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## Table of Contents



## MALARIA AT RABAUL.

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### Geography and Climate.

RABAUL, the capital and largest settlement of the mandated territory of New Guinea, is situated on the shores of Blanche Bay, which is formed by a hook-shaped promontory of high land which juts out from the northern coast of the Gazelle Peninsula. This peninsula forms the north-eastern sixth of the large island of New Britain.

Excluding natives the population of the town itself including Namanula is given at 1,350, of which it is estimated that 350 are whites and 1,000 Asiatics, chiefly Chinese. The number of natives resident in the town is said to be 1,500.

The native population of the surrounding district, less sparse than in many parts of the territory, is composed to the extent of about four-fifths of free local natives living in small villages of the type found in different varieties throughout this part of the Pacific. The rest of the native population consists of indentured labour, often from other parts of the territory.

The Gazelle Peninsula as well as New Britain generally consists of hilly country with in many places a coastal strip of flat land of varying width. The elevated land is cut into steep ridges and deep ravines and covered for the most part with tropical forest or dense bush.

In the Rabaul district the underlying rock is covered with a layer of volcanic ash and pumice, which renders the surface soil very absorbent of water.

While the town proper is on flat land adjoining the Bay, a minority of the white population lives at Namanula on the ridge about a mile to the north-east at an elevation of about one hundred and fifty metres (five hundred feet).

Rabaul is about 4.5° south of the equator. Owing to its sheltered situation in Blanche Bay it is hotter than most stations in the territory.

The average annual rainfall is given as 210 centimetres (83 inches), that for the territory generally being put at 254 to 292 centimetres (100 to 115 inches).

The period of the north-west trade from November to April is the wetter and slightly hotter part of the year. During that of the south-east trade from May to October dry spells of several weeks or even months may occur.

The seasonal variation of temperature is not great. The mean maximum daily shade temperature is given as 31.8° C. (89.4° F.) and the mean minimum as a little over 21.6° C. (71° F.), so that the

HEYDON

daily range is about ten degrees. The average relative humidity is given as 75%, varying from a little over 69% in October to 80% in April.

### Previous Work on Malaria in New Britain.

The writer has not had access to a large reference library. Few records of earlier observations on malaria in New Britain during the German occupation or later have been obtainable at Rabaul.

### The Anopheline Vectors.

*Anopheles punctulatus* occurs throughout the coastal parts of New Britain as well as in many, probably most, other parts of the territory. Specimens from Madang, the Sepik River and Manus in addition to a number of places on the coast of New Britain have been seen by the writer. Specimens of *Anopheles bancrofti* have also been seen from Madang, but neither this nor any other species of anopheline differing essentially from *Anopheles punctulatus* has so far been found in New Britain, with the exception of *Bironella gracilis*. The larvæ of this species were found abundantly in the Baining district of New Britain by Mr. G. F. Hill and the writer.

*Anopheles punctulatus* breeds in natural surface water generally, rain water puddles, more permanent pools and swamps, ditches and sluggish grass-grown streams or open wells where the water comes near the surface. It does not breed in artificial containers such as tanks, covered wells, roof gutters, empty tins and bottles, severed bamboo stems, nor with any frequency in broken cocoa-nut shells, large fallen leaves holding water or beached canoes. Tree holes and the water which collects at the bases of leaves such as banana and pandanus, are never used by this species. These statements are true generally even of empty tins *et cetera* which have long lain in the grass in favourable sites.

FIGURE I.
Roadside Pools. Breeding-place of *Anopheles punctulatus*, Dönitz (Variety near to the Typical Form).

On several occasions one or two larvæ were present in broken cocoa-nut shells; these were the only exceptions. The species prefers a fairly open situation. Larvæ do not occur in the pools and streams found in dense forests and deeply shaded gullies, even where villages are near.

Suitable breeding places occur most abundantly in the flat coastal land.

Around Rabaul, as already mentioned, the soil is very absorbent, the deepest and moistest gullies rarely contain surface water and the only natural water on the high land consists of a few tiny, rocky pools and of springs, some of which give rise to small streams which flow for short distances over the flat land. Even on the latter rain water pools within a couple of miles from Rabaul have never been observed to persist long enough to breed anopheles. Within this area most of the breeding places consist of swampy pools or ditches quite close to the shore where the sub-soil water comes very near the surface, though larvæ have been found in a few places where the flat land meets the hills and springs from the latter flow into the open. The importance of wells dug near Chinese gardens was pointed out by Mr. Wallace, until recently Sanitary Inspector in Rabaul. These are merely wide holes dug down to sufficient depth and uncovered. They are generally concealed by the surrounding scrub and easily overlooked.

