CILENTO.

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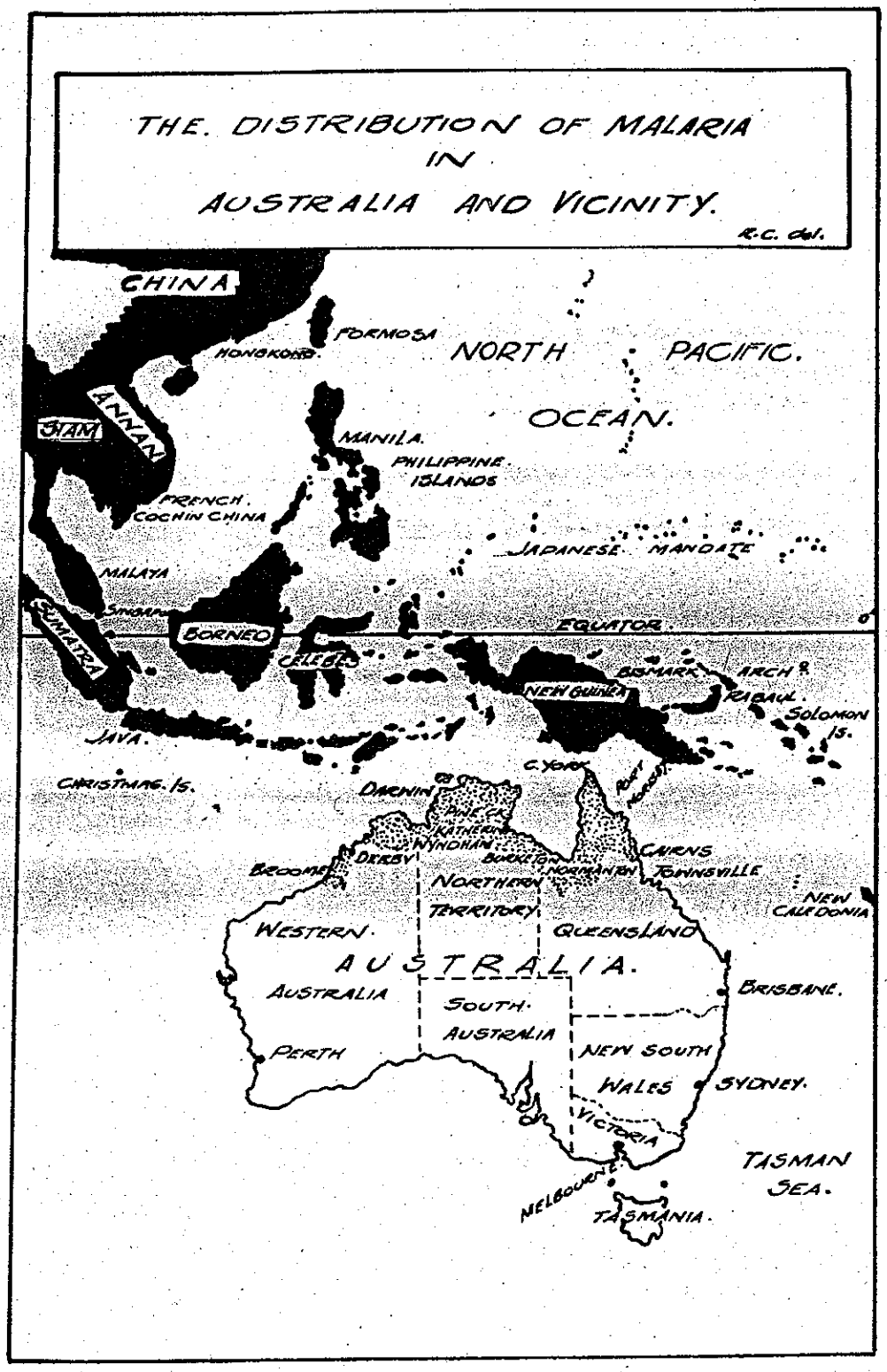
THE. DISTRIBUTION OF MALARIA
IN
AUSTRALIA AND VICINITY.
R.C. del.
CHINA
FORMOSA
HONGKONG.
NORTH PACIFIC.
OCEAN.
SIAM
ANNAM
MANILA.
PHILIPPINE. ISLANDS
FRENCH. COCHIN CHINA
JAPANESE MANDATE
MALAYA
SINGAP.
SUMATRA
BORNEO
CELEBES
EQUATOR.
BISMARK ARCH.
NEW GUINEA
RIBAUL.
SOLOMON Is.
JAVA.
CHRISTMAS. Is.
C. YORK
DARWIN
PINE CR.
KATHERINE
WYNDHAM
BURKETOWN
CAIRNS
BROOME
DERBY
NORMANTON
TOWNSVILLE
NORTHERN TERRITORY
NEW CALEDONIA
WESTERN.
QUEENSLAND
AUSTRALIA.
AUSTRALIA
SOUTH. AUSTRALIA
BRISBANE.
PERTH
NEW SOUTH WALES
SYDNEY.
VICTORIA
TASMAN SEA.
MELBOURNE
TASMANIA.

FIG. 1.

MALARIA IN AUSTRALIA.

by
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When this paper was first written, the only review of malaria in Australia was a paper published by Cleland in 1914, which dealt with all accessible references to the subject up to and including 1912. Previous to the opening of Congress, however, there appeared an article by Maplestone (1923) which was intended to continue this review of the literature from 1912 to the present date. Unfortunately, since Maplestone's departure from Australia, so much new information has come forward through the malaria survey carried out in conjunction with the Hookworm Campaign (representing the Commonwealth of Australia, the State of Queensland, and the International Health Board) that the facts of his paper were already obsolete when published, and the sole feature which remains comparatively established is that malaria is practically non-existent in Australia south of the 19th parallel of South Latitude. This fact has never been seriously questioned. Maplestone, moreover, was forced to rely for his figures upon Government reports, which, in the matter of malaria, are notoriously unreliable. It is, indeed, a commonplace that wherever malaria is endemic the inhabitants treat themselves with quinine and rarely call in a doctor unless the attack is one of considerable severity. The facts set out below are based, not upon the examination of official figures, but upon actual surveys of the areas implicated. The medical officer who carried out a large portion of the survey (and who, like Maplestone, was somewhat sceptical as to the constant presence of malaria in Northern Australia) himself acquired malignant tertian during his investigations.

The actual evidences of malaria in Australia mainly arise in certain endemic areas, and are more dramatically apparent during the occasional small epidemics which follow the arrival of malaria carriers among a non-immune population, or occur as those cyclic exacerbations from which all endemic areas suffer. Cases from endemic areas are not as a rule reported; epidemics are rare, and the cases which most commonly figure in the official records are

are/

sporadic cases of imported malaria and rare cases of malaria acquired in areas where the disease is not usually found. Most of the sporadic cases of malaria occur as an aftermath of the war, which resulted in the return to Australia of many infected persons. They are generally relapses of an earlier infection, and do not form a considerable problem, though the potentialities in this regard have been a matter of grave concern. Certain occasional cases of locally-acquired malaria, however, have been reported from the south ern States, and are of considerable interest since they indicate that in areas as yet malaria-free there are conditions occasionally suitable to the conveyance and spread of the disease.

The cases recorded, most of which are mentioned by Maplestone, have been kindly collected for me by Dr. Eustace W. Ferguson of the Bureau of Microbiology, Sydney. They include:-

1. A case at Gosford, near Sydney, N.S.W. (Jamieson), M.J.A. Vol.I., 1915, p.163.

2. A case reported to have been contracted at Wyong, N.S.W., but which was actually acquired in Sydney, N.S.W. (Wilfred Evans). M.J.A. 20/12/1919. (A further account of the case appears in the Annual Report of the Bureau of Microbiology, Sydney, 1919.)

3. A case at Rosewood, which is twenty miles from Tumbarumba, N.S.W. (Clayton) M.J.A. 7/5/1921.

4. A case at Barraba, N.S.W. reported in a note to No.3.

5. A case at Forbes, N.S.W. reported in a note to No.3 though in this last instance, the evidence of malaria is insufficiently authenticated.

6. A case at St. Arnaud, Victoria (Gerald Doyle) M.J.A. Vol.I, 1921, p.421.

7. A case at Perth, Western Australia.

These cases may be looked upon as unimportant to the broader aspect of malarial distribution. As regards endemic malaria and the rare epidemic malaria, however, there is a considerable mass of important evidence which was apparently inaccessible to Maplestone.

The earlier history is chiefly of historical interest only. Cleland, who carefully combed the literature for references, first records mention of the disease in Sturt's "Expedition into Central Australia", (1849)where it is mentioned that Dr. Leichhardt's party contracted ague in the north of the continent. The first medical description of malaria is said by Cleland to have been that of White

White/

(1867) who described the fevers of the Gulf of Carpentaria, Queensland. Though other fevers are confused with it, there is no doubt whatever, that definite malaria is included in this description. Maplestone considers that White's series of cases may be part of the same outbreak as one referred to by Elkington, when malaria was introduced to Burketown, Gulf of Carpentaria, by a ship from Java. It is to be recollected, however, that there have been several epidemics at Burketown, which on several successive occasions have devastated the town. The late Mr. J. J. Macdonald, who was in charge of the expedition which settled Burketown, related to Dr. Elkington, the following facts in connection with the epidemic:-

"The population of the little settlement was some 76 people. It was an expedition financed by a land settlement company and Mr. Macdonald was the leader. For some time after the Burketown site was settled, the health of the community was very good. One day a stockman rode in and reported that a small sailing vessel with a number of dead people on board was lying up one of the creeks some miles away. This was investigated and found to be correct, the vessel having come from Java, and the crew having died from 'fever'. A couple of weeks after, people in the Settlement began to fall ill, with an acute disease, accompanied by the vomiting of bile, great prostration, and high fever. They died rapidly. The disease was believed to be yellow fever (and is still spoken of as "Yellow Jack" by old hands in the Gulf) and the survivors vacated the Burketown site. Mr. Macdonald himself, escaped it until a few days after he left to return south, when he was taken desperately ill with it on the journey, and barely survived. About fifty of the entire little community died. This was the reason for the settlement being removed to Sweer's Island at the mouth of the river."

At the present time there is no difficulty in obtaining verbal statements from old residents which bear out the account of Macdonald, ~~that~~ but the name "Yellow Jack" has become ingrained into the consciousness of the people and it is emphatically asserted that it was actually yellow fever. There is no doubt, however, that the disease was malignant malaria and it still occurs occasionally in this vicinity.

In the early days of a new country, especially when mining is the great stimulus to immigration, and road and railway making a considerable feature of progressive activity, malaria is almost certain to be introduced if circumstances favour such an occurrence. There is little reason to doubt, therefore, that as Cleland (1914) states, there was extensive and severe malaria in North

North/

Queensland for some years prior to 1885, nor to question the substantial accuracy of the reports of Ahearne, 1890, for Townsville Hunt, 1890, for Hughenden, and James, 1891, for Croydon. Hunt may have confused typhoid fever and malaria, but James certainly described malaria, and the disease is still mildly endemic in Croydon, the locality mentioned.

With regard to Ahearne's cases the emphasis is placed not upon Townsville, but upon the northern district for which it was the centre. In conversation, Ahearne recently stated to the writer that from 1880 to 1885 malaria was prevalent to a very marked degree among the scrub cutters on the rivers between Townsville and Cairns. He believed that the early cases of the disease were introduced, but definite areas of endemicity were later established between 18 to 19°S., where, as a matter of fact, they still persist.

The same history is applicable to all the mining areas and the rushes that accompanied their opening up. There is the same initial epidemic, the same decrease in the disease as the nomadic population followed elusive Fortune elsewhere, and the same persistence of a mild endemic malaria tending more and more definitely to restrict itself as population dwindled. Croydon, for example, once boasted 12,000 people, its mines failed; its present population is from 200 to 300. It was once a hotbed of malaria; there has been only a rare sporadic case or two yearly for several years.
The same story applies to Kidston, N.Q., where in 1912, of 400 people, 120 contracted malaria, and 24 died, and to Umbrawarra Tin Field in the Northern Territory, which spread carriers all over that great sparsely inhabited country. Later again, there appeared the acute exacerbations which occasionally arise in all endemic areas. Such occurred in the Northern Territory in 1920 and 1921; in Cape York Peninsula in 1919 and 1921; in Cairns in 1916, 1917, and 1921, and elsewhere.

At the present date the distribution of malaria may be described from several endemic centres. In North Queensland the disease exists in the coastal areas from Ingham and Cardwell 19°S.

to Batavia Gold Diggings at the extreme north of Cape York Peninsula, throughout the Peninsula itself, and along the whole eastern and south eastern coasts of the Gulf of Carpentaria. In the Northern Territory three main foci extend from Avon Downs near the Queensland border (19°S.) to Roper River in the east and Victoria Downs in the west at the coastal junction of the boundaries of the Northern Territory and Western Australia. These centres converge upon Pine Creek and ultimately on Port Darwin, in which latter locality the disease, however, does not appear to be endemic according to records. In Western Australia there are said to be centres along the Fitzroy and Ord Rivers at Broome and at Derby, but this is insufficiently substantiated.

An examination was made of all the areas mentioned above with a view to establishing the position so far as malaria was concerned. In Western Australia the general disrepute of the areas regarded as centres of malarial endemicity was not borne out by actual observation. The town of Derby in particular is characterised by a sandy soil, a high evaporation rate and a scanty rainfall, which do not suggest that the continuance of malaria is favoured. Anopheline mosquitoes are, moreover, rare. This observation is not, however, applicable generally in North West Australia, and it is probable that malarial cases do occur sporadically in the riverine districts of the Rivers Fitzroy and Ord. The proximity of the latter to the infected area of Victoria River Downs immediately across the Northern Territory border renders this possibilitity more probable.

In the Northern Territory itself, as has been stated, malaria has a tri-radiate distribution. The most westerly area involved is that along the Victoria River. During 1920/21 six deaths occurred at Victoria River Downs, and cases were reported from Willeroo, Delamere, Wave Hill, and Victoria River Downs, which are stations situated along the area drained by the Victoria River. Parasites were obtained from the blood in several cases. Avon Downs in the southeast, and Roper River on the western shores of the Gulf of Carpentaria are also held in a disrepute which is confirmed by occasional deaths. Certain of these cases have present-

present-/

ed the parasites of malignant tertian. The trunk railway from Port Darwin towards Daly Waters is marked along its whole course by the occurrence of sporadic cases of malarial fever. Brock's Creek, Pine Creek and Katherine are all affected. It is possible that the extension of railway which is contemplated will give rise to an epidemic from the concentration of a non-immune population in an area where carriers and anopheline vectors are not uncommon. The general distribution of malaria in the Northern Territory appears considerable owing to the fact that sporadic cases occur over an extremely wide area. The actual number of cases is not great, but bears a relatively high proportion to the population, which is exceedingly small. In a report from Harris dated 20th September, 1920, occur the following statements:-

"Marranboy, population 39 whites, 14 aboriginals. All but four had at one time or another had malaria or some feverish disease yielding at once to quinine treatment. A malignant type of malaria is endemic. At Mount Wells where there were 12 white men, 10 had at some time or another suffered from 'fever'. Of seven whose blood was examined, two contained the parasites of malignant malaria and one shewed other evidences of malaria." Harris concluded that 25% of the whites were malaria carriers.

