PARASITES OF MAN IN PAPUA-NEW GUINEA

W. H. Ewers

Biology Department, University of Papua and New Guinea, P.O. Box 1144, Boroko, Papua-New Guinea.

INTRODUCTION

The eastern part of the island of New Guinea, together with a number of islands lying to the North, form the Territories of Papua and New Guinea. The Western part of the island of New Guinea known as West Irian, is part of Indonesia. Papua-New Guinea has a population of about 2.5 million. Most of Papua-New Guinea has a wet tropical climate.

The most common parasites of man in Papua-New Guinea are *Plasmodium*, *Wuchereria*, hookworm and *Ascaris* (Ewers and Jeffery 1971). A high proportion of the population are infected with parasites. While the people appear, for the most part, to be a well fed and happy lot, there is a great deal of poor health which is a direct or indirect consequence of parasitic infection. In Papua-New Guinea clinical cases due to parasites account for at least 12-15 % of all hospital admissions. Information on the prevalence of malaria, filariasis, and other parasitic infections are presented in this paper.

GENERAL INFORMATION

Malaria in the coastal and lowlands areas

From the start of colonization, malaria was responsible for a great deal of mortality and morbidity among the newcomers.

The German colony of Kaiser Wilhelmsland was established on the north coast of New Guinea at Finschhafen, in November 1885. Headquarters were moved to Stefansort in 1891 after about one third of the Europeans there had died of malaria within a period of a few months. Schellong, who was doctor to the colony from 1886-1888, records (1901) that he attended 1402 cases of malaria at Finschhafen during a period of 26 months. During this time the population grew from 67 in June 1886 to 276 in December 1887. More than half of the population were natives from other parts of New Guinea, or from Java, who had some immunity to malaria. In some months every European on the station suffered at least one attack of malaria. Over the whole period, an average of 44 per cent of the population, including natives, suffered each month from clinical malaria.

Between 1886-1898, 224 German officials worked for the New Guinea Company, which was the colonial authority. Of these, 41 died on the job (mostly of malaria) and 133 resigned or were given the sack. One of them wrote "I am one of the few to get out of that malaria hole, Finschhafen, with a whole skin, because I treated the fever with alcohol instead of quinine, and the orders of the Company similarly, with alcohol instead of respect" (Souter, 1963).

In the early days of Papua the malaria story was much the same. For example, the London Missionary Society brought more than 200 Polynesian teachers to Papua in the 1880's. More than half of them died of malaria within three years, and all of them suffered repeatedly from fever. They had come from places where there was no malaria and they had no immunity to it.

Malaria is endemic throughout the coastal and lowlands areas of Papua and New Guinea. The Sepik district was one of the worst areas as is shown by data in Table 1 (Peters, 1960). Infant mortality in this area was about 60 per cent.

Table 1

The percentage of people of various ages, infected with malaria, at Maprik, at the start of the Malaria Control Project in 1957.

Age	Incidence of Malaria
0-2 months	46%
3-11 months	92%
2-4 years	95%
5-9 years	82%
10-14 years	62%
15-19 years	48%
20+ years	34%

Many other coastal and lowland areas were as bad or nearly as bad as this, and malaria transmission occurs throughout most of the year in these areas.

It has been generally accepted that three very closely related species *(A. punctulatus, A. farauti, A. koliensis)* known as the *Anopheles punctulatus* complex, are the vectors of malaria in Papua-New Guinea. Their taxonomic separation depends on minor differences in markings on the proboscis. Byran (1970) has shown that the *Anopheles punctulatus* complex is much more complex than was previously supposed and the characters used to separate them are not reliable. Further study on the taxonomic relationships of the vectors would appear to be a matter of some urgency.

In the lowlands and coastal areas of Papua-New Guinea, the extrinsic cycle takes from 8-19 days depending on the species of *Plasmodium* involved. In the Highlands the extrinsic cycle takes from 16-28 days. Further details of the biology of the vectors are given by Ewers and Jeffery (1971).

Malaria in the Highlands

Nearly half the population of Papua-New Guinea live in the Highlands - above 5,000 feet. Until the area came under the control of the Administration in the 1940's, the people of the Highlands were divided into separate language groups which were almost continually in conflict with their neighbours. This state of affairs restricted the movement of people and most of them never moved more than a few miles from their birthplaces. This also restricted the spread of malaria.