In short, then, inadequate drainage along the shore line together with surface wells and one or two small streams near the foot of the hills are the sources of anopheles in Rabaul. To deal with them radically would involve no large undertakings. For about the last six months periodic oiling has been carried out by the Public Health Department and has caused a perceptible diminution in the numbers of adult anopheles. An important swampy patch near the Native Hospital has also been filled in, as well as a number of Chinese wells.

While the above remarks apply to *Anopheles punctulatus* generally, it has recently appeared from the examination of material sent to the Australian Institute of Tropical Medicine that two varieties of *Anopheles punctulatus* occur near Rabaul and in other parts of New Britain. These show differences in both the larval and adult stages. One variety is *Anopheles punctulatus*, Dönitz, variety *moluccensis*, Swellengrebel, agreeing closely with Swellengrebel's descriptions and figures, and the other is described as near to, but not identical with *Anopheles punctulatus*, Dönitz, typical form. They will be referred to as the moluccensis variety and the "D. variety."

Definite differences in the habits of these two varieties exist. The "D. variety" is found chiefly in temporary puddles and shallow pools of rain water, often muddy but not foul, such as occur at road sides, in hoof marks or in local depressions of the ground in localities where the soil is not too

porous to retain such water. It has not been found in pools in any kind of relation with salt water. The moluccensis variety occurs in more permanent pools and swamps often of less pure water, in open wells, if they come near the surface, and in depressions generally which tap the subsoil water. It is often found within a few feet of the shore, in pools and swamps which may vary in level with the tides or even show channels of periodic communication with the sea. Such waters, however, consist mainly of soakage from the land and larvæ have not been found in any which were decidedly salt to the taste, that is which contained more than about about one part of sea water in seven. This variety has been observed living and apparently thriving in a pool which, though not salt, was completely emptied at each low tide for an hour or more, the rotting leaves on the bottom remaining wet during this interval. Young larvæ of the two varieties were tested as to their tolerance of sea water and it was found that while both died within eighteen hours in a dilution of one in two, those of the moluccensis variety all survived one in four for thirty-six hours at least and some of them for seventy-two hours. On the other hand all of the "D. variety" died within thirty-six hours in a one in four dilution.

All the adults caught in Rabaul itself which have been identified, have belonged to the moluccensis variety, as have the specimens obtained through the courtesy of medical officers of the Territory Administration from Madang and Manus. Probably the moluccensis variety is the predominant one in New Britain along the coastal strip, especially where swamps exist, while the other is relatively more numerous on higher land and perhaps also in the wet season.

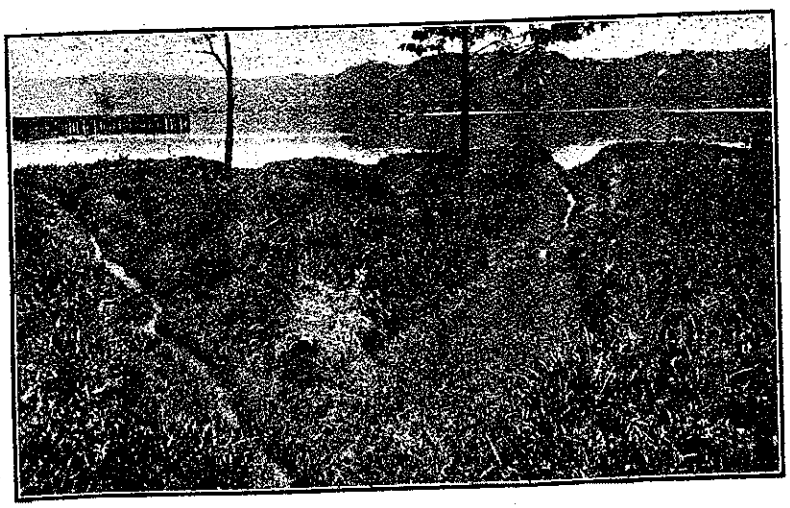

FIGURE II.
Foreshore Drains, Rabaul. Breeding-place of *Anopheles punctulatus*, Dönitz, var. *moluccensis*, Swellengrebel.

The average duration in nature of the larval stage of the "D. variety" appears to be somewhat shorter than that of the moluccensis variety, an advantage, of course, in the temporary breeding places of the former. The shortest period from oviposition to imago observed with certainty in this variety was nine days, but it is doubtful if this is the minimum.

In the laboratory observations described in this paper specimens of the moluccensis variety were infected with *Plasmodium vivax* and both varieties with *Laverania malariæ*. In the case of the specimens caught in houses *et cetera* and dissected, the variety was not ascertained, but it is probable that the majority were of the moluccensis variety.

The habits of the adults which are very imperfectly known, are so far as has been observed similar in the two varieties. Both frequent houses, where the females bite throughout the night and can be found during the daytime, most easily in the small huts and rooms of natives which are often dark, and at night full of humanity. They rest on the walls, often near the ground, on the undersides of beds, on wooden floors near the walls and in sheltered and usually dark situations generally.