Baldwin & Cooling (1922) reported finding three cases of malignant tertian malaria and one of benign tertian in white persons at Darwin. One case which died was aged 50 and came from Brock's Creek. Of the other two cases of malignant tertian, one was aged 47 and came from Katherine, the other was aged 30 and came from Pine Creek. The person having benign tertian was a woman aged 32 living in Darwin, who had previously had malaria at Mt. Bonnie. They found at Marranboy histories of malaria in two individuals who had been in the Territory for 11 and for three years respectively. At Pine Creek three white adults had splenic enlargement and a definite history of having had malaria many times. At Emungalen six whites examined (four adults and two children) gave histories of having had malaria. In examinations for splenic

splenic/

enlargement amongst the aboriginals in the Darwin compound, 36 of 159 fullblooded aboriginals (22.6%) shewed a splenic enlargement. Seventeen of 54 half castes, or 31.5% shewed a splenic enlargement. Of the 53 aboriginals shewing an enlarged spleen the following table gives particulars:-

Tribe or origin	No.examined	No.enlarged spleen	% enlarged splee
Wangite	51	7	13.7
Melville Island	33	6	18.2
Larray Keyah	32	9	28.1
Bathurst Island	18	7	38.9
Pine Creek	12	2	16.7
Marungana	9	2	22.2
Darwin	7	3	42.9
Daly River	6	1	16.7
Wave Hill	6	3	50.0
Paper Bark	4	2	50.0
Katherine	4	1	25.0
Adelaide River	3	1	33.3
Roper River	3	2	66.0
May River	3	1	33.3
Willeroo	2	1	50.0
Borroloola	2	1	50.0

Naturally, the figures shewn here cannot be taken as definite indication of malaria in the localities mentioned. The very fact of the natives being at Port Darwin indicates that they are wanderers who may have picked up their disease anywhere in the Northern Territory, and moreover, their numbers are too small to have any great significance. They indicate, however, that malaria is probably endemic to a slight degree over a wide area in the Northern Territory, and the facts recorded above, meagre as they are in numbers, have considerable significance.when related to the scanty white population and the considerable morbidity rate when expressed in percentages.

In Queensland, although cases are more frequent, the distribution of the disease is more definitely restricted. The old cattle routes which were probably the great disseminators of malaria in the old days, led southeast from the Northern Territory and the infected Roper River district to Burketown, and then directly south to Kajabbi Junction and onward. It will be recollected that Burketown was, on one occasion at least,afflicted with an extremely fatal form of pernicious malaria, leading to the abandonment of the town site. At one time Turn-off Lagoons between

between/

Burketown and Majabbi Junction was reckoned a considerable focus for infection. In both localities, however, a considerable reduction in population and communication has resulted in a very great decfease in the reported cases. This same factor operates throughout the whole of this country where the practical cessation of mining and the great reduction in cattle raising has brought about a very considerable change. It will be recollected that Croydon, which at one time had a population of 12000 people, is now a village with a mere 200. As one proceeds further eastward the Government Station at Van Rook is reached. Van Rook, Delta and Stirling Stations represent an endemic focus for the disease where cases of a subtertian nature occasionally occur. The consensus of opinion in these areas is that the malaria of the present day differs in type from the malaria of twenty or thirty years ago.

Descriptions seem to indicate without doubt that this earlier form was benign tertian with definite ague. The present subtertian form appears to have been introduced later, and is tending naturally to decrease. The absence of marked ague, however, leads to the local opinion that the disease is not malaria.

Proceeding northwards along the western side of Cape York Peninsula, malaria occurs frequently at the mission stations of Mapoon, Weipa and Aurukun. At the Batavia Gold Diggings in the extreme north the first outbreak of malaria is reputed to have occurred in 1901, and it is said there have since been sporadic cases annually "particularly when new land is opened up". A similar history attaches to the workings at Coen and Tin Creek. Reports from the inland telegraph stations of the Peninsula indicate the sporadic occurrence of the disease with an occasionally fatal result at McDonnell, Moreton, Pascoe River, Merluna, Mein, York Downs, Moojeeba, Ebagoola, Yarraden, Musgrave, Munburra Gold Diggings (Starcke River), Rossville, Maytown, and Bloomfield. Continuing further south, the Yarrabah Mission between False Cape

Cape/

and the Russell River shews occasional cases.

Charlton (1923) found parasites in one white resident who was sick at the time of his visit. In December, 1922, of 66 slides taken at random and forwarded for examination to the Australian Institute of Tropical Medicine, three contained the parasites of benign tertian. O'Brien, 1908, drew attention to this endemic focus, and it is apparent that the disease has been continuous there at the least for some fifteen years. Further soth again, we reach Cairns, to which reference has been made, and continue along the Mulgrave Valley to Innisfail and Mourilyan. At the lastnamed place and along the Johnston River, cases of malaria are by no means rare. Further south again, Ingham is reached 80 miles north of Townsville. Here the population contains a considerable proportion of Italians, many of whom bring infection from their own land. This is the furthest south point at which malaria is frequent, and it was stated to the writer that cases have increased considerably in number of recent years.

MALARIA AND FILARIA EXAMINATIONS - TOWNSVILLE HOSPITAL.

	Examined.	Positive to Malaria.	Positive to Filaria.
21st December, 1922.	45.	-	4.
20th February, 1923.	49.	-	2.
4th May, 1923.	60.	-	-
7th July, 1923.	56.	-	2
27th August, 1923.	61.	-	2.
T O T A L.	271.	-	10.

FOR[illegible] FIRST MONTHLY REPORT OF THE HOOKWORM CAMPAIGN. February, 1923

Operations for the permanent control of hookworm desease were carried on an the Northern Rivers District of New South Wales and in the Brisbane , Mackay,Ayr, Bowen, and Townsville Districts of Queensland during the month of February. The sanitary engineering unit was engaged in a re-rvey of the Maryborough District and completed the Gympie area of that district. The malaria and filaria survey was conducted in the Northern Rivers Districtof New South Wales and in the Brisbane, Maryborough , Ma c kay, Bowen, Ayr, and Townsvlle Districts of Queensland.

Page 4.

The laboratory unit in theSouthern Division examined blood slides and faecal specimens from the Mackay and Northern Rivers, New South Wales, Districts during Februar y. The filaria survey was continued in Brisbanre and a hookworm resurvey off the miners of the Ipswich colleries was completed

Page 5.

In the Northern Division of the following places were reported as completed areas of the malaria and filaria survey. The blood slides were collected and examined by the staff of Unit No. 4.

Results of Malaria an d Filaria Survey, Northhern Division, January 1. to February 28. 1923.

	Number of Persons Exam;	Number Having Malaria	Percentage with Mal;	Number Havihg Filaria	Percentage with Filaria.
Mareeba	38.	0.	0.0	0.	0.0
Yarrabah Mission Aborigines	66.	3.	4.5.	Not exam;	
Palm Island Aborigines	489.	9.	1.8.	18.	3.7.
Townsville.	367.	0.	0.0	9.	2.4.
Stewabts Creek	19.	0.	0.0.	0.	0.0
Proserpine . Area	57.	0.	0.0.	2.	3.5
Bowen Area.	66.	0.	0.0	1.	1.5

Page .6. Blood slides for examination for malaria and filaria were collecte d at Mareeba, Yarrabah Mission, Palm Islands, and the Townsville District, the Proserpine Areas, and the Bowen District. The results of the malaria and filaria surveys were given under Unit No.2.

Thirty - Fifth Monthly Report of the Hookworm Campaign. August ,1922.

Page 1.

Unit No. 2. has been re- organized, largely as a laboratory unit stationed at Central Office, Brisbane. Three microscopists have been assigne d to this unit and are now undergoing training in the examination of blood slides for malaria and filaria.

FILARIA AND MALARIA.

	EXAMINED		INFECTED.	
	Malaria	Filaria.	Malaria.	Filaria.
Ayr District.	71.	71.	0.	1.
Bowen area.	40.	40.	1.	0.
W.E. State School.	267.	267.	-	-
St,Ann's	114.	114.	-	-
Orphanage.	34.	34.	-	-
Central State.		105.	-	-
Christian Brothers		45.	-	-
St Patricks Convent		31.	-	-
T. Gramer School		35.	-	-
Belgianm Gardens		32.	-	-
St. Joseph's Convent		41.	-	-
H.M. Pen., Stewart's Crk.	20	20.	-	-
Olympia Pictures.	28.	28.	-	3.
Dispensary.	5.	9.	-	2.
Hospital.	93.	93.	-	5.
	291.	965.	1.	11.

Examined for Filaria 367, Positive 9.
" Malaria 162. " 0.

These figures are included in the above table and should be subtracted to obtain the work done during March and April.

Page 1. Forty Second Monthly Report of the Hookworm Campaign. March 1923.

The Australian Hookworm Campaign carried on operations for the permanent control of hookworm disease and conducted a malaria and filaria survey in the Northern Rivers District of New South Wales and in the Brisbane, Maryborough, Mac-kay ,and Townsville Districts of Queensland during the month of March.

Page 3.

Unit No.2. examined blood smears from the following districts during March; Northern Rivers of New South Wales , and the Brisbane. Maryborough and Mackay Districts of Queensland. Further figures for Brisbane and Maryborough and complete results to date for Lismore,Ipswich and the Mackay Districts will be found in the following table.

Results of Examinations of Blood Smears.

Place	Number of persons Examined.	Number of Persons Having Filaria.	Percentage Having Filaria.
T			
Brisbane Hospitals & miscellaneaus	493.	28.	5.7
Maryborough Hospitals and Schools	65.	3.	4.6.
Lismore General Hospital	20.	0.	0.0.
Ipswich General Hospital	66.	2.	3.0.
Mackay District Hospitals and Schools.	576.	2.	0.3.
Total.	1220.	35.	2.9.

In December,1922 , monthly report there were given the results of previous blood examinations in Brisbane, At that time 384 examinations with 22 cases of filariasis were reported. The additional examinations reported here bring the total up to 877 persons examined, with 50 persons having filariasis. This is an incidence rate of 5.7 per cent. The examinations include persons from the General, Children's and Mater Misericordiae Hospitals, with a few miscellaneous cases. It seems probable that this incidence rATE Is near the true one for Brisbane as it has remained constant since the first report.

Page 4. Monthly

In the October 1922/report there were 40 persons examined, reported from Maryborough, with one showing filariasis. The total is now 105 persons examined and 3 persons infected, an incidence of 3.8 per cent. As all the persons infected had lived in Maryborough for the greater part of their lives it seems probable that Maryborough is a lightly endemic area for filariasis .

One of the two persons found to have filariasis amongst the 576 examined in the Mackay District probably contracted his infection elsewhere. Only 96 of thetotal number of persons examined had blood smears taken at night. However it seemed possible to conclude that Mackay is very lightly infected , if at all.

Page.6.

During the Month of March Unit No. 4. conducted a resurvey of the schools of Townsville, and did special work at the Townsville Orphanage. The Malaria and Filaria survey of Townsville was continued and blood smears from Ayr District were examined. The results of these blood examinations will be included in the April monthly report.

June 11th 1923 to Dr. Cilento from Dr. Sweet. - suggesting that Dr. Richards might do some filaria work at Cloncurry

Fourteenth Quarterly Summary of Results of Malaria and Filaria Survey of the Hookworm Campaign January to March 31,1923.

Place.	Number of Persons Exam; for Malaria.	Filaria.	Number infected with Malaria.	Filaria.	Percentage Infected with Malaria.	Filaria.
Mareeba.	38.	38.	0.	0.	0.0	0.0
Townsville.	162.	367.	0.	9.	0.0	2.4
Stewart's Crk.	19.	19.	0.	0.	0.0.	0.0
Proserpine.Areas	57.	57.	0.	2.	0.0	3.5.
Bowen Areas	66.	66.	0.	1.	0.0	1.5
Brisbane.	493.	493.	0.	28.	0.0.	5.7
Maryborough	65.	65.	0.	3.	0.0	4.6
Lismore.	20.	20.	0.	0.	0?0	0.0
Ipswich.	66.	66.	0.	2.	0.0	3.0
Mackay District	480.	96.	0.	2.	0.0	2.1
Yarrabah Aboriginal Mission.	66.	-	3.	-	4.5.	--
Palm Islands Aboriginal Station.	489.	489.	9.	18.	1.8	3.7.
	2021.	1776.	12.	65.	0.6	3.6

Page 1. 14.Quarterly report continued.- It has been the custom of the Hookworm Campaignto make quarterly reports of work accomplished, on special forms provided by the International Health Board. Since th e change from the original survey of Australia and its dependencies to the permanent programme and the inauguration of the malaria-filaria survey, the forms are no longer adapted to therequirements. For this reason it seems wise to dispence with the forms and to issue the quarterly reports as supplements to the appropriate monthly reports. This policy, pending approval, was followed for the first quarter of 1923, and the tables given below give quarterly summaries of all work reported by the Hookworm Campaign during the quarter ending March 31.1923.

Forty Third Monthly Report of the Hookworm Campaign. April, 1923.

The Australian Hookworm Campaign continued its work for the permanent control of hookworm disease and carried on the malaria - filaria survey in the Brisbane , Townsville. and Ingham Districts of Queensland and the Northern Rivers District of New South Wales during the month of April. On the last two days of the month a hookworm resurvey and a malaria - filaria survey of Stradbroke Island and a malaria -filaria survey of Rockhampton were started.

Page 2.

UNit No.2 did no faecal examinations during the month. The malaria and filaria survey was carried on in Brisbane and in Toowooba. No results were ready to be given in this report.

Page 2. The staff of Unit No.4.continued the malaria and filaria survey in the Northern Division during April. The table below gives the results which could be reported by the end of the month. With the blood work, 162& examinations for enlarged spleens were reported from Townsville and vincinity done during March and April. None of the children examined were found to have enlarged spleens which could have been due to malaria.

