M.D. THESIS

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A SURVEY OF MALARIA IN THE BRITISH ARMY IN WEST AFRICA.

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A Survey of Malaria in the British Army in West Africa. With Special reference to Incidence and Preventive Measures during the Present War.

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MALARIA IN EUROPEAN TROOPS IN WEST AFRICA

CHAPTER 1

H I S T O R I C A L.

West Africa has always been recognised as a particularly unhealthy region of the Tropics and above all, as one fatal to soldiers or sailors who were stationed there. Three diseases have been mainly responsible, - El Vomito, Black Jack, or yellow fever, the flux or dysentery, and remittant or intermittant fever by which is usually intended Malignant Tertian Malaria.

Yellow Fever was also sometimes called the epidemic fever and was essentially the killing disease which suddenly appeared in a station leaving behind few survivors. In contrast, malaria, from its epidemiology was often known as the "common or endemic fever of the country."

Now that immunisation against yellow fever appears to have removed its danger, and modern hygiene and sulphaguanidine treatment have lessened the terrors of bacillary dysentery, malaria remains without near peer the principal single cause of sickness invaliding and death in Europeans on the Guinea Coast.

The first Europeans on the coast, and indeed the only ones who settled for over a hundred years, were the Portugese. History is very silent as to their early colonization, largely because the authorities in Lisbon were intent on minimising their efforts, in case other nations would be attracted to compete with their trade in gums, spices, civet and gold. Nevertheless, in the few documents which have been translated from the Cintra Libraries, there are constant references to sickness and death in the troops who defended their trading posts and castles.

Subsequent history relating to disease in troops on the Guinea Coast is conveniently grouped as follows. .

A. The Seventeenth and Eighteenth centuries, in which Dutch, British, Danes, French, Courlanders and Brandenburgers all maintained garrisoned Forts.

B. The Nineteenth century in which first the Danes and then the Dutch retired leaving Britain uncontested and in which various military expeditions were made to the hinterland, white troops being employed in these native wars.

C. The period from the relief of Kumasi in 1900 until the Great War.

D. The Campaign in Togoland and the Cameroons 1914- 1916

E. The Inter-war Period

F. The Present War.

I feel that the historical survey is worth while, as tending to put in perspective the high incidence in the early part of the Present War and the efficiency of the measures which helped to reduce that incidence. It must suffice to sketch conditions of living, to quote a few contemporary opinions and to give what scanty figures as are available which would help to estimate the incidence in the past.

A. The Seventeenth and Eighteenth Centuries

References, which are few in the earlier part of this period becoming more frequent later are mostly from the diaries or accounts of voyages kept by ship's masters or travellers. A few are in official documents.

Troops were stationed in the European Forts to protect them from assault by the natives or by rival Europeans. At first, detachments of ordinary troops or marines were posted to the forts but the mortality was so tremendous that gradually the Guinea Coast came to be regarded as a penal station to which all nations sent

their undesirables. The British system was to man the Forts with military offenders from other units. When sufficient of these was not forthcoming, civil offenders on long term or life sentences were offered release on condition that they joined the Army and were posted to Guinea. These unfortunate wretches were glad to get back some degree of liberty with the promise that when they had completed twenty years service, they would return home. Few, if any ever returned home to warn their successors what to expect, but newcomers must have been quickly disillusioned when they met the fever ridden soldiers in the Forts. It is quite clear that most gave up soon any hope of ever seeing Britain again but gave way to every form of debauchery to forget their sorrows.

Soldiers were not rationed from the Forts but had to purchase what they could from the natives from a miserable allowance. To make matters worse, they were paid in a local and certainly inflated currency. With this they purchased goods from the merchants and then attempted to barter for food with the natives. This system inevitably led to them being in debt. It is even hinted by some writers that they were encouraged to get into debt, for until they were clear of all debt they were never allowed to leave the Fort. The food which they were able to purchase must have been a constant menace to their health, both as being infected, and as being sadly deficient in protein and in B group accessary substances.

The British uniform was of thick serge, designed for a temperate climate. All that can possibly be

said in its favour is that the boots and gaiters with trousers tucked in must have served the purpose of mosquito boots as well as incubators! Other Nations were more enlightened. The Brandenburghers for example provided for each man, in 1683, "Six shirts, two pairs of shoes, two pairs of stockings, two caps, one linen suit and three linen neck cloths - - - one good rain coat in place of an overcoat" (1)

Officers in British Forts were almost invariably there for one of the three 'D's" - Debt, Disgrace or Drink. Army Lists show that they were usually posted from the half pay list. They hoped to make their fortunes by rapid promotion and private trade, but they too were paid in the local currency or in kind, so that although their expectations of rapid promotion due to deaths of their seniors were seldom disappointed, few can have realized their hopes of retiring after a few years in affluence.

Bosman (2) the Dutch traveller who visited the coast in 1696 and 1698, says of the climate "The fog happeneth most frequently in the ill season of six months - - but more especially in July and August (The latter half of the rainy season) wherefore we are more seized with sickness in that time than in the good season or summer - - and our bodies are more susceptible of it than the natives."

Several other writers comment to the same effect - that the rains bring the sickness, that newcomers are especially affected and that the natives seem relatively resistant to the ill effects of the rains. Barbot (3), a French traveller gives the following description of life in Cape Coast Castle, the main British stronghold, when he had visited it in 1680. There were "a hundred white soldiers and some Officers all clothed in red in the pay of the Royal African Company". Their condition was due(says Barbot,) to a vast over indulgence in punch -

"The garrison is very weak, the survivors looking poor and thin, not only the soldiers but also the Officers and Factors. Their whole countenances are thin and shrivelled". Bosman (2) - "advised them to avoid sleeping in the open at night when heated with debauchery, having nothing on but a shirt".

Bosman had however, some other ideas which have not stood so well the test of experience; - "Therefore I did not only take care to avoid lying so exposed but always kept to my bed - - and both day and night wore a dressed hare's skin next to my bare stomach for above two years together which kept it in good disposition and helped digestion very much; though I must own it was sometimes, and especially in the excessive nights very troublesome, and occasioned much sweating". One has no hesitation in believing in his discomfort.

In 1710, Capt Nathanial Uren (4) called at Grosse Friedericksburg the main Brandenburg Fort. He complains that he had but a bad night's sleep, for the custom is, as soon as it is dark, to shut all doors, windows and shutters very close to keep out the night air which they reckon unhealthy to Europeans. - - the soldiers looked like people which had been dead and buried for six months and returned from their graves, for I protest I never saw so poor and despicable a crew in all my life".

The records of the Brandenburg Castles are very complete and easy of access due to the publication of a selection of the original documents by the German Imperial General Staff. (1). In 1683, fifty Europeans were landed to lay out a Fort on ground above the village of Pasequoe on Gold Coast. About a month afterwards ten were dead and only eight were not suffering from fever.

From 1702 to 1708, due to the war of the Spanish Succession in Europe, the garrison was not relieved. Of the original fifty, by 1708, only thirteen were alive and only seven were fit for duty when the relief ship arrived.

In 1792, an attempt was made to form a European Colony on Bulama, the most coastwise of the Bissagos Islands (Now Portugese) at the mouth of the Rio Grande. (5) I have not been in the Bissagos but have flown over them many times. They are flat islands indented by tidal mud and mangrove creeks. There are a few flat sandy beaches, but given human hosts to feed them, they are ideal terrain for Anopheles Gambiae and A. Gambiae. Var. Melas. They come into the zone of about 160 inches annual rainfall.

Three ships set out from England on April 14th 1792 carrying 275 men women and children. The men were mostly of the type already mentioned as deemed suitable for the Guinea Coast. There was a good deal of dissension on route so that only 96 seem eventually to have landed on Bulama. They arrived on May 19th and set to to build a stockade where they could live while starting their farms.

They were attacked by the natives, there were desertions, fights and accidents but, having landed at the beginning of the Malaria season the biggest enemy of all was malaria. There was a shortage of medicine and although cinchona was in general use as a curative at that time, I could find no mention of it in Capt. Beaver's book.

It is difficult from the narrative to be certain of the course of the sickness or to be sure of figures, for names suddenly appear or disappear and are not mentioned again but the following appears to have been the

sequence of events:-

June 1792. Party landed, 50 men, 18 women, 28 children

July 44 men, 10 women and 24 children well
4 " 3 " " 24 " sick with fever.

During, in succession, August, Sept., Oct., and November 9,9,7 and 10 died of fever. In the Journal at the end of November is noted "Today is remarkable in that every single person is sick" . By the end of December, another 13 had died of Fever and the state was

Well 2 men 0 women 2 children

Sick 7 " 1 woman 1 child

During January 1793 another death from Fever is recorded. There were two more in June and one in September. In October the 9 survivors were evacuated.

Lind (1777) (6) states that since the last edition of his "Essay on the Diseases incidental to Europeans in Hot Climates - - " "Ships of war on the Guinea Station are ordered to be supplied with a large quantity of the bark (Cinchona) in powder form, to be issued occasionally to those who were sent in boats up rivers, and on shore".

Durand, (7) who was the French Governor of St Louis, states that during his period of office in Senegal from 1785 to 1787, it was usual to drink fasting a little brandy in which the bark had been infused, in order to guard against fever. Matthews (8) recommends fires and the bark as the best preventitives against fevers.

So that, while the use of cinchona as a preventitive was beginning to be realised the disasterous Bulama expedition was without the drug even for treatment.

B. The Nineteenth Century.

In 1803, Mungo Park (9) took a party of forty four

Europeans on his second journey to trace the course of the Niger. Included were Lieut. Martyn and thirty five soldiers from Fort Goree who had been induced to volunteer on promise of discharge when they returned. They left Gambia on April 26th 1805 travelling right on through the rainy season. By November 17th, only three soldiers, Lieut Martyn and Mungo Park were left alive. It is impossible to be certain from the diary how many of the thirty two deaths were due to malaria, but probably well over half were so caused.

In 1818, the shocking choice was made of St Mary's Island at the mouth of the Gambia River for the Military Post which eventually became Bathurst (Gray 10). The centre of the island is below spring tide level end nowhere is there more than 18 inches above that level. The post was first garrisoned by the Royal African Corps officered largely by veterans of the Peninsular War. The men were as usual military offenders from home units.

In May 1825, a contingent of 199 European soldiers arrived at Bathurst as there was trouble with the people of Barra which lies on the opposite bank of the mouth of the River Gambia. Owing to lack of accommodation only 108 were landed and the remaining 91 were left aboard the transport. Sickness soon appeared in those landed. The Military Hospital had only accommodation for sixty or seventy patients and the number of sick was such that "at one time they were so numerous that it became necessary to place them in the galleries. (The building of hospital is still extant in Bathurst and the 'galleries' are outside balconies.) By Sept. 27th, 87 of the 108 were dead.

There had been no sickness in the transport but the 91 were now landed as there was of course by this time, ample accommodation in the barracks. By December 21st, 73 more were dead. Only thirty nine alive was a heavy price to pay for landing in the rainy season. To replace the casualties, another 200 men arrived in May of the following year (1826) - May seems to have been a favourite time for landing newcomers to West Africa.

When General Sir Neil Campbell visited the Hospital in August 1826, he found there 93 of a total strength of 116 white soldiers. Between June 21st and Sept. 21st in that year, ninety eight men died. Eighteen men died in the following three months and of the survivors 33 were permanently unfit for further service. In July 1827 when 276 of the original 399 men had died, it was decided that Bathurst was not suitable for white troops.

It is very difficult to separate yellow fever from malaria in this epidemic. But from mention of repeated attacks and non-vomiting cases it would appear that at least half of the sickness was due to malaria.

Dr Barry, Inspector of Hospitals in West Africa is quoted as follows by Boyle (11):- In 1822, twelve white sergeants were brought from the Isle of Wight. All were men of good character and were accompanied by their families. Every individual was attacked with fever in a few weeks - eight died - and only one - the sergeant-major - appears at present fit for duty. The constitutions of the three others are in such a shattered state that plainly indicates an advanced state of visceral disease. Sickness and mortality in wives and children were nearly in the same proportion." These were definitely cases of malaria, for elsewhere in the report, Yellow Fever and "remittant fever" to which these illnesses are

attributed, are clearly differentiated.

Boyle also quotes Mr Tidlie, Acting Staff Surgeon in Cape Coast Castle in a report in 1822 to Dr Nichol, Chief Surgeon in Sierra Leone (Mr Tidlie was killed by the side of Sir Charles McCarthey in the first Ashantee war in the following year). Tidlie says that small drafts of soldiers who arrived at Cape Coast Castle were attacked as follows:-

Year.	No. in Draft.	No. attacked	No. Died.
1819	8	8	2
1820	4	4	4
1821	7	7	2

In 1826, Mr. J. Bell, Acting Surgeon to the Forces was questioned by a member of the House of Commons Commission enquiring into conditions on the West Coast. He said that he arrived on the coast in 1821, from then until June 1826, there had been in Gambia 52 European residents of whom 13 had died. He had served on the Gold Coast and stated that "On the Gold Coast there is no record of the year in which Europeans are exempt from being attacked with the remittant fever - - particularly newcomers - -" He had "seen soldiers attacked after only twelve days in Cape Coast.

The same Surgeon Bell reports in the old letter book in the Military Hospital at Cape Coast - (quoted by Ellis (12) and Gray and Dochart (13)) because he surmises "for the Colonial Government, probably not wishing to terrify its European Officials, has never published any statistics" - that two companies of white troops arrived from the Cape of Good Hope in April 1823. Only one man remained alive in December 1824. A second detachment (number not stated) arrived from the United Kingdom in November 1823. Eight were alive by the end of 1824. Of a third detachment which arrived

on the 12th March 1824 the greater part had died in three months. A fourth detachment landed on March 20th and six remained by the end of the year. 101 men landed from H.M.S. 'Thetis' on July 4th, 45 died within a week of arrival.

Wives and children were also brought out. In October 1823, 42 women, and 67 children arrived. By December 1824 the 29 women and children surviving had to be sent to England to save their lives.

There is little doubt that a substantial part of this mortality also was caused by yellow fever but from the description of people being ill for many days and then recovering, there is no doubt that malaria played a major part. Surgeon Bell concludes his report as follows:-

"The destruction of life that has taken place ought to prevent any more European women and children being sent out - - I sincerely hope that I shall never rewitness the many trying sights I have done this year in beholding the father and four or five children laid up with fever in a small hovel of a place, totally helpless to each other and gradually dying without my being able to mitigate their sufferings even in a small degree." It was this disaster to troops and their families which led to the Commission of Enquiry in 1826 to which Mr. Bell made the replies quoted earlier.

It may have been noted, that in references to the first quarter of the 19th Century, no mention is made of Cinchina Bark. This was largely due to the influence of Dr James Johnson (14) who had practised in Calcutta and who lost a patient after treating with cinchona but cured another with mercury and bleeding. In 1812, he retired to England and wrote a text book on tropical medicine which was immediately successful and ran through

many editions. He condemned entirely the use of Cinchona Bark.

The Landor brothers, Richard and George (15) record in 1829 that Sir John Webb a recognised authority recommended them to take 2-4 grains of quinine surphate every six hours as a strengthener after fever and dysentery. This may be said to represent the attitude towards quinine at that time.

In August 1826, twenty of the crew of H.M.S. 'North Star' were detailed to work in boats in the Sierra Leone River. They all took wine and bark with the exception of Lieut Boultbee R.N. who declined to take the drug. He was the only one who contracted fever. This is typical of many accounts collected by Surgeon Alexander Bryson (16) who made a long report in 1847. He records a series of outbreaks of malaria in sailors and marines especially in the boat crews who went on isolated missions up small rivers and creeks in search of slavers. He covers the whole of the coast from the Shebro River in Sierra Leone to the Oil Rivers in Calabar, and gives many instances of the preventitive action of Quinine. He summarizes by saying, "the introduction of quinine as a preventitive of fever has not only reduced the number of febrile attacks but has lessened the severity of those that do occur and thus the mortality has been reduced to a level which does not materially exceed the death rate from fever on some more healthy stations." Bryson is quite definite in preferring quinine to "the bark" and in insisting that it should be taken for at least fourteen days after leaving the infected area.

About this time, strenuous efforts were being made by the Royal Niger Company to increase its trade by dealing direct with the tribes producing palm oil further up the Niger. In 1837, McGregor Laird led an expedition of forty Europeans up the River. Quinine was not used and only nine returned alive (17). Another expedition up the Niger in 1841 under Capt Trotter R.N. (18) was equally disastrous. Of 143 Europeans, 43 died from fever and only 9 were fit at the end of the expedition. Again quinine was not used.

It would appear then that the excellent ~~advice~~ EVIDENCE COLLECTED BY of Bryson was neglected for many years.

Soon, however, the value of Quinine came to be realised again and the final blow was (or should have been) dealt to the doubters by the happenings in the Scientific Expedition up the Niger led by Surgeon W.B. Baikie in 1854 (19). As soon as the bar at the mouth of the River was crossed, each European took 6-8 grains of quinine daily. After four months up the River, all the Europeans were well with the exception of one of the second mates who had refused to take the drug. He had severe attacks of fever, accompanied by delirium, for his head had to be shaved, while in addition to quinine, he required sedatives and sudorifics. (Hutchinson (20).

These results, shewing the benefit of prophylactic quinine were confirmed by many Naval Surgeons. Eames (21) found that quinine greatly reduced the incidence of malaria in his ship operating in malarious creeks. The drug was given daily on parade and in one year, 18 gallons of rum were used as a diluent. Eames also recognised that quinine does not lose its prophylactic qualities in any degree by long con-

tinued administration. It is very remarkable how much earlier, the prophylactic value of quinine was recognised by Naval surgeons than by Army or Civil doctors. Presumably, having the opportunity of having the crew always under their eye and in a way a 'closed community' enabled them to form impressions and collect statistics more easily.

At this stage, it is well to quote Richard Burton (22) that picturesque figure born two centuries after his fitting period, that insatiable explorer whose reputation suffered so much from his being so outspoken and from having as apologist a too adoring wife. Burton is always worth reading on medical matters for he is observant and honest in his opinions. Talking of the Gambia in 1862 he says "as usual in Africa, the most dangerous period is during the drying up of the waters, when vegeto-animal matter deposited in swamps and hollows by the rain, is distilled into its miasma." "Under charge of Dr Martin, I visited the Military Hospital (in Bathurst) on the west of the town, close to the swamp. The place is murderous. There is a sick ward on the ground floor! - one night on the ground floor is certain fever in most parts of Tropical Africa - and that ground floor is, like the latrine and other offices frequently under water. - - - the beds are crowded together, each patient having 800, whereas 2000 cubic feet of air should be the minimum. This caution of a hospital is built to accommodate 32. When I visited it there were eighteen fever and dysentery cases - - - I was not astonished after going the rounds to hear of 92 deaths out of 96 admissions and at times 'El Vomito' 'improves off' everybody". At Cape St Mary he writes "A wonderment siezed me, how long will it be before the Europeans of the settle-

ment remove to it en masse?" We can now answer his question. In March 1945, the Secretary of State for the Colonies in reply to a question in Parliament as to the probability of such a move and whether many Africans would have to be resettled replied to the effect that the plans were not at a sufficiently advanced state to permit of an answer to that question. As mentioned before, the "caution of a hospital" is still used as European flats.

In the Ashanti Campaign of 1863, about two companies of West Indian troops who were expected to stand the climate better than Europeans, with a handful of white Officers, camped on the Prah River waiting for an Ashanti attack. When the rains came they began to have so much fever that they had to be withdrawn. The Ashantis knowing the ills that befall an army in the bush during the wet season, followed suit. The Ashantis say that when their King Kwaku Dua heard of the British withdrawal he said "The Whiteman brings his cannon to the bush. But the bush is stronger than the cannon". While the troops from Cape Coast were encamped on the Prah, 128 men from H.M.S. 'Rattlesnake' and 13 from H.M.S. 'Ranger' were brought ashore to garrison Cape Coast Castle. Half of them were sick with fever in a month (23).

The Ashanti Campaign of 1873-1874 was planned with great care to ensure that it would begin and if possible finish in the dry season and that European troops would be ashore for the least possible time. These two objects were achieved, but sickness from all causes was nevertheless appalling, and the amount of malaria showed beyond any doubt that the term 'healthy season' was only one of degree. The medical planning was by Deputy Surgeon-

General Home V.C., C.B. who was invalided early in the campaign and the carrying out of his plans fell to Surgeon Major Mc Kinnon C.B. His account, and the figures given by Dr Stamford Moore, Officer in Charge of the Statistical Department, are quoted by Crooks (23) and Brackenbury(24).

During this short campaign under General Sir Garnet Wolesely, the British troops were only ashore for about 7½ weeks in December, January and February. The troops were:-

Army.	23rd Regt of Foot 42nd (Highland) Regt.	1578 N.C.O's and men.
Naval Brigade		552 N.C.O's and men.

The following table gives the amount of sickness which occurred in these troops over that short period.

	Ratios per 1000 per period.		Ratios per 1000per annum.	
U N I T	Total Sick.	Malaria	Total Sick.	Malaria
23rd Regt	1037	314	6222	1884
42nd Regt	690	423	4140	2538
Rifle Bde.	770	569	4620	3414
Naval Bde.	952	536	3216	1798

It is realised that the ratios per 1000 per annum are most misleading, as much of the sickness would occur in the early months. They are included because they are so given in the original report. Deaths from sickness were very few, probably not more than five in all. This is probably, in the case of malaria, because of quinine, which though not used as a suppressive, was used in treatment. The proportions invalided to United Kingdom after the campaign were amazingly high, so high that it must have been the policy to get away at once all who were not progressing quickly. Of the total strength of the Army Units 43% were invalided; of the Naval Brigade 39%.

In the Ashanti campaign of 1900, quinine Gr V was taken daily by all ranks of the relieving force (Armitage and Montenaro (25)). One of the officers relates that he did not take quinine until he had had an attack of malaria, whereas very few of his fellow officers were affected. He took it thereafter and had no further attacks. The campaign lasted seven months and during that time, in a total European strength of 152 there were 80 admissions to hospital for malaria and two deaths from the effect of malaria. Of 53 invalidings twelve were from the effect of malaria.

Of the period between 1900 and the outbreak of the First World War, I can collect no information. No doubt the reports are in the War Office Archives but I have not considered it justifiable to ask for them to be looked out under present circumstances.

Lieut. C.E. Pollock R.A.M.C. (1915 in Medical Reference List) showed that there was a great increase of malaria on mobilisation at the beginning of the last war in Imperial Troops stationed in Freetown. This was attributed almost entirely to the troops being stationed in forts and gun emplacements in malarious spots. In subsequent chapters, it will be demonstrated that this occurred precisely in the same way on the outbreak of the present war.

In the pre-First World War period there were apparently about 280 to 300 European Troops in Sierra Leone, almost entirely Royal Artillery and Royal Engineers. They lived mainly in Tower Hill and other relatively well sited Barracks. It seems to have been the opinion that, for practical purposes,

these barracks were malaria free. Certainly they were not by any means safe places by the beginning of this war, and I doubt whether they have ever been much better, yet they undoubtedly were relatively healthy. Suppressives were not taken during this period.

On mobilisation, in 1914, the troops manned the various forts and casements which protected the harbour. They were then given 15 grains of quinine every Friday and Saturday. The effects of the quinine in such doses were severe. There was much dizziness and deafness while many were shaky and not fit for duty for some hours afterwards. The dose was therefore reduced in September to 10 grains on Fridays and Saturdays.

The relative incidence of malaria in the year of Mobilisation and in the preceding year were as follows:-

	Average Strength	Admissions Malaria	Ratios per 1000 per Annum.
Aug. 1st 1913 - Jan 31 1914	291	68	467
Aug 1st 1914 - Jan 31 1915	271	393	2900

On analysing his cases, Poblock shewed that the factor of length of stay in the command was relatively umimportant in comparison with the place in which the man lived and worked. He estimates that about 19% just did not get malaria, or rather did not get attacks of malaria sufficient to warrant admission to hospital for " a certain number of these 'apparent immunes' have also had mild attacks of fever".

Pollock concludes by condemning quinine as a suppressive. It is quite extraordinary how loath doctors have been to accept that five grains of quinine daily, while by no means a perfect suppressive, far less a prophylactic, does cut down the malaria attack rate by at least 60%. This had been known and appreciated in the Navy for about fifty years.

I cannot get any statistical data whatever about the Campaigns in Togoland and Cameroons 1914 - 1916. These expeditions were conducted entirely by the Royal West African Frontier Force, having European Officers and Non-commissioned Officers. In the Official History of the Great War, mention is frequently made of sickness due to malaria and of leaving 'dumps' of sick men to be attended by Medical Officers, for there were no Hospitals with the expedition. By the end of each campaign, the Germans, lacking medical supplies were in a very much worse state with fever than were our own troops and it is significant that in the surrender terms was a clause promising that Germans would not be kept prisoner in West Africa, but would be removed with all speed to a more healthy climate.

In the inter-war period the R.W.A.F.F. was, as a Colonial Force, in the medical care of the Colonial Medical Service. The Europeans were classed for the purpose of all statistics as Government Officials and their health records are not separated in any Medical Department Reports. I have referred in the sections on each colony to the available information

as to the health of Civilian Officials in the inter-war years. I feel that the health of the Civilian Officials was probably very similar to that of the Troops although the impression of the Civil Medical Officers is that the troops had much more malaria.

In the Chapter on Sierra Leone, I have given the scanty information remaining about malaria in the Imperial Troops of the Freetown Garrison for the few years during which a Garrison was maintained there.

MALARIA DURING THE PRESENT WAR.

CHAPTER II

A. INTRODUCTION AND OUTLINE OF EVENTS.

On the outbreak of war in 1939, little change was immediately required in West Africa. The function of the Royal W est African Frontier Force (R.W.A.F.F.) was almost exactly as it had been in 1914 - to police the colonies in an emergency and to form a cadre in each colony on which a small force of all arms could be built for the protection of the colony. The R.W.A.F.F. was brought up to strength by recalling the British Officers and N.C.O's (B.N.C.O's) who were on furlough in the United Kingdom and by calling up the reserve officers and B.N.C.O's who were normally resident in the colony, and who carried out annual training with the R.W.A.F.F. much as did Supplementary Reservists in Britain. A few extra Officers and B.N.C.O's from the United Kingdom completed the European personnel.

The first marked increase in strength followed the unsuccessful expedition to Dakar, for the force carried on and landed in Sierra Leone. The R.W.A.F.F. now began to expand in order that a more adequate defence could be offered to possible invasion from bases on Vichy Controlled Territory. The inevitable trouble was experienced when large numbers of unsalted European troops were landed in such a malarious country as West Africa.

Late in 1940 a complete West African Brigade Group went to East Africa and served in the Italian Campaign there. Expansion continued, Pioneer Companies went Overseas and eventually 81st (W.A.) Division with additional troops went to India. The 82nd (W.A.)

Division was subsequently organised and it too went to India. The Command is now mainly concerned with recruiting and training duties in support of that overseas Force. The reason for giving this outline is to make clear, that there has been a big turn-over of, and exposure to malarial infection, of Europeans ever since 1940. To a lesser extent this is still going on, for in addition to the normal single tour for Europeans of eighteen months, the policy is to supply European reinforcements from United Kingdom to West Africa, to get them accustomed to handling African Troops here and then to despatch them with African Reinforcements to India and Burma.

Figures both of Malaria incidence and of Strengths, are very incomplete before 1941. At that time, there were few Army Medical Units, the sick being treated in the Colonial Hospitals which were without adequate staff or laboratory facilities. These Medical Officers could not be expected to keep such complete records as have been maintained subsequently by Army Medical Units. The method of computing and the accuracy of the strengths is discussed below.

B. THE MALARIA PROBLEM IN WEST AFRICA.

1. Endemic Malaria in the African Population.

For practical purposes the whole of British West Africa is a hyperendemic zone as defined by the Central Committee for the Study of Malaria in India whose criteria are accepted as standard. A hyperendemic zone is one where the spleen rates in children are constantly over 50%. There are a few localized areas which by evidence of the spleen rates and the more direct evidence of Gametocyte rates, would fall under the definition of an "area of high endemnicity" but they are so small

and so few as not to matter, the more especially as they are in semi-desert sparely populated country.

The vast majority of malarial infection is by Plasmodium Falciperum the parasite of Malignant Tertian Malaria, although the others do occur and probably occur to a greater extent than will be realized if the routine laboratory diagnosis is based on thick films only. There is probably an increasing proportion of P. Vivax and P. Malariae infections from East to West along the Coast. Any controlled work shows these plasmodiae to be much commoner in Sierra Leone than Nigeria for example. There is also always more non P. Falciperum infection in the large towns, probably due to the constant re-introduction of these species by Indian and Syrian traders. The figures in the Annual Reports of the Health Departments which I extracted were so variable from year to year as to render it certain that they were not based on microscopic diagnosis. I am assured by several Pathologists in the Colonial Medical Service that B.T. Malaria is often diagnosed and included in returns because "the attack was so mild that it must have been 'benign' !! I therefore refrain from giving any examples.

The declared figures for Infant Mortality in Africans vary from 300 to 500 deaths per 1000 live births. Most observers agree that about half that mortality is caused by malaria. As might be expected, in later childhood, evidence of protective reaction is seen in the enlarged spleens and parasites in the blood of 'healthy' children. The very large spleens of B.T. highly endemic areas are not seen.

One soon learns in West Africa that according to climate and vegetation one can guess the spleen rates

so accurately, that very little is to be gained in spleen examinations in preliminary surveys. Similarly, blood examinations always serve merely as confirmation of what is suspected and could be accurately estimated. Information is badly required on the seasonal and age group variations of the gametocyte rates, as much of that available is contradictory. Note will be taken of local endemnicity in the Chapters on the individual Colonies where malaria in Stations is considered.

The two points which I wish to make therefore at this stage are that P. Falciperum is the only type which is a serious trouble, and that ~~it~~ M.T. MALARIA is for practical purposes hyperendemic everywhere.

2. The Mosquito Carriers.

a. Mosquito Breeding.

The usual breeding PLACES of A. Gambiae and A. Funestus have long been known but there have been certain advances during the war and I shall mention them in turn.

(i) The more exact definition of the breeding places of Anopheles Gambiae var melas.

Dr Muirhead Thomson, working for the Colonial Office in Freetown has correlated the type of vegetation in mangrove swamps with the degree of covering at each tide and the ecological zones. He pointed out that the zone covered completely at ordinary tides was the home of the red mangrove Rhizophora and that the zone covered only by the exceptional tides was colonized by the white mangrove Avicennia while still more to the landward, the coast grass was a variety of Paspalum. The breeding places of var melas in salt and brackish water were essentially in the avicennia orchards and swampy areas of coast grass. Gilroy and Chwatt (1944) have recently confirmed these findings

and defined the breeding zones in greater detail in Lagos (Chapter VI).

Photographs 1, 2, 3 and 4 show these mangroves and the coast grass. The actual varieties photographed are White Mangrove, Avicennia Nitata, Red Mangrove, Laguncularia Racemosa; and the Coast Grass, Paspalum Vaginatum.

There is little doubt that A. Gambiae will breed in 100% sea water as has been demonstrated by Muirhead Thomson and Ribbands and Robertson. The later showed that development time was slowed by high salinity.