In places visited by the writer this species never bites by day or even at dawn or early evening, but it is said to do so in localities where it is very numerous.

Breeding occurs throughout the year, the adults becoming more numerous after the onset of the wet season and scarcer as the dry advances.

They are not numerous in Rabaul. In the early part of 1922 it was always possible in the course of an evening spent in almost any bungalow in the town to catch from two or three up to a dozen specimens, while resting gorged females could be found in small numbers by careful searching in the morning in the sleeping quarters of natives. At present they are quite scarce even for the dry season owing, as already mentioned, to anti-larval measures.

As regards range of flight nothing certain has been ascertained.

How far *Anopheles punctulatus* or any of its varieties has been directly proved to be a vector in other parts of the world is a matter of uncertainty to the writer.

The best evidence as to the importance as a vector of any species of anopheles is generally considered to be obtained from the dissection of specimens captured in their natural haunts. This method has the disadvantages, however, that the species of parasite found is often unascertainable and that the percentage of the same species found infected varies enormously with the exact place and conditions of capture.

As a species may be an important vector for one species of parasite and not for another, the former consideration may be of importance. Observations on mosquitoes infected in the laboratory are free from this difficulty, but are subject to the greater one that it appears to be unsafe to draw too definite inferences from the degree of infectivity found under given conditions in captivity to that obtaining in Nature.

The following observations on *Anopheles punctulatus* as a malaria vector have been made at Rabaul at various times during 1922 and the present year.

### Laboratory Experiments.

*Artificial Infections.*

*Plasmodium vivax* and *Laverania malariæ* were found capable of completing their development in a large percentage of *Anopheles punctulatus* reared from captured larvæ and pupæ and fed on blood containing the gametocytes.

In the two experiments summarized below the mosquitoes after emergence were kept in wooden boxes of about eighty-five thousand cubic centimetres (three cubic feet) capacity in the dark.

They were kept at temperatures varying from about 30° C. (86° F.) during the hottest part of the day to about 23° C. (73° or 74° F.) in the coolest part of the night. The humidity in the boxes was much above that of the open air. Males were always present in the boxes, at any rate until some days after the blood feeds. From the day before the first occasion on which they were offered infected blood, until twenty-four hours after the last no other food was given; at all other times they were fed continuously on banana only.

A few experiments preceding the two described, in which, however, the mosquitoes were kept under different conditions, failed from incompletely ascertained causes and these two are those which resulted in the largest proportion of infected mosquitoes in the case of each species of parasite. In addition to one or more examinations of the blood of the carrier before the mosquitoes were fed, a number of thin films were made and 0.1 to 0.15 cubic millimetres of blood examined from each day of feeding in order to exclude as far as possible the existence of double infections.

The carrier used was an adult native whose blood contained *Plasmodium vivax,* asexual and sexual forms, and no other parasites. Of the mosquitoes all of the moluccensis variety which fed on this carrier and were later dissected, had fed on November 6, 1922, and had had additional opporutnities to feed on November 7, 9 and 10, 1922. Eight were examined between November 14 and 16, inclusive; in three of them oocysts were found in the midgut and in none was there infection of the salivary glands.

Three out of seven examined between November 21 and 23, inclusive, contained sporozoites in the salivary glands. The total number infected was six out of fifteen.

One lot of mosquitoes dissected, all of the moluccensis variety, had fed on a crescent-carrying native child on one or more of the following days, February 6, 8, 9, 10, 11 and 12, 1923. On none of these days were more than two hundred crescents present per cubic millimetre.

Dissections as follows:

On February 17, four were examined and oocysts were found in the midgut in every case; the salivary glands were infected in none.

On February 18 and 19 three were examined—all showed infected glands and one had nine oocysts in the midgut.

The total number infected was seven out of seven.

Some further *Anopheles punctulatus* of the "D. variety" were fed on the same carrier at about the same time. Those which did not feed, were not separated from the others and of seven dissected later the proportion which had fed is unknown. Two out of the seven showed salivary gland infection.

A single experiment, in which feeding took place on not more than two occasions on a native child infected with *Plasmodium malariæ* resulted in ten out of eighteen mosquitoes showing infections. Owing, however, to the period within which the salivary glands showed infection, namely ten days, being shorter than the minimum which *Plasmodium malariæ* is said to require in other anophelines at its optimum temperature, it is thought that gametocytes of *Plasmodium vivax* may also have been present in this case, though no benign tertian parasites whatever could be discovered in the blood.