Results of Blood Examinations Completed During March and April by Unit No. 4. Northern Division.

Place.	Number Examined.		Number Infected with		Percentage Infected with	
	Malaria.	Filaria.	Malaria.	Filaria.	Malaria.	Filaria.
Ayr District.	71.	71.	0.	1.	0.0	1.4.
Bowen Area.	40.	40.	1.	0.	2.5.	0.0.
Townsville.	18.	487.	0.	1.	0.0.	0.2.
Total.	129.	598.	1.	2.	0.8.	0. 3.

Page. 3. Examinations of sixty-six persons of the Bowen Area with one person having filariasis, was previously reported. There has been a total of 106 persons examined from this area, with one having filarias and one malari a. This is an apparent incidence rate of 0.9 per cent for both diseases.

The examinations reported for this month from Townsville made the totals for that city 180 examined for malaria with no persons having the disease, and 854 examined for filariasis with 10 persons, 1.2 per cent having it. The Ayr District was not previously reported.

Work done by No. 4.Unit Hookworm Campaign from December 1922 to June 1923.

Malaria and Filaria.

Malaria, Examined.	Positive.	Filaria. Examined.	Positive.
997.	13.	1,697.	32.

Month of June. Ingham & Townsville

Examined for Malaria 64. Positive nil.
" " Filaria.200. " 4.

Forty-forth Monthly-report of the Hookworm Campaign. May.1923.

Operations for the permanent control of hookworm disease were carried on during May in theNorthern Rivers District and the Murrumbidgee Irrigation Area of new South Wales and in the Brisbane, Nambour, Ingham, Cardwell and Townsville Districts of Queensland. The units working in these areas also did work for the malaria and filaria survey. I addition, this survey was continued in the Rockhampton and Longreach Districts and at the Barambah Aboriginal Settlement,all in Queensland.

Page 3.

Miss Walker, of Unit No.2. continued a mosquito and malaria-filaria surv of Rockhamptonand along the Central- Western Railway of Queensland. No reports were ready to be included here, The same was true of a similar survey of Stradbroke Island by Dr. Hamlyn- Harris during May.

Results of Completed Examinations for Malaria and Filaria.

Place.	Time slides Taken.	Number of Persons Examined.	Infected with Malaria and Filaria.
New South Wales			
Lismore.	Day smears	35.	0.
Woodburn.	" "	40.	0.
Ballina.	" "	21.	0.
	Night "	15.	0.
Grafton.	Night "	18.	0.
Casino.	Night "	18.	0.
Coraki	Night "	3.	0.
Queensland.			
Beerburrum	Night "	11.	0.
Total.	Day Smears	96.	0.
	Night "	65.	0.

Page 4. In March monthly report the examination of twenty persons from Lismore was reported . These were night smears and no infections with filaria were found. The examinations from New South Wales is small but, taken in co conjunctionwith the opinion of medical practitioners, it seems probable that there is very little, if any, of either filariasis or malaria in the Northern Rivers District of New South Wales.

Unit No.2 examined blood smears from the following districts during March; Northern Rivers of New South Wales, and the Brisbane, Maryborough and Mackay Districts of Queensland. Further figures for Brisbane and Maryborough and complete results to date for Lismore, Ipswich and the Mackay District will be found in the following table.

Results of Examinations of Blood Smears.

Place.	Number of Persons Exam;	Number of Persons Having Filaria.	Percentage Having Filaria.
Brisbane Hospitals and Miscellaneous.	493.	28.	5.7
Maryborough Hospitals and Schools.	65.	3.	4.6.
Lismore General "	20.	0.	0•0.
Ipswich General "	66.	2.	3. 0.
Mackay District Hospitals & Schools.	576.	2.	0.3.
Total.	1220.	35.	2.9.

In the December, 1922 monthly report there were given the results of previous blood examinations in Brisbane. At that time 384 examinations with 22 cases of filariasis were reported. The additional examinations reported here bring t the total up to 877 persons examined, with 50 persons having filariasis. This is an incidence rate of 5.7 per cent. The examinations include persons from the General, Children's and Mater Misericordiae Hospitals, with a few miscellaneous cases. It seemsprobable that this incidence rate is near the true one for Brisbane as it remained constant since the first report.

4.

In the October 1922, monthly report there were 40 persons examined, reported from Maryborough, with one showing filariasis. The total is now 105 persons examined and 3 persons infected, an incidence of 3.8 per cent. As all the persons infecte had lived in Maryborough for the greater part of their lives it seems probable that Maryborough is a lightly endemic area for filariasis.

One of the two persons found to have filariasis amongst the 576 examined in the Mackay District probably contracted his infection elsewhere. Only 96 of the total number of persons examined had blood smears taken at night. However it seemed possible to conclude that Mackay is very lightly infected if at all.

6.

During the month of March Unit No 4. conducted a resurvey of the schools of Townsville and did special work at the Townsville Orphanage. The malaria and filaria survey of Townsville was continued and blood smears from the Ayr District were examined, The results of these blood e xaminations will be included in the April monthly report.

45th Report. page 1.

The units of the Australian Hookworm Campaign carried on operations during June in the Northern Rivers District of New South Wales and in the Nambour, Mackay, Ingham and Townsville Districts ofm Queensland. A malaria - filaria and mosquito survey was conducted in the Rockhampton and Longreach - Emerald Districts.

page 3. Unit No.4 reported the following examinations of blood slides for the month of June. The slides came from the Ingham District;

Examined for Malaria.....64 persons
Infected with Malaria .....0 "
Examined for Filaria.....200 "
Infected with Filaria..... 4 "
Percentage Infected..... 2. 0 "

5.

Unit No.4. under Dr. Richards, completed during June an intensive resurvey of the Ingham District. Plans were completed during the latter part of th e month for Dr. Richards and Inspector Beach to make a survey trip along the Charte rs Towers- Cloncurry railway, across to Normanton and Burktown, and back to Cairns by the Georgetown- Herberton railway. This survey was to be mainly concerned with malaria and Filaria. The remainder of the unit proceeded to the Proserpine Area to complete an intensive resurvey. The complete results of the resurvey of the Ingham District follow.

COMMONWEALTH OF AUSTRALIA. KB.

TELEPHONE No. 5374.

DEPARTMENT OF HEALTH.

51 SPRING STREET

IN REPLY PLEASE QUOTE

No. 1206

Melbourne, 29th September, 1923.

AUS. INST. OF TROPICAL MEDICINE.

COMMONWEALTH DEPT. OF HEALTH.

MEMORANDUM :-

Forwarded herewith is a copy of Dr. Heydon's paper on Malaria at Rabaul, which is to be published in the "Medical Journal of Australia". This paper will be of use in connection with the preparation of the Malaria Brochure.

Director-General of Health.

Dr. R. V. Cilento,
Australian Institute of Tropical Medicine,
TOWNSVILLE. Q'LD.

MALARIA AT RABAUL.

By G. M. Heydon, M.B., Ch.M., D.T.M., Officer in Charge, Commonwealth Health Laboratory, Rabaul, Territory of New Guinea.

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 as 1350, of which it is estimated that 350 are Whites and 1,000 Asiatics, chiefly Chinese. Natives resident in the town are guessed at 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 500 feet.

Rabaul is about 4½ degrees 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 83 inches, that for the Territory generally being put at 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 89.4 degrees Fahrenheit, and the mean minimum as a little over 71 degrees, so that the daily range is about 18 degrees. The average relative humidity is given as 70, varying from a little over 65 in September to somewhat under 75 in December.

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 markedly from Anopheles punctulatus has so far been found in New Britain, with the exception of Bironella gracilis. The larvae 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 coconut 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 etc. which have long lain in the grass in favourable sites.
Several cases in which one or two larvae were present in broken coconut shells are the only exceptions which have been found. The species prefers a fairly open situation. Larvae do not occur in the pools and streams found in dense forests and deeply shaded gullies, even where vil villages are near.

Suitable breeding places occur most abundantly in the flat coastal land.
Round 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 larvae 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, Donitz, var. moluccensis, Swellengrebel, agreeing closely with Swellengrebel's descriptions and figures, and the other is described as near to but not identical with Anopheles punctulatus, Donitz, typical form. They will be referred to as the moluccensis varie 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 roadsides, in hoofmarks, 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 larvae have not been found in any which were decidedly salt to the taste, (that is which contained more than about one part in seven of sea water). 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 larvae 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 1 in 2, those of the moluccensis variety all survived 1 in 4 for 36 hours at least, and some of them for 72 hours. On the other hand all of the "D variety" died within 36 hours in a 1 in 4 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 Administrath 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.

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 malariae*. In the case of the specimens caught in houses etc., 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.

A. LABORATORY EXPERIMENTS.

Plasmodium vivax and Laverania malariae were found capable of completing their development in a large percentage of Anopheles punctulatus reared from captured larvae and pupae and fed on blood containing the gametocytes.
In the two experiments summarised below the mosquitoes after emergence were kept in wooden boxes of about three cubic feet capacity, in the dark.

They were kept at temperatures varying from about 86 degrees Fahrenheit during the hottest part of the day to about 73 or 74 degrees 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 24 hours after the last no other food was given : at all other times they were fed continuously on banana only.

A few experiments proceeding the two described, in which however the mosquitoes were kept under different conditions, were 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 each day of feeding in order to exclude as far as possible the existence of double infections.

negative from incomplete ascertained causes & these two are

EXPERIMENT 1. The carrier used was an adult native whose blood showed 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 all had fed on November the 6th and had had additional opportunities to feed on November the seventh, ninth and tenth.

Eight were examined between the 14th and 16th inclusive, and three of them showed oocysts in the midgut, and none infection of the salivary glands.

Three out of seven examined between the 21st and 23rd inclusive, showed sporozoites in the salivary glands.

Total infected : 6 out of 15.

EXPERIMENT 11. One lot of mosquitoes dissected all of the moluccen is variety, had fed on a crescent carrying native child on one or more of the following days, 6th, 8th, 9th, 10th, 11th, and 12th of February. On none of these days were more than 200 crescents present per cubic millimetre.
Dissections as follows :-
On the 17th four were examined and oocysts found in the midgut in every case - salivary glands infected in none.
On the 18th and 19th three were examined - all showed infected glands and one had nine oocysts in the midgut.
Total infected - 7 out of 7.
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 malariae resulted in 10 out of 18 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 malariae 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 malariae. 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 12 gametocytes per cubic millimetre is not infective. But different species of Anopheles and of parasite may well differ in this respect.

B. DISSECTIONS OF MOSQUITOES CAUGHT IN HOUSES ETC.

In most cases the mosquitoes were kept for a few days before dissection. They were 237 in all.
Of these, 63 were caught at the White hospital, Namanula, early in 1922 and a further 38 at different times in the writer's bungalow. Most of these 101 specimens were caught at night while attempting to bite. None showed infection. The examination of the salivary glands was omitted or totally failed in 20 of these, and of the midguts in 9.

The remaining 136 were caught in native quarters or village huts, chiefly while resting during the day. Most were caught within ten miles of Rabaul, and chiefly during the wet season. Of these 136, 8 showed oocysts in the midgut large enough to be detected with a low power, and 8 showed sporozoites in the salivary glands.
The salivary glands were completely missed in 11 of these cases, and the midguts in 8.

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 Muhlens 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 Rabaul.

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.

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; so 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 etc., 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, show 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 figure 1. The total number of examinations at different times was 2084, but the number of different individuals examined considerably less.

Age groups	0-2	3-6	7-11	12-17	Over 17.
Number of splenic examinations	382	300	347	116	939
Number in which spleen palpable	30	55	81	56	213
Percentage in which spleen palpable	7.8	18.3	23.3	48.3	22.7

It will be seen that both the form of the curve and the actual percentages in children are of the sort characteristic of a moderately malarious locality.
The villages from which these figures were got are in the following localities, the positions of which are roughly shown by their names in the accompanying map - Malakune, Matupi Island, Talurt, Bai, Nodup, Rabuana, Kerere, 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 others given in this paper considerable distortion has been caused by errors in judging ages, and also by inequalities in the proportions of different ages which 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 12-17. 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 always 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 given below and shown in figure 11. These included a higher proportion of the more malarious villages.

Age groups	0-2	3-6	7-11	12-17	Over 17.
Number of examinations	176	170	91	52	107
Number in which spleen palpable	26	50	36	23	20
Percentage in which spleen palpable	14.8	29.4	39.5	44.2	18.7
Number in which parasites found	43	55	34	19	7
Percentage in which parasites found	24.4	32.3	37.4	36.5	6.5

In the 158 cases in this group in which parasites were found Plasmodium vivax was present 98 times, Laverania malariae 43, and Plasmodium malariae 19, while 11 were doubtful. Double infections were noted in 13 cases, chiefly Plasmodium vivax with Laverania malariae.
Thin films only were used in obtaining the parasite rates here given, and the amount of blood examined averaged between .015 and .02 cubic millimetres.
The districts of Talurt, Bai, Nodup, Rabuana, and Kerere showed much lower spleen and parasite rates than did the villages on the shore of Blanche Bay (at Malakune, 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 possibly lend some support to such figures for whites as have been available, and to the writer's general impression, which is that benign tertian rises to near

its maximum near 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 those 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. 80 Chinese children of all ages up to 14 were examined in January of this year. Only three had palpable spleens and malarial parasites were found in 3, 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 effecti mosquito nets are commonly used. The children are seldom given any quinine.

As regards Whites many difficulties arise in the considerat 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-February and in May-June, with the minimum in September-October. As regards the May-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, and that the latter is due to subtertian case In the eighteen months ending with June of this year Malarial parasit were found in 62 of these examinations (chiefly Whites). Plasmodiu vivax was found 23 times, Laverania malariae 42, and Quartan once; in four cases double infections were noticed. The proportion of sul tertian to benign tertian is of course higher than the true ratio, a the former cases are more likely to come under notice.

Three cases have been collected of newly arrived Whites, who could never previously have been infected, succumbing to attacks of malaria within four weeks of arrival in Rabaul; these were diagnose microscopically and two were bening tertian and one subtertian. In couple of less certainly authenticated cases there has been no attac within the first year of residence in Rabaul although not more than dozen small doses of quinine altogetner were taken. These extremes of course quite consistent with the laws of chance: apparently the majority of those living on the flat in Rabaul are infected during t first wet season if not before, although quinine takers may of cours show no signs of it. Namanula is definitely less mararious.

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

The nieghbourhood of Toma, about 14 miles South from Rabaul, is of some interest. Toma itself consists of a plantation and a hotel, latter used as a holiday and convalescent resort. It is about 135 feet above the sea, the nearest part of which is distant about six miles. It is cooler and wetter than the coast.