In course of extensive survey work on the Gold Coast, West of Takoradi I did some work which I should like to follow up, confirming that high salinity slows development, and suggesting that high salinity also makes for a high mortality during the larval stage. I had noticed repeatedly that not only was there much more breeding in pools in the upper parts of swamps when fed by freshlets, but that I consistently found later stage larvae and pupae much more often in these pools with a greater dilution of fresh water than in neighbouring purely salt pools. Unfortunately, I was trekking about at the time with only the minimum of entomological equipment and I was unable to do salinity estimations. I carried out the following experiments.

(1) I took 100 2nd instar A. Gambiae larvae from what appeared to be entirely sea water and transferred to each of two bowls, 50 larvae. One bowl contained pure sea water and the other the water in which the larvae were found. Each bowl had a bottom of mangrove mud. The bowls were left side by side in the open and left for eight days. I found that the process of removing all larvae for examination at intervals caused such a heavy mortality that I left them as little disturbed as possible.

The results were:-

	Bowl A (Sea Water)	Bowl B. (Breeding Water)
No. died as		
2nd instar	22	28
3rd instar	14	11
4th instar	4	4
At pupal stage dead or alive.	3	8
Pupal cases left	6	9
	49(1 lost)	50

(2) This experiment was repeated starting on the third day of experiment (1) The larvae this time were mixed first and second instars.

	Bowl C. (Sea Water)	Bowl D. (Breeding Water)
Number died as		
1st & 2nd Instars.	40	36
3rd "	2	4
4th "	3	3
At pupal stage dead or alive	4	4
Pupal cases left On 8th day	1	3
	50	50

From which it was concluded that there was confirmation that breeding time was approximately the same as in sea water and that there was heavy mortality.

Experiment (3) I then took 150 1st and 2nd instars from the same area i.e. high salinity water, much as undiluted sea water, and set out the bowls with mangrove mud in thebottoms as follows:-

Bowl E Breeding water.
F Sea Water
G Half breeding water and half fresh water.

At the end of eight days, the results were:-

	Bowl E.	F.	G.
Dead as 1st or 2nd Instars	34	35	20
3rd "	7	4	6
4th "	1	2	7
At pupal stage alive or dead	6	5	8
Pupal cases left on 8th day	2	3	9
	50	49(1 lost)	50

I concluded that there was a suspicion that breeding was more rapid and development more certain when fresh water was added.

I therefore carried out experiment 4.

50 1st and 2nd instars from the same type of pool as before were added to bowls as follows:-

Bowl H	Breeding water
I	½ breeding & ½ fresh water
J	¼ breeding and ¾ fresh water
K	All fresh water.

This experiment was somewhat spoiled by extremely heavy rain which washed away some larvae. It was remarkable how few were lost, for the bowls were perforce exposed in my absence without any protection. The larvae of course seldom come to the surface in rain and they all drop to the bottom at once if drops of water are allowed to fall on a still bowl.

The results at the end of eight days were as follows:-

	Bowl H.	I.	J.	K.
Dead as 1st or 2nd Instars	30	19	20	20
3rd "	6	5	6	4
4th "	1	1	2	4
At pupal stage dead or alive	0	1	3	6
Pupal cases left. on 8th day	2	12	16	12
	39	38	47	46

The remaining larvae were lost.

I have never subsequently, due to my administrative duties, had an opportunity to pursue these results but from this, coupled with my observations in finding so much more abundant and mature breeding in freshlet streams, I incline to regard var melas rather as a facultative salt water breeder.

(ii) <u>The relative frequency of finding of breeding places and the numbers of mosquitoes found at house counts.</u>

The above may explain in part why, when trying to correlate house counts with breeding found; with var melas, the breeding is often plentiful but the house counts are low whereas the reverse holds with A. Gambiae typicus. Another explantion is of course that the var melas breeding places are so restricted as to be easily found whereas A. Gambiae typicus is much more ca-

tholic in its choice.

The 'classical' breeding places of A. Gambiae are open sunny pools exposed to the sun with scanty or no vegetation and especially the pools of casual water which form after rain and which are kept from drying by successive rains for at least a week. In practice, A. Gambiae will breed in the most surprising places especially in towns and villages. I do not propose to go into the details except to emphasise that the more larva hunting I do the more I am impressed by the number of man-made A. Gambiae breeding places; road side ditches, water holes, human and animal foot prints, pools in paths, pools at the side of village watering places and so on.

A. funestus likes more vegetation and partial shade. Rice swamps are favourite spots. A. Funestus is not so dependant on casual water but is more adopted to permanent water collections.

The characteristic finding is, through the dry season (depending on how dry the area is) relatively scanty breeding of A. Gambiae and A. Funestus often with a preponderance of A. Funestus. The first small rain which does not lie long has little or no effect on A. Gambiae breeding but the amount of A. Funestus breeding increases. As soon as the rains inrease there is a most dramatic sudden great increase of A. Gambiae Breeding. A fortnight after the rains start an immense increase of breeding is found in stubble fields old "hump cultivation" fields, cassava patches, maize patches, pools on paths, on roads, and in village compounds, and so on.

This change over to predominantly A. Gambiae production will be discussed further when adults are considered.

3. There are two further points about A Gambiae breeding which are very important when considering control. The first is the speed with which, after rain, a A. Gambiae will develop and multiply. As Dr Bruce-Wilson pointed out after his visit in 1944, we have little exact knowledge about the time this anophelene's egg takes to go through all the stages to adult. Major Berner, U.S. Army is working on this point now in Accra. It is almost certainly a very short time - much shorter than usually described, probably it can be complete in five days. The small daily range of relatively high temperature and abundant feeding probably supply the optimum conditions.

Major Mattingly tried repeatedly to see whether A.Gambiae eggs partially dried in mud would survive but he always failed. It is possible by careful filtering to find eggs in <u>liquid</u> mud at the bottom of rapidly drying pools. These can be made to complete development by keeping the pool with a minimum of water in the bottom by adding water as often as is necessary.

The practical application of the sudden increase in breeding is that an inexperienced man in charge of a control scheme(experienced men too!) can be caught unprepared by the sudden discovery that breeding is so widespread as to be beyond control with his existing staff and equipment.

(b) <u>Adult Mosquitos.</u>

The following anophelenes have been found at various times in house catches in West Africa by Army Malarologists and Entomologists. Those marked @ have been proved to be infected. Those marked % have been found infected in other parts of the world but not by Army workers in West Africa.

Anoplese Gambiae Typicus @

Anoplese Gambiae Var Melas @

Anoplese Funestus @ (The single name is used though probably future work will enable separation of the "Funestus Group" into definite members or sub-species).

A. Hancockt	@	A Nili @	
A. Coustani Group	@	A. Marshali Group	%
A. Pharoensis	@	A. Rhodesensis	%
A. Squamosus	@	A. Wellcomeli	%
A. Smithii	@	A. Cinctus.	
A. Maculipalpis	@	A. Moucheti	%
A. Obscurus		A. HARGREAVESI	@

For practical purposes only A. Gambiae and A. Funestus need be considered as influencing the malaria rate, although especially in Sierra Leone Area A. Nili and A. Hancocki have been found infected frequently.

It is extraordinary how inexact is the information available about these Mosquitoes.

The best key to the West African Anophelenes is that of Mattingly (1944).

There are innumerable Army reports of indentifications and house catches and larval findings all over West Africa, some are very complete and extending over long periods, others are most incomplete or extend over short periods. The following are some of the mistakes or omissions which made the information much less useful and which makes confirming of relative Mosquito incidence quite impossible.

(i) "House catches" in which the number of rooms or/and number of occupants are not stated.

(ii) "House catches" in which the method of collection is

not stated i.e. whether by spray drop or sucking tube

(iii) House catches in which the time of day of the catch is not stated.

(iv) A series of house catches which is not correlated with rainfall.

(v) House catches of one season compared with those of a previous season in which one series has been done by one person and another by some one else and in which success of control is alleged when any of the above discrepancies may have occurred.

It cannot be too strongly stressed that such inexactitude renders well nigh useless an immense amount of effort.

There are a few properly controlled series of house counts and observations on flighting times of Mosquitoes. These, together with a vast amount of miscellaneous information collected at reconnaissances for Camp sites, and surveys done in various stations, are sufficient to give a reasonable complete picture of the habits of Anoplese Gambiae and Anoplese Funestus, though there are large gaps which will require years of study to fill.

The proportions of the two mosquitoes follow those of larval findings. From one or two of each of these mosquitoes per room, in course of a fortnight the findings will be three or four hundred A. Gambiae, and 60 or 70 A. Funestus while in six weeks counts up to 2000 A. Gambiae per room are by no means unknown.

Graph (3) from figures produced by Major A. S. Daly in Gambia illustrates this phenomenon well.

(c) Conditions in "undisturbed" villages.

In May 1944, I began to survey with the assistance of two N.C.O. entomologists and eight trained mosquito boys, a series of villages in the Western Coastal Forest of the Gold Coast. These villages were of especial interest as being 'bush' villages and with two exceptions were well away from the main roads. Two were on a side road along which not more than one or two vehicles a week would pass and the rest were from one to six miles from any road. Some had not been visited by Europeans for four or five years. The object of the Survey was to find villages with as large as possible a mosquito population for trials of D.D.T. spraying from the air. Incidentally I was given a task with two sets of incompatible conditions, for I was instructed by high authority to select areas with the thickest possible forest which contained human habitations and in which there was prolific mosquito breeding which could be checked by house counts. The incompatibles are - that round villages there is never very thick forest for each village makes its own clearings for cultivation, and that in West Africa, prolific mosquito breeding does not take place in the forest. The mosquitoes which are found in house counts are open-to-the-sun breeders.

The following points were outstanding.

In spite of having an experienced staff it was always extremely difficult to find breeding sufficient to account for the house catches, even although we searched in lines yard by yard.

There were three places which were especially prolific sources of anopheleine larvae (i) Inside the village

itself. The most careful search was necessary but ultimately a few pools or domestic containers were found, which yielded larvae. To read any of the usual literature on A. Gambiae would not lead you to expect its common breeding in the black earthenware pots where we found them so often. (ii) The place where the water for the village was drawn. This was always at a small clearing beside a stream and the breeding places were depressions and footprints in the mud. (iii) There is one place to which an African villager will never lead you and that is to the women's washing place. Each village has a recognised pool which the men avoid and which is tucked away somewhere within half a mile of the village. Almost invariably there are breeding places in the mud and ponding on the banks of these 'mammy pools'.

(d) The Habits of the Adult Mosquitoes.

A newcomer to West Africa, even although he has been elsewhere in the tropics commonly remarks after about a fortnight "but there are no mosquitoes". Many an officer, including Medical Officers are still diligently searching for their first Anophelene mosquito after their first attack of malaria! Not a few are so convinced that there are no mosquitoes that they seriously doubt whether malaria is so transmitted! This may sound like gross exaggeration but I affirm that it is not.

Now the reason for this state of affairs is that firstly A. Gambiae and Funestus probably prefer to bite Africans and so they are not attracted in very large numbers to rooms occupied by Europeans. Secondly, both are very small (they can get through 16 TO INCH, 30 S.W.G. mosquito netting) and they are not only inconspicuous but noiseless in flight. Thirdly, their bite is painless

and is not usually followed by a reaction. A wheal following a bite means a Culicine bite unless in unusually susceptible individuals.

These attributes of As Gambiae and Funestus, together with their well known efficiency as transmitters, are the reasons why people are caught off their guard and why it is frequently so difficult to persuade troops of the necessity for measures of personal protection.

A great deal of work is required to be done on the flighting range of these West African Species AND The following outline observations require to be followed up when more staff and time are available in time of Peace. Kibbands in Gold Coast in 1942 conducted experiments to try to determine the times of movement in and out of habitations.

With sunset at 6.30 P.M. he discovered that of 566 female A. Gambiae caught over 21 days -

8.8% entered before 8. P.M.
30.1% " between 8. P.M. and 10. P.M.
40.1% " between midnight and 6.A.M.

Of 693 A. Funestus females caught over 31 days - sunset 7.P.M.

18.2% had entered before 8.P.M.
23.5% entered between 8.P.M. and 10.P.M.
36% " between midnight and 6.A.M.

The rest of the mosquitoes were 'lost'.

It seemed from his and other observations, that once in a house, mosquitoes do not normally leave before dawn.

The sooner after dawn that mosquito counts are carried out in houses, the more will be found there. If an African hut in a heavily infested area is visited at 6 A.M. dozens of females can be seen in a lethargic state, engorged with blood, hanging on to the walls. They are so sleepy, that I have drawn circles round them with a pencil and noted when they

left. At 7 A.M. one morning near Axim, I marked with circles 22 mosquitoes. They left as follows:-

7. - 7.30	5.
7:30- 8	2.
8.-8.30	10 (Some disturbance in the room)
8.30. 9	2

The remaining three had gone when I returned at 10 A.M.

I think that all of these mosquitoes flew out of the house and did not merely find a hiding place. At 10 A.M. a pyretheum drop count was carried out in the room and only three females were found, two of which had had a recent blood meal.

Work in East Africa using tents (Bagster-Wilson personal communication) indicates that probably A. Gambiae does not settle on walls until it has a blood meal and that it usually does thereafter. I have gained the impression that after a Female Anopheles Gambiae has had a full blood meal, she is <u>unable</u> to fly before she has a rest on the wall.

Major Berners U.S. Army working in Accra, has correlated a long series of most accurately recorded catches in man-baited 450 cub. ft traps, with local metereological conditions. A storm of thunder, wind and rain at night is always followed by a marked over all reduction in the catches in the traps. Some may have more but the total is smaller. A storm of a similar type during the day seems to have no effect whatever on the trap catches. From which it could reasonably be surmised that A. Gambiae (the mosquito) by far in the majority in catches) is flighting to the human habitation at night.

Accurate work on the range of flight of A. Gambiae has not been done but there can be no reasonable doubt from a consideration of a vast number of isolated happenings

in carefully controlled schemes such as Accra and Takoradi that in the ordinary strong South West wind, mosquitoes infiltrate in from up to three miles while a night of increased wind results in presumptive evidence that infiltration is taking place from at least twice that distance.

Dr Carmichael Wilson who was formerly anti-malaria officer for merchant shipping in West Africa has told me of his personal experience in a ship in the early morning, 20 miles off Dakar. Thousands of A. Gambiae were blown aboard. This must be an exceptional experience and was probably due to a rising mating swarm being caught in a strong easterly current.

(C). Malaria in the Army.

1. The Incidence
Malaria rates by colonies, 1941-1944

In the table below is shewn the ratios of the numbers of attacks of Malaria per 1,000 of average strength per annum. In addition, as is usual when giving Malaria rates, the Hospital Admissions - all causes (including Malaria admissions) are compared and for convenience, the percentage due to Malaria of total Hospital admissions is given in another column.

	1941			1942			1943		
	Ratios per 1000		%	Ratios per 1000		%	Ratios per 1000		%
	Malaria	All Cases	% Malaria	Malaria	All Cases	% Malaria	Malaria	All Cases	% Malaria
Gold Coast	1001	1737	57.6	870	1585	54.9	460	1432	32.8
Nigeria	564	968	58.2	525	907	57.9	462	1186	38.9
Sierra Leone	984	1804	43.4	751	1583	47.6	370	1017	33.3
Gambia	662	942	70.2	1071	1852	57.8	483	1162	41.5
Whole Command	815	1620	55.2	762	1436	53.1	442	1157	38.1
	1944								
Gold Coast	243	1021	23.4						
Nigeria	399	1332	30.0						
Sierra Leone	60	677	8.8						
Gambia	175	826	21.2						
Whole Command	278	1105	25.1						

Graphs 1 and 2 shows the Malaria and Total Admissions by ratios per 1000, by 28 days periods, by Colonies.

2. Notes on compilation of the above Statistics.

(a) Source of Malaria Figures.

The numbers of cases of Malaria are taken from weekly returns of cases admitted during the previous week. The numbers are the totals of "Clinical" plus "Proved" Malaria, and I have carefully checked them against the discharges of Malaria for the years 1943 and 1944. The difference between the two is not great. About 3% of the cases given in the weekly returns as Malaria are not discharged under that diagnosis. For 1941 and 1942, documents are not available for checking as some of the Hospitals have since moved elsewhere. I have, however, checked the Admission and Discharge Book of one Hospital which has 200 beds for Europeans and found 4.2% of the Malarias said to have been admitted not accounted for in discharges.

In view of the above, I have left the bulk figures for Areas given in the tables without adjustment and they are, I believe, reasonably comparable year to year, Hospital to Hospital and Area to Area.

As no one is allowed to be "sick in quarters" for more than 24 hours and the rule is kept, only hospital admissions are given, though no doubt a few "coasters" of old standing were so foolish as to treat themselves through an attack.

(b) "Proved" and "Clinical" - Criteria of Diagnosis.

It is essential, when I am taking the total of "Proved" and "Clinical" Malaria to represent the gross Malaria figure, to show that such a figure is a reasonable

indication of the incidence of Malaria and that variations in rates are not controlled by different standards of diagnosis of "clinical Malaria".

This at once raises the old question of the diagnosis of Malaria, especially Malignant Tertian. M.T. Malaria is by so far the commonest Malaria in Europeans in West Africa, that the numbers will mask the ~~most~~ MUCH smaller incidence of Benign Tertian and Quartan. The routine which has always been followed has been firstly that unless a patient is very sick he will not be treated with quinine or mepacrine until either parasites have been found or if after exhaustive search, none have been found, it is thought necessary to try the effect of these drugs.

(i) The attitude of the Clinician to the question.

Some tend to diagnose every febrile condition as Malaria although an attempt has been made to limit the diagnosis to cases of Febrile illness in which no parasite is found; in which the spleen is tender and/or enlarged and in which exhibition of quinine or mepacrine appears radically to have affected the course of the illness.

On the other hand the attitude of many clinicians, especially those who have practised in parts of the Tropics where Plasmodium Vivax is the common parasite and where drug Prophylaxis is not practised, is to regard the diagnosis of "Clinical Malaria" as almost disgraceful.

The cases which are usually in dispute, are those admitted with 'low fever'. It cannot be too often impressed on clinicians, new to West Africa, that in about 10% of all proved cases of Malaria, the presenting symtom is respiratory, and that this sympton is commoner in the less severe cases. A febrile cold or chill, in

which the temperature does not settle in 48 hours in Hospital very often proves to a case of malaria.

Ferryman (1944) working with R.A.F. patients in Takoradi, in 136 'virtually consecutive' cases admitted as low fever, found parasites in 66% after careful examination. He insists that deterioration or continuance of the condition of 'low fever' patients after 48 hours makes the diagnosis extremely likely.

Hughes and Bomford (1944) in an Army Hospital, in 968 proved cases of malaria found the parasites in 84% of cases within three days and the rest at longer intervals before the treatment was started.

I therefore believe that, to exclude 'clinical' malaria from estimates would be wrong when using them for the purpose of estimating wastage from malaria in military practice. I feel pretty sure that, when dealing with M.T. malaria in a busy military Hospital probably in only 50% of cases will parasites be found before it is deemed desirable to start treatment.

The last difficulty is in the case of febrile illness in which parasites are found in the blood, but the disease is not like malaria. Especially when suppressives are being used it is not uncommon, as will be shown later for perfectly fit men to have parasites in the blood.

(ii) The Industry and Experience of the Microscopist.

The thick film technique is very reliable to the experienced, but even using it, a proper examination of a slide takes a long time. When a technician is faced with a very large number of slides, if he is slack he fails to find parasites, if he is very slack he finds them !

On several occasions, I have personally examined a few dozen slides just examined by an experienced and cautious technician. A hundred fields have been examined in a thin film. There has never been more than two slides of a difference and as often as not the finds and misses have cancelled out.

Two of the Malariologists in the Command sat down and examined in service men, 200 slides of which about 42 were agreed as positive, 2 were, in addition found by one of the "contestant". In other words, granted reasonable experience, the deciding factor is the concienciousness of the microscopist.

It is obviously impossible to estimate the number of positive slides which are missed.

(iii) The Facilities available for Diagnosis.

The diagnosis of Malaria requires only a microscope with an oil emersion lens and a stain which will give a good contrast. These are available to all isolated medical officers. The vast majority of cases of Malaria are and always have been admitted to a Military Hospital.

In a few "bush" stations there is only a Camp Reception Station or even a Unit sick bay. Nevertheless, even there, there is always a microscope so that the only factor is again, the experience of the Medical Officer who examines the slide.

An occasional case occurs during bush exercises - If it is severe, it is admitted to Hospital, if not, it does not appear in returns.

The proportions of Proved to Clinical cases cannot be given accurately for 1941 and 1942 but those for the succeeding years are as follows:-

	1943		1944	
	Proved	Clinical	Proved	Clinical
Gold Coast	1	1.10	1	1.31
Nigeria	1	1.18	1	1.16
Sierra Leone	1	0.90	1	1.03
Gambia	1	0.91	1	0.75
Whole Command		1.11	1	1.22

(c) "Attacks" of Malaria.

It will have been noted that the ratios are always "attacks", of Malaria per 1000 of average strength. This means what it says - three attacks in one individual will be recorded three times. It is quite impossible in our present state of knowledge to differentiate between relapses and re-infections in M.T. Malaria in West Africa.

So unless a patient is re-admitted with parasites in his blood within twelve days, it is counted as a new attack.

In Military practice, we want especially to avoid time in hospital and it is the attacks as defined here, which matter.

(d) Malaria Contracted or Manifesting itself in other Stations.

No attempt has been made in the bulk figures (or later in station figures unless specifically mentioned) to allow for Malaria contracted elsewhere.

With a few exceptions, a station probably receives as many as it passes on. The notable exception is Freetown where especially in theearlier years, many infections were contracted in ships in the harbour, and others in the Transit Camp. The new-comers in transit developed Malaria 10 - 18 days later in other colonies. I have found it impossible to collect sufficient data to make adjustments.

(e) Suppressive Drugs.

When considering all figures, it should be borne in

mind that with the exception of groups used as controls in experiments as mentioned later, suppressives were taken as follows:-

Jan 1941 - Mar 1943	Quinine gr V. per day
Mar 1943 - Oct 1943	Mepacrine gm 0.4 per week
Oct 1943 - May 1944	Mepacrine gm 0.6 " "
May 1944 - Dec 1944	Mepacrine gm 0.7 " "

The conscienciousness with which the suppressiveness have been taken has steadily improved.

Probably all over the Command now about 90% take ~~as~~ more than 0.6 gm Mepacrine per week. This will be discussed in detail later.

(f) Strengths.

The greatest of care in the collection of figures indicating the number of cases of Malaria which occur would be entirely wasted unless the strengths on which incidence ratios are calculated are accurate, precisely defined, and comparable both from year to year and between Colonies.

It is to be noted first that the ratios are "so many per 1000 of "average strength", not the "total strength" which would be the total number exposed to infection or as the insurance companies would say "at risk".

It is impossible to keep track of those who arrive from or are posted to the United Kingdom. It is even more difficult to reckon the amount of interchange of personnel between colonies.

Yet the "average strength" is a bad figure for determining the Malaria incidence for as will be shown later, newcomers have been much more likely to contract Malaria, while much Malaria is also contracted in local travel, because many people fail to take their suppressive for one reason or another at such times, they are exposed to fatigue on long road, rail and air journeys

and they tend to arrive or depart in the hours of darkness without changing into protective clothing.

So that, where there is much turn over in population especially involving newcomers from Britain, the number of Malaria cases increases. If we take the average strength for calculating the ratios, there will be no indication in the strength figures of these changing populations which cause increase of Malaria totals, so that the incidence of Malaria would appear to be unduly greater than it really is in Areas or stations where there is much change in population.

A concrete example of the effect of a greater population turn over is afforded by Nigeria. This will be discussed in more detail later, but Nigeria, being the great assembly and training ground of the formations which went overseas, received very large numbers of Officers and B.N.C.Os and after a few months sent them off again. This is, I think, a very real reason for the failure of Malaria rates to fall as drastically as in the other colonies.

But the total strength, to be at all accurate would require to take into consideration two other factors of which one is impossible of calculation. These are, the duration of stay, and the season of year or arrival on the coast.

It would have been possible by enormous effort to work out a total number of "exposure months" but the season of the year and the increased liability to infection of new personnel from U.K. in short stay would invalidate this figure.

The most easily available and consistant strength

figure is that of ration strength. This figure varies directly as the Military population.

The arithmetic mean of daily ration strength is the figure used in all calculations. Where there has been any rapid change in population etc. this is always noted when Malaria incidence is considered in any particular station. Variations of strength are shewn on Colony Graphs for easy reference.

To sum up then, while there is no suggestion that the rations are accurate, it is considered that they are as accurate as are ever obtained for Health Statistics of any kind except those within a closed community. If they are considered in the light of the known factors when tend to influence them, they are of value.

THE GAMBIA

Chapter III

(A) The Climate.

The Seasons in Gambia are much more marked than anywhere else in British West Africa with the possible exception of the near-desert thorn country in the far north of Nigeria. For five or six months from November onwards, the climate is dry and pleasant with a marked night drop in temperature. In December, January, February and March, the dry wind which blows intermittantly from the Sahara - the Harmattan - is invigorating, and there may be a daily swing of temperature of as much as 40 degrees Farenheit. During the six months of the dry season, the rainfall is negligible, seldom aggregating more than an inch. Relative humidity has a big daily range although consistantly low during the Harmattan, while the daily temperature variation is from about 92 F. to 60 F. The wind is more or less steadily from the North - West except when the Harmattan blows from the North.

The entire annual rainfall of about 52" at Bathurst and less inland normally falls between April and October, being usually maximum in August. The effect of this relatively large fall over a short period is most depressing and unpleasant. Until quite recent years, only a skeleton staff of Europeans spent the rainy sea- in the Colony. In older times, the Governors usually retired to Madiera for a course of treatment of their gout.

During the rains, the maximum daily temperatures will average about 87 Degrees F but the daily fall at night is much less than in the dry season, an average early morning temperature is about 69 degrees F. The

relative humidity is continually high, on a twenty four hour average about 80, and as a result, the skin is continually not moist but wet, while books, leather etc. grow luxuriant crops of mould. It is characteristc of Gambia that during the rains, some falls nearly every day and that very large falls on a single day are uncommon. The wind is steadily from due West during the rains.

(B). The Country.

As will be seen from maps 1 and 2 The Colony is simply a strip of about ten miles on either side of the Gambia river for about 200 miles inland. The main Military Stations are in Bathurst and the Cape St Mary Peninsula, although there are odd small bodies of troops on the North Bank of the River.

This must surely be the most backward of British Colonies. Bathurst, built on a swampy Island, nowhere more than 18" above spring tide level, was described by G.M. Findlay as "a sponge which alternately with the tides, sucks up and squeezes out its own excrement". The town is built on the only semi-solid ground on the island. To add to these natural disadvantages, the few drains in the town are so levelled as to retain water all the year round. Photographs (1-8) which I took early in 1944 shew the prevailing conditions.

The river is tidal for about 100 miles from its mouth and the banks are mangrove swamps and rice swamps. Even Cape St Mary is surrounded by swamps and intersected by tortuous streams with channels cut deep in the sand and ironstone laterite. The whole surface of the Cape is pitted by depressions from old cultivation and shallow wells. There has never been any serious attempt to control water in order to check mosquito breeding, anywhere in the Gambia. The greatest extent of mosquito control attempted has been a rather incomplete Aedes Aegypti campaign which

is confused in the minds of the Africans certainly and of many Europeans, with Malaria Control.

It will be seen that conditions were to say the least far from favourable for British Troops who have been stationed there during this war.

(C) Malaria during the present War.

As would be expected from what has been said about climate, mosquito densities and malaria are much more seasonal in the Gambia than elsewhere in West Africa. Nevertheless there is no completely free season as in countries with a real winter, and in which Benign Tertian is the common malaria.

(i) The Mosquitoes and their infectivity.

Major A.S. Daly of a Malaria Field Laboratory was sent to Gambia in with a laboratory assistant and equipment from November 1942 to December 1943. He made the first really complete study of Malaria in the Cape St Mary and Bathurst area. Much of his information is quoted below.

In October and November 1941 Ribbands and Robertson of the same laboratory had done a preliminary spraying and in a total of thirty seven rooms examined in Bathurst and Cape St Mary the Anophelene counts were as follows:-

A. Gambiae. (15.1% males)	6530	or	90.5%	of total	Anophelenes
A. Funestus (6.6% males)	615	or	8.5%	" "	"
Others (As Pharoensis (& rufipes)	63	"	1%	" "	"
	7208	"	100%		

Daly analysing the results of 815 spray catches in which 7295 anophelenes were captured, reports identifications as follows:-

A. Gambiae Typicus.	7081	96%
A. Gambiae var Melas	75	1.03%
A. Funestus.	135	1.85%
A. Pharoensis	4	0.027%
	7295	

The higher proportion of A. Funestus group in Ribbands and Robertson's figures is accounted for by the season of the year. At the end of the rains, there is a slight increase in Daly's figures also.

Subsequent house catches and identifications have had of necessity to be done by a series of Sanitary Inspectors from Field Hygiene Sections who have had a variable degree of training and skill but they confirm that in 1944 Anopheles Gambiae was by far the commonest anophelene to be caught in house catches. In no observer's results have culicines exceeded 1% of the total.

Graph 3 is compiled from Major Daly's data and shews clearly the characteristic tremendous rise in total house counts accounted for almost entirely by anopheles Gambiae. The results are all from the town of Bakau and twenty comparable huts were catch sprayed weekly.

Daly's results for the dissection of Mosquitos are given in the following table

Species	No.	Sporozoites		Oocysts		Gross	
		Plus	% Plus	Plus.	% Plus	Plus	% Plus
A. Gambiae.	882	34	3.9	53	6	85	9.6
A. Gambiae. var melas.	55	0	0	1	2	1	2
A. Funestus.	78	0	0	8	10	8	10
A. Pharoensis	7	0	0	0	0	0	0
Totals,	1022	34	3.3	62	6.1	94	9.2

These figures are high and they were obtained in a village where daily large scale house spraying was in progress.

These infection rates increased month by month even with the rapid increase of the mosquito population. From his data Daly estimates that the average number of re-infections per head of population in Bakau during the period was at least 50 per annum, even if each infected mosquito is allowed only one bite.

Unfortunately there are no other available figures for infectivity rates as a full time malariologist has never been stationed in Gambia, except during the year of work by Major Daly.

(iii) Endemic Malaria in the Civil Population.

(a) Evidence from spleen rates.

The following table gives the findings of various Army Observers during the present war:- All in children of age groups 2-10 years.

Year	Month	Town or Village	No. Examd.	Plus	%Plus	Observer.
1941	June	Bakau	75	50	66	Brig.G.M.Findlay
1942	Mar.	'Ten villages on North Bank'	?	?	51	Lt.Col.A.S.Gilroy
1942	Dec.	Bakau	50	34	68	Maj. A.S. Daley.
1943	Jan.	"	50	33	66	" "
1943	Feb.	"	82	42	56	" "
"	Apr.	"	77	35	45	" "
"	May	"	100	37	37	" "
"	June	"	66	25	38	" "
"	July	"	50	31	62	" "
"	Aug	"	50	29	58	" "
"	Sept	"	85	54	63	" "
"	Oct	"	50	33	66	" "
"	Nov	"	50	33	66	" "
1944	Jan	"	73	49	77	Lt.Col.A.C.Stevenson.
"	"	Sukuta	120	76	63	" "

(b) Evidence from Parasite rates in Children.