It is hoped to repeat the observations with another carrier of *Plasmodium malariæ.* It would seem that such observations ought always to be made with more than one carrier in order to diminish the probability of error from undetected double infections. Swellengrebel has suggested feeding experiments as a diagnostic measure in cases where parasites cannot be found. He must, therefore, be of opinion that anopheles can be infected when parasites are so scarce as to be discoverable only with great difficulty. Darling, however, inferred from his experiments in Panama that blood containing less than twelve gametocytes per cubic millimetre is not infective. But different species of anopheles and of parasite may well differ in this respect.

*Dissections of Mosquitoes Caught in Houses.*

In most cases the mosquitoes were kept for a few days before dissection. They were two hundred and thirty-seven in all. Of these sixty-three were caught at the White Hospital, Namanula, early in 1922, and a further thirty-eight at different times in the writer's bungalow. The majority of these one hundred and one specimens were caught at night while attempting to bite. None showed infection. The examination of the salivary glands was omitted or totally failed in twenty of these and of the midguts in nine.

The remaining one hundred and thirty-six were caught in native quarters or village huts, chiefly while resting during the day. The greater number was caught within ten miles of Rabaul and chiefly during the wet season. Of these one hundred and thirty-six, eight showed oocysts in the midgut large enough to be detected with a low power and eight showed sporozoites in the salivary glands. The salivary glands were completely missed in eleven and the midguts in eight.

The percentages work out as follows:

| | |
|---|---|
| Total sporozoite rate, 8 out of 206 .. | 3.9% |
| Total percentage showing oocysts, 8 out of 220 .. .. .. .. .. .. .. | 3.6% |
| Sporozoite rate in those caught in native quarters, 8 out of 125.. .. | 6.4% |
| Percentage showing oocysts in those caught in native quarters, 8 out of 128 .. .. .. .. .. .. .. | 6.2% |

It is not claimed that these percentages afford any indication of the true average rates, as, apart from the smallness of the numbers, there was no attempt at random sampling.

In some of the mosquitoes infected in the laboratory and showing sporozoites in the salivary glands, as well as in one or two of those caught in huts, the thoracic muscles and body fluids were examined in the fresh condition for sporozoites without result.

It would seem, however, that if anything like the general distribution of sporozoites throughout the body described by Mühlens in some specimens of *Anopheles maculipennis* were present, it would not be easy to detect, by this method at any rate, except in insects much more heavily infected than *Anopheles punctulatus* appears commonly to be.

Some concentration of sporozoites in the salivary glands must certainly occur in *Anopheles punctulatus*.

### Malaria in Man.

Malaria of epidemic type has not been met with nor has any cerebral or other really pernicious case been seen (apart from blackwater, which is not here discussed).

All three species of malarial parasites are endemic at Rabaul. The writer has found quartan parasites in the blood of native children in several villages close to the town, as well as in the Duke of York Islands. This form appears to have been observed in New Britain by German investigators, but in what districts the writer is unaware.