A number of villages in the district, most of them a few miles to t North and West of Toma, showed spleen rates in the children as foll in December 1922.

Age groups	0-2	3-6	7-11	12-17	Over 1
Number examined	24	73	101	10	3
Number with palpable spleen	0	0	1	1	0

These villages are at lower levels than Toma Hotel, down to about 600 feet: none are within several miles of the sea.
A mission station and a plantation in the immediate neighbourhood of Toma showed -

Age Groups	0-2	3-6	7-11	12-17	Over 17.
Number examined	1	3	15	5	46
Number with palpable spleen.	0	0	6	2	12

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 roads were the only surface water existing which seemed at all suitable to Anopheles punctulatus.
It will be noticed that the plantation and the mission showed a larger proportion of enlarged spleens. It has been observed in other districts that the spleen rates of natives living at plantations and missions are sometimes higher than those of the neighbouring villages. While boys on plantations commonly come from other parts of the Territory under a three or two years contract, at mission stations a larger proportion of the adults and especially children have usually been born in the locality.
The reason for this increase of Malaria at some settlements is probably partly aggregation of larger numbers in smaller areas, but partly the fact that some of civilisation's dealing with the bush undoubtedly often tend to increase the number of breeding places highly favorable to Anopheles punctulatus, especially perhaps 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 no doubt usually leads sooner or later to at any rate partial drainage of them, but on the other hand a settlement a little inland, or in a place where previously only a few pools in dense bush and little favoured by Anopheles punctulatus existed, will often lead to a marked increase in the numbers of these mosquitoes. Clearing and pathmaking often tend to the formation of open rain water pools and roadside 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 larvae 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. A village will often be found to habitually carry its water from a distance, or to depend mainly on green coconuts. 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 387 examined 47.5 per cent had palpable spleens, and of 76 examined for parasites 7, or 9.2 per cent., were positive (Plasmodium vivax 5, Laverania malariae 2). 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 per cent.

A few additional localities may be mentioned.

The Duke of York Islands, a group of small low lying islands 20 miles East of Rabaul, the largest about 4 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, were as follows.

Age Groups.	0-2.	3-6	7-11	12-17	Over 17.
Number of Splenic examinations	93	78	87	16	76
Number with palpable spleens	22	40	52	9	8
Percentage with palpable spleens	24	51	60	56	10
Number examined for parasites	33	10	17	1	0
Number showing parasites	9	5	9	1	0
Percentage showing parasites.	27	50	53	-	-

Of the cases in which parasites were found Plasmodium vivax occurred in 13, Laverania malariae in 8, and Plasmodium malariae in 4 (1 double infection noticed).

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 below.

Spleen rates in native villages - Bainings.

Age Groups	0-2	3-6	7-11	12-17	Over 17
Number examined.	54	6	14	7	143
Number with palpable spleens	1	2	7	6	63

Spleen rates in natives at plantations and missions - Bainings.

Age Groups	0-2	3-6	7-11	12-17	Over 17
Number examined.	3	6	37	41	233
Number with palpable spleens.	1	3	22	29	116

Kokopo, formerly Herbertshohe, and at one time the capital, on the coast 11 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.

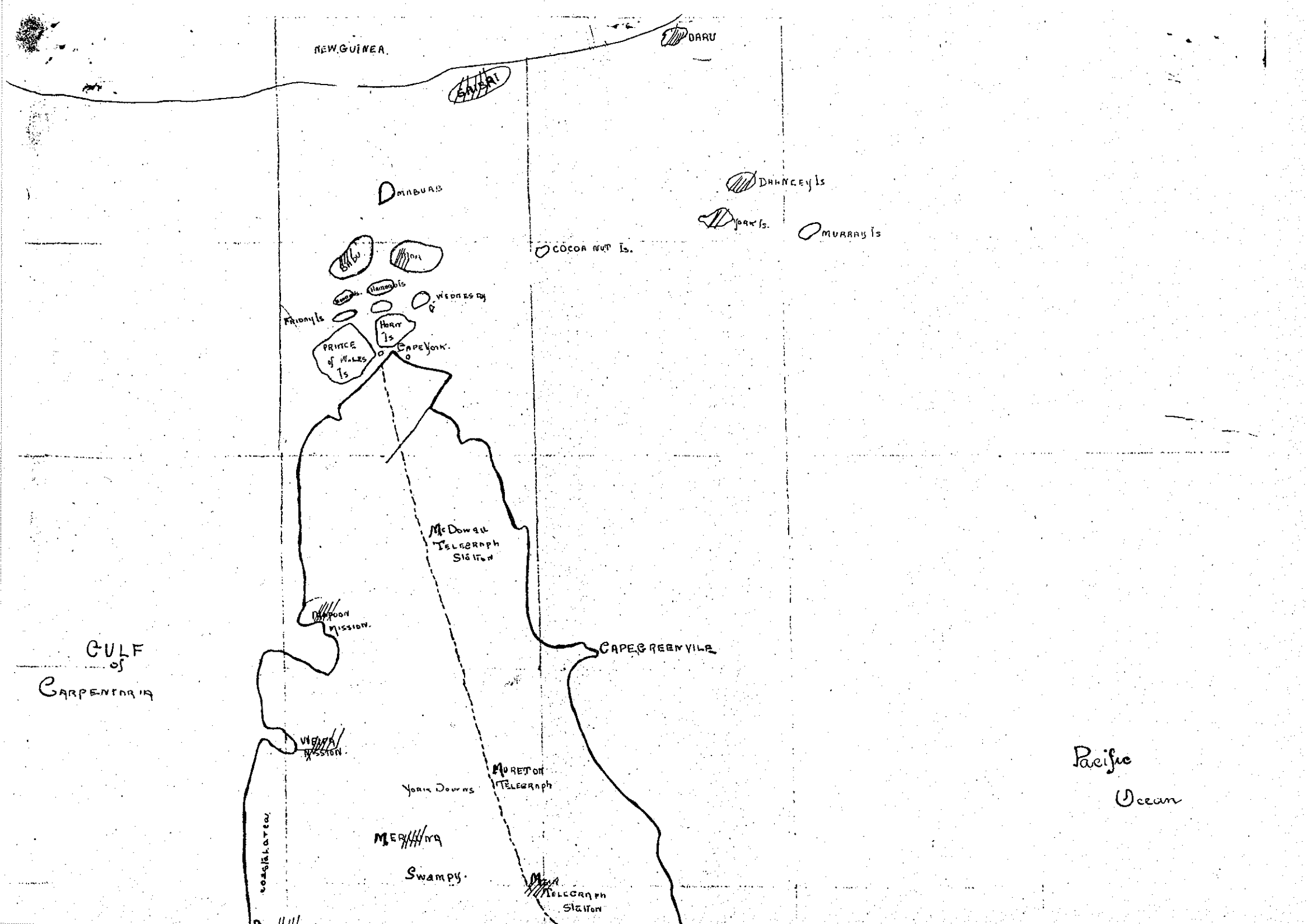
From time to time at Rabaul forms of malarial parasites differing more or less from the well recognised types have been encountered.

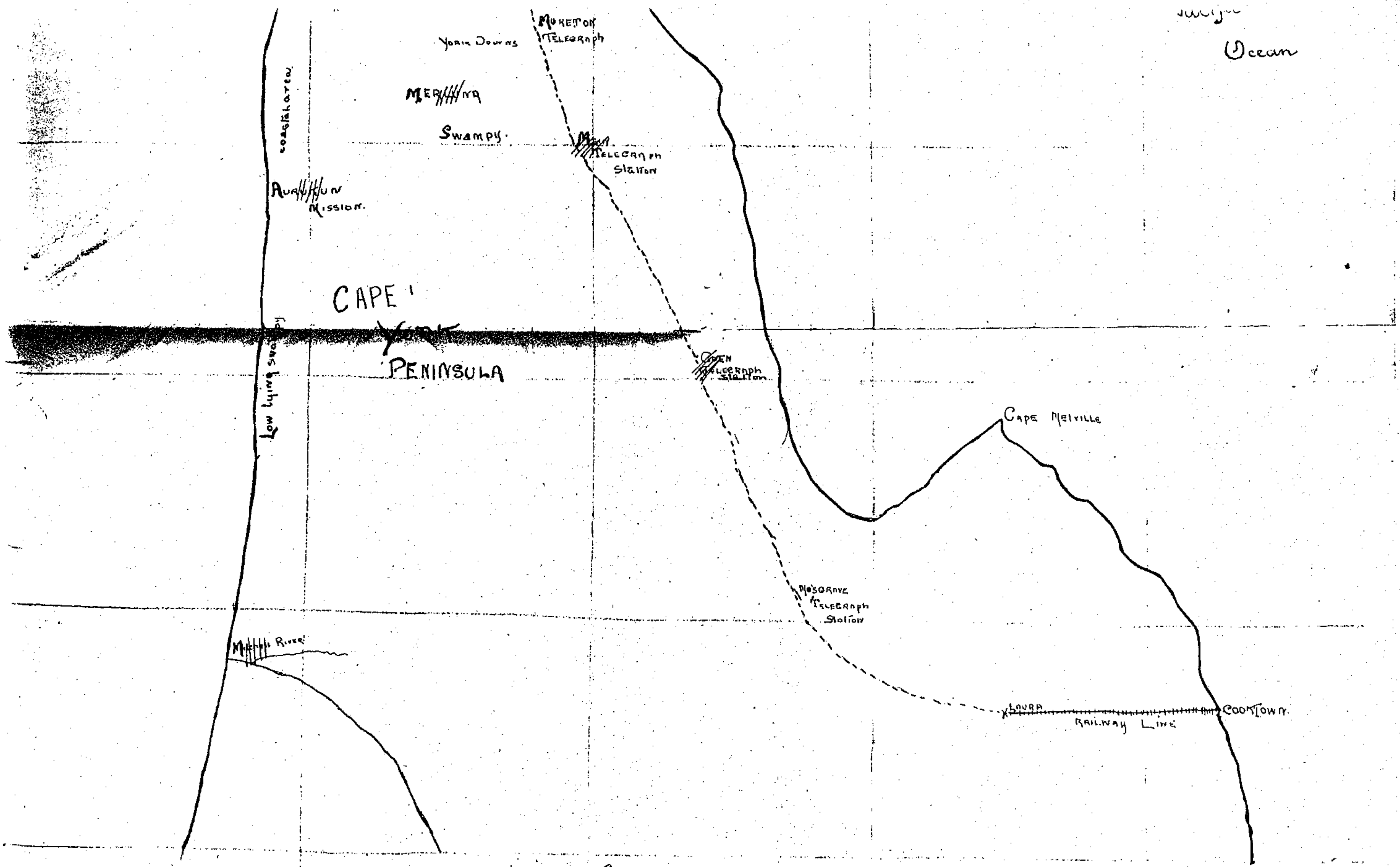
Forms resembling the younger forms of "Plasmodium tenue" have not been rare, and one case occurred showing more advanced forms of this kind, as was pointed out by Dr. R.M. Cilento to whom various films had been sent. No fully grown asexual forms or gametocytes were seen in this case. These forms appear to the writer to be variations of Laverania malariae.

One film seen from the Duke of York Islands showed forms resembling those which have been described as Plasmodium vivax, var. 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 falls fatally sick, without signs of the more obvious 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 not much in the way of 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


NEW GUINEA.
DARU
SAIBAI
DAUAN
DAHNCEY Is
PARK Is.
MURRAY Is
COCOA NUT Is.
WEDGE BY
FRIDAY Is
HERIT Is
PRINCE of WALES Is
CAPE YORK.
McDOWALL TELEGRAPH STATION
MAPOON MISSION.
CAPE GRENVILLE
GULF of CARPENTARIA
VIENNA MISSION.
YORK DOWNS
MURETON TELEGRAPH
MERIDA
Swampy.
TELEGRAPH STATION
Pacific Ocean



Areas marked thus ||||| are places where Malaria is known to occur

August 19[illegible]

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Zoological Position

Entomology recognises that division of the Phylum Arthropoda known as the Class Hexapoda (more popularly Insecta,† though by the law of priority, inadmissable). The Class Hexapoda is divided into several Orders of which Hemiptera, Lepidoptera, Diptera, Coleoptera, etc. are perhaps the better known. Our present studies involve the

Order Diptera (di-double: πτερον, wing; δίπτερος - dipteros -- with two wings)

Members of this order are characterised by the presence of only one pair of wings of mesothoracic origin; the hind wings are vestigial, being reduced merely to a pair of stalked knobs or "drum stick" processes called halteres or balances (Halteres - αλτῆρες. weights held in the hand to give impetus in jumping), which probably function in maintaining an equilibrium. They are constant in the Order Diptera and are regarded by evolutionists as being a sort of honoured heirloom of a pair of hind wings possessed by a four-winged progenitor. In extant four-winged insects (e.g., bees, wasps, etc.) there are no halters. The mouth-parts are haustellate -- i.e. formed for sucking or piercing. The metamorphosis is complete -- i.e., the young or larval form is decidedly different from the adult.

The Diptera are divided into two suborders, Orthorrhapha (orthos - ὀρθός straight; raphe - ῥαφή seam or suture), and Cyclorrhapha (kyklos - κύκλος a circle) according to the manner in which the pupal case splits when the imago (adult insect) emerges. Of these two sub-orders we have to do only with the former.

The members of the sub-order Orthorrhapha shew cruciform larvae — i.e., a form of larva with a well differentiated head — and the cuticula* of the puparium splitting longitudinally down to back, to allow the delivery of the imago. The manner in which the imago is delivered -- whether Orthorrhaphous or Cyclorrhaphous -- is reflected in the structure of the head of the imago, so that the phenomenon is one of more than transient

† The name Insecta as applied to a Class is historically incorrect and etymologically more inappropriate.

* The cuticula of an insect should be differentiated from the cuticle of a vertebrate, the former being a hardened fluid, while the latter consists of the cells themselves in a dead and flattened condition. The cuticula is secreted by the underlying layer of living cells or epidermis -- not the hypodermis as is frequently applied to this layer; the layer is the true outer skin, epidermis or ectoderm.

/transient/

interest. The sub-order Orthorrhapha is again divided into long-horned or "thread-horned" forms -- Nematocera (nema - a thread; keras - horn or antenna); and "short-horned" forms Brachycera (brachys - short; keras). Amongst Orthorrhapha Nematocera we find mosquitoes, i.e., Family Culicidae (Culex a gnat).

The system of classification showing the position of the Culicidae in relation to other families may be expressed as follows:-

Order Diptera

Sub-order I. Orthorrhapha

Section a. Nematocera, including Families Culicidae Psychodidae, Simuliidae, Chironomidae,

Section b. Brachycera including Families Tabanidae, (March Flies), Leptidae, and others.