In the 1930's, much of the Highlands was free of malaria. Early surveys by Christian (unpublished) showed that there was malaria on the edges of the Highlands where the people went to the lowlands to hunt, to get betel nut and to trade. Through part of the Western Highlands, malaria was probably present before the Europeans came, because several different groups of people have words for it in their own languages. However, early surveys in the 1940's showed that most of the Eastern Highlands were free of malaria.

Great development took place throughout the Highlands in the 1950's, and many new airstrips and roads were built. These activities often created breeding places for the vectors of malaria. There was also a great influx of policemen, public servants and traders from malarious areas. They undoubtably brought malaria with them. The vectors of malaria were already present.

The Highlands Labour Scheme was started in 1950. Under this scheme labourers were recruited from the Highlands and went to work on plantations in other (malarious) parts of the country. They were away for periods of 18 months to 2 years. Their employers were required to provide them with antimalarial drugs but many returned with malaria. One survey, done in 1956 on labourers who had just returned to the Highlands, showed that 19% had enlarged spleens. As *Plasmodium vivax* is the dominant species in most of Papua-New Guinea, many of these labourers would have had relapses of malaria after they returned home. During the period 1950-1960 about 50,000 Highlanders went to malarious areas under this scheme.

During the early 1950's there were several epidemics of malaria in the Western Highlands. This area had previously been malarious, but malaria became worse than the people could ever remember. By the mid and late 1950's, malaria had become established in the Eastern Highlands in places that had previously been malaria-free. There were many severe epidemics with a high mortality, because the people had no immunity to it. The changing situation of malaria in the Highlands is illustrated in a series of maps by Ewers and Jeffery (1971).

Malaria in the Highlands in seasonal, transmission is restricted, in most years, to a period of two or three months following the end of the wet season.

Malaria Control in Papua - New Guinea

Prior to the end of the Second World War, little was done in the way of malaria control, except in the larger towns, where there was some larviciding and *Gambusia* fish were introduced to control mosquito larvae, with some success. There were a few relatively small drainage schemes which were quite successful, but drainage never became a widespread practice in New Guinea.

There is surely a great need for the introduction of drainage and larviciding as propounded by Sir Malcolm Watson (1921), especially as many of the malaria programs throughout the world, which have been based solely on the use of residual insecticides, are failing.

In 1957 a pilot project was started to eradicate malaria at Maprik, in the Sepik District. This project involved spraying the insides of houses with DDT. The vectors of malaria usually come inside houses to feed on people. After they have fed they usually rest on the walls of the house for some hours before flying outside. If the walls have recently been sprayed with DDT they are poisoned by it.

RESULTS AND DISCUSSION

The early results of this project were good, but malaria was not eradicated and it is still serious in this area. The changes in the malaria rates at Maprik after the malaria program started, are shown in Table 2.

Table 2

Changes in the malaria rates at Maprik, following malaria control.

1957	Infant Parasite Rate	90%
1958	,,	32%
1959	,,	8%
June 1960	,,	0
Oct. 1960	,,	5%
1961	,,	2%
1962	,,	12%
1963	Overall Parasite Rate	18%
1967	,,	32%
July 1968	,,	68%
Dec. 1968	,,	16%
1969	,,	22%

There is now a Malaria Service in Papua-New Guinea which employs about 1,000 people including spraymen. It operates in 13 of the country's 15 districts, but only a few districts are completely covered. About half of all the houses in Papua - New Guinea are now sprayed with DDT once or twice a year.

The most recent data (Anon, 1970) indicate that the Overall Parasite Rate (OPR) is less than 10% in twelve districts and 10 to 20% in three districts. The malaria program has certain problems that are widespread or that are likely to occur in other countries, viz.

1. **Locked Houses**

In some areas where spraying has been going on for many years, some of the villagers lock their houses when the spray teams arrive because they do not want their houses to be sprayed.

In one area this practice has been associated with political activity against the Government. The figures in Table 3 indicate the changes in locked houses and in the OPR in this area. (Parkinson, 1970).

Table 3

Changes in the Overall Parasite Rate (OPR) and in the percentage of locked (unsprayed) houses in one area of Papua-New Guinea.