Again our only information is from Daley. During the period in which he worked in Cape St. Mary, over 50% of the total children examined on any one occasion consistantly had parasites in their blood.

(iv) Malaria Rates in the Army.

From the foregoing, and knowing the efficiency of A. Gambiae as carrier, it is not surprising that Gambia has always had a particularly bad reputation as a Military Station.

The following table shews the data relevant to the incidence of malaria in troops during this war.

Year	Ratios per 1000 of strength.		% of Total Admissions due to Malaria	Cases of Black-water Fever	Total Rain-fall	Average Strength.
	Malaria admissions	Admissions all Cases				
1941	662	942	70	1	32"	524
1942	1071	1852	58	15	51"	1650
1943	483	1161	41	5	49"	1203
1944	175	826	21	0	61"	593

It is permissible to deal with all the troops as if in one station for with a few exceptions, they have all been concentrated in a relatively small area and the climatic conditions are approximately the same. There is no question of course, that to live on the coast of Cape St Mary is to run a much lesser risk than to live in Bathurst but the control problem is roughly the same.

GRAPH 4 gives the rates, strengths ~~ratios~~ and rainfall by four week periods.

For comparison, and to increase the value of an opinion that active measures have reduced the incidence of malaria in the troops, it would be of importance to give comparable statistics covering the periods before and during the years under review in the Civil European population. Unfortunately there just are not any statistics which are of great value. Gambia Figures are of the usual variety published by the Medical Department Annual Reports. Herewith the Pre-war figures:-

Civilian Officials - Gambia.

Year	Average Strength.	Hospital Admissions for Malaria	Ratios of admissions for Malaria per 1000 of average strength.
1926	50	13	260
1927	53	14	267
1928	48	10	208
1929	61	22	360
1930	39	6	154
1931	45	17	377
1933	33	10	333
1934	50	11	220
1935	57	13	226
1936	59	18	305
1937	51	8	157

All I can elicit is that the War time figures for Hospital Admissions for Malaria are in no way abnormal and that in the opinion of the small Medical Staff of the Colonial Medical Service not more than one attack in three is admitted to Hospital. There is no question but that the figures given above are not comparable with Army figures, and to compare with the military system of every attack going into Hospital, THEY would require at least to be doubled. The attack rate in non-official ~~gardens~~ EUROPEANS is unknown but is reckoned to be much higher.

For completeness, the Hospital admission Rates for African Troops per 1000 of Strength per annum are given below. The rates for 1941 are of rather doubtful value as I have been unable to check them against the Hospital Books.

YEAR	Ratios per 1000 of Strength Hospital Admissions.		% Total Admissions due to Malaria.
	Malaria.	All Causes	
1941	89	500	18
1942	94	881	10.7
1943	51	803	6.3
1944	74	852	8.4

The most notable aspects of all these statistics is the steady reduction in Hospital Admissions DUE TO MALARIA in Army Europeans since 1943 and the diminishing proportion of the total sickness which is caused by this disease. The reduction in Blackwater Fever is dealt with later for the whole Command. The African troops, who do not take any anti-malarial precautions, continue to have very much the same amount of malaria, and there was quite a sharp rise after the rains in 1944.

During 1941 and 1942, there was a steady influx of European Troops into the area and this increasing proportion of susceptibles undoubtedly contributed to

the abnormally high incidence in 1942. In addition, these troops arrived at hastily prepared camps and were often on long exercises involving night work and bush camps. The suppressive employed was quinine.

The problem of Mosquito Control in Gambia is so enormous that no serious effort has ever been made to tackle it. There are three main problems in larval control. The first is the huge area of swamp and lagoon which may be seen in sketch Map 3 and which is untouched. These are A. Gambiae var Melas breeding areas. The second source of prolific breeding is a series of deep cut, tortuous streams with side channels and rocky pools notably the Sando River which enters the sea at Kotu, South-West of Cape St. Mary. These two, the swamps and the streams, provide the site of most of the dry season breeding. The Tidal swamps could be controlled and the land reclaimed by bunding, while the streams are relatively amenable to canalization and larviciding but the third source of breeding is almost impossible of control in our present state of advance. This is the breeding which occurs all over the Cape St Mary Peninsula on cultivated patches, rice swamps, shallow wells, foot paths etc in casual water during and after the rains. After a heavy day's rain, the whole countryside is broken up by small lakes which quickly subside leaving pools behind everywhere.

The natives use hump cultivation; that is, instead of ploughing and furrowing, they plant their vegetables, groundnut and cassava in little mounds about a foot to eighteen inches high. The 'borrow pits' from which they scrape up the soil are left between the mounds. Then in the dry season they are accustomed to dig shallow wells

at each patch of cultivation. After one or two years cultivation, leaving the land fallow (and pitted), they pass on to another patch where they duly dig another well. As a result the whole surface of the peninsula is irregular and full of depressions which are ideal for anophelene breeding, for A. Gambiae when bare and for A. Funestus when grassy.

Very little work on larval control has been attempted by the Army. Dry season partial canalization of streams has been attempted without notable success. Too often, an entire dry season's work is rendered useless by the first storm. Oiling and Paris green dusting round camps has always been carried out, but each year, breeding, even close to camps has been completely out of control for a period of six weeks in the wet season. Since the rains of 1944 we have had the loan of two bulldozers and an attempt has been made to level the ground for a mile radius round each camp and to make paths through each area so as to zone it for the purpose of easy oiling in the rains.

The main attack on the mosquito has always been house spraying of native villages and this has been carried out for longer, on a big scale, than at any other place in the four colonies. Bakau for example has now been sprayed daily during the rains and twice weekly during the dry season for over three years. In 1944 the system was extended to ensure that every native habitation within two miles of a military station was sprayed. The only exception is Bathurst Town where a few troops are located. The task there is too big and the Civil Medical Department cannot help.

D.D.T. is going to be of immense value in the Gambia. Commencing in January 1945 all villages are being sprayed once in six weeks to give a dosage on the

surfaces of 75 mgm D.D.T. per square foot. Preliminary findings in Gambia and elsewhere indicate that the time between sprays will probably be able to be considerably lengthened especially in the dry season. The use of D.D.T. will enable labour and money to be diverted to anti-larval work.

It will be appreciated from all the foregoing, that unless there is some unknown epidemiological variation it is unlikely that the reduction of malaria in Gambia over the three years is due to mosquito control. The main causes for the fall must be attributed to lesser exposure of troops due to static conditions and better accommodation, and mepacrine suppressives. The ~~latter~~ LAST will be dealt with later.

S I E R R A L E O N E

Chapter V.

(A). The Climate.

There is a larger annual rainfall in the Southern part of Sierra Leone than in any other parts of British West Africa (See Map 1). In Freetown the annual total averages about 150 inches while in an exceptional year 250 inches have fallen. The difference in climate between wet and dry season is much less marked than in Gambia though there is no doubt to anyone stationed in Freetown whether they are experiencing the one or the other.

In Freetown, December, January and February are the only months really free from rain and the Harmattan blows intermittently during this period. Even in the course of this short dry season, there is usually a fall of about three inches of rain. This usually falls during and after the "Bullams", which are tornadoes so named because the first warning is usually the accumulation of clouds over the Bullam shore on the other side of the estuary from Freetown. They blow at the beginning and end of the rains.

July and August have the heaviest rainfall and thereafter the rains dimimish steadily. Over the whole year, rain falls on about half the days and five inches of rain in one day is quite common.

There is remarkably little variation in the temperature the year round. In the dry season there is not uncommonly a daily variation of up to 15 degrees F but the average daily range is about 10 degrees F and the extremes are 89 degrees F and 72 degrees F. During the rains, there is seldom as much as 10 degrees

F. daily range and the extremes of daily range are approximately 88 degrees F and 72 degrees F.

The humidity is invariably high, Even in the season of the Harmattan it seldom falls below relative humidity 60, while the normal daily range during the rains is from about 93 to 75.

The wind at Freetown is always South-West with the exception of the time of the Harmattan and when tornadoes are blowing.

Inland, the rainfall is less than on the coast, though even in the far north it is about 80 inches per annum. The daily variation of temperature is more marked, especially in the hills where it may fall as low as 55 degrees F at night.

It will be realized from the above resume that everywhere, the deciding factor in personal comfort is the breeze and that protective anti-mosquito clothing is not popular.

(B) The Country.

Only Freetown will be considered in detail, as over 90% of troops have always been in Freetown and District. Freetown, (Map 5) is fringed in the sea by mangrove swamps in most areas, these being succeeded by a narrow coastal strip of relatively flat country and then by irregular hills within a mile or two of the sea, rising as high as 25000 feet. These hills are thickly wooded and have a much higher rainfall than Freetown itself. From them descend a whole series of rivers and streams in deep, irregular, pooled channels in the laterite. In addition, the hillsides have many seepage areas some well inland, and some right down at the sea. In the latter case, these freshlets often feed the upper ends of mangrove swamps.

Sanitary conditions are primitive in Freetown. There is no water borne sewage system and the streams are extremely foul even the running water having a saline ammonia content of 20 parts per million in the dry season. The main streets are adequately side drained but the side streets are just laterite, pitted with hollows and edged(or even crossed!) by thousands of tortuous earth drains with irregular pooled bottoms. These drains overflow with each big fall of rain, leaving every hollow in the laterite a puddle. In the rains there are an immense number of such pools all over the town, in the yards of and between the native shanties. In the sub-urban and rural areas, round Freetown, there is in addition, as in Gambia, much 'hump cultivation' which results in hollows and depressions.

The soil, the layers of which lie revealed in the deep cut gorges of some of the streams, is on top of a thin layer of clay sand humus and laterite. At varying depths of an inch to three feet, there is a rock like layer of laterite conglomerate of depth varying from one to forty feet. There are then succeeding layers of hard and soft laterite. The results of these formations which interest the Malariologist are that the top and any subsequent hard layers exposed will hold pools, while if a hard crust is broken through, by natural erosion or artificial drain cutting, the soft layer underneath will rapidly be washed away thus undercutting the banks of rivers or streams. For the same reason, any hillside in which these strata are exposed will show seepages and springs after rains. It will be appreciated that control of surface water is extremely difficult in such geological formations especially in an area with so heavy a rainfall.

(C). Transmission of Malaria - The Mosquitoes and their infectivity.

There is a very large literature on the Mosquitoes of Sierra Leone, commencing with the early work of Sir Ronald Ross and continuing with the many papers from the Alfred Jones Laboratory of the Liverpool School of Tropical Medicine. The outstanding impression from these papers is that, while the mosquitoes have been known and classified for many years and their relative importance recognised, the sources of breeding sufficient to account for the adults have been sought, 'up hill and down dale', in Mangrove Swamps and in hill side streams around Freetown while the vast majority of breeding places have in fact always been inside the native town.

In the annual report of the Medical Department for 1938, the following figures are given for Anophelene mosquitoes found by workers from the Alfred Jones Laboratory during that year:-

Larvae Identified:-	A.Gambiae	1,174.
	A. Funestus	158
	A.Rhodesiensis	52
	A. Coustani	250
	A. Hargreavesi	90
	A. Squamosus	249
	A. Hancocki.	46
	A. Obscurus	30
	A. Nili	2.
Adults identified:-	A. Gambiae	745
	A. Gambiae var melas	37
	A. Funestus	152
	A. Coustani	44
	A. Hargreavesi	1
	A. Squamosus	4
	A. Hancocki	5
	A. Marshalli group	2

Army observers have found all these and the following have been found to be infected:-

A. Gambiae Typicus
A. Gambiae var melas
A. Funestus
A. Nili
A. Hancocki
A. Hargreavesi

These bulk numbers do not of course represent a fair proportion of the various types of mosquito, for the density varies from place to place and at different seasons of the year. The Gambiae: Funestus ratios vary in the same manner as described for the Gambia while the others are mostly found in association with streams.

Probably vectors other than As. Gambiae and Funestus play a greater part in malaria transmission in Freetown than anywhere else in West Africa. Nevertheless, A. Gambiae and A. Funestus over all account for over 90% of all adult mosquitoes found in houses and for about 98% of all mosquitoes found infected on dissection. A. Nili breeding is relatively common in the pools by the streams especially in their higher reaches, and Lt.Col. R.F. Tredre of a malaria Field Laboratory found sporozoite rates of 7.6 to 9.1% in this species in Grafton (Map 4) in 1941. Nevertheless as a practical consideration, only A. Gambiae and its var melas, within local areas (Such as Kissy (Map 4)), and at certain seasons of the year A. Funestus ,are of practical importance as malaria vectors.

The Western end of Freetown is an area of mixed A. Gambiae Typicus and Melas breeding. Both drift out to shipping in the estuary. Urban Freetown and Kissy are predominantly A. Gambiae typicus producers Wellington further East is mainly a var Melas area.

A. Gambiae var Melas breeds in the usual situation already described. A. Gambiae typicus breeds in decreasing frequency in pools in laterite, streams, tins and boats, so that it is very nearly as 'domestic' a breeder in Freetown as is Aedes Aegypti, and certainly almost invariably a breeder in man made breeding places.

Clearly of course, the relative importance of these breeding places will vary with the season. The extremely rapid multiplication during the rains takes place in the pools of casual water in the laterite which last for five or six days even if not replenished by further rainfall.

Prior to 1940-1941 there were no routine house catches and the only information available is from sporadic observations by various investigators. In 1931-1932 Davy and Gordon reported the average anophelene density in Kissy, November to April as 1.75 per room while from May to October, the figure rose to 14.2. These results were compiled from catches by the ordinary sucking tube method. This has been superseded in the army since 1941 by the technique evolve by Lt Col Tredre and his unit which consists of saturating the catching station with pyrethrum spray and catching the mosquitoes on a white sheet on the floor of the hut. This has been found much more satisfactory, as firstly a much greater catch is obtained so long as the sheet is well tucked in to the walls where the mosquitoes mostly fall down. Secondly, it is much more popular with Africans and more houses can be done in a given time than by the sucking tube method with less dependence on the human element.

Since 1941, an increasing number of catching stations have been established and catch-sprayed regularly. The table below gives the results of these catches expressed as anophelene densities (No. per catch per room) by quarters. All catching stations are of four rooms and the figures are the averages. It will be seen that there is, in most places, a very marked reduction and that there is an all over reduction of well over 50%. Stations in the Army areas are underlined.

	1941				1942				1943				1944			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Aberdeen.	2.8	7.0	14.1	0.7	0.7	5.3	17.6	5.8	0.5	2.5	3.9	1.4	0.3	0.3	0.8	0.1
Murrayteen					0.03	0.2	0.4	0.5	0.2	0.2	0.2	0.2	0.4	0.3	0.3	0.06
Cockerill					0.7	2.5	2.0	0.7	0.4	1.0.	2.3	1.2	1.2	0.6	0.2	-
Brookfields	0.5	2.6	4.5	0.03	-	-	2.1	0.1	0.1	0.2	0.5	0.1	0.02	0.2	0.6	0.003
Wilberforce					0.3	0.4	0.2	0.07	0.5	0.3	0.3	0.02	0.3	0.2	0.1	0.02
City Central							0.5	0.1	0.8	0.1	0.2	0.1	0.4	0.05	0.08	0.007
Congo river	4.0	2.2	0.7	0.4					4.1	2.2	0.5	0.3	1.8	0.5	0.3	0.03
Kline							0.1	0.04	0.01	0.08	0.09	0.09	0.08	0.1	0.3	0
Kissy							1.8	0.3	0.2	3.5	4.3	0.5	0.2	0.03	0.1	0.04
Wellington										6.7	3.1	1.9	2.2	-	15.7	15.3
All Freetown							0.6	0.1	0.4	0.4	0.2	0.08	0.2	0.03	0.2	0.005

Infectivity rates of An. Gambiae and An Gambiae var melas.

There is a lack of uniform and regular records of anopheline infectivity in Freetown prior to 1942. However, some older records when compared with recent data, show that the infectivity rates of An. gambiae have kept a remarkable stability, during the last 13 years.

In 1900 the anophelene infectivity rate was found to be 5.3 per cent (Ross, Annett, Austin). in 1930 - 32 Gordon, Hick, Davey and Watson found that the anopheline infectivity rate at Kissy varied from month to month between 7 per cent and 18 per cent. In Freetown the corresponding infectivity rate was found to vary from 8 per cent to 10 per cent (wet season).

In 1943 Lt. Col. Tredre recorded the infectivity rates in A. gambiae var melas (mostly from Wellington) and found the annual average rate of 4.2 per cent with monthly variations from 0 to 13.5 per cent. In 1944 the infectivity rates of An gambiae in Freetown averaged 2.73 per cent; during the period March to August the rates varied from 0 to 14 per cent. (All rates refer to sporozoite infections).

It is remarkable that in 1942 and 1944 the highest infectivity rate should have been found in March and the lowest in April. This may be due to the rapidly increasing young anopheline population in April.

Dr. Turner, the Malaria Control Co-ordinating Officer has calculated the "Anopheline Infective Bite Index" for various areas of Freetown for 1941, 1943 and 1944.

This index is calculated as follows:-

$$\text{A.I.B.I. (per year)} = \frac{p\ q\ o}{r\ s}\ 365$$

P = numbers of female anopheles caught per day (average per station.
q = average infectivity rate
r = number of rooms per station.
s = number of people per room.

Thus this index indicates the average number of infective bites received by one person during a year.

Dr. Turner's illuminating table of indices is quoted here in extenso.

	1941	1943	1944.
Aberdeen @	28.0	9.0	2.0
Murraytown @	2.0	1.0	1.1
Brookfields @	8.0	1.1	1.0
Cockerill @	30.0	5.0	2.5
Wilberforce	0.8	1.0	0.7
City Central		0.5	0.2
Congo river	8.0	9.0	3.3
Kline	-	0.5	0.7
Kissy	-	10.0	0.4
Wellington @	-	50.0	100.0

Note @ = indicates An. gambiae melas breeding areas.

(D) Endemic Malaria in Freetown.

Information prior to 1943 is scanty and scatterd, but during the past two years more extensive and more regular investigation of this problem was carried out by No. 5 Malaria Field Laboratory and by the Civil Malaria Investigation Unit.

(a) (1) Spleen rates.

The following table summarizes the findings of various authors. All figures refer to percentages of positive spleens in samples of African child population between the ages of 3 and 10 years. All the samples may be conveniently classified in three groups according to their permanent settlement in a defined area. (Urban, sub-urban, rural).

This is a most inexact method but figures prior to 1943 are copious but quite unsystematically collected.

	1912	1913	1926	1935	1942	1943	1944			
							1	2	3	4
Urban	-	-	50.0	44.1	39.1	-	10	14	12	11
Sub-urban	24.1	43.0	72.0	42.6	51.1	36.0	23	36	23	-
Rural	-	-	-	-	70.2	54.0	44	-	70	-

(QUARTERS)

It appears that the urban and sub-urban areas can be classified as endemic or highly endemic, but show a steady decrease of spleen rates (this decrease is even more marked in 1945). The rural area ~~is and~~ remains hyperendemic.

(2) Parasite Rates.

There is the same lack of long term records as regards the parasite rates of the natural reservoir of malarial infection the African child population. Some of the existing old data show quite striking differences, which are probably due to many factors acting singly or in combination under varying circumstances. Bearing in mind that only a relatively small number of children could be examined, that wide seasonal variations occur in the intensity of parasitism, that the technique and thoroughness of the examination varies with each investigator, these differences are understandable.

Fortunately during the period 1943 - 1944 the investigation of parasitism in native children has been carried out under standard conditions, at regular intervals, throughout the year and gives therefore a much clearer picture of the amount of endemic malaria.

All the data available for the period 1913 - 1944 are tabulated below. Children are classified according to the type of the area from which they were chosen. Figures refer to crude parasite rates (all species) in African children aged 3 - 10 years. ~~The table is quoted~~

	1913	1926	1931	1932	1935	1943
Urban	50.0.	41.0.	39.0.	-	34.0.	-
Sub-Urban	-	72.0.	-	81.5	38.5.	22.0
Rural	-	0	-	94.0.	-	35.0.

1944

	1	2	3	4
Urban	29.5	0	18.3	12.2
Sub-Urban	36.0.	49.0.	42.0.	-
Rural	48.0.	-	78.0.	-

(3) Comments.

(a) The decrease of parasite rates in the African child population in Freetown is considerable in the urban area, less evident in the sub-urban area and remains high in rural areas.

(b) Seasonal prevalence of the actual rate of infection is recorded by most investigators. The peak of the parasite rate is most in evidence during the period June - October. However, in some areas (Grafton and Aberdeen) this seasonal peak of parasitism was not noted. (Gavin 1943).

(c) Parasite rates in infants and in children aged less than 3 years are not quoted here. While some authors agree that the percentage of positive findings is lower in this age group than in the age-group 3 - 10, others (Gordon and Davey) found that it is higher. According to Turner, the peak of the parasite rate is in the age group 2 years.

(d) The degree of infestation of native children carriers of malaria parasites was investigated by Turner, who found that in children from the urban area infections are scantier than in children from both sub-urban and rural areas. Heavy infections are more common in the two last named groups.

There are no records of finding of P. Ovale.

(a) ~~(a)~~ Gametocyte rates. Information is scanty. In 1943, Gavin reported that in the Waterloo area, the gametocyte rate for P. Falciperum varied between 3.1 and 3.7% of all slides examined. In Grafton valley the rates varied between 0.65% and 1.3%. No gametocytes could be found in 80 children examined at Aberdeen in spite of the actual P. Falciperum (rings) infection being 25.5% to 31.5%.

According to Dr Gosden, Senior Pathologist of the Connaught Hospital in Freetown, in P. Falciperum infections, crescents are found in below 2% of all bloods examined. All the infections found in surveys of the health are scanty, i.e. less than one crescent in 20 thick films.

(b) Species Distribution.

Scattered reports in pre-war years, give widely different proportions of the various parasites. According to Butler (1913) Gordon and Davy (1932) and G. Macdonald (1926) Plasmodiom Falciperum was found in about 45% of all children in the 3-10 age group. Gordon (1931) and Pearston-Ronner (1935) found unusually low rates of P. Falciperum infection (18.5%) in certain groups of children with corresponding very high rates of infection with P. Malariae (22.4% and 69.0%) All these rates are quoted from

In 1943 the records of the Malaria Field Laboratory reveal that in areas of great endemnicity such as Waterloo and Aberdeen, P. Falciperum infections were found in 22% to 43% of all slides examined. P. Malariae was only found in 1.9 to 4.0% of these slides. In 1944, of 1252 children examined in Freetown schools by Dr Turner, 421 children had parasites and they were all P. Falciperum.

P. Vivax was found in 0.1% of Children by Gordon and Davy in 1931 in 0.7% of children by G. Macdonald in 1926 and in 0.6% of children by Gordon and Davy in Kissy in 1932.

One reason why I have gone into the question of the type of infecting parasite in so much detail is that there was some discussion as to whether troops returning from the Far East might not bring back with them Benign Tertian and Quartan infections which might even start troublesome epidemics, this in spite of the known difficulty of infecting Negroes with Vivax in the deliberate injection of infected blood etc. in the treatment of late cerebral syphilis. I feel that there are so many Syrians and Indians in West Africa that ample opportunity has been given in the past for P. Vivax infection to have been introduced many times and that the risk of a serious epidemic is extremely small. As a matter of interest, the first 500 invalids who returned from the Far East all had blood examinations with negative results though there was doubtless a proportion of soldiers infected with P. Vivax.

(E) The Incidence of Malaria During the Present War.

After the fruitless expedition to Dakar in the Autumn of 1940, the troops proceeded to Sierra Leone and lay for a time in their transports in Freetown Harbour. They were then landed and sent to various camps in and about Freetown. The Malaria incidence in these troops was exceedingly high. More and more Europeans arrived over 1941 and 1942 and the strength was at its highest in January 1943. Since then, the numbers have dropped steadily.

The following tables shew the incidence for the whole Colony from 1941 to 1944.

YEAR	Hospital Admissions Ratios per 1000 per annum		% of Total due to Malaria	Cases of Black water Fever	Total Rainfall.	Average Strength.
	Malaria	All causes.				
1941	984	1804	54.4	12	140"	3478
1942	751	1583	47.6	17	143"	4216
1943	370	1017	33.3	10	142"	3673
1944	68	677	8.8	0	126"	1858

For comparison, the ratios per 1000 of average strength per annum of admissions to Hospital for malaria are given for the three Services and Civilian Officials in Sierra Leone over these years.

Ratios Hospital Admissions - Malaria - per 1000 per Annum.

Year	R.N.	R.A.F.	Army	Civil Officials	African Other Ranks.
1941	?	?	984	371m	124
1942	843	839	751	512	38
1943	730	360	370	534	31
1944	185	128	68	478	54

Graph 6 shews the Army incidence by four weekly periods, and the variation of strength which is very important, as increases of strength mean a higher proportion of newcomers at risk

Notes on the foregoing statistics:-

1. In the case of the services, the standards of diagnosis are the same, because they were all treated in the same Army hospitals.

2. Suppressives were as follows in the services.

All took quinine gr. V daily until March 1943.

The Army then began 0.4 gms mepacrine per week and increased in Oct 1943 to 0.6 gms per week and in May 1944 to 0.7 gms per week.

The Royal Navy and the R.A.F. did not switch over to 0.4

gms mepacrine per week until Sept. 1943. They continued on thisdosage until April 1944 when they increased to 0.7 gms per week.

The Civilians mostly took quinine but they are now unable to get supplies and they now mostly take mepacrine irregularly and in quite inadequate dosage.

The Africans do not take suppresives.

3. Dr Turner Malaria Officer Freetown comments as follows on the civilian figures which are accurate records of Hospital admissions. 'Records not very reliable as A TRUE INDEX OF MALARIA,- many people carry on their duty such as it is and treat themselves. The result of course is a period of relative innefficiency'.

The figures for the Royal Navy refer to shore based personnel only. The new base at Kissy where the ratios are high is not included since it did not exist in 1942-1943.

4. Of the Army personnel, all but about 5% are now stationed in and about Freetown. In the early years, they were often in camps in bush for short periods. R.A.F. are entirely in Freetown and area but they have many at Wellington and Jui which are still much more malarious than most parts of the district in spite of a good deal of village removal. The Navy on the whole are in areas comparable to those of the Army. Of the Civilians about 15% are up country and the rest in Freetown living in very good areas.

5. At risk of being considered prejudiced, I must state that in my opinion, the standard of personal anti-malaria discipline is appreciably higher in the Army than in the other two Services. Dr Bruce Wilson of the Rockifellar Foundation commented on this in his report to the Colonial Office after his visit in July August 1944.

6. The Royal Navy and the R.A.F. live and always have lived in mosquito proofed quarters. The Army have few mosquito-proofed buildings in Sierra Leone.

7. When considering the incidence in Africans it should be noted that in 1941 many troops arrived from Nigeria and Gold Coast and that of these, the vast majority had left the Colony by March 1942. On looking through the Hospital Admission books for this period, the number of non-Sierra Leone names which occur is most striking. In a rapid check of the first 200 cases of malaria in Africans in 1941, 153 had names and Regimental numbers of Gold Coast or Nigeria. It is I consider a fair deduction, that these troops were affected by a Malignant Tertian strain to which they had less resistance than to the strains common in their own countries. It is of interest to note that the same phenomenon occurred when Belgian Congo troops were stationed at Oyo in Nigeria.

8. I have gone very carefully into the question of the standards of diagnosis in Sierra Leone, but I cannot find any significant variation from those of the other Colonies. As was noted earlier, the proportions of Proved to "Clinical" in Sierra Leone are comparable with those of other colonies. It is probable that in the peak years of 1941 and 1942, too little "clinical' malaria was diagnosed.

I have discussed the very marked reduction of Army malaria in this Colony with everyone likely to have special knowledge or opinions of value, for the reduction is so much more in degree than in the other three colonies. Chwatt, from a Malaria Field Laboratory in another colony, whom I instructed to visit Sierra Leone to make an unbiased investigation in the light of his knowledge of the other

colonies, tends to the opinion that "The spectacular decrease of Malarial Incidence in 1943-1944 should be regarded rather as a spectacular rise during 1941-1942, a rise due to the fact that, owing to Military Expediency very large numbers of European Service Personnel were concentrated in a relatively small area, often on notoriously dangerous sites near large African settlements and they were accommodated in hastily built and mostly unscreened quarters." There can be no doubt of the truth of these statements but Chwatt took no account of the following in coming to these conclusions:-

(i) The very marked reduction of the Army European rate in comparison even with the fall in the other European rates. (The significance of the extremely low figure for Africans is impossible to assess.).

(ii) The information which was not available to him and which I have subsequently managed to find with the assistance of Dr. Turner about prevailing rates in the pre-war period in Officials and to a sadly incomplete extent about European troops. The admissions to Hospital for malaria of Civilian Officials per 1000 of average strength per annum for the years previous to 1944 were as follows:-

1930	238	1938	346
1931	242	1939	357
1932	250	1940	363
1933	271	1941	371
1934	479	1942	512
1935	337	1943	534
1936	434	1944	478
1937	245		

(up to 1939)

These figures include all Royal West African Frontier Force Europeans but it is not possible to get separate figures. The opinion of all the Colonial Medical Service Doctors who looked after the R.W.A.F.F. is that the incidence of Fever was always higher in the Army than in Civilians. These figures are accurate and are completed from the

actual hospital Records.

The following are approximate ratios for the few years about which I have been able to get information, concerning incidence in Imperial Troops when stationed in Freetown.

Hospital Admissions for Malaria per 1000 strength per annum.

1920	...	500
1921	...	696
1922	...	510
1924	...	511
1925	...	367

It would seem reasonable to suppose that the average hospital admission rate in civilian officials per 1000 per annum was about 350 and certainly the attack rate was much higher than that, as at least half of all attacks were treated at home. No Medical Officer in any of the Colonies has ever given me a figure of less than two attacks at home to one in Hospital. I therefore feel justified in assuming that a rate which was equivalent to 500 per 1000 per annum in the current Military statistics is not far from correct. For the Army to have reduced this to 68 in 1944 in one colony seems to indicate that unless the cause is better mepacrine discipline, IN THE ARMY factors other than Mepacrine suppression, which has brought down the figures in the other services, have been operating in Sierra Leone. If we take 500 as the norm on irregular quinine, and 175 as the norm when taking mepacrine pretty regularly I do not think it would be far wrong.

9. If the average Army rate for 1941 to 1943 is taken in all four colonies the relative decreases in the four colonies are as follows:-

Percentages of rate for 1944 of that of the average rate over the previous three years:-

Colony	Average rate 1941-1943	Rate in 1944	Percentage of 1944 rate of those of 1941-1943.
Gold Coast.	777	243	31%
Nigeria	517	399	75%
Sierra Leone	703	68	10%
Gambia	739	175	24%

It is clear that Sierra Leone has an enormous reduction. But as Chwatt points out the 1941 and 1942 figures are abnormally high, nevertheless the Sierra Leone rate is still only 13.6% of what I have presumed to be the normal European level i.e. 500 per 1000 per annum or even more convincing only 18% of the Sierra Leone Army level for the previous year 1943, when conditions were much the same as in 1944.

10. I am of the opinion that a combination of favourable factors accounts for this reduction and I would list them as follows:-

(a) Mepacrine suppressive. (discussed later).