Sub-order II. Cyclorrhapha.

Section c. Aschiza

Section d. Schizophora with 2 tribes - Muscoidea Acalyptratae and Muscoidea Calyptratae, the latter including House Flies and their allies.

Structure of the Mosquito in brief:-

Sub-order and Order Characters:- Taking a mosquito and examining it with a hand lens (a Watson's aplanatic lens x 20 is most desirable) we find it presenting the following characters of the Order and Sub-order, as may be found in any of the recognised manuals of entomology:-

i., Two wings attached to the mesothorax;
ii., halteres on metathorax;
iii., proboscis adapted to sucking;
iv, palpi jointed and pendulous;
v, antennae usually long and frequently having whorls of long hairs, especially in the male;
vi, legs long and slender;
vii, abdomen usually long and slender;

Family Characters:-

i, Proboscis long and slender in sub-family Culicinae, short and soft in sub-family Corethrinae;
ii, Wings slender, veins bearing small scales (hairs in Corethrinae), and the distal and hind margins fringed with scales. There is no discal cell.*

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* A discal cell is one not reaching directly on to the wing margin or wing-base, but bounded entirely by veins.

N.B. The one distinctive feature which divides the family Culicidae from all other flies is the wing venation, the chief point of which is that towards the tip of the wing there are two bifurcated veins separated from one another by a single simple vein; apart from this the veins are clothed with scales. These two characters will separate the Midges and Daddy Long Legs which are frequently mistaken for mosquitoes.

Further Consideration of Sub-family Characters:- The antennae illustrate generally a typical sexual dimorphism -- being plumose or "bottle-brush"-like in the male and pilose in the female It is only the female which sucks blood. The palpi also afford secondary sexual dimorphic characters by means of which the two principal groups of Mosquitoes can be distinguished, viz:- the Anophelini and the Culicini. The palpi are almost invariably extended or elongated in the male mosquito, i.e., they are generally almost the length of, as long as, or slightly longer than the proboscis — and they shew a tendency to be clubbed in some kinds, especially in the male Anopheli. General ly in the female Culicini the palpi are short — at most about half the length of the proboscis and sometimes only about a sixth the length. In all female Anophelini the palpi are about the same length as those of the male, but the sexual difference is that they do not shew tendency to be clubbed. The male of Aëdes (Stegomyia) aegypti (which is a Culicine) has palpi rather resembling the female of Anopheles annulipes. The segments of the abdomen and the segments or "joints" of the legs and antennae are numbered from the proximal portion outwards; the large globose segment of the antenna -- the apparent first segment -- is attached to the headonly through the medium of a small inconspicuous underlying segment, and it therefore is, in reality, the second segment or torus; the next segment which is long and cylindrical is spoken of nowadays as the first flagellar segment, although the earlier works (written even as recently as 1914) refer to this first flagellar segment as the 2nd joint, and so on. All Diptera are regarded as possessing a five-segmented tarsus (not four as some textbooks say). The first elongated visible segment of the leg is the femora, the next the tibia, the next the 1st tar-

sal segment, and so on. The distal tarsus is usually tipped with a pair of claws (ungues). The scutellum is the semicircular piece of the posterior end of the mesothorax from which it is separated by a transverse suture. The hinder edge of the scutellum may be produced into a median and two lateral lobes -- whence it is termed trilobed, as is found in the [redacted] members of the group Culicini; or it may be simple (i.e., without lobes) as is found in the [redacted] Anophelini.

Insert here 4a-4c

Taxonomic grouping of the Sub-family Culicinae.

The taxonomic grouping of the family Culicinae has been, and still is a subject of great discussion, each worker having some preference to which his fellow-workers do not accede. There are many arguments as to the phylogenetic relationship of various structures, but it must be borne in mind that every system of classification is to a greater or lesser extent arbitrary and artificial, and probably every basis for division has some value, and none are absolutely without objection. The early division on palpal lengths is severely criticised by some although retained by equally good authorities; the division on scale structure (Theobald's system) shares a similar fate although Edwards says "It is true that groups of species frequently shew the same type of ornamentation in all their members", and it must probably have some value as a basis for classification, but in very recent years the ungues have been considered as minor incidents in classification. Any classification which has for its basis the structure of the male hypopygia without known differences in the female, must be, at least, very inconvenient. In recent years, it has been shewn that the method of oviposition and the position of the 8th abdominal segment in the female, whether it be slender and retractile, or broad, truncate and non-retractile, are more or less correlated with modifications in the male hypopygia, and in the ungues. For instance, in those mosquitoes with broad, non-retractile abdomina, the eggs are laid in rafts and the female ungues are never toothed)Edw. F.W. "Synopsis of the Species of African Culicidae other than Anopheles" Bull.Ento.Res .iii,pt.1,p.1) In the group having the abdomen slender and usually retractile, the eggs are

As Edwards' system depends, to a great extent on the thoracic pilotaxy, it is essential to very briefly outline the structure of the thorax tog ther with the grouping of the chaetae.

In the nomenclature of the constituent parts of the thorax we have followed the terminology of Snodgrass (1912). The coalescence of the three parts -- prothorax, mesothorax and metathorax -- has made it not an easy matter to determine their exact limitations and homologues, the confusion being made worse by the excessive hypertrophy or atrophy of certain parts. The thorax of the mosquito is roughly wedge-shaped, the base of which is strongly convex, representing the dorsum, and the lateral part of the wedge the pleura; to the truncated apex (ventrally) are attached the three pairs of legs. Each of the thoracic segments is formed of a dorsal sclerite, known as the tergum or notum, the two lateral plates or pleura and a ventral piece or sternum. Each of these parts may be further subdivided. The pleuron on each of the three thoracic segments is usually divided into two pieces, the anterior one being termed the episternum because it rests on the sternum, and the posterior one the epimeron or epimerum. The sternum is generally located between the episterna as a ventral breast-plate, and therefore, cannot generally be observed in a lateral aspect. To the sternum and pleural pieces, the legs are articulated.

There are two very convenient landmarks in the form of the spiracles; each is a large black-rimmed aperture in the intersegmental membranous areas, the first near the middle of the anterior half of the side, the second somewhat behind the middle of the posterior half.

The Prothorax consists of three plates on each side, the most prominent of which is a sausage-shaped plate, the protergum, or prothoracic lobe; each of the proterga projects slightly beyond the edge of the dorsum, the edges being slightly curved. The second plate or the prothoracic episternum is roughly triangular above the proximal end of the forecoxa. The third plate or proepimerum (proepimeron) lies behind the first two and is connected with both of them; it extends posteriorly to the first thoracic spiracle and is the largest of the three.

Chaetae of the prothorax:-

The protergum carries generally hair-like chaetae, termed by Edwards the pronotal bristles. The propisternum carries bristles — the prosternal bristles of Edwards — which Christophers considers important in the Anophelini but which appear to be constant throughout the Culicini. The propimeron bears bristles which are regarded as being of important taxonomic value; these chaetae in consequence are termed the propimeral bristles. The propimeral chaetae are usually arranged in a row near the posterior margin of the propimeron.

Lodging between the propimeron (and separated therefrom by a well-marked ridge) and the first thoracic spiracle is a small more or less triangular area. The chaetae which are found in this small area are termed by Edwards the spiracular bristles; when present they are directed posteriorly, covering and guarding the spiracles. When the spiracular bristles are absent their function is often assumed by the propimeral chaetae. It is necessary that close observation be made to determine whether the chaetae present are spiracular or propimeral or perhaps both; their location relative to the ridge previously alluded to is the necessary factor.

The mesothorax constitutes the largest part of the entire thoracic mass. Dorsally the mesotergum consists of four pieces, the prescutum, scutum, scutellum and post-scutellum (postnotum of Snodgrass). Theobald called the postnotum the "metanotum", thereby implying a methoracic derivation, but it is morphologically mesothoracic inasmuch as the metanotum lies behind it as a distinct bridge.

The mesopleuron (mesopleurum) is roughly triangular, its corners being marked by the first thoracic spiracle, the wing base, and the base of the mid coxa. The parts of the mesopleuron, which form the lateral walls of the mesothorax, are difficult to name with certainty; they comprise three large plates, viz., a more or less divided plate constituting the mesepisternum (the mesosternum of Nuttall and Shipley) and one the mesepimeron (mesepimerum). The main portion of the episternum meets its fellow sclerite (of

the opposite side) in the middle line ventrally between the bases of the first and second coxae. The mesepimeron (mesepimerum) is a fairly large plate lodging behind the main episternum. Below it is a sclerite lying posterior to the mid coxa and connected ventrally with the mesosternum.

Chaetae of the mesothorax:-

The post-spiracular chaetae comprise a distinct group of some importance situated slightly behind the first thoracic spiracle and below the margin of the mesonotum.

The prealar chaetae form a tuft on the prealar prominence of the mesepisternum. They are apparently always present but variable in number.

The sternopleural chaetae are found in a vertical row extending across the mesepisternum almost in the same line with the row on the mid coxae. These chaetae are nearly always present.

The mesepimeral chaetae are arranged in two groups on the mesepimeron. The upper mesepimeral chaetae form a distinct clump which is always present. The number constituting the lower mesepimeral chaetae is variable and appears to be of great phylogenetic importance; the chaetae of this group may be absent or present, and in a few cases there may be only one or two. For instance in the genus Lutzia, there are at least six lower mesepimeral chaetae while in Culex there are 0 -4, but generally one.

Postnotal chaetae (post-scutellar chaetae) - The presence or absence of chaetae on the postnotum has been used by Theobald to separate the section Metanototrichae (Sabethini of Edwards) The Oriental Sabethines are almost all devoid of these chaetae.

Scutellar chaetae. -- The position of these is explained by the name.

are/

laid singly and the claws on the fore and hind legs of the female are nearly always toothed. These differences have reference to the general group Culicini and do not apply to the Anopheline.

The family Culicidae was founded by Latreille in 1825. He did not consider it as representing a higher group than a tribe. Only the forms with an extended proboscis were known to him. The short proboscidate forms were erected by the Italian naturalist Rondani into a distinct Sub-family, Corethrinae, in the year 1856. Rondani evidently used the name in the sense of a family name. Schiner, in 1864, regarded the Corethrinae, as being merely a sub-family of the Culicidae -- a view nowadays held by many and upheld in this paper. In the year 1883 Brauer proposed to include in the Family Culicidae the genus Dixa, upon which Schiner, fifteen years previously had established the family Dixidae. In 1905, Dyar suggested the union of the Dixidae and the Corethrinae -- the two groups to form one family, distinct from the Culicidae.

It is undoubtedly the case that these three groups, the Dixidae, the Corethrinae and the Culicinae are closely related. It is moreover, evident that the Corethrinae are much more closely related to the Culcidae than they are to the Dixidae. Thus, the larva of the latter are provided with a pair of fleshy anal prolegs a structure found in some of the Chironomidae, but never present in any of the known larvae of the Corethrinae nor the Culicinae. In the adults the subcosta in Dixidae terminates at a point opposite the "root" of the Radial sector (Rs); in the other two groups it is prolonged nearly one half of its entire length beyond the origin of Rs. In the Dixidae the posterior margin of the wings is provided with hairs only, in the other two groups it is fringed with scales. Again, in the Dixidae the antennae are almost bare, and are similar in the two sexes; in the Culicinae, with a single exception or two, and in the Corethrinae, these organs bear many whorls of hairs (verticillate hairs) which, with few exceptions are longer and much more numerous in the male than in the female. It is, therefore, obvious that the Dixidae are sufficiently distinct

distinct/

to be maintained as a separate family.

The difference in the structure of the mouth-parts in the adults of the other two groups together with the difference in the food habits of the female, has been considered by some to warrant their separation into distinct families; thus, following the lead of Rondani, some consider the short proboscidate forms to constitute a family by themselves, the Corethridae. In Volume I of Theobald's Monograph of the Culicidae of the World, he recognises 6 sub-families of the Culicidae of which the Corethrinae are regarded as one, and this grouping is retained in Vol.III published in 1903. In 1905 Kysell published a paper in which he suggests the separation of the Corethrinae from the Culicidae, raising them to family rank -- the family Culicidae being retained for mosquitoes alone. Theobald, in Volume IV of his monograph (1907) following this suggestion, divided this family Culicidae into 10 sub-families and more than 100 genera, many of which were sub-divisions of older genera. Theobald otherwise adopts a modification of Lutz's classification in employing the character of the presence or absence of setae on the postnotum of the thorax. In Volume V, published in 1910, he retains this classification, but adds several new genera. Williston and others have taken exception to this system, holding that scale-structure is not of sufficient phylogenetic importance. Since the year 1911, Edwards has been reclassifying mosquitoes upon fundamented bases other than scale-structure, and he has modified his views from time to time in accordance with current conceptions. The " tribe Anophelini" (of Edwards, Christophers, Alcock and others) becomes the sub-family Anophelinae of Theobald and others; or, in other words, if we expunge the sub-family Corethrinae from the family Culicidae, we automatically raise the "tribes Anophelini and Culicini" of Edwards to sub-family rank. It is more natural, however, to consider the family Culicidae as constituting two sub-families, Corethrinae and Culicinae, and if we disregard the Corethrinae as of no pathophoric importance, then we can define the sub-family Culicinae as including two main tribes, the Culicini and the Anophelini.

Amongst the latter tribe are found the malarial pathophores.

Classification of the Sub-family Culicinae.

The Culicinae are arranged into four tribes, viz:-

Tribe I. Megalorhini -- Proboscis very long and finely tapered, the distal half curved ventrally backwards. The free margin of the scutellum is indistinctly trilobed. Abdomen with a dense vestiture of scales. Usually large metallic species.

Tribe II. Anophelini -- Proboscis more or less straight. Palpi long in female. Scutellum simple (not trilobed). There is a tendency towards the suppression of scales on the abdomen; if present, they never form imbricating areas.

Tribe III. Culicini -- Scutellum very distinctly trilobed. Proboscis straight. Abdomen with a complete vestiture of scales. Postnotum in Australian genera without a central ridge. Mesonotum usually with longitudinal rows of chaetae. Head with a well-defined median pair of chaetae projecting anteriorly over the vertex.

Tribe IV. Sabethini -- Postnotum with a median keel-like ridge with or without chaetae. The Oriental Sabethines are almost all devoid of postnotal setae. Vertex with a pair of long, coarse bristles projecting more or less horizontally above the eyes. Proboscis, scutellum and abdomen as in the Culicini.

The Megalorhini and Sabethini are not of pathophoric importance and need not be considered further.