	% locked houses	O.P.R. (%)
1967	5	1.7
1968	5	3.6
1969	15	5.0
1970	29	8.0

In certain other areas the people are not convinced that spraying serves any useful purpose. Many of them do not remember how serious malaria used to be, and due to superstitions throughout most of the country, malaria and many other illnesses are often attributed to sorcery and evil spirits.

2. **Insect Pests**

In most areas where DDT has been used for some years there has been an increase in the number of bedbugs and in the number of larvae of a moth *(Herculia negrivitta)* that eats the sago palm leaves. The palm leaves are used to make walls and roofs of houses in Papua-New Guinea. In many areas bedbugs are now resistant to DDT in the concentrations used in the malaria control program. It seems that numbers of both pests have increased because DDT kills the predators, such as lizards and spiders, which naturally control them.

There have also been many reports of dead chickens and cats that are attributed to the spraying of DDT. These things have all contributed to the problem of locked houses. Malathion is now being added to DDT in areas where bedbugs inhabit and this is reducing their numbers dramatically. (Parkinson, 1970).

3. **Change in the behaviour of the vectors**

Following the use of DDT in the Malaria Program, two kinds of changes have occurred in the behaviour of the vectors of malaria in Papua-New Guinea. The first change is in peak biting time. Before the use of DDT, the vectors usually bite man throughout the night. The peak biting time was around midnight, and most vectors come to feed on people while they were asleep inside their houses.

In some areas the peak biting time has shifted to dusk (1800-1900 hours) and dawn (0400 - 0600 hours) (Parkinson, 1970). At these times many of the people are outside their houses cooking and working in their gardens. This means that many of the vectors do not enter houses and are therefore unlikely to come in contact with DDT.

The second change is excitor-repellancy. The vectors become excited and repelled by DDT and they avoid settling on sprayed surfaces. They still come inside houses to feed, but they fly out again without settling on the walls. The data in Table 4 illustrate this phenomenon (Sweeney, 1969). The figures

Table 4

The number of vector mosquitoes caught on the walls at 0600 hours and during the night, in two identical test houses, one of which had been sprayed with DDT. The figures are for the total number of vectors caught on selected nights, over a six month period.

Number of vectors on walls	Sprayed house	Unsprayed house
at 0600 hours	25	626
at night	50	319

represent the number of vector mosquitoes caught during a six-month period on the walls of two identical test houses, only one of which had been sprayed with DDT. Collections were made during the night as well as at 0600 hours. Other experiments have confirmed that mosquitoes in this area avoid settling on surfaces that have been sprayed with DDT.

It is not known how widespread these two phenomena are. Changes in biting time have been reported from several widely separated places in Papua-New Guinea, but excitor-repellancy is at present known only from one place near Rabaul. These changes in the behaviour of the vectors may be a major threat to the Malaria Control Program which is based on the use of DDT.

Filariasis

The periodic form of *Wuchereria bancrofti* is endemic in most of the low-lands and coastal areas of Papua - New Guinea. No other human filarial infections are known. The incidence of filariasis varies a good deal from place to place, but in many areas 20% or more of the population have microfilariae in their blood.

In the Maclay Coast area, where filariasis is highly endemic, 10% of the population had elephantiasis and 19% of the adult males had hydrocoele (Kessel and Massal, 1962). During the six year period 1961-7, there were 1,165 admissions for filariasis to government hospitals in Papua - New Guinea. About 80% of the patients were males (Vines, 1970).

Not much work has been published on filariasis in Papua - New Guinea, although Dutch workers have published a good deal on the situation in West Irian (formerly Dutch New Guinea). The most important vectors of filariasis in Papua - New Guinea are probably the *Anopheles punctulatus* complex. They are also the vectors of malaria. The following species are known to be vectors in West Irian or other neighbouring areas, and they must be considered as potential vectors in Papua - New Guinea: *Anopheles bancrofti*, *Aedes kochi*, *Armigeres obturbans*, *Culex annulirostris*, *C. fatigans*, *C. bitaeniorhynchus*, and *Mansonia uniformis*. In addition, several other species have been experimentally infected in West Irian.

As many of these species are known to feed outdoors it is likely that the incidence of filariasis will not be reduced very much by the malaria program, which is based on indoor spraying of residual insecticides.

Some attempts have been made to control filariasis in certain areas of Papua - New Guinea by the mass administration of diethyl carbamazine, but the results of this work have not yet been published.