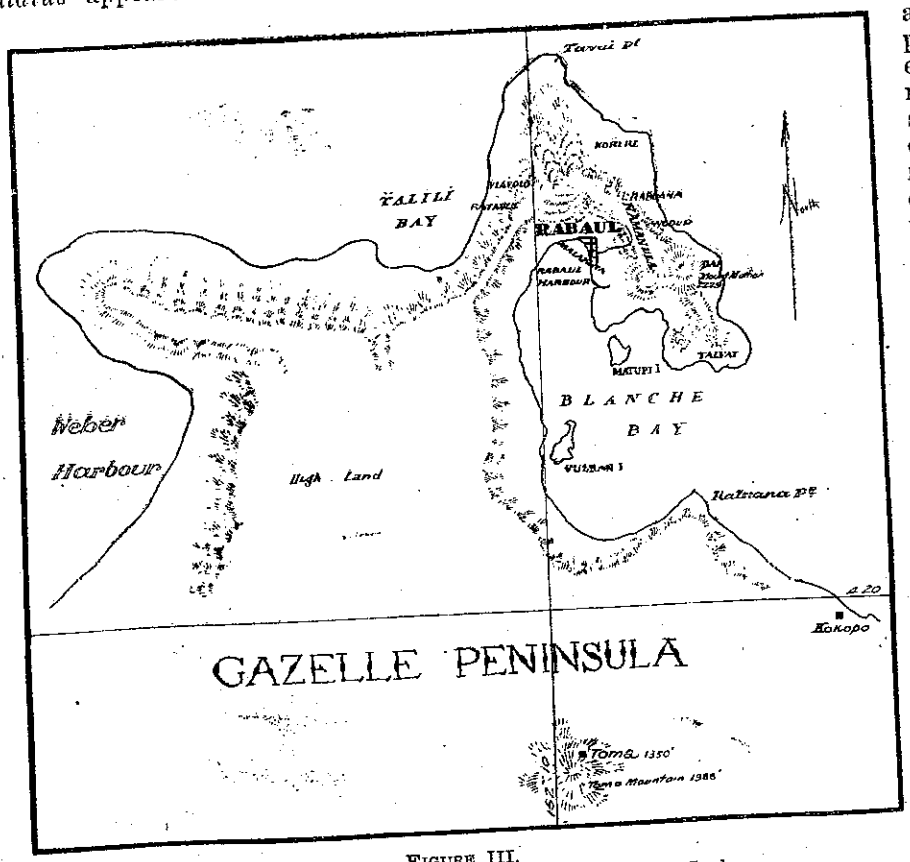


FIGURE III.
Map of Rabaul District. Scale: 4½ Miles to the Inch.

An estimate of the amount of endemic malaria in a locality is most readily obtained by the examination of the local non-immune population, which includes native and other children who have been born and bred in the place, as well as white adults who have never visited other malarious regions and have taken no quinine. Of these classes natives indigenous to the place are often the most numerous and accessible; as the spleen and parasite rates of such have been determined in many parts of the world, standards of comparison are afforded. The rates in these natives should be taken not only in children, but at all ages, because although the absolute rates in young children are roughly direct measures of the "malariousness," the form which the curves take as age and acquired immunity increase, gives further valuable information. The more malarious the place, the earlier is the age at which maximum rates are found, and the higher they are at this age and at ages below it. At later ages the less malarious place may show higher rates and it is said that a low spleen rate in adult natives means either very little malaria or a great deal of it, a high degree of immunity having been acquired in the latter case. In general the parasite rate rises to an earlier maximum and falls sooner than does the rate for enlarged spleens. When rates at similar ages are compared in different classes or races in the same place, very different results may be got, quite apart from quinine or deliberate protective measures. They would still often be different even if in each class the rate of new infections were the same, for the reason that the general standard of life, quality and abundance of food *et cetera* have a great effect on the duration of attacks and on the frequency with which relapses occur.

Turning then to the consideration of that part of the Rabaul population which has spent its life in the place, two classes are available, local natives and Chinese children.

*Local Natives.*

The villages near Rabaul show great differences, but the figures collected from a number of them taken together, reveal a moderate average amount of endemic malaria. Benign tertian parasites are more common than subtertian, while quartan is common in some villages.

The spleen rates at different ages in natives of villages within five miles of Rabaul (most of them within three miles) are given below and shown in

TABLE I.

| Physical Condition. | Age Groups (Years). | | | | |
|---|---|---|---|---|---|
| | 0—2 | 3—6 | 7—11 | 12—17 | Over 17 |
| Number of examinations | 382 | 300 | 347 | 116 | 939 |
| Spleen palpable | 30 | 55 | 81 | 56 | 213 |
| | 7.8% | 18.3% | 23.3% | 48.3% | 22.7% |

TABLE II.

| Physical Condition. | Age Groups (Years). | | | | |
|---|---|---|---|---|---|
| | 0—2 | 3—6 | 7—11 | 12—17 | Over 17 |
| Number of examinations | 176 | 170 | 91 | 52 | 107 |
| Spleen palpable | 26 | 50 | 36 | 23 | 20 |
| | 14.8% | 29.4% | 39.5% | 44.2% | 18.7% |
| Parasites found | 43 | 55 | 34 | 19 | 7 |
| | 24.4% | 32.3% | 37.4% | 36.5% | 6.5% |

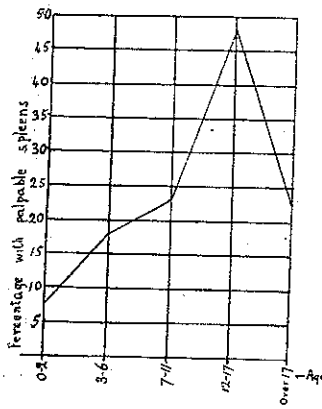


FIGURE IV.
Spleen Rates in 2,084 Natives of Villages near Rabaul.

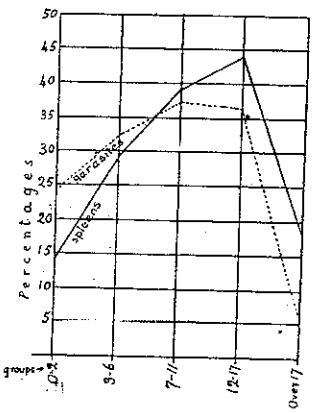


FIGURE V.
Parasite and Spleen Rates in 596 Natives of Villages near Rabaul.

Figure IV. The total number of examinations at different times was 2,084, but the number of different individuals examined was considerably less.

It will be seen that both the form of the curve and the natural percentages in children are of the sort characteristic of a moderately malarious locality.