(b) The accommodation of the army personnel during 1944 in good well sited camps, the surplus camps being abandoned.

(c) The cumulative results of much excellent anti-larval and anti-adult work round Army camps on a temporary basis which was first advocated and inaugurated by Lt.Col. Jamieson Carr in 1941 and extended and intensified by Lt. Col. R.F. Tredre.

(d) The diminution of the number of 'carriers' of malaria in the civil population especially in the areas of the camps controlled by the military and then joint Military Civil measures, to a degree whereby, together with or as a result of the degree of mosquito control achieved, the transmission of malaria has been

drastically reduced.

(e) The Area of Freetown is small and a succession of good Malaria and Hygiene Officers have, by constant inspections, education and propaganda so improved the standard of personal protection that the number of bites received has been drastically reduced.

(f) Good welfare facilities for the troops including provision of transport of healthy amusement. It should be remembered that Army personnel are all Officers or N. C.Os whereas the other Services have many ratings and aircraftsmen for whom general standard of amusement required is less critical. Very few Army N.C.Os are to be seen walking the streets of Freetown at night. It is most significant, not only that the incidence of Venereal Disease is much less in the Army than in the other Services in Freetown, but that it is lower than the Army rates in Gold Coast and Nigeria. The following table shows the position over four years:-

Incidence of venereal disease per 1000 of strength per annum.

Year.	Gold Coast	Nigeria	Sierra Leone.
1941	71.4	37.2	52.2
1942	62.3	47.8	44.8
1943	64.8	105.0.	39.1.
1944	68.6.	110.2	46.4.

There is no doubt whatever that much malaria is contracted in African houses and brothels.

(F). Outbreaks of Malaria in European troops landed in Sierra Leone without adequate preparation.

After the fruitless expedition to Dakar three separate large bodies of troops were landed in Freetown and their experience is most instructive. It is also disheartening as it would seem that the lesson must be learned the hard way in every war.

1. 1/5 Bn. "X" Regt. arrived in the estuary off Freetown on August 15th 1940. They remained on the transport until Sept. 15th 1940 when they landed. They took over on 17th October from African troops, the beach defences at Lumley and Aberdeen. The Battalion was accommodated at Wilberforce which is 600 feet up and is a well sited camp though at that time there was no control round it. They supplied beach patrols by day and forty men were on duty on the beach every night. They were issued with quinine and repellant cream. It is to say the least doubtful if quinine was taken, as no parades were held and urines were not tested. It is axiomatic that when soldiers are told to take anything for the first time they do not take it. It does not matter whether the order is for quinine, mepacrine or vitamin pills, the first reaction is always unfavourable and compulsion is essential. (It is a lawful order under the Army Act to order a soldier to take quinine or mepacrine and religious or conciencious objection is not a legitimate reason for refusing to obey this order). In this particular instance, the Senior Medical Officer of the Brigade was unwilling to advise quinine and had to be overruled while the brigade Medical Officers argued hotly on the matter although none of them had ever been in the tropics before, far less in West Africa. The repellant cream was a citronella ointment. An ointment base is most unsuitable in West Africa where sweating is so very trying. The sweat globules rise under the ointment making for great discomfort and precipitating prickly heat.

Cases of malaria occurred in the unit as follows:

Sept. 9th. 1 case i.e. occurred while on the transport

Up to Oct. 12th 71 admissions for malaria.
" " Oct. 21st 18 further admissions.
" " Oct. 28th 11 further admissions.
Total 101 cases in 43 days on shore.

2. On Nov. 4th the beach defences were handed over to a Royal Marine Brigade also just landed, but by Nov. 25th another 72 cases had occurred. By the end of December, there were another 33 cases. So that in two and a half months after landing 205 out of an approximate strength of 800, had had attacks of malaria. The Ashantee Campaign of 1873 was being repeated!

The Royal Marine Brigade which took over the beach defences on Nov. 4th was mostly accommodated in tents at Lumley. They had mosquito nets but no beds. About 50% had gum boots issued in lieu of Mosquito boots. The rest had no special protection. In the same camp were 1500 African labourers. The marines were constantly exercised, practising night manoeures and before dawn landings. Their malaria incidence was:-

Week ending	Nov 30th	...	96	
" "	Dec 7th	...	135	
" "	" 14th	...	173	— Quinine commenced
" "	" 21st	...	20	— left the beach area.
" "	" 28th	...	29	
		Total	453	

Quinine was not begun until 12th and 13th December.

When local conditions in the Area in which these two formations were located are considered this incidence is not surprising. Enormous breeding of As. Gambiae, Funestus and Hancocki was going on in wells, washing holes and swamps along the edge of Aberdeen beech. The splenic indices in local villages were - Murraytown 83%, Aberdeen 73%, Wilberforce 39% and Lumley 70.2% and the time of the year was the end of the rains.

3. These two disasters are paralleled by the experience of 2/5 Battalion of "X" Regiment which arrived in the same convoy and was sent to Benguema.

This unit arrived at Benguema on Jan 25th 1941 and cases occurred as follows:-

Week ending Jan, 25th	25
Feb. 1st	38
" 8th	64
" 15th	29
" 22nd	19
Mar 1st	10
" 8th	20
" 15th	11
" 22nd	20
" 29th	11
Apr 5th	7
" 12th	44
" 19th	36
" 26th	21
May 2nd	11
" 9th	4
" 16th	11
" 23rd	22
" 30th	42.

The Battalion then left Benguima on route for service elsewhere. The unit Medical Officer thought, as did all other Medical Officers at that time, that exposure in bush was the greatest danger and had the unit confined to camp. My own conviction is that, except for right inside a native village, these troops were much more exposed to infection in their own cam; for A. Gambiae is so determinedly an inside biter.

That this high incidence occurred mainly during the dry season shows just how much transmission is carried on all the year round in uncontrolled areas in Sierra Leone.

Only the last quoted of these three disasters contributed materially to the high incidence for the whole colony in 1941, but further, smaller, all European Units arrived and the figures for 1941 and 1942 were undoubtedly influenced by the amount of malaria contracted by the personnel of Royal Artillery Units, especially Anti-Aircraft gun crews stationed on unsalubrious gun sites chosen entirely for tactical reasons.

When it is realized that July in Dakar is the peak of the rainy season there, it may be considered well that a campaign was not attempted, for unless immediate success had been achieved, there would have been a sadly reduced number of effectives after a month's fighting by troops so ill prepared as these.

(G). Control measures adopted in the present war.

Early in 1943, a Joint Services and Civil Malaria Control organisation was begun in Freetown with the Officer Commanding the Army Malaria Field Laboratory as advisor. The Laboratory was withdrawn from West Africa early in 1944 and the control continued under Dr. J. Turner as Civil Malaria Control Co-ordinating Officer.

The organisation consists of an Army Area (Roughly - Aberdeen, Lumley, Laevuma, Murraytown, Cockerill, Wilberforce, Benguema and Grafton) and a Civil Area, east of the Congo River (Map 5). The Army Area is controlled by the O.C. Field Hygiene Section. The Royal Navy and Royal Air Force simply control within their own camp boundaries.

Army measures have been almost entirely aimed at temporary control and the following notes are made of points relevant to the filling in of the whole picture of the Army's work and the results achieved.

(1) Anti-Adult work.

Native villages within at least a mile radius of Army camps are sprayed twice a week all the year round by gangs using pyrethrum spary. This has been going on now for two and a half years. Now that D.D.T. is available and being used in these villages, the intervals between sprays will be lengthened. A big 'follow up' by pyrethrum drop catches is going on now to determine what value is likely to result from spraying D.D.T. treated houses. Preliminary

results would seem to indicate that the numbers of mosquitoes brought down in such spray catches is practically nil. It would appear that they will be stopped. Varying dosages between 2^0 and 200 mgms D. D.T. per square foot are being used, and the intervals between treatments adjusted so that a safe interval may be determined.

(2) Anti-larval Work.

The Army area is divided into sectors which are oiled by gangs in a weekly roster. "Malariol", Pan oil, sump oil and paraffin, and diesel oil are all used as available. In marshes and seepage areas where production of an oil film is unlikely, Paris Green is spread by hand. This anti-larval work has been on a high scale, has been well organised and thoroughly carried out over the past three to four years.

(3) Permanent or Semi permanent Surface water control.

Very little of such work has been done. A few areas have been drained usually by following the natural drainage line and with contour drains. Some streams have been canalised and many have regular attention. It is unlikely that this small scale work has an appreciable effect in areas where breeding is prolofic, and the tendency has steadily increased to reduce this work to the bare minimum and concentrate on really thorough oiling. The remarks at the beginning of this chapter on the geology will make this understandable.

Some interesting work which has been carried out by the Field Hygiene Section, is the bunding of a stretch of mangrove swamp on the lagoon side of the Aberdeen peninsula (Map 6.) This was the first work of its type in West Africa and it will be considered

later in detail when assessing the value of control methods in West Africa as a whole (Chapter VII).

As another experiment at Lumley, a series of drains 15 yards apart were dug straight down from the coast grass through the mangrove to the sea. The object was to see whether this would reduce more quickly at each low tide, the surface water level in the var Melas breeding areas in the Coast grass and in shorewise (Avicenia) mangrove areas. As an additional safeguard, an oil drip can is placed over the drain at the level reached by the normal tide. There is no doubt, that a considerable reduction in breeding can be achieved in this way while the work can be done quickly and cheaply by unskilled labour.

Finally I wish to emphasise that the main attack in Sierra Leone has been by oiling and Paris Green. In the table of anophelene density variation given earlier, the areas under Army Control are underlined. It will be seen that considerable success was achieved.

GOLD COAST

Chapter V.

(A) Climate.

The Great belt of equatorial rainfall which stretches from the Sierra Leone Coast and Liberia across Southern Nigeria and through French Equatorial Africa and the Congo is interrupted about Cape Three Points in the Gold Coast. At that point the line of the 160 inches rainfall is interrupted so that the rainfall on the Coast West of Cape Three Points is very much heavier than in the rest of the Colony. The sketch map (1) shows the lines of equal rainfall.

From West To East along the coast the average rainfalls are as follows:-

Axim	82	
Takoradi	51	Locations of these
Cape Coast	34	places are on Map 7.
Accra	27	
Keta	19	

At varying distances from, three to fifteen miles inland, there is a scarp which rises up to 600 feet. There, the rainfall is heavier especially in the forest area. Thus in Kumasi, the rainfall averages about 52 inches and in the area of the Tarkwa and Prestea gold mines in the Forest inland from Cape Three Points the Rainfall is about 60 inches.

In the North, the forest gradually thins to savannah and orchard bush and except along the course of the great River Volta and its tributaries the rainfall is less. Thus at Tamale, the rainfall averages about 43 inches and further North or away from the rivers, there is less. The variation in total rainfall from year to year is greater in the North than in the South.

The rainy season on the coast is from March to October. There is a period of less rain in August and September, particularly marked in the West. This is

sometimes called the 'little dry' season and is then said to be succeeded by the 'little rains'. The rains begin later in the North.

Temperatures on the Coast vary little during the year. They are least just after the rains and increase steadily until in March and the beginning of April it is very hot indeed with a high relative humidity which makes for great discomfort. In the rains the average daily maximum and minimum are about 85 degrees F and 71 degrees F while in the dry season the maximum is about 95 degrees F and the temperature from January onwards seldom drops below 80 degrees F day or night. in the forest, the temperature range is greater, due to the greater fall at nights. In the far North there are higher day temperatures with considerable drops of up to 30 degrees F at night.

Humidity is of course highest in the West of the coast and in the forest. All over the coast and forest the relative humidity at 7 A.M. is seldom below 85 and may be over 90 while even in the heat of the day at 2. P.M. the humidity is still seldom less than 65. There are of course 'freak' recordings if the Harmattan blows over several days. The humidity may fall by 40% in a few hours. In the far North, the humidity rises steadily from a 24 hour average in January of about 50 to about 70 in August.

Except during the Harmattan, the prevailing wind on the Coast throughout the year is a steady South Westerly breeze which unfortunately falls at night. Further inland and in the far North the breese is less constantly from the South West and the further North the more northerly winds there are in the dry season.

(B). MALARIA DURING THIS WAR.

The Gold Coast is a much larger country than either of the two so far considered and the climatic conditions, especially the time of onset of the rains vary so considerably, that, with troops stationed in various parts, it would be surprising if the bulked figures of malaria incidence gave an even graph as for troops situated in a small area. The main military stations are in order of numbers of Europeans normally stationed there - Accra, Kumasi, Takoradi, Tamale and Kintampo.

Bulk figures for the past four years are as below:-

Year	Hospital Admissions per 1000 strength		Per cent. total admissions due to malaria.	Cases of Black-water Fever	Average strength
	Malaria	All causes.			
1941	1001	1737	57%	12	1437
1942	870	1585	55%	28	2750
1943	460	1432	33%	10	2800
1944	243	1029	22%	1	2418.

Graph 7 shews the ratios by four week periods and the variation in strengths.

It will be seen that there has been a reduction to one quarter of the 1941 figure over the four years and that, as in other colonies the seasonal increase of malaria was relatively small in 1943 and 1944. In the first three months of 1945 the incidence per 1000 per month was very low as will be clear when the individual stations in the Gold Coast are described. The fall in 1944 would have been much greater if the bulk rates had not been kept up by a relatively heavy incidence in the smaller stations in the North. Until just before the rains in 1944, there was no effective control in these stations.

It has unfortunately proved impossible to get accurate

figures for attacks of malaria in Civilian Officials, in the Gold Coast. The only published records show merely the number of days lost through malaria per official but give no indication whether in hospital or out, or the average duration of 'off duty' per attack. I refrain therefore from any attempt to make an estimate.

That the military bulk rate should be 250 attacks per 1,000 per annum when the troops are on mepacrine is I consider, proof without further question that mepacrine is not being taken concienciously.

In Accra and Takoradi, in the past two and a half years very big schemes have been carried out by Major O.J.S. Macdonald I.M.S. who was seconded to the staff of the Resident Minister in West Africa for the purpose. In the other stations very little work indeed was done until early 1944.

In view of the differences in climate just mentioned, it is proposed to take the five military stations separately and to trace the malaria incidence. Each is in a different type of country. In two, very complete controls have been established in the others the control, as said above, only began this year.

(C) Accra.

Graph 8 shows the malaria rates and rainfall in Accra. The big drainage scheme was begun in 1943 before the rains. It has been supplimented by what is probably the largest scale and most complete oiling and spraying programme ever carried out in Africa. Since Sept 1944, we have also had good supplies of D.D.T. and it has been used on a very large scale also. It is extremely difficult to apportion fairly, the relative effects of the drainage works, the insecticiding and the effects of mepacrine. There is no reason to suppose that mepacrine has been taken in Accra any more or less concienciously than

elsewhere and I shall venture to make a comparison later of the stations with and without control.

The combination of the measures taken has certainly had a most striking effect on the amount of malaria in Military Forces. This reduction is paralleled by the fall in American and R.A.F. rates. Reference should be made to Graph 18 in which the British and American rates are compared.

It is impossible to show graphically the mosquito reduction, as the number of new catching stations has constantly been increasing and been changing in position as the course of events warranted. Both civil African houses, and laterally an increasing number of one man traps have been employed. An enormous amount of careful entomological work has been done in Accra and this will be published shortly by Major Louis Berner U.S.Army.

There was very little information available about the mosquito population of Accra when, in 1942 it was decided to start a large permanent control scheme which would protect the town, the airodrome and the military camps. On investigation, there was found to be enormous breeding in deserted quarries, borrow pits, badly designed roadside ditches, hillside seepages, in the yards of native houses in Accra and surrounding districts, and along the side of the railway in ditches and borrow pits. There were also extensive A. Gambiae var melas areas at the sides of large lagoons in and about the town.

At the time of a survey in Accra Town in December 1942 house catches averaged 10 to 20 A. Gambiae per room. Spleen rates were all over 55% and averaged 74.2%. In sourrounding villages - up to 4 miles, the spleen rates at the same time(Dec 1942 - Jan 1943)were less averaging 48%. The following table is of value as indicating the effect of

the control measures taken. It shows the effect of these measures on the gametocyte rates in children in the Fulani Zongo just outside Accra. (A Zongo is a village where the people of other tribes than those of the area live; in this case it was originally a home of Fulani). Children were all under 10 years and 100 fields on thick films were examined in each case.

Month	No. of children examined	No. with crescents.	Percentage with crescent	No. with rings	Percentage with rings.
Nov. 1943	49	5	12.5%		
Dec. 1943	40	6	15.0%		
Jan. 1944	40	7	17.5%		
Feb. 1944	30	9	30.0%		
Mar. 1944	22	5	22.7%		
Apr 1944	32	4	12.5%		
May 1944	50	5	10.0%	34	68.0%
Jun 1944	25	5	20.0%	18	72.0%
Jul 1944	40	2	5.0%	29	72.5%
Aug 1944	57	2	3.5%	14	24.5%
Sep. 1944	39	1	2.6%	8	20.5%
Oct 1944	29	1	3.4%	5	17.2%
Nov 1944	58	2	3.4%	4	6.9%
Dec. 1944	63	2	3.1%	3	4.7%

The engineering work done has been on the lines of that at Takoradi but on a much larger scale and in much more difficult country. The insecticide work has been controlled by ~~20~~ TWENTY to thirty Europeans, and three hundred Africans HAVE BEEN employed full time on oiling, dusting and spraying. A great deal of difficulty has been encountered in larval control for neither Paris Green nor oil will stay on the surface of exposed pools but gets blown to the leeward. D.D.T. in oil is no more effective.

(D) <u>Takoradi.</u>

Graph 9. in respect of malaria in Takoradi is even more convincing than that of Accra. Takoradi-Sekondi is very much more amenable to control by engineering

than any of the other West African Ports. The scarp here comes down to the sea and forms a shallow half circle away from the sea about seven miles across with Takoradi at the Western and Sekondi at the Eastern ends. Drainage was therefore relatively easy and the main problems, a large swamp in the middle of the area and a shallow lagoon on the West side of Sekondi could easily be drained.

The results have been enhanced by an extremely thorough pyrethrum spray programme. This has been well described by Eddy (5)

Graph 9 also shows the rainfall in inches and demonstrates more clearly than any others, the relationship of rainfall and Malaria rates.

The Anophelene density (Average anophelene per room per week in catching stations) is plotted for the mean of thirty six catching stations with 144 rooms, which remained in one place from May 1943 to the end of 1944. Before that, new stations were being added as bad areas were found so that the mean of all the catching stations would not be of graphic value.

Finally the army strength in the station is plotted on the lowest panel of the chart.

It is of interest to note that the R.A.F. rates in Takoradi have followed closely month by month the Army rates for three years. The R.A.F. rates began about 30 per 1000 per month lower than those of the Army and have gradually approached the ~~amrm~~ ARMY rates and are now for practical purposes the same. The R.A.F. have here had exactly the same regime as the Army except that they have had better sites and better mosquito proofed quarters.

The only accurate information I have about conditions in pre-war Takoradi is that in 1937 of 378 CIVILIAN admissions to the European Hospital, 159 were admitted for malaria and of the 378 on routine blood examination, 341 or 90% had parasites in their blood. Clearly Takoradi was no Health Resort for Europeans! That there was still plenty of malaria transmission in 1943 is shewn by the epidemic in Lascars mentioned in Chapter VII.

Ribbands in Dec 1941-Jan 1942 found on an average of 34 rooms, 10 A. Gambiae and 90.2 A. Funestus per room. Breeding in Takoradi was then to a very large extent in a series of five swamps between Takoradi and Sekondi and in a large marshy area near the Airodrome. There was also some A. Gambiae var melas breeding in the Sekondi lagoon. This, and the season of the year, when the vegetation had grown at the end of the rains, account for the high proportion of A. Funestus in Ribband's house counts. Now that control has been going since early 1942 the proportion of A. Funestus found in house counts has fallen to about 1 A. Funestus to 8 A. Gambiae at the same time of year in 1944-1945.

(E) Kumasi.

Graph 10 shows the malaria rates and rainfall in Kumasi over the period for which accurate returns are available. In early 1941, the Kumasi rates included those of Tamale and Kintampo as all the stations were under the same S.M.O. so that they now cannot be separated and the Hospital A. & D. books are not to be found for the period. Some cases were also admitted to Civil Hospitals. The extremely high rates in Kumasi in 1942 are paralleled by those of Takoradi, but they did not fall correspondingly in Kumasi in 1942.

The station malaria control programme (Chap VII) was instituted before the rains in the Spring of 1944 and I think

that it is fair to attribute the much steeper fall in rates in 1944 to this cause.

The main breeding places in Kumasi are (a) those within the straggling native city (b) the pools in the beds of irregular streams in the dry season (c) the swampy bottoms and seepage-wet hillsides of the shallow valleys of the three streams which flow through the city and suburbs. These valleys are favourite grazing places with the herdsmen who bring down ~~herds of~~ cattle from the Northern Territories. The cattle footprints are a never ending source of trouble. Also in these valleys, favoured breeding places especially for A. Funestus are a large series of old over grown and neglected herring bone drains which were dug by the Civil authorities many years ago and forgotten.

Lieut J.D. Robertson who made a short mosquito survey in February/March and again in June/July 1943, classified breeding places as follows:-

Pools and Seepages. (Open to sky?)	In shade of Cocoa Trees.	In taller grass and vegetation.
A. Gambiae.	A. Obscurus.	A. Funestus.
A. Funestus.		A. Coustani.
A. Coustani.		
A. Obscurus		

I can confirm that this is a reasonably good classification from personal experience in Kumasi, though I have found A. Obscurus only in very thick bush and in cocoa plantations, not in the open.

House catches in Kumasi consistently show ratios of A. Gambiae: A. Funestus. about 6 : 1 during the dry season and 100 : 1 during the rains so that, even in the dry season this is predominantly an A. Gambiae area. This is rather surprising in view of the amount of vegetation in the forest region in which Kumasi is just a large clearing. It makes me inclined to believe, that there is even more breeding than is generally believed within the huge maze of houses and com-

pounds in the town. It is sometimes difficult to get into the family compounds in the town as the men do not like their women folk disturbed. Probably they simply refuse to let African searchers in on many occasions and thus these breeding places are missed.

A. Hancocki is frequently found in house counts in Kumasi but it is not often infected.

Catches in European quarters in Kumasi have always been high, and invariably, when I have been on inspections there, I have found A. Gambiae in about one third of all sleeping quarters.

It is impossible, without civil cooperation or an adequate military staff to spray all the houses in Kumasi and the military units are dotted here and there in and about the town, so that the amount of transmission must be very considerable. The results of the second season of 'Station Control' will I hope be reflected in a considerably reduced incidence in 1945 but in view of the large area of untouched houses, the rates will probably not be reduced by a very striking amount.

(F) Tamale.

Graph 11 shows the malaria rates and rainfall in Tamale as far back as accurate figures are available. The concentration of the rainfall over a relatively short rainy season results in widespread flooding during the rains while towards the end of the dry season, it is common to see a circle of women waiting round a water hole with gourds. As soon as a little muddy moisture appears in the bottom of the hole, one of the women leaps down and carries off the precious fluid.

The mosquito population towards the end of the dry season is therefore very low and the latent interval after the commencement of the rains before the malaria rates start to rise is correspondingly long. The geometrical

progression of the number of mosquitoes starts of course at a disadvantage. A comparison of the graph II. with those of other stations in the South will make this clear.

In 1944, in turn each company of the Battalion stationed in Tamale have camped at Daboya on the Volta, so that approximately one fifth of the total strength has always been there. Disease incidence is all grouped round 'Tamale'. Daboya is a pleasant but most unhealthy spot. The A. Gambiae population, breeding in the riverside marshes is immense. It is also incidentally a bad place for Schistosomiasis, Guinea Worm and Trypanosomiasis. This Daboya camp accounts for the higher Malaria incidence in Tamale' in 1944.

(G) Kintampo.

Kintampo (Map 7) is a single unit station in North West Ashanti. In this region the forest is thinning out to savannah country in most areas, but persists near the rivers. Kintampo is on a high ridge overlooking the wide valley of the Black Volta., and the soil is on limestone which is eroding fast. The main breeding places apart from the native towns themselves are the marshy sides of streams and collections of water in erosion pockets in the limestone, puddles in paths and roads and roadside ditches. As might be expected, A. Funestus is responsible for a higher proportion of malaria than elsewhere and breeds particularly in the side pools and marshes along the rivers.

The military lines which are a peace time Company Station, are surrounded by a ring of villages which require strict inspection or they provide continuous breeding.

An examination of the blood of children from 100 children from these villages in December 1942 showed 88 with parasites and of these 37 had crescents.

Graph 12 shows the malaria incidence in Army Europeans in the station for the past three years. It will be seen that the ratios are high and have not come down as satisfactorily as in other stations.

Station Control was introduced only once the rains had started in 1944, so that an improvement may be expected in 1945. Photograph 15 shows one of the streams which have been canalised, and the banks planted with grass in an endeavour to check erosion and thus avoid the pooling and the breeding places which result. Photograph 16 shows the extreme degree of erosion in a small stream which is passing underground.

N I G E R I A

Chapter VI

(A) The Climate.

The Climate in Nigeria is very much more complex than in the other colonies, although it follows in many ways, the pattern of the Gold Coast. Southern Nigeria is essentially a large flat plain injected from the sea by a series of tidal lagoons, creeks and swamps, which connect with the deltoid mouths of the rivers. The rainfall, temperatures and humidity are all high with little variation in the two last throughout the year. Mean annual rainfalls over the last twenty years are:-

Lagos	71 inches
Calabar.	121 "
Benin	99 "
Onitcha	58 "
Bonny	155 "

The dry season lasts only from November/December, to the beginning of March.

In all the Southern Plain, the mean maximum and minimum daily temperatures are about 91 degrees F and 67 degrees F and daily variations are seldom more than 10 degrees F. Relative humidity is normally extremely high. In the dry seasons with a high wet bulb temperature and a relative humidity with a mean daily variation between 90 and 68 it can be extremely uncomfortable. In the harmattan for periods of hours or days, the humidity may drop to as low as 25.

During the rains, the relative humidity is even higher, being consistantly over 90 but the wet bulb temperature (which governs comfort) is relatively low

The Forest Region proper stretches right down to the coast in many areas and from 100 to 400 miles inland. The climate is very similar to that of the forest area of the Gold Coast.

The prevailing wind in the south, except at Harmattan time, is the south-west trade.

In the Far North of Nigeria, the land is mostly poor grass land and thorn country approaching desert conditions in places. The camel is used in the dry season as far south as Zaria. The rainy season is from May to October, and approximate annual rainfalls are

Kano	35
Maiduguri	26
Sokoto	48
Zaria	47

The heaviest rainfall is in July and August.

The range of maximum temperature is high. 120 degree F sometimes occurs in Bornu while in Kano 105 degree F is not uncommon. On the other hand the humidity is low in the dry season when these high temperatures occur and the fall at night may be as much as 40 degrees F. During the harmattan, the dryness is extreme, so that one's hat which was a good fit in Lagos has so shrunk by the time one reaches Kano as to be unwearable! The humidity at 12 noon may be less than 16 for weeks at a time.

In the wet season, temperature and humidity approach more those of the South.

The prevailing winds are from the South-West during the rains, and from the North-East during the rest of the year.

The Bauchi Plateau just North-East of the centre of the country is about 100 miles long and 60 miles across. The whole plateau is over 3000 ft above sea level. As might be expected, the rainfall is higher than in the

South, but over the year the Wet Bulb Temperature is comfortably low and the nights are cool. The plateau is the only approach to a Hill Station in the whole of West Africa and while not comparing with those of India or even Malaya, the climate is very much pleasanter and more bracing than anywhere else nearer than South Africa.

(B) Malaria during this War.

Nigeria is an enormous country, as big as Germany, Austria, Holland Belgium and Switzerland together. Places where the rainfall varies between 121 inches and 26 inches have, as already shown widely, different climates and it is only for convenience that malaria figures are given for the whole colony. That the country is ~~largely~~ EXTREMELY malarious for Europeans is shown by the table below which is in respect of the PRE-WAR years for which accurate figures are available.

Civilian Officials Nigeria. Hospital Admissions.

Year.	Malaria	Cases of Blackwater Fever	Average Strength	Ratio Hospital Admissions malaria per 1000 average strength.
1930	1334	17	2649	500
1931	1170	18	1581	740
1932	876	15	1641	533
1933	928	12	1586	586
1934	1025	16	1508	679
1935	947	10	1473	642
1936	995	11	1560	641

[redacted].

Unfortunately, due to movements overseas of Medical Units whose Commanding Officers were responsible for local malaria control and statistics and to the destruction of past records in the office of the A.D.M.S. very inadequate data are available about the distribution of malaria by stations in Nigeria.

The bulk figure (Table below) and Graph 13 were collected on the same basis as for the other colonies but I have not been able to cross check them exactly by

Hospital Records except for 1944.

Bulk Figures for the past Four Years are as below:-

Year.	Hospital Admissions per 1000 strength.		Per cent total admissions due to Malaria.	Cases of Black water Fever	Average strength.
	Malaria	All causes			
1941	564	968	58.1%	11	1835
1942	525	907	57 %	46	3718
1943	462	1186	39 %	18	5910
1944	399	1332	30 %	1	3736

(1) The main stations may be divided into three groups.
(2) the forest stations Abeokuta, Ibadan and Enugu, and the Northern Stations with a lesser rainfall, Kaduna, Zara and Kano.

As would be expected (Graph (3)) THESE LAST stations have a much more seasonal malaria incidence.

1. (a) <u>POSSIBLE REASONS FOR THE HIGH MALARIA INCIDENCE IN NIGERIA.</u>

Nigeria has been used to a greater degree than the other colonies as a training ground for units and formations before proceeding overseas. As a result there are two factors which immediately present themselves as probable explanations of the failure for the bulk malaria incidence to fall. The relationship to other colonies is best seen in Graph 1.

These two factors are:-

(i) The greater turnover of Europeans so that rates based on average strength do not give ~~proper~~ comparable figures. Probably the total numbers exposed for varying periods in 1943 and 1944 bear a relationship of about 3:1 as opposed to the relationship for the other Colonies of 2:1. As a considerable number of the new comers were not transfers from other colonies but straight out from the United Kingdom there was inevitably a greater proportion of the population at greater risk.

(ii) The advanced training of formations involved long exercises which might be thought to have contributed to the rate. From arguments I have advanced previously in theory, exercises in bush should not have involved a greater risk. In 1944 I made check over four months with interesting results that the rate in the Division under training was practically the same as in the rest of the Colonies.

(b) There are other risks which are based on local knowledge, which are, I am sure, contributory. Anti-Malaria discipline is not as good in Nigeria as in the other Colonies. The country is so large that units are not visited and pepped up sufficiently often by Hygiene and Malaria Officers. It is often impossible to avoid posting new Medical Officers straight from U.K. as Unit Medical Officers. It is extremely difficult for them to advance their opinions in the face of what frequently amounts to active opposition from Commanding Officers who have been 'on the Coast' for many years.

(c) There is yet another factor and that is the very large concentration of African civilians round the big standing camps in Nigeria. West Africa is a relatively thickly populated part of the world and the West Africans except in isolated tribes do not live in family compounds but in large villages.