As malaria becomes less important it will be appropriate to start a program against filariasis. In order to prepare for this, a research unit should be set up to gather the essential biological and epidemiological information on filariasis in Papua - New Guinea.

Hookworm

Between 70 and 90% of the population are infected with hookworm. Nearly all hookworm infections are due to *Necator americanus;* less than one per cent of the hookworms recovered from man are *Ancylostoma* spp. (Bearup and Lawrence, 1947). They surveyed 656 people from five villages in Papua-New Guinea, for parasitic infections. Analysis of their results shows that about 16% of the people has egg counts of more than 5,000 eggs per gram of faeces, and 5% had egg counts of more than 10,000 eggs per gram. In other countries people with loads exceeding 5,000 eggs per gram are usually considered to be likely to develop anaemia (Faust and Russell, 1964). However, Bearup and Lawrence found that the haemoglobin values of people with high egg counts were not significantly lower than those with low egg counts. This finding is unusual and the significance of hookworm infections in Papua-New Guinea needs further investigation.

Parasitic Infections of Pigs and Man

Pigs are common in most parts of Papua-New Guinea. They are more common in the Highlands than most other places. In some parts of the Highlands a man's status depends on the number of pig feasts he has given. Thus, pigs are very valuable and are well looked after because of this. Baby pigs are often breast fed; immature pigs are led about on a rope by day and frequently sleep inside their owners' houses at night. Under these conditions people acquire certain parasites from their pigs in a way that is unknown in other countries. This is illustrated by the incidence of human *Balantidium coli* and *Entamoeba polecki* infections in the Highlands.

Balantidium coli is a ciliated protozoan which normally lives in the gut of pigs. It is a common infection of pigs and various surveys report local incidence of 20-100% throughout the world (Levine, 1961). It is a rare parasite of man. In twelve surveys, totalling nearly 25,000 faecal examinations throughout the world, its incidence was 0.77 per cent (Levine, 1961).

The incidence of *Balantidium coli* in man in the Highlands of New Guinea is high. An incidence of 2% was reported by Vines (1970) and Heydon (1940) found 11% of the people infected in the Mount Hagen area. Vines (1970) did not find *B. coli* infections in man on the North Coast or New Guinea Islands during a recent survey. An incidence of 20% has been reported in man from the Highlands of West Irian and 100% of the pigs there were found to be infected (Heoven and Rijpstra, 1957). *B. coli* is generally considered to be pathogenic to man, yet no reports of dysentery due to this organism have been recorded in Papua-New Guinea.

Entamoeba polecki

A species of *Entamoeba* occurs in pigs in many parts of the world. It is generally known as *Entamoeba polecki,* although *E. suis* may be the correct name (Levine, 1961). The incidence of infection in pigs ranges from less than 1% to 70% (Levine, 1961). It is a very rare infection in man. Until recently only 28 human cases of *E. polecki* were known. McMillan and Kelly (1970) estimate that 20% of the people in the Highlands are infected with *E. polecki.* They have analysed the reported cases of this infection and estimate that 227 of the 225 known human cases reported from various parts of the world are from New Guinea. *E. polecki* is not known to be pathogenic to man or pigs.

Ascaris

There has been some uncertainty about the relationship between *Ascaris lumbricoides* of man and *A. suis* of pigs. Experiments by Takata (1951) and Lysek (1961) indicate that pig *Ascaris* can develop to maturity in man. Furthermore, these and other authors have reported that larvae of pig *Ascaris* cause lung symptoms in man. Other workers, however, have not been able to get pig *Ascaris* to develop to maturity in man. *Ascaris* infections are commonest in man in the Highlands, where the incidence is about 60% compared with an incidence of 10-30% in other parts of the country (Vines, 1970). Pigs are more common in the Highlands than in other parts and they commonly have *Ascaris* infections. Pneumonia is responsible for about 15% of all hospital admissions in the Highlands compared with 6-9% in other regions. It is not at all impossible that lung infections of *Ascaris* larvae from both man and pigs pave the way for secondary lung infections which cause pneumonia. This problem needs further investigation.

SUMMARY

Many parasitic infections cause some subclinical ill health, and this may have a considerable effect on work output and on the physical development of school children in Papua - New Guinea where such infections are common.