The villages from which these figures were obtained are in the following localities, the positions of which are roughly indicated in the accompanying map (Figure III.): Malakuna, Matupi Island, Talvat, Bai, Nodup, Rabuana, Korere, Vlavalo, Ratavul.

The huts belonging to what is in name a single village, are often much scattered, so that a village of, say, a hundred inhabitants may be spread over several hundred yards in small groups of a few huts each.

In these figures and in others given in this paper considerable distortion has been caused by errors in judging ages and also by inequalities in the proportions of persons of different ages who were secured for examination at different villages and at different times. The latter source of error applies especially to the adult age group, "over 17," while both have been operative in the group 12 to 17. Spleen rates were taken standing, or in the case of infants while held by the mother. The age groups chosen, given as "0—2," "3—6," "7—11," "12—17" and "over 17," mean respectively the first three years of life, the next four, the next five, the next six and the remainder. Most of the adult natives examined were young and nearly all were males.

Further figures of both the spleen and parasite rates in a smaller number of natives, namely 596, from some of the same villages are shown in Figures IV. and V. These included a higher proportion of the more malarious villages.

In the 158 cases in this group in which parasites were found, *Plasmodium vivax* was present ninety-eight times, *Laverania malariæ* forty-three and *Plasmodium malariæ* nineteen, while eleven were doubtful. Double infections were noted in thirteen patients, chiefly *Plasmodium vivax* with *Laverania malariæ*. Thin films only were used in obtaining the parasite rates here given and the amount of blood examined averaged between 0.015 and 0.02 cubic millimetres.

In the districts of Talvat, Bai, Nodup, Rabuana and Korere there were much lower spleen and parasite rates than in the villages on the shore of Blanche Bay (at Malakuna and Matupi Island). On the coast on which the former are situated, the land rises rapidly from the beach and there is little flat land.

These and other figures for natives were collected from different places at various times of the year, both before and after the introduction of anti-

anopheline measures by the Public Health Department, in such a way that unfortunately the nature of the seasonal variation in the rates is not apparent with any certainty. However, they may lend some support to such figures for white men as have been available and to the writer's general impression which is that benign tertian rises almost to its maximum about the middle of the wet season, while that of subtertian is not attained until the end of the wet season or early in the dry. The difference between the most and least malarious villages is much greater than the seasonal variation in any one village.

*Chinese Children.*

Most of the Chinese children in Rabaul have lived there all their lives, Chinatown lying about half a mile north of the administrative centre of Rabaul and about one-third of a mile from the shore. Eighty Chinese children of all ages up to fourteen were examined in January of this year. Only three had palpable spleens and malarial parasites were found in three, of which all were *Plasmodium vivax*. These are strikingly low figures and probably related in part to the situation of Chinatown, within several hundred yards of which, in spite of its low lying position, Anopheline breeding places are scarce. But the difference in the standard and mode of life is probably responsible for the greater part of the relative immunity of Chinese children compared with those of natives. The Chinese in Rabaul live well and more or less effective mosquito nets are commonly used. The children are seldom given any quinine.

*White Men and Natives.*

As regards whites many difficulties arise in the consideration of statistics of malarial morbidity, especially when the figures are small and arrivals from other stations frequent.

Some figures of the Public Health Department of the Administration in Rabaul and some German figures which have been available, indicate, however, as regards the matter of seasonal prevalence, that in whites maxima occur in January to February and in May to June, with the minimum in September to October. As regards the May to June crest, its height may possibly be increased by the onset of the cooler weather disposing to relapses.

The figures of routine diagnostic blood film examinations of whites and Asiatics in this laboratory, although small and impaired by discontinuities, also show a minimum towards the end of the dry season and a maximum about May; they also show that the latter is due to subtertian infections. In the eighteen months ended on June 30 of this year malarial parasites were found in sixty-two of these examinations (chiefly whites). *Plasmodium vivax* was found twenty-three times, *Laverania malariæ* forty-two times and the quartan parasite once; in four cases double infections were noticed. The proportion of subtertian to benign tertian is, of course, higher than the true ratio, as the former cases are more likely to come under notice.

Three instances have occurred of newly arrived whites who could not previously have been infected, but succumbed to attacks of malaria within four weeks of arrival in Rabaul. These infections were diagnosed microscopically; two were benign tertian and one subtertian. In a couple of less certainly authenticated cases there had been no attack within the first year of residence in Rabaul, although not more than a dozen small doses of quinine altogether had been taken. These extremes are, of course, quite consistent with the laws of chance. Apparently the majority of those living on the flat in Rabaul are infected during their first wet season if not before, although quinine takers may, of course, show no signs of it. Namanula is definitely less malarious.

Sundry other observations on natives, other than villagers near Rabaul, may now be referred to.