In view of the prevalence of family compounds in tribes at a more primitive stage, this is probably the result of their crowding together in the old days in fortified towns as a protection against slave raids. The gregarious habits have persisted when the need has passed.

The result of the prevalence of these large villages always with a highly infected population is that although

the anophelene house index may be relatively low, the total number of mosquitoes which may find their way into the neighbouring army camp is extremely large. This factor of the concentration of large numbers of infected Africans is not adequately stressed in the literature of Malaria Control but I feel sure that it does explain some of the high rates of malaria infections of Europeans in West Africa and particularly in Nigeria.

In East Africa the position is very different. Small Military stations on the Kenya and Tangayika Coast or immediate Hinterland have a very similar climate to that of West Africa. The anophelene indices arrived at by the same methods are just as high. Yet Malaria rates in these stations, even when suppressives are not taken, never reach the very high figures which are commonplace in West Africa. In East Africa the native population is firstly much less dense and secondly what there is, is scattered through the bush for miles. Each family compound is on its own farm, whereas in West Africa the man often sets off very early in the morning to walk miles from his village out to his farm.

As I have tried to stress elsewhere, a very great amount of A. Gambiae breeding is actually inside the villages and their presence near camps is a constant menace.

For completeness I have given the R.A.F. rates in Apapa near Lagos and Army rates in Lagos in Graphs 14 and 15. They are the only stations for which records have survived.

THE PREVENTITIVE MEASURES TAKEN
AND THEIR RELATIVE VALUE.

Chapter VII.

(A) Suppressive Drugs.

The times at which the various suppressive drugs were taken are given again here for easy reference:-

Jan 1941 to March 1943	Quinine Gr. V daily.
March 1943 to Oct 1943	Mepacrine 0.4 gms weekly
Oct. 1943 to May 1944	Mepacrine 0.6 gms weekly
May 1944 onwards	Mepacrine 0.7 gms weekly

Some of the information below of the earlier period was submitted as a formal report to the War Office, and was sent for publication. (FINDLAY AND STEVENSON)

As noted before, there was at first much opposition to the use of quinine, although it has been used as a suppressive on "the Coast" without marked ill effect for many years. The arguments against its use which are usually produced are not really sound when the frequency and severity of West African Malaria are weighed against them. Some are of course fantastic, but those quoted are actual objections which have been advanced. They may be grouped as follows:-

1. That quinine produces sterility and/or impotence. This is probably a confused association with the use of the drug as a contraceptive and abortifacient but it is also an inevitable reaction to trying to get men to take any 'tablets'. This is of interest as revealing how widespread in men is the fear of such a happening, for even if the idea does not occur "de novo" to many, it is an acceptable fear to the vast majority.

2. That quinine produces dental decay. There is no scientific evidence to support this contention and no Dental Officer in West Africa lends it support.

3. That it masks attacks and impedes diagnosis, making

for much chronic 'sub-clinical' malaria. There is some truth in this but quinine does keep on their feet, and in a condition fit to fight, many soldiers who would otherwise be in hospital. When taken regularly it reduces the number of serious hyperpyrexial choleraic and cerebral attacks.

4. That it has a depressing effect when taken in adequate dosage. This is the most effective criticism when taken with 3(above). The usual suppressive does is 5 grs per day, but 8-10 grs is much more effective. Unfortunately, this dosage causes signs of cinchonism if persisted in, in a large proportion of people. It is of intrest to speculate whether the humid hot climate irritation at the backward African, alcohol, chronic malaria or quinine is the most potent single factor in inducing the slight mental confusion and lethargy said to be characteristic of "the Old Coaster".

The effectiveness of quinine in reducing the attack is beyond doubt. In the Chapter on Sierra Leone, it will have been noted, that the attack rate in the Marine Brigade fell drastically immediately quinine was started and there are many examples quoted in the historical section which do not admit of any other interpretation. As it is hoped to show, mepacrine is more effective but, failing mepacrine, quinine is certainly second best.

With the loss of the Dutch East Indies, and the world shortage of quinine which resulted, it became necessary to search for some substitute. An investigation, using the personnel of Military Units in the four colonies was started on May 10th 1942, and this preliminary trial ended on Nov. 6th 1942, thus covering the six most malarious months of the year. They were divided into two groups, corresponding as far as possible in work done and length of tour. Owing to various 'accidents' such

as postings and Medical Boardings, 37 were rejected from the final figures which consisted of:-

On Mepacrine	822
On Quinine	1180

Few data were available as to the daily amounts which were necessary or would be tolerated. In the Far East, the usual dosage had been two doses of 0.2 gms per week. On the other hand Rose (1941) when dealing with German troops in the Balkans and Crete recommended seven daily doses per week of 0.06 gms. In the work from the Far East, the experiments had been carried out with the indigenous population so that in view of their natural resistance, the effects were more difficult to interpret. Neither these nor the German results shewed any comparison with quinine, and the results were derived from observations extending over a few months of one malaria season. It was therefore determined, as troops in West Africa would have to take a suppressive all the year round, that a start would be made with 0.2 Gms per week the tablets being taken on Wednesday and Saturdays on a parade. It was soon clear that this dosage was at any rate insufficient to suppress latent malaria for between May 10th and May 31st, 93 out of the 600 developed malaria, mostly between 10 and 14 days after the change from quinine to mepacrine. During the same period of 648 men on quinine, only 42 had attacks of malaria. These results are tabulated for reference below.

	Quinine gr V daily	Mepacrine 0.2 gms weekly.
Number on suppressive.	648	600
Number of attacks.	42	93
Attack rate per 1000 May 10th to May 31st	64.8	155.0.

It was clear, not only that the mepacrine dosage was insufficient even after it had been taken for three weeks but, that Quinine was suppressing and not preventing infection. On June 1st the dose of mepacrine was therefore doubled and the test continued to September 6th until results for the period as follows:-

	Quinine Gr V.			Mepacrine gms 0.4		
	No. of Men.	No. of Attacks	Attacks per 1000	No. of Men	No of Attacks	Attacks per 1000
Gold Coast	270	137	507.4	143	68	475.5
Nigeria	588	379	644.5	302	125	318.9
Siera Leone	88	30	340.9	88	21	238.6
Gambia	234	223	952.9	199	125	628.1
Whole Command	1180	769	651.7	882	339	412.4

It will be seen that although the results from the various colonies varied considerably, they all shewed a reduction, and the overall reduction in the Command in mepacrine takers was considerable.

It so happened, that in 1943 there were three different groups of Europeans (in different Services) resident in the same area all on different suppressives. Each group consisted of between two and three thousand people and were living under very similar conditions although Group B had screened quarters.

Group A. took Quinine Gr V. daily
Group B. took Mepacrine 0.4 gms weekly in two doses
Group C. took 0.6 Gms mepacrine per week, - 0.1 gm daily except Sunday.

Graph 17 shews that group A. had a higher malaria rate than the other two.

For cosmetic reasons certain Nursing Sisters did not change to mepacrine on March 15th 1943. For the remainder of the year the relative rates in the sisters

who took Mepacrine and those who took quinine were as follows:-

Suppressive.	Number of Sisters	Number of Attacks	No of attacks per sister.				No of attacks per 1000 of strength.
			0	1.	2.	3.	
Quinine.	49	29	20	18.	4.	1	591
Mepacrine	16	6	10	6.	-	-	333

These numbers are small but when taken with the other evidence are suggestive.

It was decided early in 1943, that from March 1st 1943 the whole Command should take 0.4 gms mepacrine per week, so that thereafter, that possibility of experiment in quinine and mepacrine had gone.

The effect on the malaria rate as a whole is seen in every graph for colonies and stations.

It may be said that the peak of the malaria season aborted in 1943. In October 1943 the whole Command increased the dosage to 0.6 gms per week and an interesting event occurred in Takoradi which was mentioned before. 86 Indian Lascars from a torpoedoed ship were landed at Takoradi on Dec 26th 1943 and were accommodated in the African Other Ranks Transit Camp. They were not given a suppressive and 34 of them were admitted to Hospital with M.T. malaria by 7th February, when they were transferred elsewhere. This is a ratio of 395 per 1000 over the six weeks. The incidence in European Troops who were on 0.6 gm MEPACRINE ~~malaria~~ in Takoradi over the same period was 81 ~~130~~ per 1000.

The Malaria incidence in the U.S. Forces and the British Army in Accra afford a very interesting comparison. The Americans started on 0.4 gms mepacrine weekly but discontinued it in March 1943 and took no suppressive until

early August 1944 when they began again to take mepacrine, this time 0.7 gms weekly. The British Army took Quinine gr V. daily until March 1943, Mepacrine Gm 0.4 until October, 1943, Mepafrine Gm 0.6 until May 1944 and Mepacrine 0.7 gm thereafter.

It should be noted that the Americans are by the sea, and in a considerably more healthy area on the whole than the British Army. The American quarters are all well screened and the enlisted men are not allowed out of camp after 6.30 p.m.

Graph 18 shews the relative malaria rates by ratios per 1000 of average strength per month. It will be seen that after being for six months at a level about half of the British rates, the Americans rose to almost double the British rates when they stopped mepacrine and that they maintained that relationship for eighteen months. They were certainly falling [redacted] before the recommencement of mepacrine could have had any effect but they dropped below the British rates and have remained there for five months. (The relationship has continued until the end of March 1945).

It is difficult to avoid the conclusion that the determining factor in this example was mepacrine.

Experience in the change over from Quinine emphasized the importance of continuing quinine until a sufficient concentration of mepacrine has been built up. The incidence in the change over to 0.2 gms mepacrine WITHOUT OVERLAP has already been noted. In August 1942 a large group was changed over to 0.4 gms quinine to test mepacrine toxicity. This group numbered 346. Due to a misunderstanding, there was no 'carry over' of quinine. For the previous weeks, this group had had an admission rate of 5 to 10 per 1000 per week. In the first week after the change over, the

rate rose to 15 per 1000 and in the second week to 41 per 1000. At the same time, the incidence showed no increase in the members of the group who remained on quinine.

As mentioned before it was not possible to compare the relative values of 0.4 gm and 0.6 gms mepacrine. The incidence in groups B and C in graph 17 offer a comparison on a small scale.

I am not satisfied as to the value of detailed comparisons between the rates of the periods while on the differing doses, as conditions vary so much from one year to another. Even attempts to follow the history of individuals through the periods in which they were on both dosages are unsatisfactory, as (as will be demonstrated later) the liability to a first attack is much greater early in the tour. Consideration of groups who started their tour on 0.6 gm mepacrine and those who went on to 0.6 gms later would almost inevitably be in favour of the latter on this ground alone.

It is however most notable that all colonies have shewn a marked reduction since the dosage was increased to 0.6 and then 0.7 gms. There are two very striking examples. The first of these examples is demonstrated by the Strength - malaria incidence graph in Nigeria where the average strength continued to increase until well into the rainy season in 1944. The 'total' strength i.e. the total number of people exposed was greater than ever before owing to a continuous stream of Europeans fresh from the United Kingdom who stayed for a month or two and then left. Yet the malaria rate decreased steadily and the lowest incidence of the four years was recorded.

The second example is in the comparison between Civilian and Military rates in Sierra Leone over the four years.

The rates per 1000average strength were:-

Year	Military	Civilian.
1941	984	371
1942	751	512
1943	370	534
1944	68	478

It will be remembered that the civilian figures are accurate. It would seem that some factor has operated very much in favour of the Military in 1944. The only new factor apart from a reduction of the number of newcomers, is the increased dosage of mepacrine. That the full effect of mepacrine is not obtained until a reasonable concentration is built up in the blood, is suggested by many laboratory experiments which shew that a dosage of about 1.8 gms over at least 14 days is necessary to raise the plasma level to 20 mgms per litre) which is the generally accepted standard. The effect is well shewn when quinine is stopped and mepacrine started on the same day. There have been many cases of malaria which have started after sudden stoppage of quinine and the only way to avoid them is to take mepacrine and quinine for fourteen days and then stop the quinine.

The number of men who developed malaria in the first month of their tour when on mepacrine suppressives was striking. Investigation shewed that for a number of reasons, few were arriving having had more than 0.7 gms of mepacrine. Graph16 shews the time of tour at which the first attacks of malaria developed in 840 consecutive first attacks beginning January 1st 1944 in people on their first ~~two~~ tour. It will be seen that an undue number were developing malaria in the first month. Since then every man who disembarks takes 0.3 gms on each of the first three days and then goes on to the 0.1 gm daily maintenance dose. I have not had time to gather the

figures for a comparable series after this innovation but the impression is that it is having the desired effect. There is no doubt whatever that men should have 21 tablets before they arrive in West Africa.

The Actual Amounts of Mepacrine taken by the Troops.

It is not easy to devise a method of ensuring that under all circumstances, every Officer and N.C.O. takes one tablet each day. A few units hold parades for B.N.C.Os but it is impracticable in the majority and various substitutes have been tried. Some have a book which must be signed each day, others have a tablet of mepacrine on each plate at one meal in the day. At the end of 1944, I arranged a confidential check on four units in each area. An Officer and an N.C.O. questioned each Officer and N.C.O. in confidence and under the assurance that no action would be taken if the Standing Order had not been obeyed. (It is a lawful order to tell a man to take mepacrine and Religious or conciencious grounds is no excuse). The results of this check are given below. The units were a General Hospital, a Base Ordnance Depot, an R.A.S.C. training Unit and a Training Regiment in each area. The results are grouped - None. Very irregular, less than 0.g gms per week; Irregular 0.4 or 0.5 gms per week; Regular 0.6 or more gms per week.

Gold Coast.

Unit.	Total	None.	Very Irreg.	Irreg.	Regular.
A	77.	0	1	6	70
B.	85.	1	2	9	73
C.	38	0	0	0	38
D.	82	1	4	7	70
Total	282	2	7	22	251

Only 89% therefore of the persons questioned took an adequate dosage. At the same time, I checked on mepacrine issues from the Base Depots Medical Stores to these units with the surprising result that on average twelve tablets

per head per week were found to be issued!

Sierra Leone

Unit	Total	None	Very Ireg	Irreg	Regular.
A	40	0	0	0	40
B	66	0	0	0	66
C	57	1	0	5	51
D	112	1	2	7	102
Total	275	2	2	12	259

Therefore 94% were taking adequate dosage.

Check of mepacrine issued to the units revealed that on an average 8 tablets per head per week were demanded.

In Gambia 194 or 48.5% of the total European strength were questioned. All said that they took over 0.6 gns per week.

Nigeria.

Unit	None.	Very Irreg.	Irreg.	Regular.	Total
A	1	0	0	48	49
B	3	7	11	51	72
C	0	0	0	102	102
D	0	0	0	60	60
Total	4	7	11	261	283

In Nigeria therefore the sample represents 13% of the total population AND 92% were taking mepacrine regularly.

Very recently, as a result of extremely fine experimental work which is still on the secret list, by Brigadier Hamilton Fairley in New Guinea, the opinion in the War Office seems to have changed to a belief in the 100% efficacy of mepacrine if the following conditions are complied with. The mepacrine is to be taken in 21 daily doses of 0.1 gn for 21 days before entering the malarious country. Thereafter, a minimum of six daily doses of 0.1 gn mepacrine are to be taken per week.

I have no experience of the prevention of Malaria by mepacrine in other countries but I do not think that the protection is absolute or that mepacrine in such doses is a 100% true prophylactic in West Africa.

It should be mentioned by the way that only M.T. malaria is considered. My proof cannot be absolute for I cannot find cases which will fulfil the condition of having had the twenty-one daily doses before arrival. A voyage to West Africa may take less than 14 days. Nevertheless, it seems most unlikely to me that parasites would remain in the blood for seven or eight months on continuous intake of 0.1 gm mepacrine daily and then suddenly cause an attack. Indeed we have found parasites in apparently fit individuals who have sworn that they have not missed their mepacrine so many times that it would be folly to deny that it is impossible to harbour parasites with an adequate blood mepacrine concentration. When, however, such cases are followed up, they either cease to have parasites in a few days and do not subsequently develop malaria in the rest of their tour or, they have an attack of malaria within five days while continuing to take their usual dose of suppressive.

I disagree with this current opinion for the following additional reasons.

(1) A great amount of experimental work in the West Africa Command Laboratory has been carried out on the attainment and maintenance of protective plasma mepacrine levels and as I have said 20mgms is the accepted minimum for adequate protection. Repeated observations on men taking 0.7 gms mepacrine per week has shewn that the individual limits of variation are wide and that the average is about 23 mgms per litre. There is a suggestion also that fluctuations in the individual are much greater in the early months of a tour.

If 90% of the Command take 0.6 gms a week as seems likely from our checks, then in 1944 there were 'at risk' according to the War Office 10% of the <u>total</u> not the average population. The average population was 8605 and

the total number who were at any time on the coast during the year was certainly not more than 14,000. So that 1400 at most were at risk.

There were in the Command in 1944, 2314 attacks in 1925 individuals, so roughly 500 (1925 minus 1400) individuals who were taking mepacrine regularly are left having had attacks. Of these, if the proportion in Graph 16 which is a reasonably even curve are taken, 18% had their attack in the first month due to having had insufficient mepacrine on arrival. 18% of 500 is 90 so there still remains to be accounted for at least 400 individuals who had malaria, while taking regular mepacrine in adequate dosage <u>after</u> they had built up a reasonable protective plasma concentration.

(2) The history of certain individuals whose history is accurately known and can be trusted:-

Major P. Arrived Jan 1944 - had 14 daily doses of 0.1 gm mepacrine before arrival in West Africa. Has never missed a day taking mepacrine. Had an attack of proved M.T. Malaria in September 1944. Capt. S. Arrived July 1943 - had 10 tablets on the boat. Took 0.6 gms mepacrine per week and from May 1944 0.7 gms per week. Never missed as far as he knows. Had attack proved malaria in Sept 1944. Sister. Q.A.I.M.N.S. McM. Arrived January 1944 - had 12 tablets on the boat. Took 0.6 gms and subsequently 0.7 gms weekly without ever missing a day. Attack proved malaria in March 1945.

While then I think that we could reduce our over all command rate from the 1944 figure of 280 per 1000 per annum to under 50 per 1000 per annum if everyone took their mepacrine regularly, there would be I believe some cases no matter how carefully the dosage was checked.

It should be mentioned that experience with regard to suppression of Benign Tertian malaria in West Africa is the same as elsewhere. Cases are very seldom seen indeed in West Africa while taking mepacrine but relapses many months afterwards in the United Kingdom are relatively common.

Intolerance to Mepacrine, - Toxic reactions.

When large numbers of people begin to take mepacrine together, there is usually an epidemic of gastro-intestinal upset. There is little doubt that quite a proportion of people are indeed mildly upset for a few days, but the vast majority of cases are psychological in origin if they persist for more than a few days. About two per thousand seem unable to take the drug. The proportion in this Command has never exceeded that figure. A certificate from a Medical Specialist is required before a man is excused and allowed to take quinine.

There is no evidence from the 4,000 or so Europeans in this Command who have been on mepacrine, some for nearly three years, of any cumulative toxic action on heart, liver or kidneys. These organs have been examined at every post mortem examination in Europeans and liver and kidney function tests carried out after increased dosage, have all proved negative.

The only upsets which can reasonably be attributed to mepacrine are one case of mild confusional psychosis which cleared up rapidly when mepacrine was stopped and one case of severe recurrent urticaria.

Effect of Mepacrine in Reducing the Severity of Attacks of Malaria.

I have no evidence to offer on this point for the total number of Hyperpyrexial, Cerebral, Choleraic or Algid attacks and for deaths which have occurred in Army cases is so

small (26) that the small reduction in 1944 proves nothing. The tables below show the proportions and invalidings from malaria.

Invaliding - Malaria. - Whole Command.

	1942	1943	1944
No. invalided all causes	870	778	708
No. invalided because of Malaria	249	165	80
Percentage of total invaliding due to malaria.	28.6%	20.5%	11.1%
Ratios. No. invalided per 1000 of average strength.	2.01	1.3	0.93

It will be seen that, since 1942, the proportions of invalidings per 1000 of strength has been reduced by half. It should be remembered that the total attack rate has been reduced by very little more than that. As the total invaliding (ALL CAUSES) has not fallen in proportion, the invaliding due to Malaria is a much smaller percentage of the total invaliding in 1944 than in 1942.

Mepacrine in the prevention of Blackwater Fever.

I hope to show that not only has mepacrine reduced the incidence of Malaria in West African Command, but that it has reduced the incidence of Blackwater Fever even in a greater degree than would be accounted for merely by the great reduction of the number of the malarial attacks. The table below shews the incidence of Blackwater fever in the Command over the four years. The actual number, ratios per 1000 of average strength and the ratios per 1000 attacks of Malaria are given in separate columns.

YEAR	GOLD COAST			NIGERIA			SIERRA LEONE			GAMBIA		
	No.	No. Per 1000 Strength	No. Per 1000 cases Malaria.	No.	No. Per 1000 Strength	No. Per 1000 cases Malaria.	No.	No. Per 1000 Strength	No. Per 1000 cases Malaria	No.	No. Per 1000 Strength	No. Per 1000 Cases Malaria
1941	12	8.4	8.4	11	5.9	10.6	12	3.4	3.5	1	1.1	1.6
1942	28	10.1	11.7	46	12.4	23.6	15	3.5	4.8	15	9.0	7.9
1943	10	3.6	7.0	18	3.4	7.4	7	1.9	5.1	6	5.0	10.3
1944	1	0.4	11.7	1	0.27	0.53	0	0	0	0	0	0

YEAR	WHOLE COMMAND		
	No.	No. Per 1000 Strength	No. Per. 1000 cases Malaria
1941	36	5.0	5.5
1942	104	8.4	11.1
1943	41	3.2	7.2
1944	2	0.23	0.86

It will be remembered that mepacrine was started in March 1943, and the differing incidence of Blackwater Fever before and after that is well shewn in the two Block Charts Graphs 19 and 20. Graph 19 shews the incidence in the whole Command of European and African cases. The ratios per 1000 of strength in Europeans is plotted. The Second Graph 20 shews the incidence by Colonies.

The fall in 1944 to two cases, is the most striking feature of all these statistics, and the two cases which did occur require comment. The Nigerian case occurred in an Officer in Hospital six days after an operation for perforated peptic ulcer. He had a generalised peritonitis at the time of onset of the haemoglobinoria and the haemoglobinoria ceased before death so that there is some doubt as to whether this was a guinine case. The case in Gold Coast is of the greatest value in support of the contention that Blackwater is a less likely occurrence in people on mepacrine suppressive as opposed to quinine.

The patient was an Officer who had spent 7½ years on the Coast before and during this war. Contrary to orders he continued to take quinine and he took it irregularly. He was accustomed to dose himself if he suspected the onset of an attack. After four months in his CURRENT TOUR and two days before the onset of the attack of Blackwater Fever, feeling unwell, he commenced to dose himself with quinine. In all, in the 48 hours before the onset he took 60 grs of quinine. He was suddenly prostrated by Blackwater and died in twelve hours.

Apart from the first of the above cases, no attack of Blackwater fever has occurred in a person on Mepacrine suppressive, unless he had been treated by quinine. The cases in the latter half of 1943 either occurred in those who treated themselves with quinine outside or in eight cases in those treated in Hospital with quinine. As a result of this experience, Malaria is not now treated with quinine unless in an emergency when the risk of Blackwater Fever is outweighed by the serious condition of the patient and the necessity for rapidly clearing the blood of parasites. A case which is admitted with cerebral malaria, or with serious symptoms and a very high parasitic index would be treated with intra-venous quinine.

In 1942 87.5% of cases occurred after April 1st, in 1943 only 41.4%.

The African cases are plotted on the first graph in order to show that the conditions contributing to Blackwater Fever in Africans have continued. The increasing incidence in Africans is difficult to explain. Many so-called Blackwaters are undoubtedly sickling crises and some are self induced haemoglobinuria induced by taking infusions of the bark of various trees, camphor balls etc. The cases plotted are those which, on investigation of all circumstances seem to have been true cases.

The condition is often relatively mild in Africans and occurs several times in the same individual. It is not certain whether the hereditary tendency which has been described is really a tendency to Blackwater Fever or (as one suspects) a manifestation of the sickling trait which is hereditary.

Unfortunately, I cannot get any figures for Blackwater Fever in Civilians either before or since the War. Certainly, cases are still occurring in civilians and in conversation with the Deputy Directors of Health Services of the Colonies, I have been told that there is no change from the pre-war rates when the incidence was in the region of 5 per 1000 of average strength per annum.

There can be little doubt that it is a reasonable deduction from the foregoing that mepacrine suppressives and treatment have diminished the incidence of Blackwater Fever in European troops. As I write (April 1945) no cases have occurred so far this year.

(B) Discipline - Personal Protection.

The enforcement of personal protection is not a medical matter. On the advice of his Medical Staff, the Commander of a Formation or Unit issues the necessary instructions and thereafter the carrying out of these orders is a matter of ordinary discipline. There are really only two such orders, that the men will sleep under sound mosquito nets and that between dusk and dawn, unless when going to bed, men will wear long sleeved shirts buttoned up to the neck, long trousers and mosquito boots.

It is difficult to get these orders enforced. They are irksome in a climate where sweating is continuous and is drastically increased by such clothing. Many of the responsible officers are not convinced of their necessity

or are not prepared to trouble to observe them themselves. The effect of the latter particularly is to make enforcement impossible. One of the great difficulties is the tendency of individuals, particularly as regards medical matters to argue from the particular to the general. An officer who has spent two tours on the Coast often boasts that he never takes any precautions while many newcomers are talked to in this vein by civilians on the voyage out.

The times when personal protection is particularly disregarded and when, undoubtedly, many contract malaria are five in number:-

(1) When, after their evening exercise, people sit around and chat and have a drink until they must bath and change in the dark.

(2) When people go on journeys on posting or tour, they are reluctant to start off early in the morning in protective clothing because of the trouble of changing later on. Similarly they do not change as darkness approaches when nearing their destination.

(3) In units where the hour of first parade was so early that men had to rise and shave and dress in the dark. This is now forbidden.

(4) When, after the evening meal, they return to their Giddahs (huts) and sit reading or writing letters stripped, in order to try to get slightly more comfortable before going to bed. This last is very tempting and understandable on really hot nights.

(5) When as mentioned already, men go to African houses at night.

All observers who have been out for two or three tours agree that the standard of personal protection has improved over the four years, nevertheless only in Sierra Leone can it be considered nearly as good as it could be.

(C) Mosquito Proofing of Quarters.

I am unhestitatingly in favour of complete mosquito proofing of quarters IN WAR TIME provided certain requirements are fulfilled. These requirements are:-

(a) That any accommodation standards which apply to non-proofed buildings are suitably increased if the accommodation is to be mosquito proofed. More air space per head is essential.

(b) That, unless in exceptionally favourable circumstances, existing buildings should not be proofed. Satisfactory proofing is only achieved when the building is designed specially.

(c) That where buildings are proofed, electric fans or, if electricity is not available, punkahs should be installed.

(d) That buildings of wood construction should not be proofed unless seasoned timber and a high standard of workmanship are available.

There is no doubt, that with the best of designs, through air flow is obstructed by screening and in a hot, humid climate as in West Africa where comfort is dependant on breeze, it can be intolerable in a badly ventilated or crowded building. The effect on general health is exercised through the difficulty in sleeping and nothing affects morale so much as this. The temptation to dispense with protective clothing is much increased by such conditions.

In construction, the maximum number of entrances should be two and each entry should have double doors separated by a lock and opening outwards. The doors must be a good fit, and should have a strong self closing mechanism. The distance in the lock between them should be such that it is impossible for a person in

transit to reach the second door before the door behind him is closed. These points are elementary but they are restated, because in military practice, it is seldom that engineers with experience in Tropical Construction are available to a war time army and all these first principles have been broken not once but many times.

The proofing should be in the form of a single large outside cage enclosing the whole building. The height of this outside cage must be from about 18 inches from the ground to at least seven feet. It follows that, to avoid rain being driven into the house proper, the surrounding verandah must be 7 to 8 feet wide, and its floor must be impermeable and drained.

Inside the cage, there should be no further proofing, and the partitions between rooms should end six inches above the floor and be in height not more than 7 ft 6 ins unless required complete for privacy

Good workmanship and seasoned wood ARE essential or the most enormous warping takes place, allowing entry of mosquitoes between the seams. In some of the buildings constructed of unseasoned wood for lack of better, inch gaps appear between the boards when they dry out at the time of the Harmattan.

T.H. Davy of the Sir Alfred Jones Laboratory (Quoted in the Report of the Medical Department of Sierra Leone 1938) showed that Anophelenes Gambiae and Funestus could pass through mosquito netting any larger in opening than

18 to Sq. Inch of 30 Standard wire gauge.
16 " " " " 28

The best netting is one of the good varieties of the new plastic nettings, as such gauze is unaffected by heat, damp or termites. It can be washed with a brush and soapy

water. It has the advantage of passing more light than metal gauze and above all it is not subject to the rust which destroys the best galvanized netting in six weeks or copper netting in three months when placed near the sea in Gambia. Its only disadvantage is that rats and mice can eat their way through it.

The effect of proofed buildings in reducing malaria is difficult to assess and I have no statistics which give any very convincing evidence. The Army policy has always been to proof only in selected places and since we have never had any considerable number of proofed buildings, the overwhelming effect of mepacrine in reducing the rates has masked the smaller reductions likely to be due to proofing. It is difficult to prevent people becoming careless in proofed buildings when they see for themselves the reduction in the insect population. We have always insisted on sleeping in nets even in proofed buildings. Fig 4 is a copy of our standing orders.

Proofed buildings must be disinsecticised just as carefully as others. The locks especially should be well treated with D.D.T. and the whole building must be sprayed with kerosine-pyrethrum spray morning and evening. A particularly heavy dosage of the latter is required owing to the impossibility of closing up the building for a period after the spraying in the normal manner.

(D) Temporary Control.

Bruce Wilson and Soper (1943) in Brazil have shewn how A. Gambiae was eliminated completely there, by a very vigorous campaign of house spraying, paris green dusting and oiling. It should be noted that in Brazil, it was a question of attaching a 'Bridgehead' of the species into that country, whereas in Africa, it is a matter of making and maintaining a bridgehead

in an Anopheles Gambiae area which extends from Dakar in the West up into the Southern Saharan oases and in a broad belt South of the Sahara right across Africa to Southern Arabia and the East African Coastal swamps as far South as Biera in Mozambique.

The Army policy has always been to provide temporary larval and adult control round military stations except where these stations were located within the boundaries of a permanent or semi-permanent control area. The latter, in West Africa, have only been executed since the war and are all joint Civil-Army works. These areas are only Freetown, Takoradi and Accra.

The control had always been exercised in an extremely haphazard manner in the smaller stations. In the vast majority, until 1944, there was no control worthy of the name or, more important, likely to exercise any effect on the mosquito population sufficient to influence the transmission of malaria. One old West African fetish constantly has to be combated, "bush clearing". It was remarkable how much grass and low bush cutting was carried out under the head of 'Malaria Control'. It used to be found to the surprise of the originators that the cleared areas often made good golf courses! However it did serve to let light into swampy places and convert them from breeding places of A. Obscurus and harmless culicines into excellent A. Gambiae and A. Funestus breeding places. The only justification for bush clearing is where there are open pools in thick bush. Paths must then be cut into the bush to allow spotters and oilers easy access.