The Malaria Control Program in Papua - New Guinea has reduced the amount of malaria considerably, but it is doubtful if malaria will ever be eradicated in this country by the use of DDT alone. In order to eradicate malaria it may be necessary to employ larviciding, drainage, drug distribution and every other possible means, as well as DDT.

Where pigs and man live in close association, pigs may be an important reservoir of certain human infections. The relationship between pig and human *Ascaris* infections in Papua - New Guinea needs investigation because secondary infections or pneumonia may follow the migration of *Ascaris* larvae through the lungs of man.

ACKNOWLEDGEMENTS

The author wish to thank the Director and the staff of the Institute for Medical Research, Kuala Lumpur, Malaysia for their hospitality and assistance, during his sabbatical leave.

REFERENCES

ANON, (1970). Quarterly Report Malaria Service, Sept., 30th, 1970. Department of Public Health, Papua - New Guinea.

BEARUP, A.J. and LAWRENCE, J.J., (1947). Parasitological report in "Report of the New Guinea Nutrition Survey Expedition 1947". ed. by E.H. Hipsley and F.W. Clements. Government Printer, Sydney. (The same data are given in *Med. J. Aust.*, 1950, *1* : 724).

BRYAN, J.H., (1970). The *Anopheles punctulatus* complex. *J. Parasit.*, 56 : (4) Section II part I : 40.

CHRISTIAN, S.H., (1945-51). Unpublished reports on malaria in the Highlands of New Guinea. Department of Public Health, Konedobu, Papua - New Guinea.

EWERS, W.H. and JEFFERY, W.T., (1971). "*The Parasites of Man in Niugini*" Jacaranda Press, Brisbane. 282 pp.

FAUST, E.C. and RUSSELL, P.F., (1964). "*Clinical parasitology.*" Lea and Febiger, Philadelphia 1099 pp.

HEYDON, G.A.M., (1940). Parasitological and immunological observations in natives of Central New Guinea. *Far East Ass. Trop. Med.* Comptes - Rendus du Dixième Congress, Hanoi, 1938, *2* : 621.

HOEVEN, J.A. VAN DER and RIJPSTRA, A.C., (1957). Intestinal parasites in the central mountain district of Netherlands New Guinea : an important focus of *Balantidium coli. Doc.Med. Geogr. Trop.*, *9* : 225.

KESSEL, J.F. and MASSAL, E., (1962). The control of Bancroftian Filariasis in the Pacific. *Bull. W.H.O.*, *27* : 543.

LEVINE, N.D., (1961). "Protozoan Parasites of Domestic Animals and Man" Burgess Publ. Co., Minnesota, U.S.A.

LYSEK. H., (1961). Contribution to the problem of pathogenicity of *Ascaris suum* in man. *Českoslov. Epidemiol. Mikrobiol. Immunol.*, Prague *10* (2) : 134-6. (Abstract in *Trop. Dis. Bull.*, *58* : 1371).

MCMILLAN, B. and KELLY, A., (1970). *Entamoeba polecki* von Prowazek, 1912, in New Guinea. *Trans. Roy. Soc. Trop. Med. Hyg.*, *64* (5) : 792.

PARKINSON, A.D., (1970). Malaria control in New Guinea Duplicated, Malaria Service, Port Moresby, Papua-New Guinea.

PETERS, W., (1960). Studies on the epidemiology of malaria in New Guinea. Part I. Holoendemic malaria : the clinical picture. *Trans. Roy. Soc. Trop. Med. Hyg.*, *54* : 242.

SCHELLONG, O., (1901). Die New Guinea Malaria einst und jetzt. *Arch Schiffs. Trop. Hyg.*, *5* : 303.

SOUTER, G., (1963). "*New Guinea - The Last Unknown*". Angus and Robertson, Sydney. 296 pp.

SWEENEY, A.W., (1969). Duplicated report presented at Malaria Conference, Kundiawa.

TAKATA, I., (1951). Experimental infection of man with *Ascaris* of man and the pig. Kitasato *Arch. Exper. Med. 23* (4) : 49. (Abstract in *Trop. Dis. Bull.*, *49* (4) : 423).

VINES, A.P., (1970). An epidemiological sample survey of the Highlands, Mainland and Islands Region of the Territory of Papua and New Guinea. Govt. Printer, Port Moresby.

WATSON, M., (1921). The prevention of malaria in the Federated Malay States. John Murray, London.