. *Anopheles punctulatus, An. koliensis* and *An. farauti* were all identified at Migalsimbip. Larvae hatched out in the laboratory at Tabubil confirmed the identity of the adults caught during the night collections. The hourly man-biting rate for anophelines caught at Migalsimbip was 0.67 with a peak around 1900-2000 hours; *An. punctulatus* persisted throughout the night. All midguts and salivary glands were negative for infection. None of the ovaries examined were parous or gravid, the nulliparous state indicating that the mosquitoes had recently emerged. The majority of anophelines at OM 11 and Migalsimbip were caught near recently disturbed ground, excavated roots or footings for house posts.

## DISCUSSION

The 1983 survey (1) placed emphasis on the Wopkaimin people. The surveys since have included a closely related kinship group, the Faiwolmin, many of whom were resident in the Wopkaimin villages before or since OTML construction began in 1981.

The malaria parasite rate for all age groups in the four Wopkaimin villages was reduced by 73% from 36.8 to 9.8% and falciparum ratios and spleen rates were almost halved. The decline was most evident in the under-2-year age group, where the parasite rate was reduced from 54.8 to 3.6%, indicating that transmission had been substantially reduced. The malaria and spleen rates in children 2-9 years were reduced by 74% and 54%, respectively; the adult spleen rate dropped less, by 34%.

The Wopkaimin on average tend to relocate their villages every 10 years. Wangbin II and Bultem II were established in 1980 and 1982 and the other four villages have relocated since 1983 for easy access to Tabubil. Health and sanitation have improved in villages moving to better drained areas, but Wangbin and Bultem were unfortunately built on permanently boggy ground. Pigs allowed to run free create ideal breeding sites for disease vectors such as *Anopheles punctulatus* and *Culex* spp. Attempts to encourage drainage and sanitation improvements at Wangbin have been only partly successful, since villagers have been reluctant to put effort into improvements. The malaria decrease at Wangbin may not have been as dramatic had supplementary vector control measures, such as ULV fogging and larviciding, not been carried out on the plateau. The parasite rate in this village in children under 10 years of age was reduced from 70% to 7.5% in 3 years.

Bultem, the largest of the Wopkaimin villages with a population of over 300, has the added benefit of an aid post. The malaria parasite rate figure of 68.6% in children under 10 years during the 1983 survey was reduced to 18.5% by 1986, and from 23.3% to 11.9% for all age groups. A regular increase in population, families relocating from other villages, days spent in distant bush gardens, and the perpetual bog which existed in the village were causes for the lingering parasite rates. Attempts to stimulate a community drainage project in 1984, with engineering input and supervision from OTML, failed. In early June 1986 the survey results, Figure 2, were presented to the Bultem people during health education talks. *Culex (fatigans)* sp. was found to be a recent nuisance in the village, and its role as a vector of filariasis was described. The breeding problem had actually worsened with individual householders digging dead-end drains, and poorly designed pit latrines made the situation worse. Within two months a functional drainage system was installed. Demonstration concrete water-seal squat toilets were provided by the OTML Public Health Section, to overcome pit mosquito-breeding and other obvious complaints.

The original Finalbin village, only metres from Bultem, faced a similar situation before relocating to higher, well-drained ground in late 1983. The result is reflected in a parasite rate of 7.1% for children under 10 years and 4.7% for all age groups in 1986, markedly reduced from the baseline figures of 62.9% and 42.1% in 1983.

Studies in the Solomon Islands have shown a natural decline pattern of *W. bancrofti* infection in areas where malaria control

activities had been implemented for some time (9). A theoretical model indicated a proportional decrease of filariasis over 8 years. The pattern produced a close fit when tested against survey data collected between 1968 and 1975. The adult female *W. bancrofti* is capable of reproducing for up to 10 years, but not exceeding 15. In areas where *Anopheles* are important vectors for *W. bancrofti* transmission, adulticiding and larviciding should have a noticeable impact on both diseases. Webber (9) applied MacDonald's formula for the Critical Density of Malaria to filariasis. A theoretical calculation of 10.62%, based on the Solomon Islands data for malaria, was derived, below which filariasis would not occur. It was also suggested that the anopheline vectors would have to be maintained at a much lower level for the cessation of transmission of filariasis than of malaria. This theory appeared to have some relevance when tested against data available for malaria and filariasis in the Eastern Outer Islands.