The neighbourhood of Toma, about fourteen miles south from Rabaul, is of some interest. Toma itself consists of a plantation and a hotel, the latter used as a holiday and convalescent resort. It is about 412 metres (1,350 feet) above the sea, the nearest point of which is distant about six miles. It is cooler and wetter than the coastal district.

The spleen rates in the children in December, 1922, in a number of villages in the district, most of them a few miles to the north and west of Toma, are given in Table III.

These villages are at lower levels than the Toma Hotel, down to about 183 metres (600 feet); none are within several miles of the sea.

The number of persons examined and that of persons with palpably enlarged spleens at a mission station and a plantation in the immediate neighbourhood of Toma, are set out in Table IV.

The village spleen rates are very low and are correlated with the scarcity of anopheles breeding places near these villages and in the neighbouring country generally. The deep ravines unlike those near Rabaul usually contain clear, deeply shaded streams. These never contain anopheles. Mr. G. F. Hill and the writer were unable to find a single anopheline larva or adult near Toma. A few pools formed in the marginal drains of government-made

TABLE III.

| Physical Condition. | Age Groups (Years). | | | | |
|---|---|---|---|---|---|
| | 0—2 | 3—6 | 7—11 | 12—17 | Over 17 |
| Number of examinations | 24 | 73 | 101 | 10 | 3 |
| Spleen palpable | 0 | 0 | 1 | 1 | 0 |

TABLE IV.

| Physical Condition. | Age Groups (Years). | | | | |
|---|---|---|---|---|---|
| | 0—2 | 3—6 | 7—11 | 12—17 | Over 17 |
| Number of examinations | 1 | 3 | 15 | 5 | 46 |
| Spleen palpable | 0 | 0 | 6 | 2 | 12 |

roads were the only surface water existing which seemed at all suitable to *Anopheles punctulatus*.

It will be noted that there was a larger proportion of enlarged spleens among the persons in the plantation and belonging to the mission. It has been observed in other districts that the spleen rates of natives living at plantations and missions are sometimes higher than those of natives in the neighbouring villages. While boys on plantations commonly come from other parts of the territory under a three or a two years' contract, at mission stations a larger proportion of the adults and especially children have usually been born in the locality. The probable reasons for this increase of malaria at some settlements are the aggregation of larger numbers in smaller areas and the fact that some of civilization's dealings with the bush often tend to increase the number of breeding places highly favourable to *Anopheles punctulatus*, especially the "D. variety." The formation of a white station near low-lying coastal swamps or pools due to depressions below the level of the subsoil water usually leads sooner or later to partial drainage, but on the other hand a settlement a little inland or in a place where previously only a few pools existed in dense bush little favoured by *Anopheles punctulatus*, will often lead to an increase in the numbers of these mosquitoes. Clearing and path making often tend to the formation of open rain water pools and road-side puddles by interfering with natural slopes, compacting the surface soil and reducing plant transpiration. Ponds or surface wells may be constructed, one of which may contain more anopheles larvæ than could previously have been found for miles around. It may be mentioned that natives' notions of making a water supply are confined to the scraping of evanescent holes on the beach for the tapping of subsoil water or to catching a little water by leaning a cut bamboo against a tree trunk. Villagers will often be found to carry water from a distance or to depend mainly on green cocoa-nuts. During a later visit to Toma the writer was again unable to find any anopheles, except at the hotel itself, where adults were abundant and were found to be coming from a small pond which had been dug in the open; they were of the "D. variety." This observation, besides illustrating the previous remarks, shows that the scarcity of anopheles in this neighbourhood, shared by many inland districts in New Britain, is due to lack of suitable breeding places and not to climate or elevation, at any rate as regards this variety of *Anopheles punctulatus*.

The following are figures for native labour in Rabaul, little of which is drawn from local boys.

In April, 1922, out of three hundred and eighty-seven examined 47.5% had palpable spleens and of seventy-six examined for parasites seven or 9.2% harboured malaria parasites. Five of these were *Plasmodium vivax* and two *Laverania malariæ*. The inferences which can safely be drawn from such adult rates in non-local natives, are still a matter of some doubt to the writer and will not be discussed here. The spleen rate in Rabaul police boys taken in July of this year by the Public Health Department was less than 20%.

A few additional localities may be mentioned.

The Duke of York Islands, a group of small low-lying islands twenty miles east of Rabaul, the largest about four miles across, are somewhat highly malarious. Figures for villages on the main Duke of York Island and the island of Mioko, taken in July, 1922 are given in Table V.

Of the parasites found thirteen were *Plasmodium vivax*, eight *Laverania malariæ* and four were *Plasmodium malariæ*. There was one double infection.