The Anophelini are a homogeneous collection, and as a tribe can be easily distinguished from the Culicini by the elongated female palpi, and the simple scutellum. Very often (there are only a few exceptions) the wings are spotted, and generally the adults rest at an angle to the surface upon which they stand, -- not as with the majority of Culicini with the body parallel to the surface. Furthermore, the proboscis, head, thorax and abdomen in the Anophelini are almost in the same straight line like an awl, whereas in the Culicini they are not so; the head being partly concealed (posteriorly) by the anterior edge of the mesonotum, the appearance of Culicini is somewhat "hump-backed". The difference be-

be-/

tween the two groups even commences ab ovo, for we find a special development in the form of frill-like "floats" on the egg; the larva is a syphonate and therefore lies awash, a condition facilitated without muscular exertion, by the provision of palmate hairs which grip the surface-film and so maintain the body in a horizontal position.

It is this tribe with which the sanitarian is concerned on account of the fact that, so far as is known, it is the only one which comprises the several species of pathophores responsible for the diffusion of the human malarias. The descriptions of the four principal Anophelines of North Australia and New Guinea are therefore embodied in this paper.

Life History

It will be desirable to take Culex quinquefasciatus -- a common domestic mosquito of the tropics and subtropics -- as a convenient species for detailed study, and as representative of the family generally. The structure of Anopheline larvae will be noted en passant.

The mosquito, like the silk-worm moth, beetles and very many other insects, undergoes a complete metamorphosis in its development from the egg to the imago.. Thus it has a definite larval or "wriggler" existence which is followed by a pupal or semi-quiescent stage before the appearance of the fully-fledged insect. Different species of mosquitoes are more or less selective as to the kinds of water used for breeding, and a careful study of the habitats together with the oecological factors is indispensable to a just comprehension to the subject at large, and in mosquito-control operations. Thus, C.f-fasciatus prefers foul waters like sewage-collections, septic tanks, cesspools, liquid manure barrels, while Aedes (Stegomyia) aegypti shews a decided preference for the clean waters, lodging only in artificial

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Cavity trees which hold water are included in the term "artificial" receptacles, although strictly incorrect. Perhaps it would be better to state that this species never breeds in water, naturally loding on the ground, as in pools and swamps.

receptacles. Others like Aedes vigilax, Culex sitiens, Mucidus alternans, etc. breed in salt-water.

Oviposition and the Egg Stage.

The eggs of C.b-fasciatus are cylindrical, thick, and rounded at one end, and slightly tapering to a point at the other (upper end); the individual egg measures about 0.7 mm. long by about 0.16 mm. in diameter at the thicker end (base). On the thicker end is a fringed cap surrounding the micropyle. The eggs, averaging in number 250, are arranged in the form of a narrow, curved boat or raft, each egg being placed in an upright position and fastened to its neighbours by a viscous secretion. The most common shape of eggraft is the pointed ellipse concave above and convex below. Viewed from above the egg-raft appears to be blue-black but immediately after having been laid it is milky-white, changing rapidly to the dark colour on exposure to the light. When forcibly removed from water and examined from the under surface, it is silvery white, due to light interference of the thin film of air with which the surface is invested. It seems impossible to wet the eggraft owing, no doubt, to the entrapping of air in the fine interstices formed by adjacent eggs. Thus, if the raft be pushed under water it will bob up again none the wetter.

Aedes (Stegomyia) aegypti, Aedes (Finlaya) notoscriptus and Aedes (Ochlerotatus) vigilax deposit their eggs singly on the water-surface, and the eggs may thus be found adhering to leaves and minute particles on water surfaces, or stranded nigh and dry against the sides of vessels (in which latter condition they will hatch, in the case of A.aegypti, only after a subsequent submersion). Anophelines deposit their eggs separately in small numbers on the surface of the water of swamps, and about the edges of grass-obstructed watercourses; the eggs are curved at each end like a boat and lie with their long axes parallel to the water surface (not perpendicularly as in those eggs which are deposited in raft-like masses). The egg of Anophelines when viewed dorsally is of a rather regular elliptical outline, the two ends having practically the same shape; seen from a lateral aspect it is strongly convex inferiorly and

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nearly plane dorsally. The eggs are kept afloat by a peculiar hydrostatic float, a partial envelope of sacular shape on each side in the middle third and nearly meeting dorsally in the midile line. This flat is draped over the side in transverse corrugated, frill-like, arrangement; it contains air and helps the boat to float and maintain an even keel. The "pleated fold" as well as the general shape of Anopheline eggs is variously modified according to species.

Under favourable conditions of warmth the eggs of C.5-fasciatus hatch in from 16 to 36 hours; if cold weather supervenes the process is delayed. The shell breaks round the thickest part, and the detached portion is often suspended by a bit of ligament, or falls off entirely. The larva slips out to lead an aquatic life.

The larva and its Habits

Soon after the larva emerges, it commences to feed. The food varies according to the species, but in C.5-fasciatus it usually consists of decaying animal and vegetable matter. Some species of mosquito larvae are carnivorous -- either devouring dead or living organisms, such as carrion, and the larvae of their own species. In general, there are three larval ecdyses (moults) before the pupal stage is reached -- a period involving about seven days or even less in summer weather.

The body of the larva consists of thirteen chitinous segments, one of which constitutes the head, three interfused the thorax, and nine the abdomen.

The appendages of the head are a pair of antennae curved and rod-like, clothed with short, minute appressed spines. About two-thirds from the base on the inner surface is a notch from which arises a stout cluster or tuft of hairs (24 -30 in number) -- called the antennal plume or tuft. Five bristles, unequal in length s spring from the tip of the antenna. The antennae can move laterally in a semi-rotary fashion, so as to touch each other at their apices; they are of great importance in specific identification. The antennal tuft may be represented by merely a single bristle, or may have as many as 30 plumed hairs. The shaft of the antenna may

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be either simple or irregular in thickness. A pair of mandibles is found at the sides of the upper lip; below these a pair of maxillae, and triangular "labial plate", -- the "lower lip" of Meinert or labium -- possessing lateral teeth. This plate is of value in determining species, but in the great majority of specimens, cannot be seen except in specimens cleared in potassium hydroxide; it can, however be observed excellently in larval exuviae.

Attached to the mandibles and maxillae are chitinous brush bearing plates which can be projected outwards or retracted into the buccal cavity. This projection and retraction in rapid succession give a very striking effect on the movement of the so-called "mouth-brushes", -- heaving brush-like tufts of hairs or filaments. When a larva is viewed through a handlens, the constant vibratile action of these brushes is seen to cause a current of water to flow into the buccal cavity, along with a supply of minute aquatic organisms (such as the spores of Algae, etc.) and other particles. In this manner the larva is enabled to feed The brushes are of use in the separation of some of the larvivorous larvae (like Mucidus alternans, Lutzia halifaxi, Aedes (Ochlerotatus) vittiger, and several others) whence they are seen to be combed or serrated.

The rapacity of these species is truly remarkable, for when a few of their larvae are confined together in small aquaria, only a few survivors will be observed after a few hours, the smaller specimens invariably falling victims to their larger rapacious fellow creatures, and like the condition of events in Pharaoh's dream of "the seven ill-favoured and leanfleshed kine" which "did eat up the seven well-favoured and fat kine", the survivors (larvae) generally appear none the better after their gastronomic transaction. Occasionally like Aedes (O.) nigrannulatus, where the larva is not larvivorous, the mouth-brush is also combed; the inner hairs of the brushes of Aedes (Stegomyia) aegypti are also observed to be minutely combed, but generally speaking, when the mouth-brushes are highly chitinised and combed or serrated, the larva must be viewed with suspicion as to its larvivorous qualities.

The various "hairs" which must be considered in studying

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(mainly) Anopheline mosquito larvae may be tabulated in the following arrangement, using chiefly the terminology of Stanton (1915).

Dorsal head hairs	Clypeal hairs	anterior	inner
			outer.
		posterior	
	frontal hairs		
	occipital hairs		inner
			outer
	antennal hair		
	sub-antennal hair		
Dorsal thoracic hairs	anterior sub-median group (the "shoulder hairs" of Swellengrebel)		
	palmate hairs		
Abdominal hairs	palmate hairs		
	lateral hairs of segments 4 to6		
	lateral comb of segment 8		

The thorax is broad, slightly compressed dorso-ventrally, and bears 3 sets of sensitive balancing hairs (thoracic tufts) extending horizontally from the sides. The serial distribution of the thoracic tufts corresponds roughly to the divisions of the thorax, pro-, meso-, and meta-thorax.

In some Anopheline larvae there are feathered hairs which project from the prothorax, anteriorly. The character of the thoracic lumes is also of use in the separation of larvae.

From the dorsal part of penultimate body segment (i.e., the apparent eighth abdominal segment), protrudes a long or short tube, nearly the thickness of the body itself, and it is this tube, or "respiratory siphon" which touches the surface of the water when the larva rises to the surface for respiration. The breathing siphon is absent or vestigial in Anopheline larvae.

It is usual to refer to the mosquito larva as having nine abdominal segments. The spiracular apparatus is considered as an outgrowth from the tergite of the eighth segment, whilst the so-called ninth segment in this notation is the lobular piece which bears the sub-dorsal hairs or dorsal beard, and the ventral beard. Recently, however, Christophers (1922) has very ably contested this view by ontogenetic studies on mosquito larvae, and the fundamental pre-imaginal developments enunciated by this observer should form the basis of all the morphological relationships in Culicini and

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Anopheline larvae (as well as in the adult structures) and should be established as the nucleus of any regular system of homological terminology. By a study of the abdominal segments of the larva and their ontogenetic history, Christophers has shewn that whilst much of the apparent eighth segment is actually this structure, the greater part of the spiracular apparatus might be assigned to a tergite of hitherto an unrecognised ninth abdominal segment. On this basis, the terminal segment is morphologically the tenth abdominal segment. Furthermore, the toothed structure in Anopheline larvae which has been familiarly known as the "comb" is not homologous with the comb of Culicine larvae but with the pecten spines on the siphon. Our views as to the application of one or other of the terms must therefore be modified, and as Christophers points out, less trouble is likely to arise from calling the comb in Anopheles the pecten than vice versa. In this work, this terminology has therefore been followed.

During respiration at the water-surface, the larva hangs head downwards (in the Culicini) at various angles (sometimes) characteristic of the species. At the tip of the tube is a spiracle in to which open two main tracheae which extend throughout the length of the body of the larva, sending out branches to all parts of the tissue. In Culicine larvae, the proportions of the siphon, and the relative length (to other parts of the body) are of great diagnostic value. The number, character, distribution of the tufts of hair on the siphon, and also the disposition of the pecten spines, are of great importance in specific identification. The tip of the siphon is provided with 5 flaps which may be opened or closed at will, and which, when opened, form a small cup-shaped receptacle which prevents the surface film of water entering the air-tube. These flaps are closed when the larva is about to descend, which prevents the air within the breathing siphon escaping. On regaining the surface, the larva carries the pointed tip of these flaps through the surface film. Although the specific gravity of the larva is greater than that of water, the physical properties of the so-called surface film of the water, and the method by which the flaps 'grip' this film, enable the larva to rest without effort just below the

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surface.

Owing to the absence of a siphon in Anophelini, the larva is obliged to maintain a horizontal position just beneath the surface of the water, in order that it might bring the spiracular openings of the tracheal system into communication with the air. To maintain this horizontal position, the larva is provided on the dorsum of several of the abdominal segments, with a pair of peculiar palmate hairs shaped more or less after the fashion of a cabbage palm, or an umbrella turned inside out with four ribs missing. These palmate hairs arise at equal distances from the centre of the back, and each "palm" springs from a short channelled stalk, the tips of the "leaves" gripping the surface film. Thus the combined pull is so strong that the body of the larva lies awash with the greatest ease, and without any muscular exertion. To sum up: the significance of the palmate hairs is a correlated development in asiphonate (Anopheline) larvae. The structure of the palmate hairs is of importance in distinguishing Anopheline larvae.

On the lateral portions of the apparent 8th abdominal segment -- just below the base of the siphon -- is a series of a few or many spiny scales, spoken of as the lateral comb. The number, size, arrangements and shape of spines constituting the lateral comb are of great diagnostic value. For instance, in Aedes (Stegomyia) aegypti the lateral comb is comprised of from 8 to 12 rather elongated, large, simple, sharp pointed spines in a single, and more or less straight, line. In Culex quinquefasciatus it comprises a group of 30 to 40 small spinous spines distributed in a cluster.

The terminal segment of the abdomen is the ninth visible abdominal (the morphological 10th abdominal segment) or anal segment. Dorsally, the anal segment is covered with a chitinous plate, the largest truly chitinised structure in the larva with the exception of the head-sclerites. In many cases this sclerite is produced ventrally so that the whole segment consists of a ring of chitin. Posteriorly are the tracheal gills (or anal papillae). These tracheal gills (two ventral and two dorsal) are hyaline and their function is partly branchial and partly natatory. In the salt-water breeding species, it is a very remarkable fact that the

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anal papillae never assume (at least in Australia) any more than a rounded or ovoid form, while in the fresh water breeding species, the anal papillae are elongated. Their atrophy or development is entirely one of adaptation, depending on the salinity or freshness of the water respectively. It recalls the classical experiments of Schmankewitsch on the Brine-sarimps, Artemia salina and A.milhauseni This transformation of so-called distinct 'species' of Crustacea by a change in salinity is no more remarkable than the case of modification of anal papillae (tracheal gills) in mosquito larvae by change in the salinity or freshness of water. If we maintain a natatory function of these anal papillae, then the question of their reductio in salt-water (i.e., water of greater density) and their elongation in fresh water, is merely one of flotation; and it is obviously unnecessary for a larva to possess elongated papillae in saline waters. On the dorsal edges of the segment just behind the posterior border of the tergal plate are long hairs, while on the ventral portion a number of plumes which may be quite at the end, or fringe the venter; this latter is the ventral beard. The chitinous plate which bears the ventral beard is homologised by Christophers as the tenth sternite of the larva.

The Pupa and its Habits.

The larval life continues in suitable weather, for 8 or 10 days at the end of which time the larva transforms into the pupa.

The pupa is obtected, i.e., it arises by shedding the last larval skin. The whole appearance is much like that of a comma (,) -- a condition due to the enormous increase of the thoracic (or rather cephalothoracic) region. The abdomen has become much shortened and now terminates in a pair of oval fins or swimming fans; the abdomen is pointed after the pattern of a lobster. At first the pupa is of a light hue, but it rapidly changes to a darker tint, owing to the action of the light. If examined in a good light we may be able to trace the wings, head, antennae and legs of the future fly, through the pupal case. The respiratory tubes no longer open at the caudal end of the body, but through two trumpet-shaped sclerites on the cephalothorax from which it results

that the pupa remains upright at the surface instead of with cephalic end downwards. There is a very obvious reason for the reversal of the position of the body, inasmuch as the imago issues from the cephalothorax and requires the coracoid pupal case to support itself while its wings are expanding.