The only exception to this inefficient control in the past might be made in the case of Gambia at Cape St. Mary, although as has been shewn, this control breaks down every year at the most critical time. Much money

and labour was wasted in small scale drainage of limited areas on the inspiration of enthusiastic but inexperienced Medical Officers and Sanitary Inspectors. Records were so inadequate that the Senior Medical Officer in a station had no real check either on what work was being done or even of the true incidence of Malaria. Because, in a small station, cases of malaria were not pouring into hospital, S.M.Os often thought that 'there is very little malaria here'. For example, when I visited Enugu in S.E. Nigeria, early in 1944, in one unit there with an average European Strength of 56, I was told by the S.M.O. and the Commanding Officer that they had had an odd case in the past three months but that malaria was no problem in that station. When I went into the matter, I found that in the previous 12 weeks (Dec. Jan and Feb) there had been 17 cases from this unit. This represented an annual rate of 1300% per 1000 of average strength - and this in the dry season!

As it was becoming increasingly clear that this kind of thing was happening elsewhere, it was decided that a certain amount of uniformity on methods of control was required and that certain minimum standards, much higher than those existing would have to be imposed. Accordingly in March 1944 I drew up the following directive. It is quoted in full as it is illustrative of the problems of temporary control here.

Appendix C. was added later when D.D.T. became available.

CONTROL OF MOSQUITOS IN STATIONS.

1. The following instructions are not applicable to Sierra Leone Area with the exception of Gambia Sub Area and Daru, to Accra, Takoradi in the Gold Coast, nor to any part of Lagos except Yaba.

2. Control by Stations.

On receipt of this letter arrangements for control of Mosquito breeding will be organized on a "Station" basis where two or more units are in one Station.

Isolated units will be responsible for their own larval control but the same methods will be applied.

3. Objects of "Station Control".

There is no intention of embarking on any comprehensive control of mosquito breeding by drainage. The main object of this instruction is to get a more thorough control of breeding in Stations by means of systematic brushing, cleaning and oiling carried out by labour under the direction of one authority in each Station. The control will be vested in the Senior Medical Officer in each Station and he will be responsible to Sub Area Commanders for carrying out the work.

The other object is to save waste of money on partial drainage schemes and works which have, in West Africa as elsewhere, always failed to achieve their object. It is not disputed that the ideal is a comprehensive drainage scheme; but water control by drainage on a lesser scale will not give results comparable to systematic intensive brushing, cleaning, oiling, etc.

The only anti-mosquito measures left to units will be (a) spraying of European quarters, and (b) a day a week when all standing water in the camp is changed ("dry pot day").

4. The instructions which follow will be applied also to isolated units with modification to suit circumstances and resources.

5. Instructions for defining Control Areas.

In every Station a control area or areas will be laid down. These areas will be decided after consultation with the Civil authorities and the Area Malariologist, and will in principle be an area extending to a distance of ½ - 1 mile beyond the area formed by joining on the map the tips of buildings occupied by Europeans. The boundaries will then be finally determined according to local circumstances.

6. Sub-division into Zones.

Each area will further be sub-divided into three to five control zones. The entire programme of a systematic larval catching, oiling, adult catching in fixed catching stations, and house spraying of adults will be carried out at least weekly in each zone.

Permission to establish catching stations and, where necessary, to spray civil African houses will be obtained from the civil authorities.

7. Duties of S.M.Os.

The Senior Medical Officer in each Station or isolated unit will be Malaria Officer, and he will be responsible to the Sub-Area Commander or O.C. Unit for the organization and carrying out of control.

8. Employment of Labour.

Employment of labourers by Stations or units on a scale of 1/64th of a labourer per acre is authorised for this scheme. Increase up to 1/16th of a labourer per acre may be authorised by Sub-Area Commanders.

9. Personnel to assist S.M.Os.

A.Ds.M.S. will attach a sufficient number of Europeans and Africans from Field Hygiene Sections to the S.M.O. of the Station or to the unit to enable this system to be carried out.

10. Expendible Stores.

The scale of issue of larvicidal oil is at present 165 gallons per 1,000 men for 30 days. This should be sufficient. S.M.Os will draw in bulk for the Station. Similarly Paris Green (scale 112 lbs. per 1,000 men for 30 days) will be drawn in bulk by S.M.Os as required.

Anti-mosquito spray+ may be drawn by units to a scale of 1 pint per head per month for each European. The remainder of the spray authorised in the G.R.O. scale will be drawn in bulk by S.M.Os for use by spraying gangs.

11. The Methods of Control.

The two methods of control will be:-

(a) Elimination of mosquito breeding by intensive regular oiling at weekly intervals.

Paris green will be used in some places where it is likely to be more effective than oiling. (See notes on Paris green in Model Scheme).

(b) Killing of adult mosquitoes by regular spraying

(i) in Military buildings,

(ii) where necessary and by agreement with Civil authorities, in African civil houses.

12. Checks on Effectiveness of Control.

The checks on control will be:-

(a) by catching stations - visited on a certain day each week at the same time, and numbers of mosquitoes found noted.

(b) by larval spotting in zones before and after oiling.

13. A Specimen Scheme is set out at Appendix 'A'.

The methods shown there and the form of instructions will be followed as closely as possible when each Station draws up its own scheme.

14. Notes on efficiency of Larvicidal Oils are at Appendix 'B'.

LARVAL CONTROL SCHEME

ZONE 1

ZONE 2

ZONE 3

ZONE 4

SECTOR 1

SECTOR 2

SECTOR 3

SECTOR 4

SECTOR 5

- RAILWAYS.
- ROADS.
- FOOTPATHS.
- STREAMS.
- MARSH.
- BUILDINGS MILITARY.
- CIVIL AFRICAN HOUSES.
- LINE OF LIMITS OF MILIARY BLDGS.
- MILE LINE FROM ABOVE.
- UNDER CONTROL (MILITARY)
- AREA UNDER CONTROL (CIVIL)
- ZONE BOUNDARIES.
- SECTOR BOUNDARIES.

N.

WET SEASON.

DRY SEASON.

S.

PREVAILING WINDS.

0 1 2 3

SCALE 4" TO 1 MILE

APPENDIX 'A'.

MODEL MALARIA CONTROL SCHEME - LARVAL CONTROL - FOR A HYPOTHETICAL AREA OR STATION

(A). STAFF.

1. S.M.O., who is area Malaria Officer.
2. Staff Serjeant or Serjeant(B.O.R.) from Field Hygiene Section.
3. N.C.O. - African. " "
4. Fifteen A.O.Rs. " "
5. Civilian Labourers on a scale of 1/64th to 1/6th per acre.

(B) AREA TO BE CONTROLLED.

The area to be controlled is shown on the attached map. The area is approximately five square miles = 2,560 acres. Therefore thirty to one hundred and fifty labouters may be employed according to the season of the year and local terrain. The area is divided into four zones and each zone is subdivided into five sectors; these are shown on the map.

(C) CONTROL METHODS.

(1) CLEARING.

All water will be rendered accessible to larvicides by the simplest methods. This will involve bush cutting, clearing and banks, sides and channels of streams from vegetation which would interfere with oiling etc., clearing stream channels of obstructions, drainage of small seepage areas, etc. Casual small amounts of this work will be done by labourers accompanying spotting and oiling gangs, while the systematic work will be done by gangs on a definite programme laid down by the S.M.O.

(2) MARKING.

All areas to be oiled or dusted which are not obvious or which might for any reason be missed will be marked with posts bearing small numbered plaques. The marking

will be done by larval spotters.

(3) OILING and DUSTING.

(i) OILING.

Each of the four zones will have one oiling squad consisting of:-

One Head boy,
Two oiling boys,
Three boys with spades and matchets.

Each zone is the weekly oiling task of one squad and is divided into five oiling sectors. The working schedule for each squad is one sector per day.

The following instructions will regulate the work of oiling squads.

Working Instructions for Oiling Squad No. ... Zone .....

(a) One sector will be completely oiled each day.
Sector 1 will be oiled on Mondays,
2 " " " " Tuesdays,
3 " " " " Wednesdays,
4 " " " " Thursdays
5 " " " " Fridays.

(b) There will be no change from this schedule without due reason.

(c) Oiling will be carried out by the spraying apparatus provided. All surface water irrespective of breeding will be oiled.

Head boys will see that proper clearing precedes oiling. If more clearing is required he will notify the Sergeant well ahead so that labour may be diverted to the particular zone.

The Head boy is responsible for keeping his apparatus in good order.

(d) Each zone and each sector will be visited once a week by an inspector who will check the efficacy of oiling. Presence of fourth stage larval instars or pupae is the indication of bad oiling. 'Burning' (brown discolouration) of vegetation along drains and streams is another good test,

but it must be noted that gas oil alone does not burn vegetation. Malariol and Gas oil - sump oil mixtures have a marked burning effect.

(e) Besides this main technique of oiling with pressure sprayers, other methods such as oil bags, drip cans or oil sawdust may be used where they are likely to be more efficient.

(f) The amounts of larvicidal oil drawn from store by each oiling squad will be recorded weekly in the oil record book.

(g) After a heavy shower, if the oil is carried away, a particular sector may have to be oiled again ahead of schedule.

(h) It cannot be too strongly emphasized that the success of oiling depends entirely on its thoroughness.

Head boys must be reminded that they are the oilers, the spray men merely oiling where they indicate.

(ii) PARIS GREEN DUSTING.

(a) One or more Paris Green squads of two boys will be formed. They may or may not be allotted to specific zones.

(b) Dusting with Paris Green will be substituted for oiling where suitable as, for example, in marshy areas with rapidly growing vegetation and in some actively cultivated places especially at the peak of the rainy season. It is suitable also for irrigation channels and furrows.

(c) Checking of dusting (with Paris Green) is more difficult than that of oiling.

(d) The usual 3% - 5% dilution of Paris Green will be used. The best diluent is fine road dust. In this concentration, Paris Green is more or less harmless but boys should be issued with a little soap for washing after handling the mixture. Mixing of Paris Green and dust will

be done exclusively in a 'turning tin' closed mixer.

(e) The normal method of distribution of Paris Green will be casting by hand as in sowing grain. It is conveniently carried in a tin slung over the shoulder. The approximate amount required for efficient larval killing is 60 lbs. of the mixture per acre of water surface per week.

In certain circumstances it may be more efficient to suspend the Paris Green (undiluted with dust) in paraffin oil and to throw it in cigarette tinfuls over the area to be controlled.

(f) Amounts of Paris Green drawn and the Zones in which it is used will be recorded in the Paris Green register.

(4) SPRAYING OF ADULT MOSQUITOES.

(i) Responsibility.

(a) European Quarters: the occupants (See GRO 170/44).

(b) A.O.R. Quarters and civilian African houses: the spray squads.

(ii) Composition of Spray Squads.

Each team will consist of one trained A.O.R. and two civilian labourers. There will be one team in each zone.

(iii) Duties.

To spray every A.O.R. quarter and every civil African house allotted each day during the rainy season and every other day in the dry season.

(iv) Directions for Spraying.

(a) Prior to spraying all doors, windows and shutters will be closed.

(b) The nozzle of the spray will be directed towards the walls and not towards the middle of the room. Particular attention will be given to corners, cupboards, under beds, chairs and tables, behind hanging clothes, etc. It is useful in a hut with open eaves to spray first from

the outside, the spray being directed through the gap between the wall and the tatched roof.

(c) The amount of spray to be used will be ½ oz per 1,000 cub. ft. This corresponds to twenty five strokes with a Four Oaks Manney large hand sprayer per round ghidda.

(d) Guns must be kept in good condition or the insecticide will not be properly vapourized and will be wasted.

(e) A record of insecticide drawn per week will be recorded in the spray register.

(v) Procedure to be followed in spraying A.O.R. lines.

S.M.Os will notify units of the approximate times of arrival daily or on alternate days of the Spraying Squads, so that arrangements can be made for them to be accompanied by an N.C.O.

(5) CATCHING STATIONS.

(i) A mosquito catching station will be set up in each zone. The station will be an African quarter or a civilian house occupied by Africans.

(ii) Each station will be visited by a trained African Collector (A.O.R.) or civilian) on a fixed day.

(iii) Catching will be done between 0630 and 0730 hours. Duration of the catching will be 30 minutes.

(iv) The method used will be that of the spray-sheet. Electric torches required for catching will be supplied by the S.M.O.

(v) Captured mosquitoes will be collected in tubes. They will be identified and counted by the collector. But the tubes must be deposited daily at the Malaria Office.

(vi) The Serjeant i/c mosquito control will from time to time inspect the technique of catching, its regularity, and the identifications.

(vii) The results of generic identification (Anopheles, Culex, Aedes) will be recorded daily in a log book. The log books will be checked every Saturday by the N.C.O. i/c. He will maintain a weekly density curve for the genera separately for each catching station.

(viii) In addition to the daily mosquito catching in stations, there will be a once weekly catching of adult mosquitoes sheltering in African huts at or beyond the control bounday in the direction of the prevailing wind. This will be done by the 'Insecticide spray - bed sheet technique'. The results of these catches will be recorded separately in the Log Book.

(6) LARVAL SPOTTING.

On the day before oiling or dusting is due in a sector, that sector will be searched by larval spotters. Each spotter will be accompanied by two boys with shovels and one boy with a hand oil spray. He will mark with a post any areas not on regular oiling schedule and will record breeding found in the breeding log book. If practicable, the boys with the shovels will eliminate the breeding place.

(7) RECORDS TO BE KEPT BY THE S.M.O.

(i) The plan of the control area divided into zones and sectors. Scale: six inches to the mile.

(ii) A record of weekly incidence of malaria in Europeans in the station in ratios per 1,000 of strength per week.

(iii) A record of expenditure by zones of each of the following:-

(a) Larvicidal oil.
(b) Paris Green.
(c) Insecticide Spray.
(d) Paraffin oil.

(iv) A record of breeding places found will be kept in a log book and if possible flagged on the map.

A record of Marking Posts (Para. (C) (2) above) will also be kept.

(v) A record of adult catches and identifications by zones.

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APPENDIX 'B'.

NOTES RE USE OF GAS OIL AS A SUBSTITUTE FOR MALARIOL.

The defects of Gas Oil as a larvicide are:-

(1) Poor spreading pressure on water surfaces.

(2) Does not 'burn' vegetation.

These defects may be rectified by the addition of waste 'sump' oil, in the proportion 80% Gas oil to 20% sump oil.

Treatment of sump oil before use.

Sedimentation by "standing" for several days will result in a sludge forming at the bottom of the container. The supernatant oil may be run off for use.

Preparation of the mixture.

It is recommended that the 4 to 1 mixture be prepared for use daily; the "stock" drum and the knapsack sprayer container require shaking to ensure adequate mixing of the oils.

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A P P E N D I X 'C'

The use of D.D.T. as a residual insecticide for adult mosquitoes.

1. The following will be used as a guide to the method and dosage of D.D.T. as a residual anti-adult mosquito insecticide.

2. Places to be Sprayed.

It should be understood that the spraying with D.D.T. of the walls of a house occupied by Europeans who are to be protected, will not prevent persons being bitten in that house.

The safe presumption is that most mosquitoes bite on first entering a house before they rest. What probably happens is that the mosquito, having bitten and being engaged with blood, is then forced to rest. It is at this stage that the D.D.T. is given its opportunity.

From the above it follows that the most effective way of catching adult mosquitoes is to spray the African houses where they become infected. European and African lines and native houses will all, therefore, require attention.

3. Vehicles of D.D.T.

The most convenient solvent is crude kerosene. Information has been sought from U.K. as to any possible method of manufacturing a water emulsion from the powder in West Africa, but until such a method is found kerosene must be the vehicle.

4. Preparation of D.D.T. for issue.

The question now arises, whether D.D.T. should be issued in paraffin solution or in solution in the existing anti-mosquito spray. There is some evidence to suggest that the presence of D.D.T. in a given pyrethrum

spray decreases the immediate knock down, but the first result is enhanced and it is extremely unlikely that a mosquito hit by such a spray would ever have sufficient control over itself to bite again before death.

It would seem that as a matter of comfort and convenience every European ought to have a "flit" gun available in his room, but it would be wasteful to have such "flit" guns charged with a D.D.T. solution.

It is, therefore, suggested that by agreement with your "Q" Branches and C.R.A.S.Cs you arrange for a diminished scale of issue of "flit" per head to Europeans - say 1/3rd of the present issue, which is 200 galls per 1000 per month and that the rest of the "flit" spray plus paraffin be used as a vehicle for D.D.T.

5. Dosage of D.D.T. on walls.

Varying estimates between 25 mgm. and 200 mgm. per square foot of surface have been given. Unfortunately very little work has been done on the variation of minimum effective dosage in accordance with the type of wall surface. It does seem, however, that the higher figure which represents 4 quarts of 5% D.D.T. spray per 1000 square feet is is unusually high. Trials at Takoradi have given effective sprays on cement rendered concrete walls lasting seven to eight weeks - with about 20 mgm. per square foot.

It is suggested that a suitable dosage would be 75 mgm per square foot to begin with, but that in each Area a suitable experimental check be made with a view to a subsequent reduction in dosage.

6. Dilutions and Technique to achieve required dosage.

Having decided the dosage the next step is to decide

at what dilution in kerosene anti-mosquito spray and by what method the dosage can be applied.

It is recommended that the dilution be 2½% and that a technique be evolved by experiment whereby 3 quarts are applied per 1000 square foot. As a guide to technique or as a basis of experiment, it is reckoned that with the nozzle of any type of spray, held at an angle 15 inches from the wall and the whole surface moistened (short of trikling down the wall), a dosage of 75 mgm per 1000 square feet will be obtained with 2½% spray.

To begin with the spray should be applied at two monthly intervals.

7. Types of Spray Apparatus.

The type of spray is not very important but it will at once be realised that the hand flit gun has a small capacity and is hard to work and that the power sprayers of the paint spray type have too small a capacity for convenience.

Suitable sprays are - the stirrup pump, knapsack sprayers or power sprayers with two quart containers fitted.

8. Organization of Efficient Spraying.

Spraying of native houses and A.O.R. lines will, of course, be carried out by the present spray gangs. Spraying of European quarters with D.D.T. cannot be the responsibility of the Europeans. Arrangements will have to be made whereby at two monthly intervals a B.N.C.O. from the unit takes the unit or station spray gang round the quarters.

Hygiene sections will have to work out a simple technique, as foolproof as possible, and teach station and unit gangs their technique. A demonstration squad from hygiene sections would seem to be indicated.

9. Checks on results.

It will be realised that a good deal of work will be

required in this matter and that unless the results are checked and controlled we shall not increase our knowledge.

Walls, roofs under furniture, etc., must all be dealt with thoroughly if good results are to be obtained.

10. It is requested that A.Ds.M.S. will report from time to time the technique evolved, the results of spraying dosage, wall surfaces, etc.

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RESULTS OF "STATION CONTROL"

In every project such as this, the carrying out of the scheme or even the ensuring that it is carried out is much more difficult that the broad arrangements. As was to be expected, the execution was much more thorough in some places than in others. I visited the stations constantly on inspections and there is now, in each station, a reasonably satisfactory and systematic scheme.

The greatest difficulties in the running of such schemes are that not only is the European staff constantly changing due to reversions to United Kingdom after completion of the short tour, but there are unavoidable postings within the command. The African takes a little time to get used to and like a European and without a proper relationship between the two, good work is not to be expected from the African. The average Medical Officer too

is not interested in preventive work and is almost antagonistic to the idea that it is his responsibility. Fortunately by making full use of the odd Medical Officer who is keen and appreciates the never ending interest in the country which is aroused by walking it and working in it with the African, and by the help of the N.C.O. Sanitary Inspectors, it is usually possible to get together an enthusiastic team. These Sanitary Inspectors are first class. They have the education and intelligence to grasp what is required and with few exceptions they thrive on responsibility. It is always essential to have a sufficient number of Europeans for supervision if the many petty frauds like carrying about larvae in bottles and "planting" them, selling Pyrethrum spray for lamps instead of using it as intended, and so on are to be avoided.

PERMANENT OR SEMI-PERMANENT CONTROL.

To assist the Civil Authorities, who have never in West Africa had malariologists to advise them (if we except the privately sponsored Alfred Jones Laboratory in Freetown), Army Malariologists have carried out drainage schemes of varying extent at Freetown, Takoradi, Accra and Lagos. I propose merely to discuss our experience in these works in so far as they would affect future policy in the siting and protection of Army Establishments, for I am convinced that to go back to the old 'laissez faire' policy after the war would be too foolish to contemplate.

DRAINAGE OF INLAND AREAS.

The problem is of course as always in mosquito control, the management of the surface water. This is of course a task for civil engineers but there must be the closest laison between the malariologist and the engineer

if any satisfactory results are to be expected. With a rapidly maturing mosquito such as Anopheles Gambiae as the main enemy, it must be the aim to have sufficient control over surface water level to run off the heaviest accumulation of rain in four days. I have mentioned already how difficult is the problem of constructing drains in a soil of hard and soft layers of laterite. The ordinary earth drain is doomed to failure as scouring soon reduces a drain with a perfect invert to the condition shewn in Photograph 12.

Except in the wet forest regions, it has not proved possible to find a grass which will grow sufficiently fast and whose roots will bind the soil, with which the drain sides could be sewn or planted and so protected against scouring. Nor have sub-soil drains proved feasable as when the laterite is broken up to lay the drain, it is so pulverized, that when it is filled in again over openwork porous clay, fascine or bamboo channels it ~~silts~~ SILTS them up within three ~~months~~ WEEKS of the first rains.

Thus the two main stand bys of open earth grassed drains and sub-soil drainage, which have been successful in Malaya and which have so influenced malarial drainage all over the World, have not been of much value in West Africa.

Concreting in long sections of drains is an exceedingly expensive business. The impermeable drain sides are not an advantage, and unless they are exceedingly well constructed and of enormous size to compete with the rainfall of an exceptional day, the end result is sometimes disasterous. Photographs 9,10, and 11 shew the condition of a concrete drain constructed in 1942 to drain a valley in Freetown. It will be seen that the drain being too small, has been persistently overflowed. Scouring at the sides has made a

new channel on both sides of the drain, loosening its bed and the whole drain has been shattered. This is admittedly an example of really bad engineering but there is a danger of this happening even when experienced men have put sound work into the construction.

In the urgency of war time and the necessity, for political reasons, of protecting rapidly some airodromes, the lesson had to be relearned the hard way-that malaria drainage cannot be hurried. As a result, too many drains have sometimes been constructed where a more sober progress would have achieved the same result with fewer channels. Every drain adds to the maintenance cost and difficulties which must always be given at least equal consideration to that of the first cost and snags of construction. Every drain which is not properly maintained is a menace, as providing excellent breeding places in its pooled bed. The use of mechanical diggers has aggravated the tendency to furrow the countryside, for it is so easy to mark out a line for a machine and for that machine to cut out a subsidiary drain in a matter of hours.

The more I see of Drainage in West Africa, the more hesitant I am to allow a spade to be put to earth. Certainly, before any but the most minor works are commenced, it is essential to survey the area thoroughly over a dry and a wet season. During the next dry season a minimum number of pilot drains should be cut so that the effect may be watched during the next rains. The third year, contour drainage may be embarked on and the final size of the main drains decided. There is no reason why concreting should not proceed on the main drains at this stage for this size can be calculated with accuracy.

On the sea coast, the problem also arises of outlets to such main drains. All except the largest rivers in

West Africa discharge into small lagoons behind sand bars thrown up by the heavy surf and silt from the streams. Photograph 17 shows the mouth of a typical small river. The lagoon at the mouth of the stream is land-locked and only drains away slowly at low tide through the sand bar.

If a large area is drained rapidly into such a lagoon, it will either flood the countryside round and in recession leave pools everywhere or, when it reaches a certain level, the sand bar breaks down, the surf roars in and the while lagoon bed may be altered. In addition, the sides of all such lagoons being of very shallow gradient and swampy, have to be controlled by digging out and making clean the banks.

It is thus necessary to carry out major works on the banks of the lagoon and to provide some kind of tide gates. These gates will vary from small flap gates in small schemes to huge caissoned gates in the larger outlets. The largest of these gates, being invariably built in sand bars are a major engineering work, quite beyond the capacity of Army or Civil Public Works Department Engineers. They must be of enormous weight or they move in the sand. They must be of great strength to withstand the spring tides and they must be extremely well sited and designed to ensure that they are self clearing, and <u>not</u> self silting. Finally they must have a very large reserve of opening capacity in hand for otherwise, the highest tides coupled with rapid raising of the lagoon level owing to rains will result in insufficiently rapid emptying between tides and subsequent breaching of the sand bar on one or other side of the gates. Such a disaster may well result in an alteration in the shape of the lagoon

so extensive as to make it problematic whether the gates will be able to be used again, or will remain high and dry in the sand bar, an undesirable monument to the "skill" of the malarial engineer.

Another difficulty which requires consideration on parts of the coast such as the Eastern Gold Coast where the rainfall is low is that by increasing the run off rate after the rains, the countryside may have its whole water table so lowered, as seriously to interfere with agriculture and to produce near 'dust bowl' conditions in the dry season. The coastal plain in this area has already been denuded over much of vegetation by over population, unscientific native agriculture on too intensive a scale near the larger towns, and tree cutting for firewood.

One last possible error which may be committed in land drainage and canalization of streams is in the regions where glossina holds sway and sleeping sickness is endemic. Photograph 15 taken in the Kintampo, Gold Coast shows a stream canalized and the banks cleared in the area round an Army Unit as mentioned before, re malaria control. The hollows at the foot of the tree stumps left in the clearing among thin vegetation were affording breeding places for Glossina Palpalis where, in the thicker vegetation before clearing, there was no breeding. I had to intervene when I found similar clearing being carried out by a Hygiene Section on the outskirts of Kumasi in Ashanti. It is possible to get infected now, by Glossina in the middle of Kumasi (as was proved recently by a case on the orphan home there in a child who had never been out of the city) but there is no point in providing possible breeding places any nearer to the city than necessary.

All these difficulties would be worth overcoming if the results of such land drainage schemes were comparable with those achieved in Malaya and elsewhere but, as I have pointed out before, in so many places, the commonest breeding place is the pool in impermeable laterite in and about villages, and these pools are quite unaffected by any amount of such drainage. It would be necessary therefore to supplement such drainage schemes by very extensive village improvement projects.

From the foregoing, it will be seen that I am full of negative ideas on land drainage in West Africa but lacking in any constructive recommendations for improvements. I cannot at present see how progress is going to take place along these lines. They have been an imitation of Malayan methods in a totally different country where the soil is much less suitable and where the rainfall is much less evenly spread over the year.

CONTROL OF ANOPHELES GAMBIAE VAR MELAS IN TIDAL MANGROVE SWAMPS.

The work of Muirhead Thomson on the selective breeding places of A. Gambiae var melas in mangrove swamps has already been mentioned. There are three methods of control of breeding in increasing order of efficiency and cost.

1. Digging of artificial pools in the swamps.

If round or rectangular holes are dug in the upper (and breeding) parts of such swamps, the sides of these pools properly sloped, and the spoil removed used to raise the level of the surrounding swamp a fair degree of control can be achieved quickly and cheaply with untrained labour. The method is of limited application but might be used in conjunction with controlled tipping to allow carriage of refuse out into the swamp on reclaimed bunds and eventually to reclaim the whole area. Certainly,

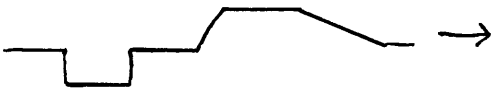
breeding can be reduced to a minimum if the pools are further controlled by oiling.

2. Parallel Drains through the swamp to the sea.

These parallel channels starting in the coast grass and carrying on straight down to the sea were described in the section on Sierra Leone.

3. The enclosing of the breeding areas by Bunds and thus controlling the water levels in these tidal area.

The first bunding was that on an experimental basis on the Aberdeen Peninsula in Sierra Leone, before the rains in 1943 it was designed to protect SERVICE installations on Aberdeen Hill. On a line laid down by Dr Muirhead Thomson, a drain was cut for half a mile in a curve at the "Avicennia - Rhizophora" mangrove margin, but following the contour in places, thus leaving some islands of Avicennai mangrove outside the bund.
A cross section of the bund at the Avicennia - Rhizophora margin would be



The work was carried out entirely by the Field Hygiene Section without engineer assistance. Three tide gates were provided. They consisted of concreted sections of the bund pierced at the bottom by circular tunnels about two feet in diameter, the outer ends having a heavy wooden flap tide gate hinged above. This bund was a success, demonstrating the practical application of the findings with regard to breeding zones.. Breeding was completely controlled except at the Northernmost end at the base of Aberdeen Hill, where seepages from the hillsides gave trouble and where the African women from Aberdeen village used the fresh water from these seepages into the end of the bund, as a clothes washing place. This difficulty was overcome by contour draining of Aberdeen Hill and leading

the seepages into the end of the bund, and by providing a concrete washing place for the 'mammies' at the north tip of the main drain inside the bund. This washing place was in the form of a large concrete slab, properly drained and the washings fed into the bund drain below. In 1944, before the rains, the bund was extended another half mile towards Lumley on exactly the same plan. At the same time, the small swamp on the North of Lumley Creek was drained by parallel channels as described above. Sketch Map 6 illustrates the remarks.

The lessons learned from this bund were essentially, that it was sited too far from the sea, as laterly, after a series of high tides there was some breeding in the bottom of the drain. Also that the tidal gates were both too small and not deep enough, for as the drain was scoured by the tides, and by erosion from crab holes, the level of the bottom of the drain was lowered and the level of the outlets became relatively too high to empty the drain completely. Silting up constantly interfered with the closing of the flaps. In spite of these difficulties which have now been remedied, after two years, the first part is standing up well, the Anophelen index in Aberdeen has been reduced from 7.3 in 1942 to 0.4 in 1944 and many valuable lessons have been learned. On the landward side of the bund, a steady change of vegetation has taken place. The coast grass and other vegetation from the peninsula is steadily creeping in and the avicennia mangrove drying out. This is seen from photographs 13 and 14. The avicennia on the seaward side of the bund is unchanged although it is now covered at each tide more completely than before the bund was constructed.

Later in 1943, Lt.Col. Gilroy and Major L.J. Chwatt (1944) of a Malaria Field Laboratory commenced work in mangrove swamps on the mainland of Apapa near Lagos with the object of protecting the Docks at Apapa and the Airodrome. Subsequently, they extended the work out onto the Islands in Lagos lagoon with the object of clearing a two mile radius. Sketch Map 9 shows the areas now controlled. It will be seen how impossible it is with the high areas of swamps to deal with a greater radius than two miles. Gilroy and Chwatt's work followed much more closely the pioneer models of Sir Malcolm Watson in Malaya (1906). The area South of Apapa Wharf, on which the Airodrome to be protected is built is about 15 ft above sea level on dry land reclaimed over a large number of years by sand pumpings and dredgings from the estuary.

Sketch Map 10 (Gilroy) shows the ecological zones on Magazine Island which is typical of all the areas controlled. Sketch Map 11 shows how the bund was sited and the contour drains leading to the circular wall drain inside the bund. Exactly the same methods were applied in the other areas. It is difficult to appreciate without visiting these swampy islands and mangrove capes round Lagos just how thick is the mangrove and how sticky and wet is the muddy ground intersected by narrow but deep tongues of the lagoon. In preliminary surveys a tunnel had always to be cut with machetes through the mangroves before Col Gilroy could cover the ground.