TABLE V.

| Physical Condition. | Age Groups (Years). | | | | |
|---|---|---|---|---|---|
| | 0—2 | 3—6 | 7—11 | 12—17 | Over 17 |
| Number of examinations | 93 | 78 | 87 | 16 | 76 |
| Spleen palpable | 22 | 10 | 52 | 9 | 8 |
| | 24% | 51% | 60% | 56% | 10% |
| Number examined for parasites | 33 | 10 | 17 | 1 | 0 |
| Parasites found | 9 | 5 | 9 | 1 | 0 |
| | 27% | 50% | 53% | — | — |

TABLE VI.
SPLEEN RATES IN NATIVE VILLAGES—BAINING.

| Physical Condition. | Age Groups (Years). | | | | |
|---|---|---|---|---|---|
| | 0—2 | 3—6 | 7—11 | 12—17 | Over 17 |
| Number of examinations .. .. .. .. .. .. .. .. | 54 | 6 | 14 | 7 | 143 |
| Spleen palpable .. .. .. .. .. .. .. .. .. .. | 1 | 2 | 7 | 6 | 63 |

TABLE VII.
SPLEEN RATES IN NATIVES AT PLANTATIONS AND MISSIONS—BAINING.

| Physical Condition. | Age Groups (Years). | | | | |
|---|---|---|---|---|---|
| | 0—2 | 3—6 | 7—11 | 12—17 | Over 17 |
| Number of examinations .. .. .. .. .. .. .. .. | 3 | 6 | 37 | 41 | 233 |
| Spleen palpable .. .. .. .. .. .. .. .. .. .. | 1 | 3 | 22 | 29 | 116 |

Spleen rates taken in the Baining district, towards the north-west end of the Gazelle Peninsula in June, 1922, at a number of villages, plantations and missions both on the coast and at short distances inland, are given in Tables VI. and VII.

Kokopo, formerly Herbertshöhe and at one time the capital, on the coast eleven miles south-east from Rabaul, appeared from the few figures collected in native children at a mission station there to be less malarious than Rabaul.

From time to time at Rabaul forms of malarial parasites differing more or less from the well-recognized types have been encountered.

Parasites resembling the younger forms of *Plasmodium tenue* have not been rare; one case occurred in which there were more advanced forms of this kind, as was pointed out by Dr. R. W. Cilento to whom various films had been sent. No fully grown asexual forms or gametocytes were seen in this case. These forms appear to the writer to be variations of *Laverania malariæ*.

One film seen from the Duke of York Islands contained forms resembling those which have been described as *Plasmodium vivax*, variety *minuta*.

The view popularly held that malaria in the territory is of importance chiefly to whites is, of course, quite a mistake. The chief sufferers are native infants. A native baby is a new arrival in the country and unprotected by acquired resistance to malaria. When it is dangerously ill without signs of the more obvoius diseases, the cause remains obscure or is attributed by the village to a ghost in the night. Malaria is certainly an important cause of the high infantile mortality in the native. Naturally few infantile mortality figures are yet available in the territory. It is, however, of interest to note that the average size of the family, as shown by figures collected by the present District Officer for Kokopo, is higher in the neighbourhood of Toma than in villages on the adjacent parts of the coast, peopled by the same tribe.

All the work on the identification of anopheles and their varieties referred to in this paper has been done by Mr. G. F. Hill who, the writer believes, is publishing an account of these and other Australian forms.

## Reports of Cases.

### IRREDUCIBLE INTUSSUSCEPTION IN CHILDREN: SUCCESSFUL RESECTION IN TWO CASES, ONE BY LATERAL ANASTOMOSIS AND ONE BY MAUNSELL'S OPERATION.

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THESE two cases present such unusual features that I think that they should be recorded.

#### Case I.

E.P., aged four years and four months, had been ill for ten days before admission to hospital. At first there was swelling of the legs. This disappeared two days before admission. But the patient had had no natural motion for the ten days and enemata had yielded no satisfactory result in that time. During several days he had vomited all food immediately.

He had had broncho-pneumonia at the age of six months, whooping cough at the age of twelve months and measles at the age of one year and six months.

On admission the patient complained of abdominal pain. The abdomen was distended, but moved on respiration. There was no rigidity. There was dulness in both flanks, which shifted. No tumour could be felt.

The general condition was one of shock verging on collapse. There had been no passage of blood *per rectum*. Intestinal obstruction of uncertain origin was all that I was able to determine as to diagnosis.

The patient was anæsthetized. Nothing in the shape of a tumour could be felt. The usual median incision was made. The caecum was immediately felt to be collapsed, indicating a small gut obstruction. Thereafter a sausage-like tumour was felt in the pelvis. On further examination this proved to be an enteric intussusception about ninety centimetres above the ileo-caecal valve. Attempts