The specific gravity of the pupa being lighter than that of water, the pupa is ordinarily found in a motionless condition at the surface of the water, but when disturbed, darting about with great activity. It does not sink without effort, as does the larva but is only capable of descending by a violent muscular action; mainly by striking the abdomen with its swimming-fans against the water, it moves by a series of jerks. Immediately the violent muscular activity ceases, the pupa rises passively to the surface by its own buoyancy. Since the pupal stage is a more or less quiescent period during which the process of histolysis and histogenesis is taking place and the imaginal organs are developing, the pupa is an essentially fasting organism -- drawing its nourishment from that reserve supply accumulated during the period of growth -- i.e., the larval stage. Insects once they reach the imaginal state, or in general terms, once they acquire wings, never grow; there is indeed no true growth in an adult mosquito, and the merely mechanical distension of the abdomen of a gorged female mosquito is not "growth in a physiological sense. Hence it follows that the so-called "young" fly or "young" mosquito, when referring to the wing stages, may be none other than an adult which has arisn from a starved larval form, or perhaps may relate to a distinct species, the adults of which only attain the size under observation. From what has been said, it may be inferred that the pupa has no need of a mouth, and indeed, it does not possess one. Eating, is an impossibility even should an anomalous pupa develop the pangs of appetite.

It is not an easy matter to distinguish pupae of Anopheles from those of Culex or Aedes by naked eye appearances It is necessary to use a strong hand lens and examine the breathing trumpets where it will be seen that in Anopheles they have a square truncated end and are proportionately much shorter than in Culex.

In some species of Culex they may be long and narrow, and possess a slit-like opening. In Aedes (Stegomyia) aegypti they are broad and triangular.

In warmer weather the pupal stage is from 48 hours to 3 or 4 days, varying with the species as well as with the temperature.

Delivery of Imago.

As the important crisis draws near, the pupa becomes still more buoyant till its back rises slightly above the surface film. The cuticula now begins to dry, and then splits longitudinally between the two breathing trumpets, and gradually expanding f forms a coracle in which rests, unwetted and secure, the perfect insect or imago. Firstly, the head, antennae and the proboscis slowly emerge through the vent. The prothorax instantly follows, enlarging the break in the pupal skin, so as to render the extrication of the body and its appendages comparatively easy. It raises itself well up, withdraws its wings and carefully tries them. When the mosquito has extricated itself all but the tip of the abdomen, it first stretches out its forelegs, and then the hind legs, bending them down to feelfor the surface film upon which it is able to walk as upon dry land -- making minute dimples upon the surface film -- the only aquatic faculty which it retains after the commencement of aerial life. With the leverage of its first two pairs of legs, the tip of the abdomen and the hind legs are withdrawn. Standing on the buoyant coracle of its own pupal case, it lifts itself well into the air, and afterwards flies away on its mission of annoyance and death. Immediately after hatching, the insects may be seen resting quietly upon the water surface, and refusing to take flight even when disturbed.

The delivery of the imago is a risky undertaking and requires only stagnant water -- illustrative of the "foresight" or instinct on the part of the parent in selecting her place for oviposition, a place destined to be the nursery of her progeny. During delivery the most important and indeed most indispensable part of the mechanism, is the maintenance of a vertical posture, so as not to get wetted, which would otherwise spoil its wings and so prevent flight. Its chief support is the ~~tenacity~~ rugosity of the pupal case

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which it is discarding and which now serves it as a life-boat till its wings are set at liberty and trimmed for flight. The body of the insect serves this little boat as a mast, which is raised in a manner similar to movable masts in lighters constructed for passing beneath a bridge, with this difference, that the mosquito raises its body in a vertical direction from the first. When one observes what depth of water is drawn by the prow of the miniature boat, one becomes anxious for the fate of the little mariner, particularly if a puff of wind ripples the surface, for, the least agitation of the air will waft it rapidly along, since the body performs the duty of a sail as well as a mast; but, as it bears a much greater proportion to the small boat than the largest sail does to the ship, it appears in greater danger of being capsized; and, once laid on its side, it suffers drowning. The surface of the water (of a mosquito breeding place) may sometimes be seen covered with the bodies of mosquitoes which had perished in this way; but for the most part all terminates favourably for the mosquito.

PART II

The Common Anophelines of North Australia & New Guinea

Introductory Remark.

When Skuse monographed the Australian Culicidae in 1888 only one Anopheline mosquito from this Continent was known -- viz., Anopheles annulipes Walker, 1856 -- and he included this species along with two other valid ones, Anopheles atratipes and Anopheles stigmaticus. His species "musivus" and "mastersi" have since been reduced to synonyms of A.annulipes Walker. In 1902, Giles described his Anopheles bancrofti which modern systematists regard as being merely a race of Anopheles barbirostris van der Wulp, 1884. In 1907 Theobald added another name to the list of Australian Anophelin by the inclusion of Anopheles corethroides. Thus, only five valid species of Anophelines are listed from Australia, and, if we include the newly defined "species" amictus of Edwards as a distinct species then we may number the recorded Anophelines on the mainland as six.

In view of the almost unlimited intergrading of varieties of A. annulipes we must, at least, look askance upon the raising of the form amictus of Edwards to specific rank. Assuming, for the present, with every justification, that amictus is but a grade in a "polymorphic" species, there are only two from the Australian mainland which could warrant separate discussion as "common" Anophelines; these are Anopheles annulipes and Anopheles barbirostris var.bancrofti.

Anopheles atratipes Skuse, is decidedly rare even in the neighbourhood of the type locality Berowra (N.S.W.) and whenever encountered, usually only in single specimens. A. stigmaticus Skuse is almost as rare, while A.corethroides Theo. is present to the extent that, over a course of a decade, a collector has only raked in one specimen in the neighbourhood of the type locality! If we admit the very feasible assumption that new species are arising daily and that the rarer forms are undergoing extinction -- even in the very short lapse of time since they were actually described -- then we may find a means of explaining how frequently the case arises where type specimens are the only "survivors" of a given "species

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in Nature". It may, therefore, be not unjustifiable to regard A. corethroides as a gerontic species.

Of the two common Anophelines on the mainland, only one species, viz:- A. annulipes, is of widespread distribution on the continent. The rarity with which A.barbirostris var.bancrofti occurs in the more southern places like Brisbane (about 28° S.latitude will become obvious when it is mentioned that only as recently as 1920 were the larvae and pupae described from these specimens secured for the first time about Brisbane.

Anopheles annulipes Walker, 1850

(The "Spear Mosquito" -- The "Pile Driver" of Wyndham, Western Australia, and the "Up-ender" of the Northern Territory.)

A slender mosquito with slate-grey scaled thorax, with dark spotted wings and the upper portions of the legs mottled.

Length 5-6 mm.

Head with white scales in front and dark scales behind; two long tufts of white hair project in front. Antennae in male dark brown with band of white scales and pale hairs; in female, brown, with white pubescence and basal segments testaceous in colour, first two flagellar segments white scaled. Proboscis either wholly dark, or pale on the distal half; female palpi brown, slightly shorter than proboscis, with 4 white bands, the distal ones broad, the proximal narrower and sometimes reduced to a few scales; male palpi clubbed, with three distal segments with patches of white scales above. In general the palpi have three well defined white bands, and one or two additional (more proximal) bands the size of which is subject to great variation. The distribution of the palpal banding (in general terms) is:- 2 narrow dark bands on a background of whit comprising the distal half, and 3 narrow pale bands on a dark background comprising the proximal half.

Thorax covered with slate grey scales with three rather faint longitudinal lines. Halteres, brownish-yellow at base with the stem pale and the knob dark.

Abdomen brownish-black with yellow hairs and either with a few scales confined to the distal segments or with many scales constituting more or less a vestiture.

Wings profusely speckled, costa with four well-defined black spots; the points of bifurcation of veins enclosing cells R2 and M1 the seats of pale interruptions.

Legs profusely banded with alternate black and yellowish-white scale in femora and tibiae. Tarsi with apical and basal pale bands, involving the articulations.

Anopheles annulipes has a wide distribution in Australia and it is probably, on epidemiological evidence, the chief natural carrier of the malarial parasites in the north of Australia. Kinoshita in Formosa has shewn that this species is capable of transmitting under experimental conditions, Plasmodium falciparum. It does not seem to cause a very great nuisance in the Southern

Southern/

portion of Australia, but in the more northern country places (Roper River, N.T., Wyndham, W.A.)-- it may sometimes occur in abundance, so much so that vernacular names have been conferred on the species by the public. A. annulipes seems to bite chiefly though not exclusively at dusk.

This mosquito rests as the majority of Anophelines do, i.e at an acute angle to the surface upon which it stands.

Life History. -- Shallow, grassy pools, the weedy edges of marshes and slowly running creeks, surface wells, are the natural breeding places of A.annulipes. Salt marshes are sometimes selected as breeding places for this species, but the condition is not very usual, and it seems to be quite a recently acquired habit. An atrophy of the anal papillae is observed according to the density of the water. The larvae, have a great predilection for green Algae, and very frequently they are coloured green as a result of the ingestion of such food.

Egg.- Length from 0.7 to 1 mm. by 0.16 mm. in width; of a black colour marked with nexagonal reticulations. The ends are curved like a boat and from the centre, a delicate silk-like membran rises and drapes over on the sides in transverse folds or festoons.

Within 3 days in summer weatner, the egg splits transversely near one pole and the larva emerges. The number deposited at a time varies from 50 to 80. The eggs are laid singly and not infrequently they lie side by side like a fleet of canoes or adhere by their ends into stellate groups -- a purely mechanical condition arising as a result of the wind.

Larva.- Head comparatively large. Antennae covered with sharp, more or less appressed spines which are distinctly longer on the medial edge, and when seen in silhouette, presenting the appearance of a serrated edge -- owing to a slight projection of the spines (more or less equal in length -- although forms occur which show dissimilar lengths; between the bases of the two distal spines a very fine lifid seta arises, and its length is about equal to twic the length of the spines. Sub-inner anterior clypeal hair simple and minutely plumed, outer anterior clypeal hair consisting of a tuft of hair of about 10 branches, two or three of which latter are dichotomously branched. The prothorax is provided with a couple of feathered hairs which project anteriorly towards the cephalic portion. Abdomen with long, branched hairs. Thorax and abdomen with long, branched lateral hairs. On the dorsum of abdominal segments 5 to 6 (generally speaking) and sometimes on the 7th segment, there is a pair of palmate hairs. Pecten with many simple spike-like spines, a short one roughly alternating with a long one. Anal papillae equal and elongated when the larva occurs in fresh water, but reduced when it is found in salt water. Ventral board provided

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Colour is absolutely no guide to specific distinction of either larvae - at least in so far as Australia is

provided/

with numerous long, branching hairs. Dorsal beard with the usual type of "grappling masts"; consisting of a plume of 5 or 6 hairs on each side.

The duration of the larval stage is rather variable, occupying from 14 days to as long as a month and much longer in winter

The pupa is distinguished by the broad, triangular breathing trumpets, and they are pale and rather mottled. In summer weather the pupal stage covers about 3 days.

Distribution.- Australia generally, especially in the northern latitudes; Formosa.

Anopheles punctulatus Donitz, 1901.

A species resembling and closely related to A.annulipes, but differing in the palpal banding and the male hypopygium.

Length. 3.5/4 mm.

Head.- black with the usual type of obsagittate scales and with a frontal tuft of white hairs and linear scales. Proboscis black on the proximal half and at tip; the rest tawny or white. Palpi slender, proximal 5/6 almost entirely black-scaled, with the exception of 2 very narrow bands of white scales situated (approx.) at 1/3 and 2/3 the distance respectively from the base; distal 1/6 is white-scaled and involve (generally) slightly more than half the distal portion of the last segment. In addition to the definite banding, th palpi are sometimes mottled with an occasional white scale on the proximal segment and between the fourth and third white bands. Antennae with pale hairs.

Thorax.- brown with frosty tomentum, with two dark spots in front and laterally, and a dark area near the scutellum. These dark spots are more or less the effects of light and shade and are apparent on the denuded surface, as a kind of chiaroscuro.

Abdomen.- clothed with hairs, but the hypopygium carries in addition a few light scales; otherwise, abdominal scaling appears to be suppressed (cf. A.annulipes)

Wings - much spotted black and tawny, the veins clothed with rather broad scales; costa with 4 large and 3 or 4 small dark spots the three proximal ones small, then a large one, then a small one, followed by 3 large ones. Vein "R " with black-scaled areas corresponding to the outer 5 costal areas, but the middle area is divided into 3 by 2 small white spots. Vein 'R (2nd long vein) with 3 black-scaled areas on "R's", and each branch has four or five small dark spots. "R. " with many very small black area The 4th at its proximal third is chiefly light-scaled, its middle third is chiefly black-scaled, its branches have 2 or 3 dark areas on each. Veins Cu and Anal have many small alternate areas of black and white scales. The wing-fringe is light-scaled at the apex and to the level of vein. "R "; the remainder is dark-scaled except at the terminals of the longitudinal veins.

Legs - dark brown, the femur and tibia copiously, the 1st tarsal segment less copiously speckled with light tawny spots; the next 3 segments (i.e., tarsi 2-4) have white bands at their distal and (except in the hind legs) proximal ends; these proximal and distal bands of tarsi 2-4 (in fore and hind legs) consequently involve the articulations, and in the forelegs they show as broadish bands. The 5th tarsal segment is neither banded nor speckled.

Swellengrebel, Schuffner and Swellengrebel de Groof (1919) have found that experimentally, the Dutch East Indian strain of Anopheles punctulatus is hospitable to Plasmodium falciparum to the extent of 4%, but that, in 1391 specimens examined none were seen to be naturally infected. Heydon (1912 and 1923) in Rabaul, Territory of New Guinea, succeeded in experimentally parasitising local strain of A.punctulatus with all the three species of human malarial parasites (Plasmodium vivax, P. malariae and P falciparum) In all the above investigations of Heydon "a large percentage" of specimens of this species became parasitised (no figures given).

Anopheles barbirostris van der Wulp, 1884, var. bancrofti Giles, 1902.

A large black mosquito easily recognised by its densely an shaggily-scaled and entirely black palpi.