There is only a range of 3. ft 10 ins between low and high water ordinary spring tides though this may be increased by wave action up to about five feet.

The ~~silting~~ SITEING of the bund here was, as opposed to Aberdeen, only 50 ft to 60 ft inland from the low tide line.

Here there would be no question of breeding in the mangrove outside the bund as the depth of covering water at high tide would average about three feet! The fringe of mangrove between the bund and the sea gives some protection from wave action. Waves may be quite considerable in such a large lagoon in certain winds, or from passing disturbances by launches, steamers or flying boats. Fig 1 is a diagram of the cross section of the bund prepared by Gilroy showing the dimensions eventually found optimum.

Clearly, construction of such a bund can only proceed at lowest tide and there will be a fair degree of subsidence in the bund as the wet mud from which it is constructed dries out. Gilroy now allows for 9-12 inches subsidence in the first year.

The bund, being exposed to wave action is thus liable to erosion. It was found that protective fascine facings were useless and merely concealed erosion. Protective groynes built at an angle to the prevailing wind proved of value, but a ~~total~~ length of half a mile out of A TOTAL OF over nine miles had to be faced with six inch concrete. This has given complete protection, and no trouble has been experienced since.

Tide gates were sited as far as possible at the natural runs off. Wooden gates proved useless due to attacks of toredo and the difficulty of providing a foundation for a pile driver to work on liquid mud. Concrete, hand opened, slide gates are now used. A man has to be stationed permanently on each set of gates. I reproduce Gilroys drawings at figs 3 and 4.

Altogether, Gilroy and Chwatt have dried out and reclaimed 1677 acres with 9.3 miles of Bund at a cost of £18.6. per acre. The whole water table ~~had~~ HAS fallen

from 18 to 24 inches. Here in contrast to Freetown, the drying out has so far had little effect on the mangrove either Rhizophora or Avicennia inside the bund in the dried out ground, but as in Freetown, the coast grass is thriving. The complete elimination of breeding inside the bund or outside has been achieved without any larviciding whatever and the work seems likely to require the very minimum of maintenance.

The effect on the mosquito population at Apapa is shewn in Graph 14.

Both the Freetown and the Lagos schemes have demonstrated that such A. Gambiae var melas breeding areas can be controlled effectively and cheaply and that at the same time the amenities of these noisesome swamp areas can be improved.

APPLICATION OF LESSONS LEARNED AND SUGGESTIONS FOR FUTURE POLICY

Chapter VIII

It is not suggested that West Africa is still 'the White man's Grave!', but it is one of the most unhealthy parts of the world and one of, if not the most important single cause, is Malaria.

What emerges as the outstanding disappointment from my survey seems to me to be that as yet we have no methods of clearing areas of Malaria to a degree whereby malaria precautions may be disregarded. We have not approached that ideal and until we do, any success we have by other methods will be far from complete for the restrictions are irksome and people will not in peace time willingly carry out precautions which are accepted as a temporary restriction in War Time.

In contrast, the outstanding success, is I think the virtual elimination of Blackwater Fever which for the first three years under review was the largest single cause of death in Europeans. Quinine in West Africa should be classified as a dangerous drug and kept with its fellows in Poison Cupboards to be used with discrimination when necessary.

Between the extremes of these successes and failures lies I think a very large amount of useful practical experience with useful applications some positive and some negative. If, as seems possible, there are more Europeans in the post-war R.W.A.F.F. than before, then there must be a complete change of heart as regards malaria, both for the protection of the officers and men themselves and in order that they may form a nucleus more informed and of sounder based medical opinions than in the past.

I think that I can best express my recommendations

as those which I should make if asked to do so as the senior Medical Officer in West Africa or as an independant consultant in Tropical Medicine.

The following then would be my advice.

1. Provision of Anti-Malarial Personnel.

The system must cease whereby not only the curative but also the preventive medical work has been a responsibility of the Medical Officers of the Colonial Medical Service. These medical officers are usually overworked and the care of troops is merely another burden. There are no malariologists in the Colonial Medical Service in West Africa in the sense that would be accepted elsewhere. Even if they wished, their opportunities for post-graduate study and almost nil. It could not be expected that they would have the time or experience to look after Army Health as it is looked after elsewhere. I would recommend therefore that administrative, Hygiene and Malaria Officers together with the appropriate N.C.Os be on an R.A.M.C. establishment.

West Africa is an excellent training ground for Tropical Medicine and a Malaria Centre should be maintained with facilities for Research, Touring Survey Teams and Practical Control Units.

2. Suppressive Drugs.

Until such time as methods of adequate mosquito control over very large areas have been evolved, suppressives must be taken. Even if Officers and men live in a completely controlled area, they must go out on manoeuvres, on local leave, and to visit friends and entertainments such as cinemas in Civil Areas. Mepacrine is at the moment far ahead of any other known suppressive if it is not indeed a true prophylactic, and it must continue to be used,

but it must always be remembered that Mepacrine takes a very minimum of 14 days before an adequate protective blood level is attained, so that it cannot be started and stopped indiscriminately.

3. Methods of Mosquito Control to be adopted in Military Stations.

No capital expenditure should be authorised on large scale drainage works to protect military camps. The results will be a great disappointment if anything less than complete elimination of breeding is achieved for a radius of three miles round the Camp. This means draining of nearly 27 square miles or over 17,000 acres and probably a minimum of 40 miles of drains. ~~As~~ The largest number of Europeans in a station is unlikely to exceed 200, AND the first cost would be in the region of £300 per head with a maintenance cost of £20 per head per annum, EVEN FOR THAT NUMBER.

How valuable D.D.T. will prove we cannot yet say but it will probably in view of the determinedly androphilous character of the mosquitoes prove of more value in West Africa than almost any anywhere else. Some of the new larvicides such as I.C.I. 666 may also revolutionize the control of breeding. It is all the more essential in view of these possibilities not to embark on expensive engineering works.

Each station should have a most thorough scheme on the lines of that laid down in Chapter VII but expanded to deal with the larger area. The long intervals between house spraying with D.D.T. will make the expansion of the area of control much more economical.

4. As a measure of hygiene and economy, in view of the impossibility of freeing any site of malaria carrying mosquitoes it is the more essential that when new sites are selected, only places should be considered which are

amenable to control with a prospect of as near as possible to complete elimination of mosquitoes at minimum expense For example, Brikama in the Gambia, however suitable for military purposes could not be protected without enormous expense and a large European staff.

There is no habitable region in West Africa where M.T. malaria is not hyperendemic but there are localized areas which by reason of geological, topographical and metereological conditions are very much less malarious than others. The factors which determine this are:-

(a) The proximity and condition of African Villages.

(b) The prevailing wind.

(c) The potential breeding places within a three mile radius.

I shall discuss why these are the important factors in turn.

(a) <u>The proximity and condition of African villages.</u>

As I have pointed out before, Anopheles Gambiae is or can become by adaptation, almost as domestic a mosquito as Aedes or Culicines. It is extremely difficult to keep a native village free from breeding places. Calabashes, canoes, cocoa nut husks and earthenware pots have all been found containing larvae. In addition, the village is a magnet for adult mosquitos from miles around and the population is inevitably neavily infected.

Apart from the disadvantage from the point of view of Malaria, there are other serious disadvantages in having villages near European dwellings. Fly breeding is inevitable. Noise at night cannot be controlled. The drumming abd shouting from dusk till dawn at least once a week and oftener if there are funerals, is extremely trying and not conducive to sleep. The constant

proximity of Africans is one of the major factors in causing breakdown and invaliding of Europeans. To work with them can at times be trying but there are few who do not eventually get upset by the sound of their loud voices which, on a quiet night, carry half a mile in ordinary conversational tones! In addition, African villages near military camps become places of resort for thieves and prostitutes.

To complete this section, it should be recorded, that only a limited number of mess servants should be allowed inside the compound and that they should live in proper quarters on the perimeter without their families. No woman should be allowed in the compound for any purpose by day or night and markets in African lines must be under the strictest supervision. It is curious, that one never meets a European, High Official or minor Official or Trader who does not agree, that controlled, isolated European Reservations are necessary for decent living. Yet, except in Nigeria the policy being pursued, is to do away with Reservations. I am not concerned with political considerations but merely the preservation of a good state of physical and mental health in the average European and therefore his efficiency. I say without hesitation that the policy is retrograde. There need be no hard feelings about European Reservations if the matter is stated as in the Public Health Section of the Annual Report of the Medical Department of Nigeria in 1937 - "The Government re-affirmed the desirability of providing in so far as may be possible Government Residential Areas in which European Residents might live with the minimum risk of exposure to the infections of Yellow Fever or Malaria, diseases against which, the indigenous population possess a considerable degree of immunity."

2. The Prevailing Wind.

In most places, especially near the coast, for nine months in the year the wind is the steady south-West trade. The wind is always and everywhere from this direction in the rainy season. It would follow that after checking over a period, to ensure that there are no local variations due to topographical features, that a new building would be so sited as to ensure that the country from which the wind normally blows can be put under complete control at a reasonable cost. Similarly, that native dwellings within a three mile radius, are as few as possible in the direction of the prevailing wind.

3. The Potential Breeding Places within a Three Mile Radius.

It is useless to select a knoll or a large hill feature with a fine view, if that view is principally available due to the flat and swampy nature of the country. A site on a slope which permits of natural drainage is much less likely to hold casual water in the neighbourhood. If one bears in mind that the malaria carrying mosquitoes of West Africa breed largely in man made depressions, which hold water, then one will not select a site overlooking 'farms' and villages. Three miles is a long distance in so thickly populated a region as many parts of West Africa and it is not envisaged that a military unit should be perched in splendid isolation in the bush but, the siting of Stations to the windward of large towns or villages will render all control ineffective and it should always be remembered that the future political outlook is going to make control of farming or movement of villages much more difficult than it is at present.

There remains the problem of the African Military Lines which in peace time very properly include married families lines. There should be an adjoining compound to the European lines, at least 440 yards from the nearest building used at night. The African lines should be to the windward. The

houses should be of concrete and on a concrete or asphalt surface. The best of wash places should be provided for all purposes by sexes, and their sole use should be enforced. Lines in a military establishment like this are always kept very hygienic condition because they can be inspected regularly and prevented from being a danger.

To sum up and consolidate the recommendations which I should make:-

1. Every site should be chosen only after approval by a malariologist who knows West Africa. The method should be for the widest limits for the site to be indicated and the Malariologist and an Engineer to inspect and make recommendations. Expenditure on half a mile of road or water piping may save many times the amount in Malaria Control.

2. Land for Buildings should be so bought, leased, or rented, that the fullest control is vested in the Military Authorities so that farming, collection of mud for houses, house building etc. can be embarked on only with the permission of the Commanding Officer of the Station.

3. European Bungalows must be within the European Military Area, The Old System of Officers having Bungalows in the civil residential area should not be permitted unless approved malaria control is afforded.

4. Any necessary malaria control works should be begun at the same time as the buildings in a new station and the Malariologist who will be on the spot must by arrangement with the engineers or contractor prevent potential breeding places from being formed during construction as in 'borrow pits' surface drains which are too small, unsatisfactory outfalls, and roadside ditches.

5. No African village should be allowed to remain within

1½ miles to the windward or ¾ mile to the leeward of the European compound.

6. African lines must be properly constructed and not closer than 440 yards to the leeward. The usual method of interposing a parade ground as part of this distance is excellent.

7. Bungalows UNLESS PROPERLY CONSTRUCTED AND VENTILATED, should preferably not be proofed but should be on 'stilts' so that the levels of the bottom of windows of sleeping quarters are at nine feet above the ground.

8. The Establishment of each station should include at least two qualified European Sanitary Assistants (A S/Sgt and a Cpl. would be suitable) who would be responsible for the supervision of Malaria control under the S.M.O. It might be well to have a small separate establishment of a Malaria Control Unit.

Choice of European Personnel and Length of Tour.

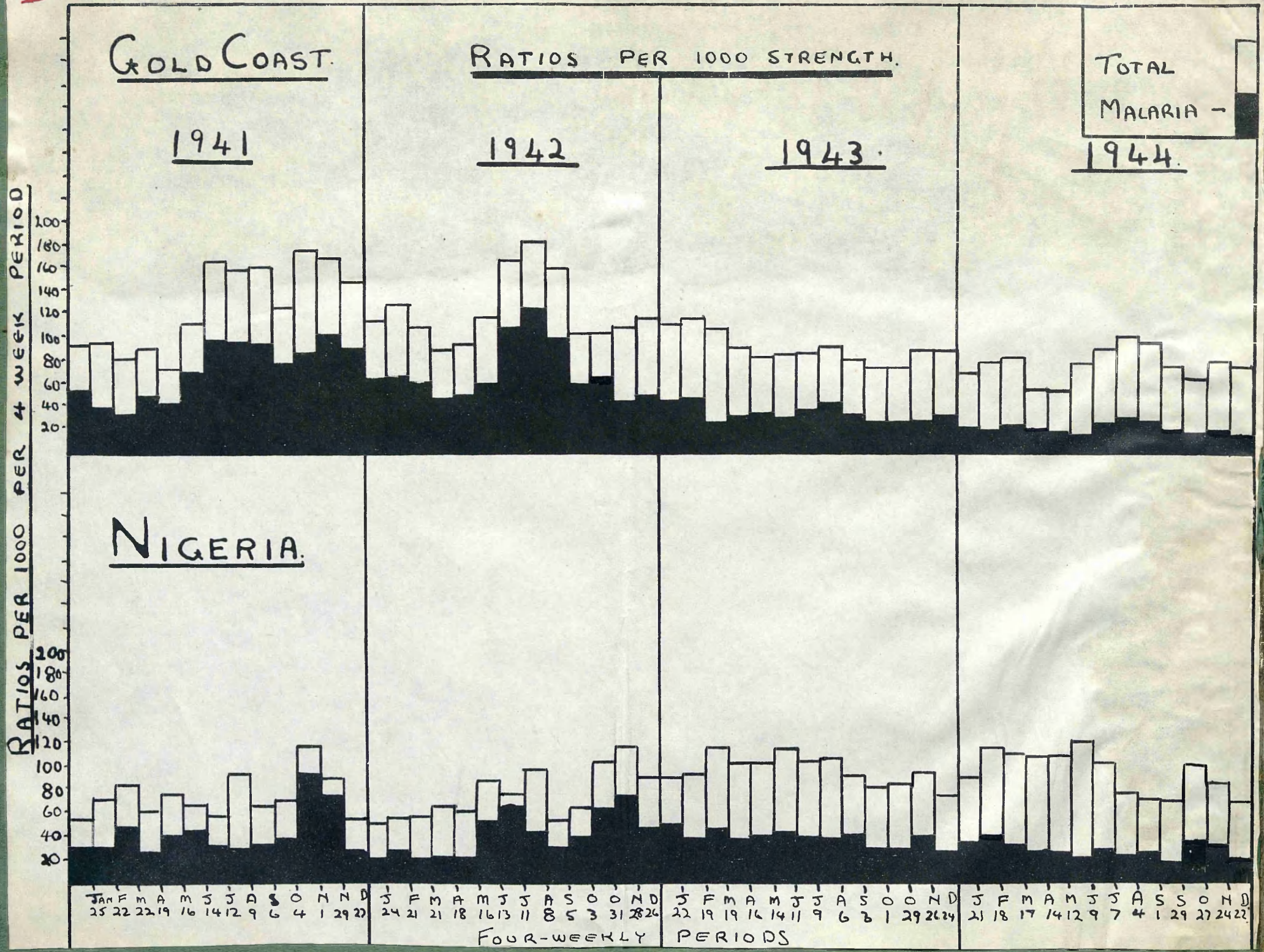
There is no way of telling whether a man is susceptible to malaria although there are undoubtedly big individual variations. There is no statistical evidence to support the belief that young men are more likely to succumb to the climate but the universal opinion is that men under 20 should not be sent out and that preferably they should be over 25. I think that this is probably sound. The very young man who tries to take too much violent exercise is galled by the restraint imposed on him by the climate and the need to take anti-mosquito precautions.

The length of tour of 18 months could with advantage be shortened so that none was in West Africa during two successive rains but on the other hand, by improving quarters and providing more amenities such as combined

proofed and air conditioned sleeping quarters, the tour might well be extended to two years.

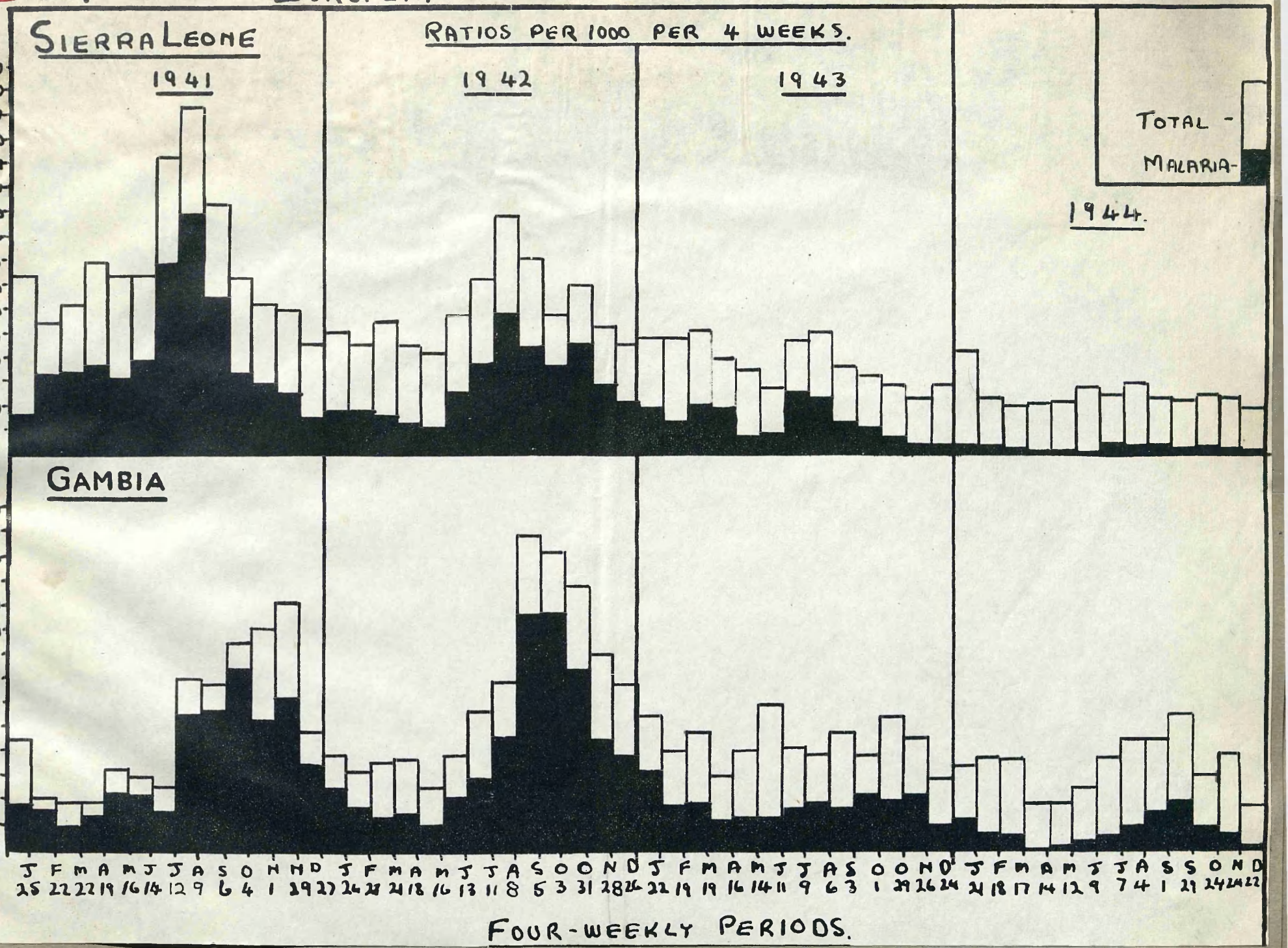
Blackwater Fever should as at present be a cause for immediate invaliding and forbidding of return to West Africa. Three attacks of malaria on one tour indicates either that a man is careless and is not taking precautions, or that he is unduly susceptible to infection, or that he cannot free himself of infection once he gets it. Each of these is a reason why he should not return to West Africa.

1. E1 European - Total and Malaria - Hospital Admissions.



2. E1

EUROPEAN - TOTAL AND MALARIA HOSPITAL ADMISSIONS



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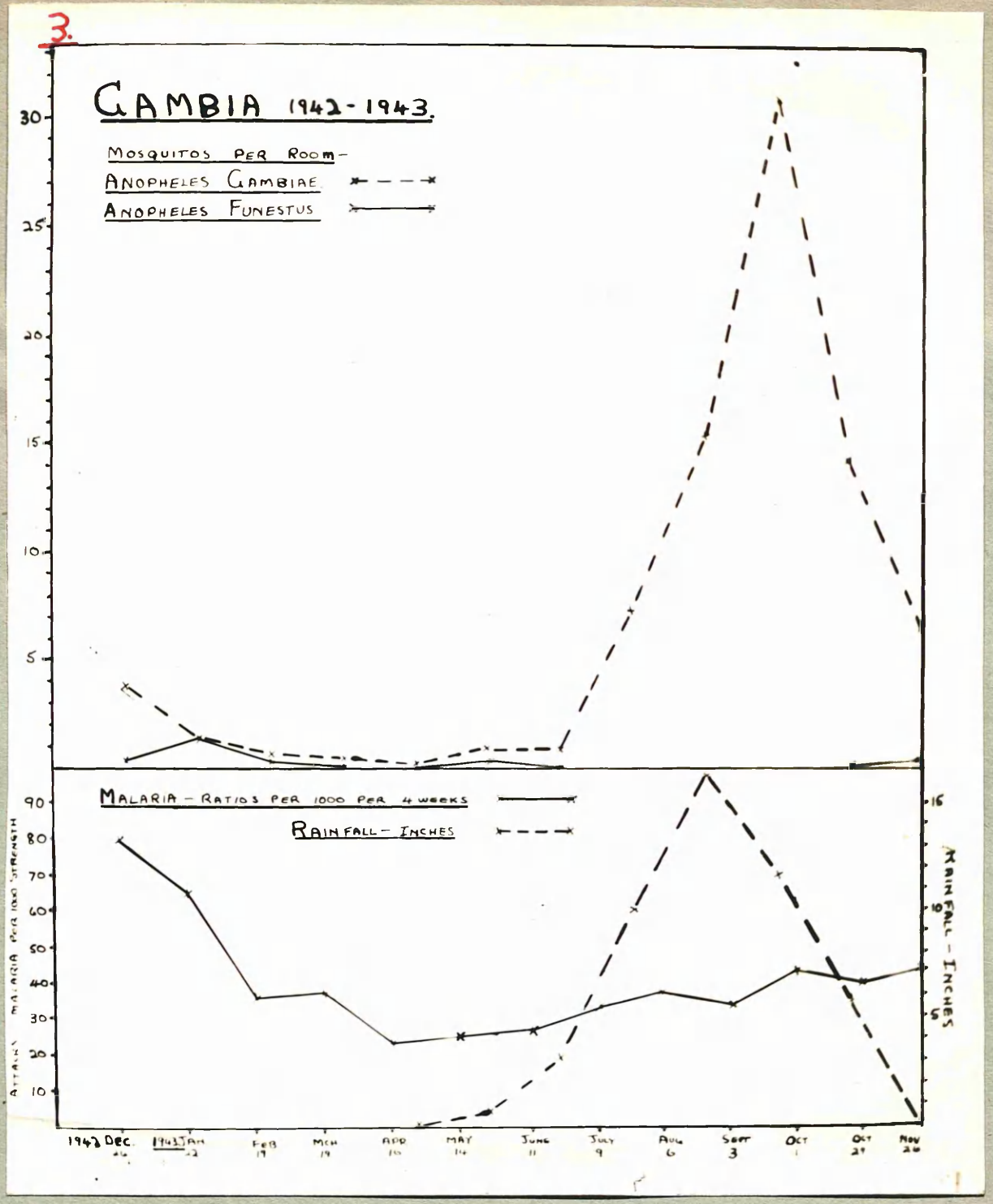
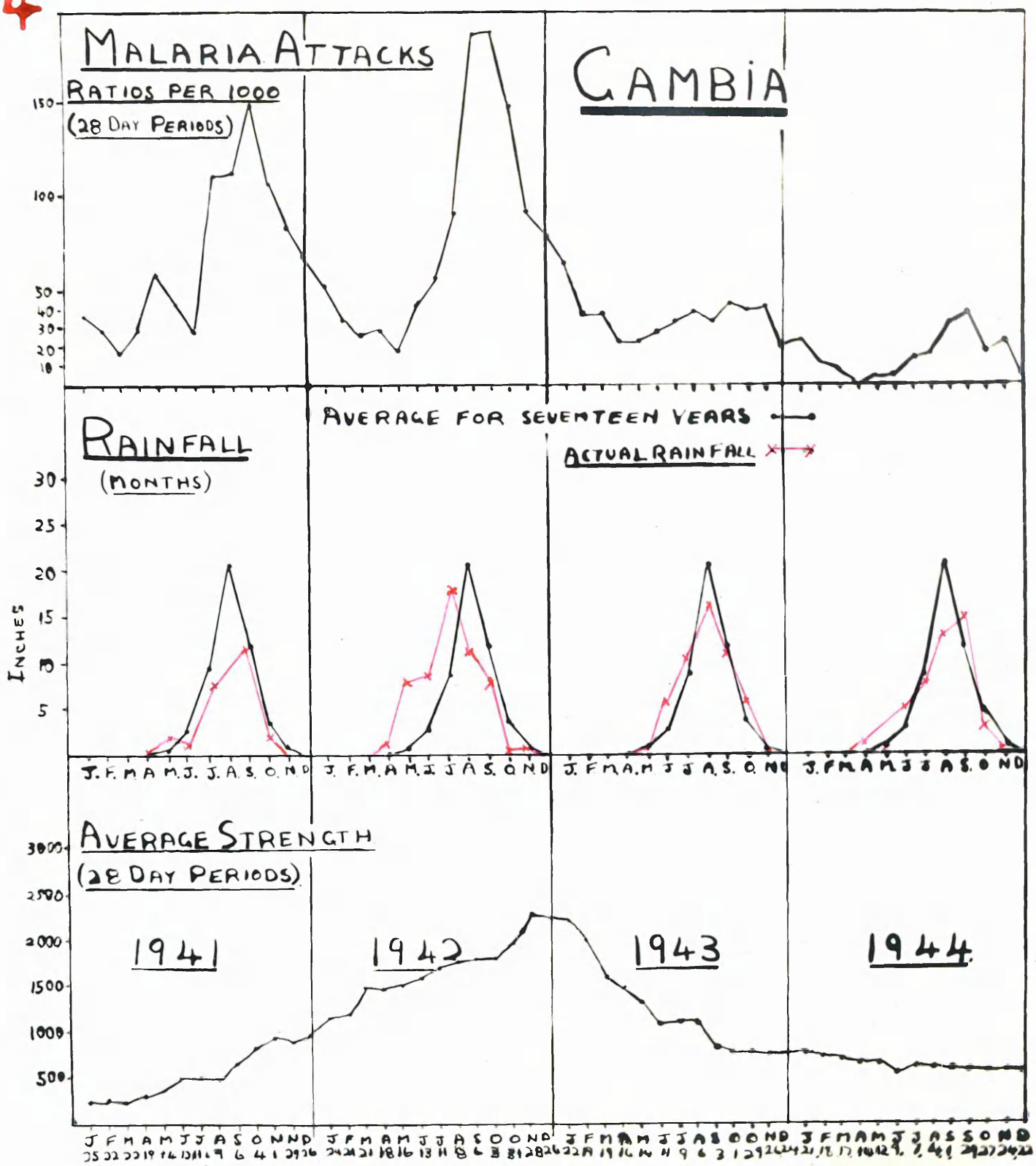
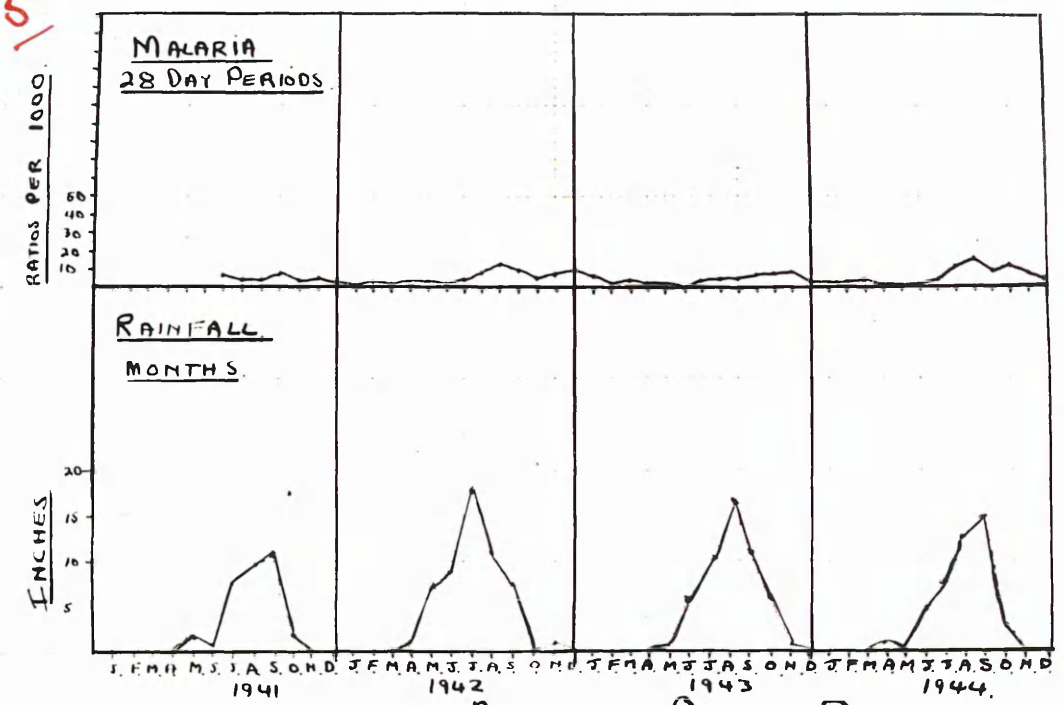

GAMBIA 1942-1943.
MOSQUITOS PER ROOM-
ANOPHELES GAMBIAE
ANOPHELES FUNESTUS
30
25
20
15
10
5
MALARIA - RATIOS PER 1000 PER 4 WEEKS
RAIN FALL - INCHES
ATTACK MALARIA PER 1000 STRENGTH
90
80
70
60
50
40
30
20
10
16
12
8
4
RAIN FALL - INCHES
1942 DEC. 26
1943 JAN 2
FEB 19
MCH 19
APR 16
MAY 14
JUNE 11
JULY 9
AUG 6
SEPT 3
OCT 1
OCT 29
NOV 26

4



MALARIA INCIDENCE IN ARMY EUROPEANS

5/



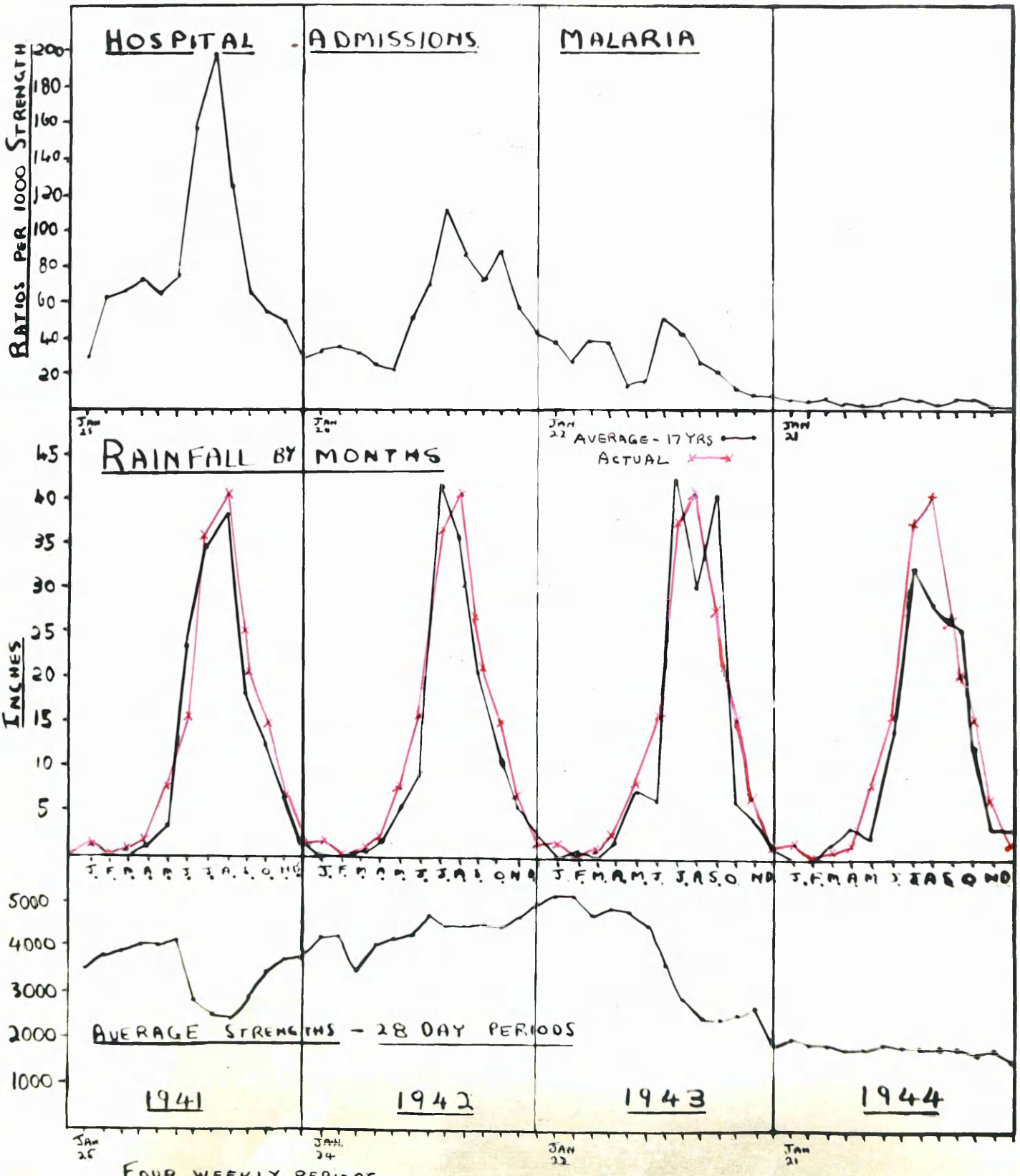
MALARIA – AFRICAN OTHER RANKS.