The high rates for malaria and filariasis in the baseline Star Mountains data suggests that the anopheline is a common vector. *Anopheles punctulatus* is the most prevalent species in the Star Mountains. When the 1983 rate of 34.3% microfilaraemia in the Wopkaimin villages was tested against the natural decline pattern, using 25.1% as the 1986 rate, a zero microfilaraemia would not be expected until June 1994, 11 years after vector control measures commenced.

Table 3 shows the rate of malaria and filariasis during recent night surveys. Detectable microfilaraemia in the Wopkaimin has been reduced by 27%, but malaria by 79% in the same group. The malaria rate in 1986 was less than 10%, the highest rate of malaria being 7.1%, found in adults surveyed at night at Migalsimbip. The Star Mountains appear to be an ideal location to test Webber's theoretical calculation in relation to vector control. If minimal treatment with diethylcarbamazine (DEC) was used in conjunction with vector control measures, the high rate of filariasis in the Ok Tedi areas could possibly be reduced at a faster rate. Laigret (10) reported a successful filariasis control campaign in Tahiti using a single dose annual treatment with DEC 6mg/kg. A semi-annual DEC treatment progra was adopted for the villages around Tabubil the Ok Tedi area in conjunction with residu DDT spraying. A semi-annual DEC dose will b used for the first two years because of the high prevalence of filariasis in the villages, 13-70%. Annual DEC dosing will continue until the rate of detectable microfilaraemia is reduced to $\leq 2\%$, at which time vector control measures and health services should be able to maintain control over malaria and filariasis. It is anticipated that the control of filariasis can be achieved in 4-5 years, by which time the parasite rate for malaria in children under 10 years of age should be $<5\%$ in all protected villages, which is the ultimate control objective.

No problems were experienced during tl June 1986 DEC treatment round, though abou 20% of villagers checked 24 and 48 hours after treatment complained of dizziness, nausea and weakness.

**TABLE 3**

A COMPARISON OF THE PROPORTION OF PERSONS POSITIVE FOR BOTH MALARIA AND FILARIASIS IN THE OK TEDI AREA

| Year | No examined | % Positive for malaria | % Positive for filariasis |
|---|---|---|---|
| 1983* | 169** | 20.1 | 34.3 |
| 1986 | 215** | 4.2 | 25.1 |
| | 259*** | 3.9 | 31.2 |

* Cattani et al. (1)
** Wopkaimin village results
*** Wopkaimin and Ningerum villages combined

Improved health awareness at the village level has seen villagers seek relief from malaria symptoms at Tabubil to curtail prolonged illness. This was verified by the monthly passive case detection (PCD) monitoring of fever cases. All fever cases are presumptively treated with chloroquine, compliance with a 3-day treatment regimen being encouraged once a blood smear is found positive. Since chloroquine has not been used prophylactically, the reduction of parasite and spleen rates is attributed to vector control activities. In January 1986 in vivo monitoring of *P. falciparum* for suspect chloroquine resistance began at Tabubil. The prompt treatment of cases since 1982 has reduced the spread of possible drug-resistant strains in the Star Mountains area. In association with radical cure treatments or gametocyte sterilization, glucose-6-phosphate dehydrogenase (G-6-PD) deficiency screening is being carried out to prevent possible haemolytic anaemia in known deficient patients.

The remoteness of the Star Mountains and the ability to screen all incoming company personnel allow control programs implemented by the OTML Public Health Section to succeed. The control of malaria and filariasis at the village level around the Ok Tedi area is for the mutual benefit of a successful Project and a healthier people in the Star Mountians.

## ACKNOWLEDGEMENTS

We thank Prof. R.H. Black, Dr T. Taufa and Dr P. Spicer for their comments in a review of this article. We also thank Peter Bulungol, Public Health (Medical) Laboratory Technician, for his assistance with some of the earlier survey work; the OTML Vector Control Assistants for a job well done; the Kiunga-based PNG Malaria Control Programme Entomology Team for their cooperation in the vector survey; and Jacqueline Cattani for the 1983 malaria breakdown of the Wopkaimin villages sprayed.

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