Length - about 7 mm.
Head - clothed chiefly with broad obsagittate scales which are black on the extreme occiput and sides and whiteon the occiput anteriorly. On the vertex a few white curved scales and a tuft of hairs project forward. Palpi unbanded, thickly clothed with broad outstanding black scales which are mor or less densely aggregated and longer on the proximal than the distal segments. Proboscis clothed entirely with black scales which are rather outstanding on the proximal half. Antennae with black hairs
Thorax - black; the dorsum with grey bloom, with some indications of linear markings imparted by irregular lines of scattered golden linear (hair-like) scales. Prothoracic lobes with a tuft of broad scales projecting anteriorly. Scutellum fringed with pale brown setae and with a few

few/
scales like those on the dorsum. Pleura mottled black and brown. Halteres ochreous, with black knobs.

Abdomen black, with the dorsal surface of segments 1-7 clothed with golden brown hairs. On the venter there are true scales (black and white) on segments 3-7.

Wings with the veins thickly clothed with large broad black scales The costa has a small patch of creamy-white scales at its distal end -- i.e., at the tip of the vein "R," and another small patch at a point two-thirds the distance from its base - i.e., opposite the middle of the stems of the fork-cells. Proximal half df vein "R," with a few white scales interspersed irregularly. Vein "R_2" with the apex creamy-white; vein "R_3" sometimes with a similar spot near its base, the distal part with a small patch of light scales. Vein "R_{4+5}" with a few light scales towards its distal end, the remainder with irregularly scattered light scales. Veins "M_{1+2}" and "M_3" with patches of white scales (sometimes with only a faint mottling of "M_3"). Vein "Cu" (5th vein) irregularly clothed with patches of black and white scales; on "Cu", and "Cu_2" the white scales form two distinct patches. On vein "An" some of the scales are black, some white, the white scales forming two more or less well-marked spots. The wing-fringe is mostly dark-scaled, but there is a tendency to show light-coloured fringe-patches near the tips of the longitudinal veins.

Legs light brown to sooty, clothed mostly with dark scales, with small but distinct apical rings of creamy scales to the tarsi (i - iv of hindlegs; i and ii f fore and mid legs) ten tarsi iii and iv of hind legs. There are in addition, proximal bands of creamy scales, the banding of which, together with the adjacent apical bands of the adjoining segments, involves the articulations.

The larva is large and very dark, with very large and pronounced palmate hairs just discernible to unaided vision under the best illumination (incident obliquely).

Larva.- Length 7 mm. Head and anal segment dark and heavily pigmented. Antennae slightly curved, covered with many sharply-pointed but simple spines the size of which latter decreases from base to apex. Proximal portion of antennae slightly swollen. Antennal plume sub-median in position, consisting of about 12 branches; the branches are more or less equal in length and give the appearance of a radial grouping. Each antenna is tipped with two stout spine-like processes, weakly chitinised, also with an extremely delicate, branched seta of about 5 branches. Mouth brushes consisting of moderately chitinised simple "hairs". Labrum clothed with minute slightly recurved and distally serrated setae. Mandibles consisting of small but heavily chitinised teeth. Labial plate roughly triangular, the base obtusely and symmetrically crenated; there are about 3 lateral, more or less irregular, blunt teeth and a median (apical) one of average size. An asymmetrically shaped foramen occurs on either side of the median line of the labial plate. The frontal "hairs" of the head exist as six well-defined branched setae. Inner anterior clypeal hairs, long, stout and very minutely branched - the branches being few, and hardly more than the diameter of the hair. Each of the outer anterior clypeal hairs consist of simple tuft of branching, tree-like hairs. Thorax: in addition to the usual chaetotaxic grouping, there is a group of 3 long simple hairs which arises from a moderately chitinised tubercle on the antero-lateral margins of the thorax, in the prothoracic region; at the base of each of these hair tufts are two unequal spines, one markedly chitinised, the other (longer one) weakly so. On the inner side of thesehair-tufts are two minute, branched setae, one on each side of the median line; these comprise the anterior sub-median group of Stanton. There is a small but pronounced feathered hair on each side of the mesothorax and a maller and less pronounced one on the antero-lateral aspect of the prothorax. Several very minute palmate hairs are to be found on

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the thorax. The abdominal segments 1-3 have branched lateral setae rather much like those of the thorax; segments 4 - 6 with long bifid setae. All the abdominal setae arise from distinct chitinous tubercles, and in addition to the ordinary lateral setae there aremuch smaller branched ones.arising near their bases. The typical palmate hair takes the form of rather large and mottled sharply tapering "leaves" the edges of which can be observed to be minutely serrated; from 15 to 19 such "leavee" go to make up one of the large palmate hairs. There are large palmate "hairs" on segments 3 - 7; minute ones (less notched) on segment 2, and still more minute ones on the thorax (2 pairs). The thorax and abdominal palmate hairs show a gradual transition both in size and complexity, which a good example in the development of the typical "palm" from a simple "hair-tuft". The spines of the pecten take the form of simple undifferentiated (except for size) spikes, large roughly alternating with smaller ones. The number is about 14 in each side, and altogether the comb is very similar to that of Anopheles annulipes Walker. The anal segment is of a mahogany colour and its surface is invested with numerous minute, sharp, simple spines, of almost the same shape and size as those existing on the shafts of the antennae. Ventral beard arranged in about 10 paired groups of typically branched hairs. Dorsal beard well represented, the "grappling hooks" consist of a plume of 5 or 6 branches on each side; swimming fans (anal papillae) equal, moderately elongated and obtusely pointed.

Pupa: A most striking feature of the pupa is the linear extensions of mottled or variegated colour-markings of the cephalothorax due to the chitinous incrassations of the pupal cuticula. Caudal fins rather striking by reason of their relative diminutiveness. The fans are also closely approximated and do not show any tendency to lateral spreading. Breathing trumpets small, broad, and triangular. There is a pair of large tree-like plumes of much branched setae at the base of the cephalothorax. On each of the sides of abdominal segments 2 to 6 is a short, stout, bluntly pointed and strongly chitinised spur. Each segment has a pair of branched setae each of which branches from a short stalk into five more or less equal and regularly disposed "hairs". There are also minute bifid and trifid "hairs" on each segment. The 7th segment bears a pair of small plumes and peculiarly branched hairs on the posterior angles. The leaves of the caudal fin are hyaline, each stiffened in the ordinary way by a midrib, which latter is very faintly striated transversely and terminates in a short chitinised spur or bristle.

Geographical Distribution. Rather common in the Northern Territory, especially in the islands off the mainland, and at Roper River. The species extends as far south as Brisbane.

Papua and New Guinea; Straits Settlement; Upper Burmah; North West Provinces of India; Punjab.

Sanitary Importance:- Stephens and Christophers (1902) failed to transmit plasmodium falciparum experimentally by Anopheles barbirostris v.d.W.; they do not include (1906) the typical species as a malarial pathophore. Christophers (1912) says that because of its sylvan habits, it is believed not to "play much part in the transmission of malaria", though it may act as a carrier in the case of forest camps. James (1902) was successful in experimentally infecting and securing development of oocysts and sporozoites of the malarial parasite in A.barbirostris. Stanton (1912) was unable

unable in eight trials to infect the Malayan strain of this species with the parasites of A.falciparum. Schuffner (1902) failed to infect "Anopheles II" which is noted by Walker and Barber (1914) as being possibly A.barbirostris. Walker and Barber state that this species carries aestivo-autumnal malaria experimentally, but the susceptibility to infection is rather feeble and that the mosquito probably plays a subordinate part in the spread of malaria in the Philippine Islands. Swellengrebel (1919) secured experimentally a thirteen percentage of mid-gut infection of A.barbirostris with Plasmodium vivax (2 in 15). Swellengrebel, Schoffner and Swellengrebel de Graaf (1919) found A.barbirostris in the Dutch East Indies, naturally parasitised with P.vivax in three out of 573 specimens examined, while under laboratory conditions there was a receptivity to the same species of parasite of 10%. Erring on the right side, we may reasonably assume that our local variety of the species along with A.annulipes Walker, is the disseminator of malaria in northern Australia; but it must be understood that, although statements have been freely made in Australia as to what species of Anophelines are responsible for the transmission of malaria, we have no absolute scientific (except on epidemiological and zoogeographical grounds) proof of malarial pathogenes in Australia.

Bironella gracilis Theobald, 1905.

This Anopheline is told by the very abnormal wing-venation -- cell "R " being very small. The abdomen is devoid of scales but hairy.

Length 5.5 mm.

Head brown, with numerous yellowish and black obsagittate scales the yellowish ones being broad with expanded apices, the black ones thin. There are small, thin, outstanding irregular scales, and over the vertex is an expanded tuft of long white narrow-curved scales, and a tuft of light yellow setae The scales on the occiput are long and lanceolate and their colours are light grey, dark grey and black. Palpi in male slightly shorter than the proboscis, but longer than those of female. They are from 4/5 to 6/7 the length of the proboscis in the male, while in the female they are about 2/3 the length of the proboscis; the distal segment in both sexes is slightly swollen; scaled with deep brown scales. Proboscis moderately long and thin, clothed with deep brown scales; labellae very acuminate, and sombre grey. Antennae plumose in male, brown with pale bands below the whorls of long verticillate hairs; hairs deep brown. Antennae clothed with short grey pubescence in both sexes.

The two distal antennal segments of the male scarcely longer than the preceding two or three which are slightly longer than the rest. Torus bare. Hairs of 1st flagellar segment implanted irregularly.

Thorax dark brown, the mesonotum with a slaty sheen and with short dull golden incurved hairs projecting backwards. There is a median tuft of lanceolate scales, grey in front. Prothoracic lobes well developed, clothed with golden brown hairs. There are linear extensions of denuded areas, paramedian in position on the anterior 2/3 of the mesonotum, and denuded lateral lines on the posterior half. Hairs darker above the bases of the wings. Scutellum pale yellowish-brown; post-scutellum deep brown, and provided with long golden-yellow hairs. Halteres with the pale stem much swollen proximally, constricted distally; the knob dark.

Abdomen black; without scales but with golden-yellow hairs, numerous all over segment 1. In the male the hairs on the distal segments are slightly more pronounced than in the female Male Hypopygium: basiandropodites (side-pieces Edwards) short and stout, less than twice as long as their width at the base, basal membrane large and apparently striated; from the outer basal corner of each side-piece arises a stout curved finger-like process, which is more than half as long as the side-piece, finely pubescent towards its base, otherwise bare, its apical half strongly chitinised, tip blunt and slightly lobed. Apart from these processes there are no spines on the basiandropodites. Epiandropodites (claspers Edwards) rather long, nearly cylindrical, with a post-median lump on the outer side, terminal claw short and broad. Ninth tergite a narrow, transverse oval, posterior margin simple. Anal segment membranous, elongate-conical, 2/3 as long as the side-pieces. Phallosome (aedoeagus Edwards) a long, slender, cylindrical tube, with a single pair of reflexed leaflets at its tip, the leaflets a little over a quarter as long as the tube. There is only one spermatheca, spherical in shape, with a chitinous duct the length of which latter is about 2/3 the diameter of the spermatheca.

Wings with spatulate scales of a sombre brown hue. Wing-membrane with well-defined microtrichia. Cell "R " very small, in the female, 1/10 the length of the wing and 1/3 the length of its petiole. In the male this cell is shorter than in female; 1/13 the length of the wing, and its petiole is longer, from 4 to 5 times that of its cell. Cell "M " well developed about 2½ times the length of cell "R " in the male, and about twice its width; it is about 1/5 the length of the wing. Petiole of cell "M " in the male slightly longer than or about equal to the cell. In the female cell "M " is about ¼ the length of the wing, and its petiole is between 2/7 and 3/5 (average ca.3/7 or more nearly 2/3) length of its cell. Petiole of cell "M " curved about its centre. Vein "R " curved, continued to the base of the wing as a distinct pseudo-vein. Vein "Cu" with its upper branch distinctly waved after its junction with cross-vein "m-cu" (anterior basal cross-vein). Vein "An" almost straight until its apex, where it curves abruptly; a distinct pseudo-vein between veins "Cu" and "An". Wing of male smaller than that of female.

Legs long and thin, yellowish-brown, without markings; the coxae and inferior surface of the femora pale ochreous, covered with small scales. In the female the tips of the tibae are slightly swollen. Ungues equal and simple in both sexes.

Brug and de Rook state that the length of the distal and the penultimate antennal segments of the male is about 1½ times tha of the 11th flagellar segment. The length of the distal segment in the female is 1½ times that the penultimate; flagellar segments i xii about equal in length.

Theobald in 1905 founded this species on three males. On account of its anomalous characteristics Theobald was hesitant about placing this genus (with its single species) in the Anophelini-- the apparently natural taxomonic position. There is so far as is known, no Culicine or Aedine or Megarhinine in which the abdomen is nude and the scutellum simple. Brug and de Rook are of opinion that in Pionierbivak (New Guinea) at least, B. gracilis could not be regarded as of any pathophoric importance.

Life History:- Its breeding places were located by Brug and de Rook in the virgin forest which encompassed the principal encampment (Pionierbivak) of the French Scientific Expedition to New Guinea. The breeding places comprise very peaty bogs. The larvae being only slightly active and not very timid, are easily captured. Although the distance from the bivouac to the forest was only slight, specimens of B. gracilis were never found infesting the thatched cottages of the encampment. On the contrary, Anopheles punctulatus var. moluccensis Swellengrebel was abundant in the encampment.

Larva: asyphonate as in other Anophelines. Antennal tuft plumose and median in position. Inner anterior clypeal hairs simple and closely approximated to the median line. Outer anterior clypeal hairs plumose, as long as the inner anterior clypeals, and arising in the same transverse line. Posterior clypeal hairs small and bifurcated and placed behind the outer anterior clypeal hairs. Frontal hairs six in number, plumose. There are 4 occipital hairs, all bifurcated and of the one size; inner pair more posterially situated than the outer pair; these are arranged along the line of a semicircle with its concavity directed anteriorly. The anterior submedian thoracic pairs form 2 groups of 3 hairs; a small external simple pair, a median plumose, which is the largest, and an internal plumose one. There are 2 pairs of palmate hairs on the thorax; the first abdominal segment is without palmate hairs; segments ii -vii, each with one pair. The "leaflets" of the palmate hairs are narrow, lanceolate and simple -- i.e., without serrations. The spines of the pecten alternate irregularly; one or two short teeth are placed between two long teeth. In this alternation there are individual differences. The spines are simple and do not shew a basal fringe of denticules. Anal papillae well developed.

Geographical Distribution:- Territory of New Guinea:- Nuina Biro, 1900); Pionierbivak, Mamberano River (Brug and de Rook, 1922).

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