GAMBIA.

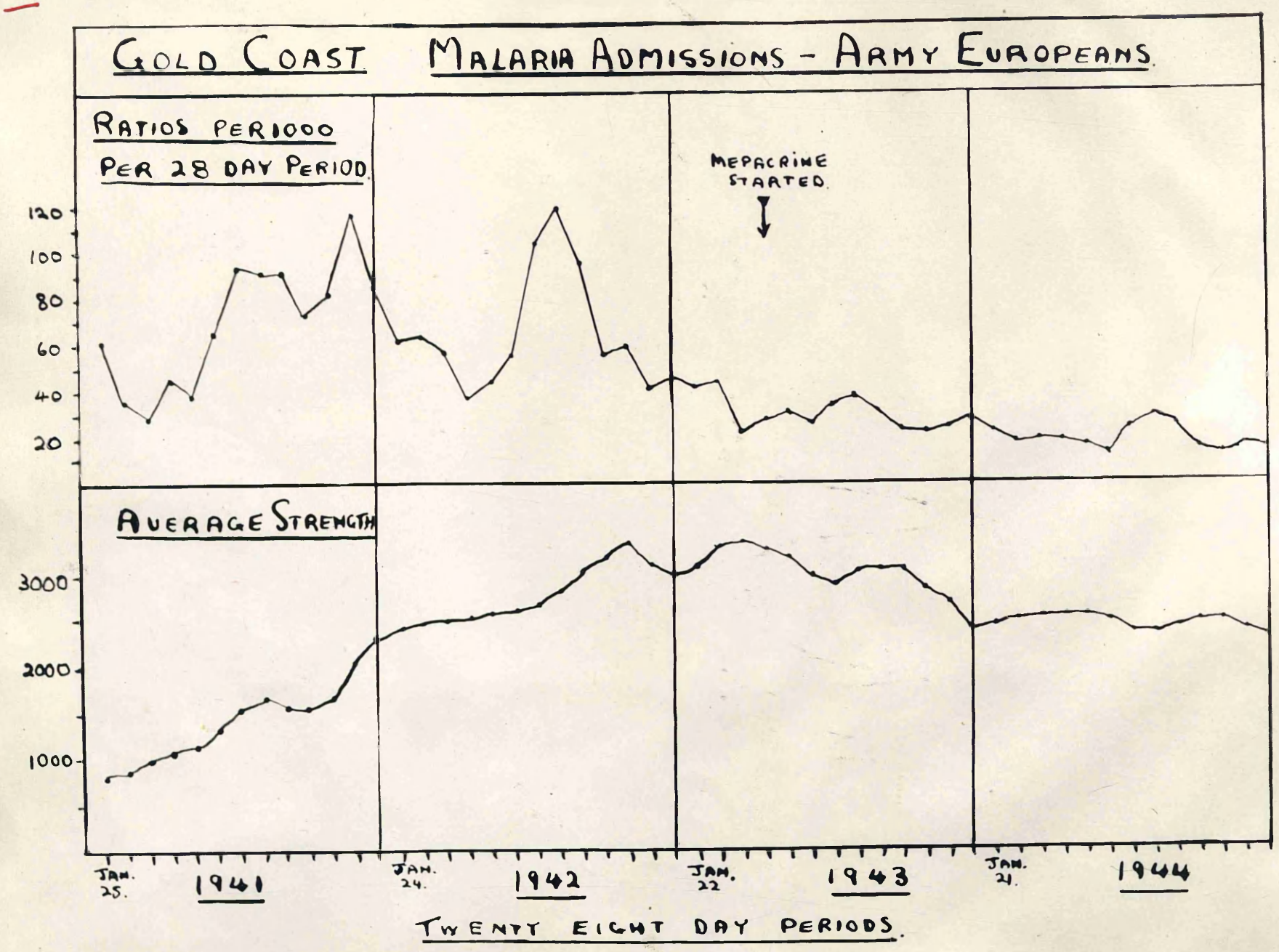
6

SIERRA LEONE

ARMY - EUROPEANS

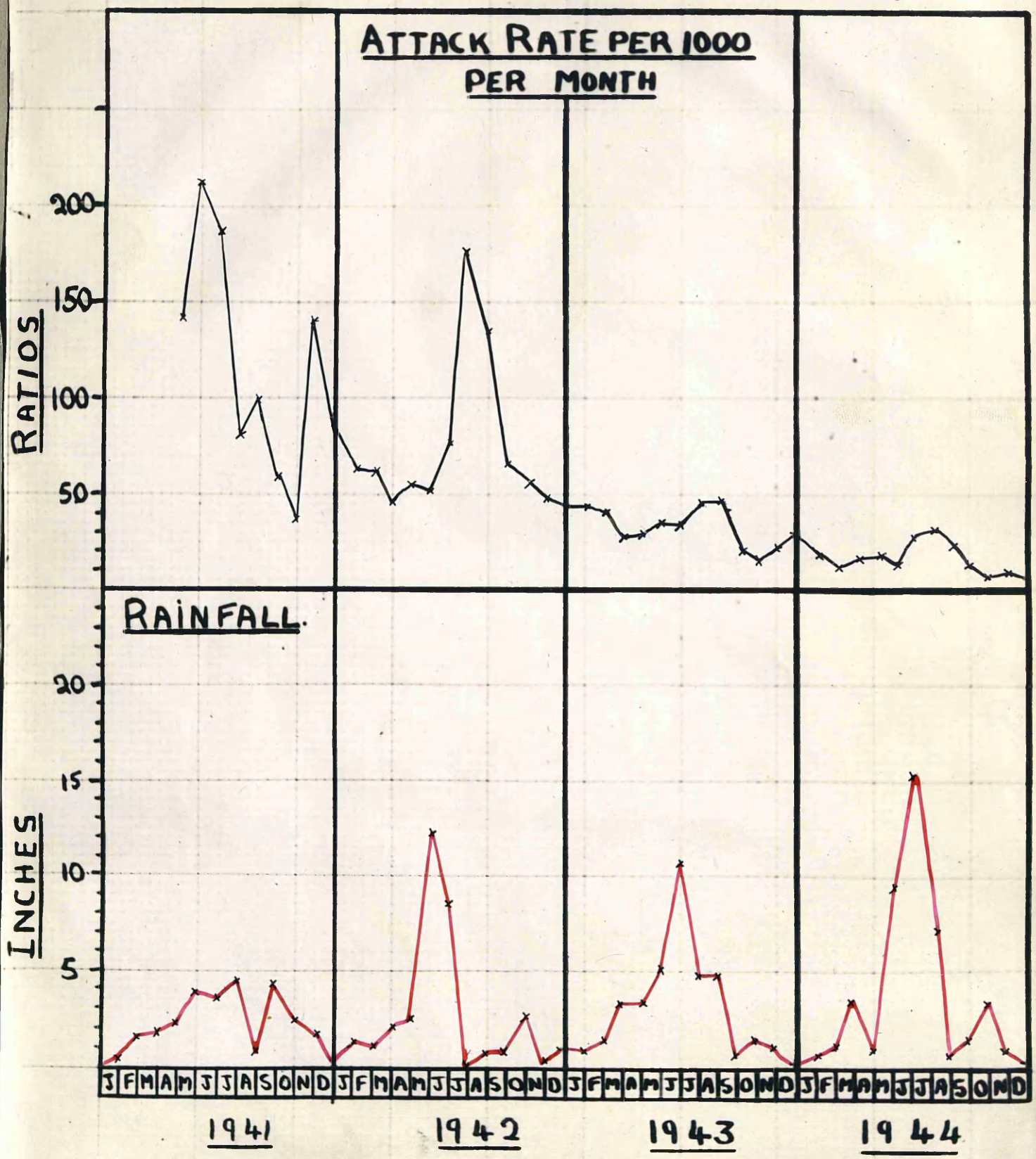


7

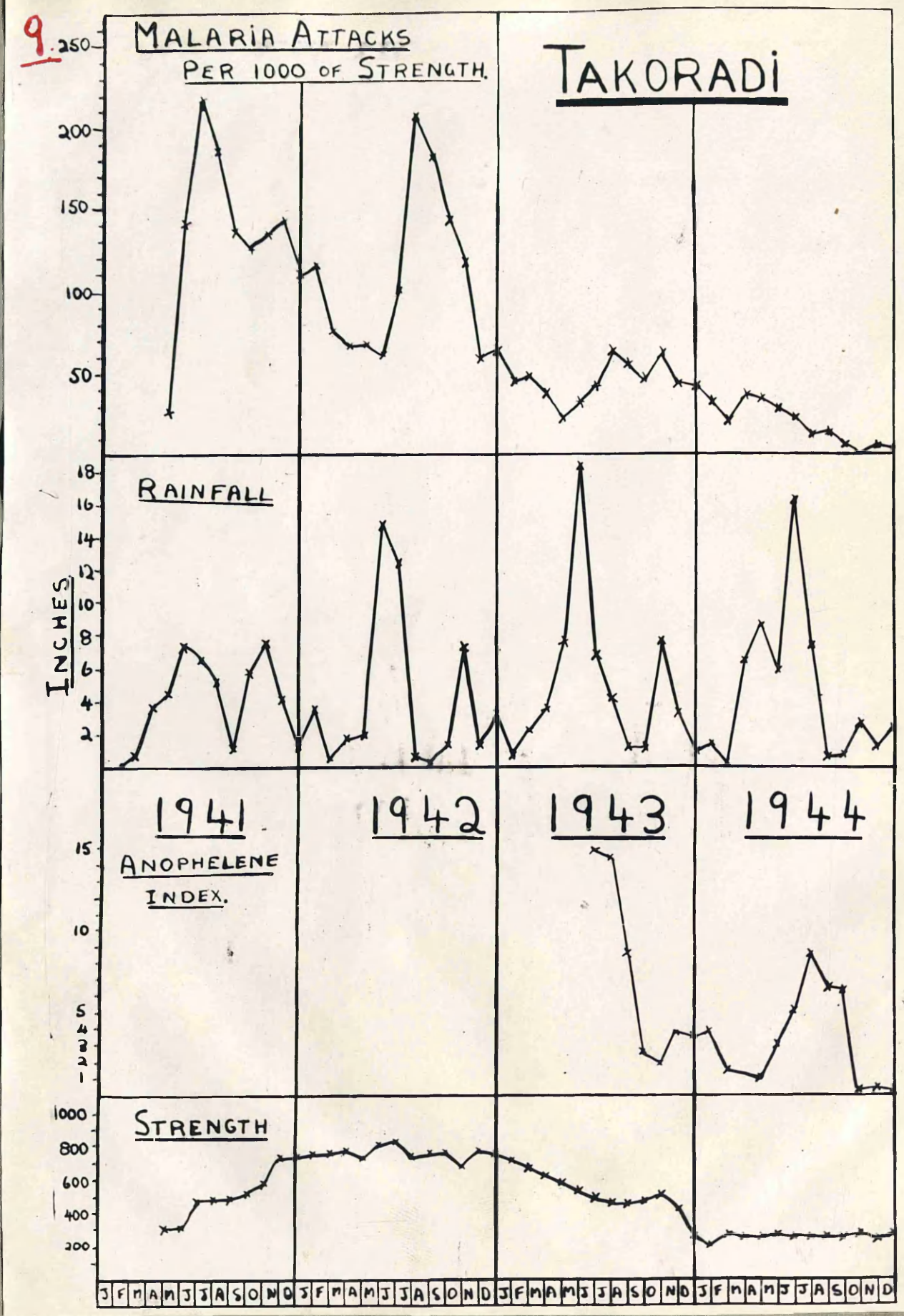

GOLD COAST MALARIA ADMISSIONS - ARMY EUROPEANS.
RATIOS PER 1000
PER 28 DAY PERIOD.
120
100
80
60
40
20
MEPACRINE STARTED.
AVERAGE STRENGTH
3000
2000
1000
JAN. 25.
1941
JAN. 24.
1942
JAN. 22.
1943
JAN. 21.
1944
TWENTY EIGHT DAY PERIODS.

8.

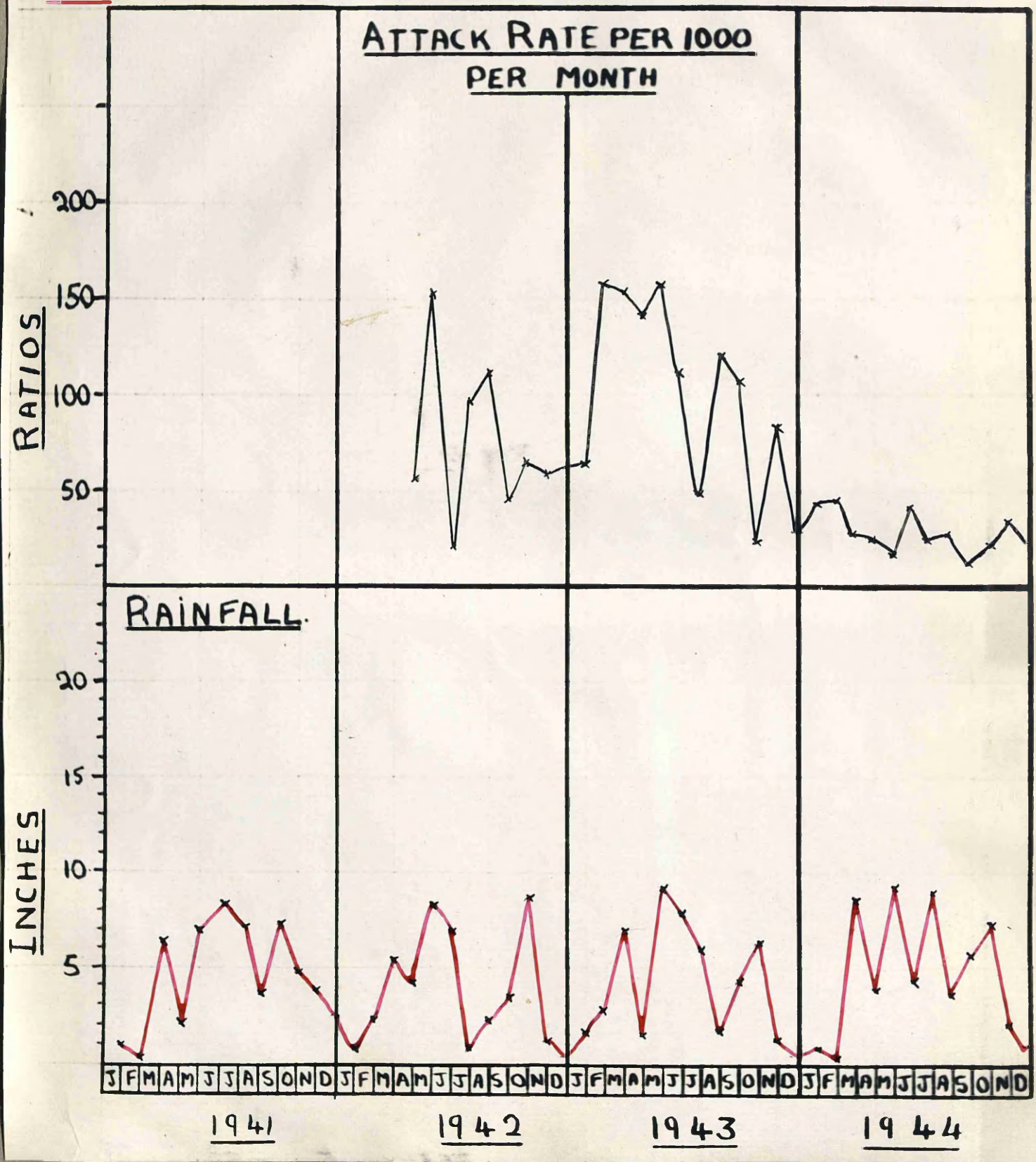
MALARIA - EUROPEANS - ACCRA.



9.


MALARIA ATTACKS
PER 1000 OF STRENGTH.
TAKORADI
250
200
150
100
50
RAINFALL
INCHES
18
16
14
12
10
8
6
4
2
1941
1942
1943
1944
ANOPHELENE
INDEX.
15
10
5
STRENGTH
1000
800
600
400
200
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

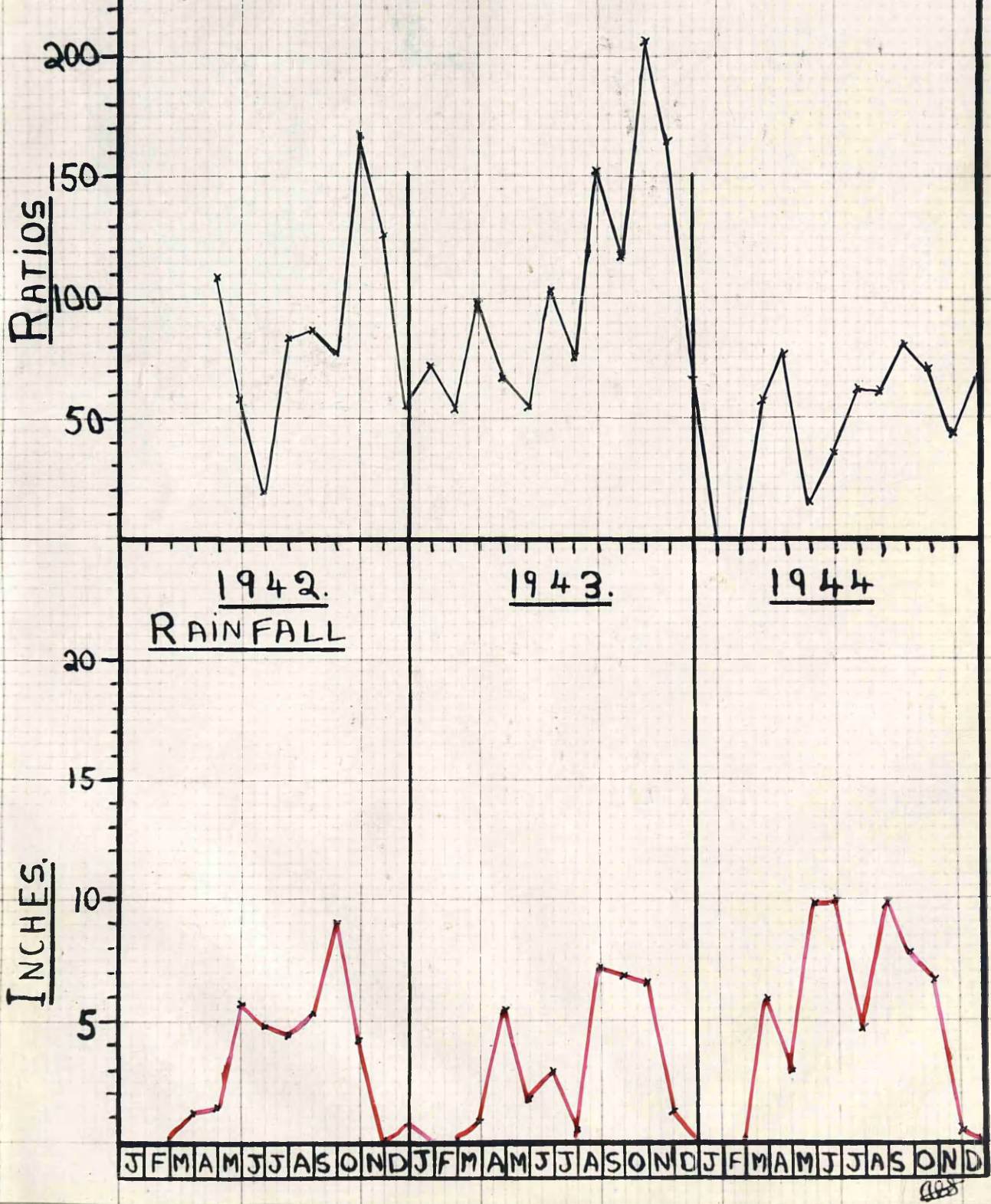
10. MALARIA - EUROPEANS - KUMASI.



11.

MALARIA - EUROPEANS - TAMALE.

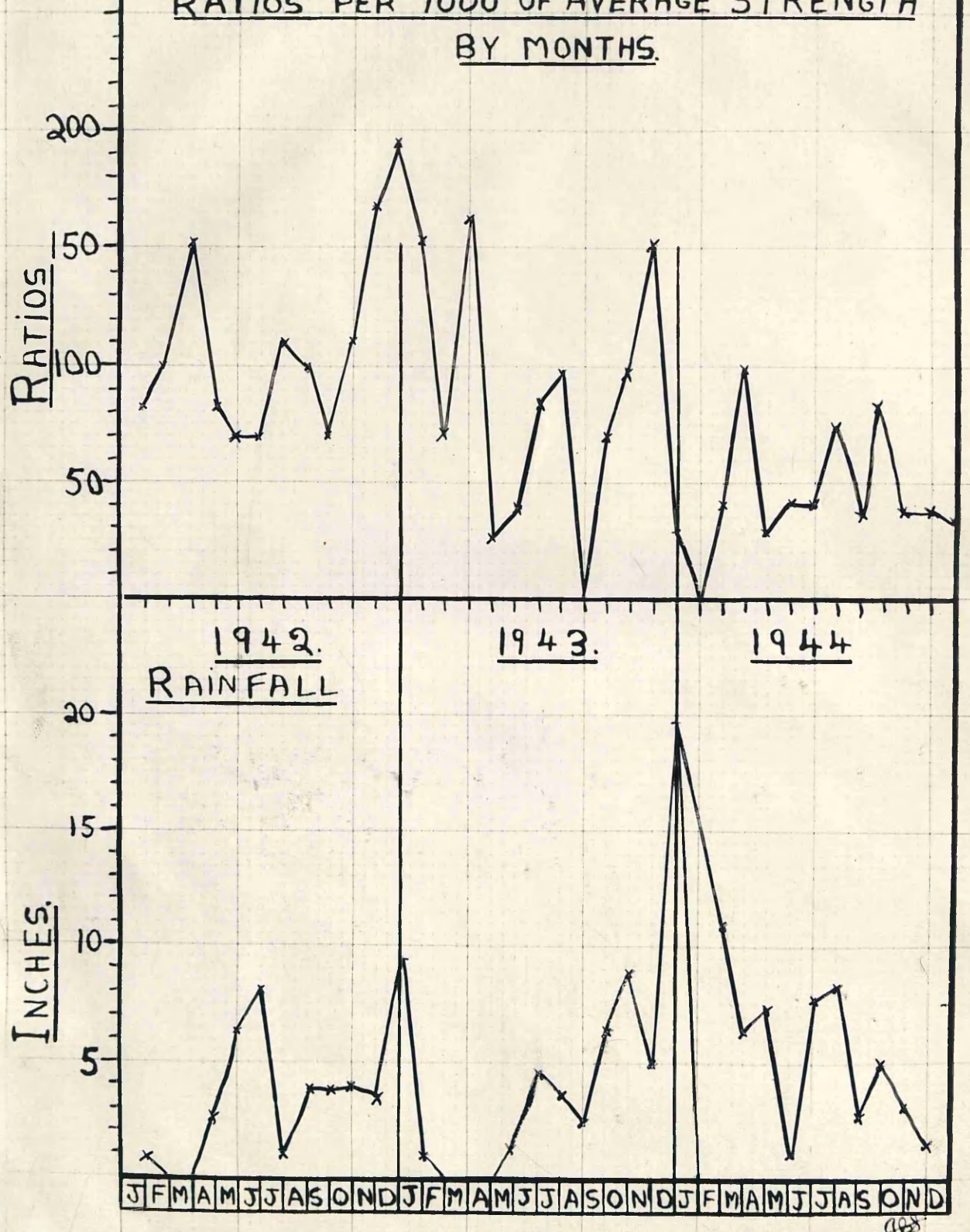
RATIOS PER 1000 OF AVERAGE STRENGTH BY MONTHS.



12.

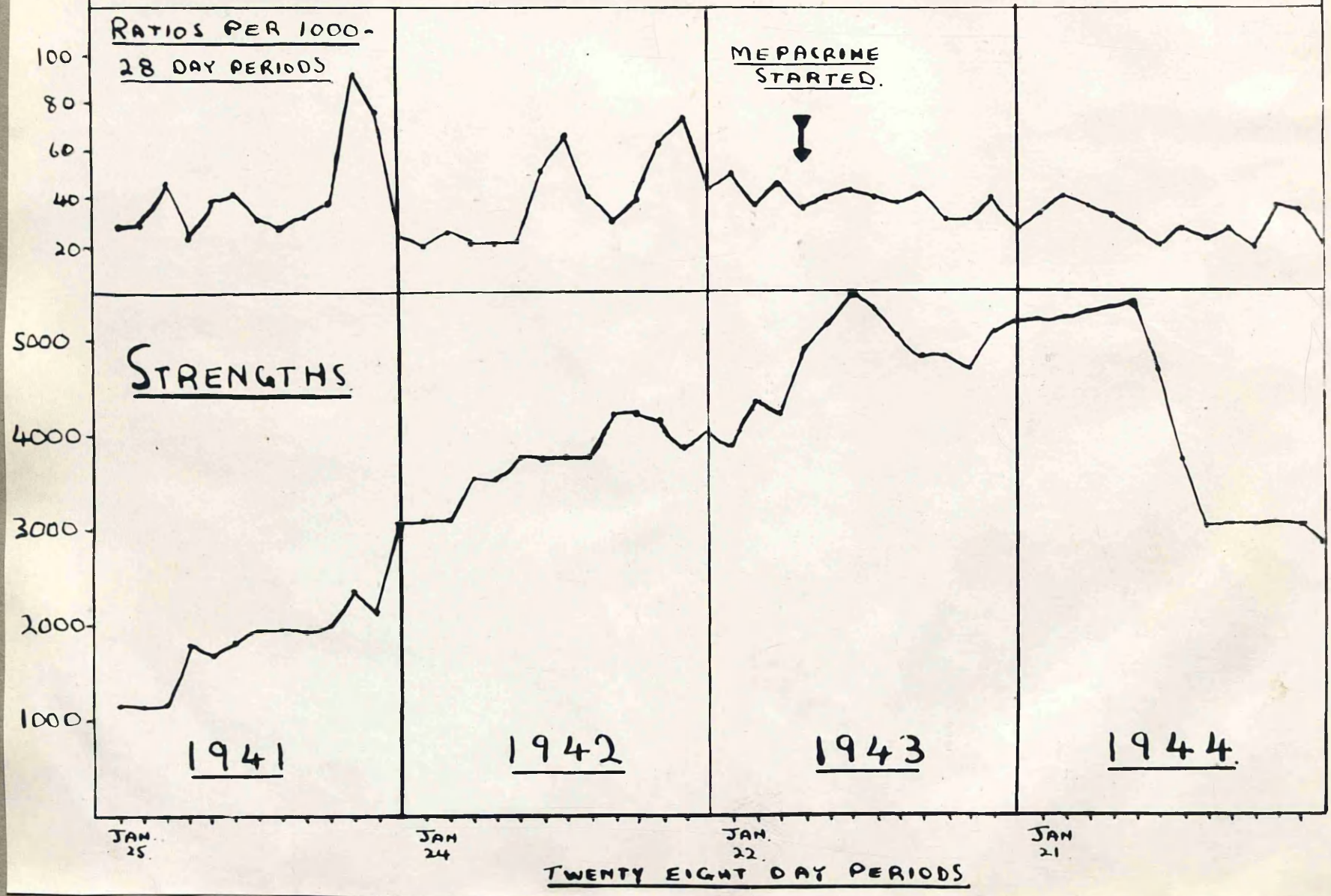
MALARIA - EUROPEANS - KINTAMPO

RATIOS PER 1000 OF AVERAGE STRENGTH BY MONTHS.



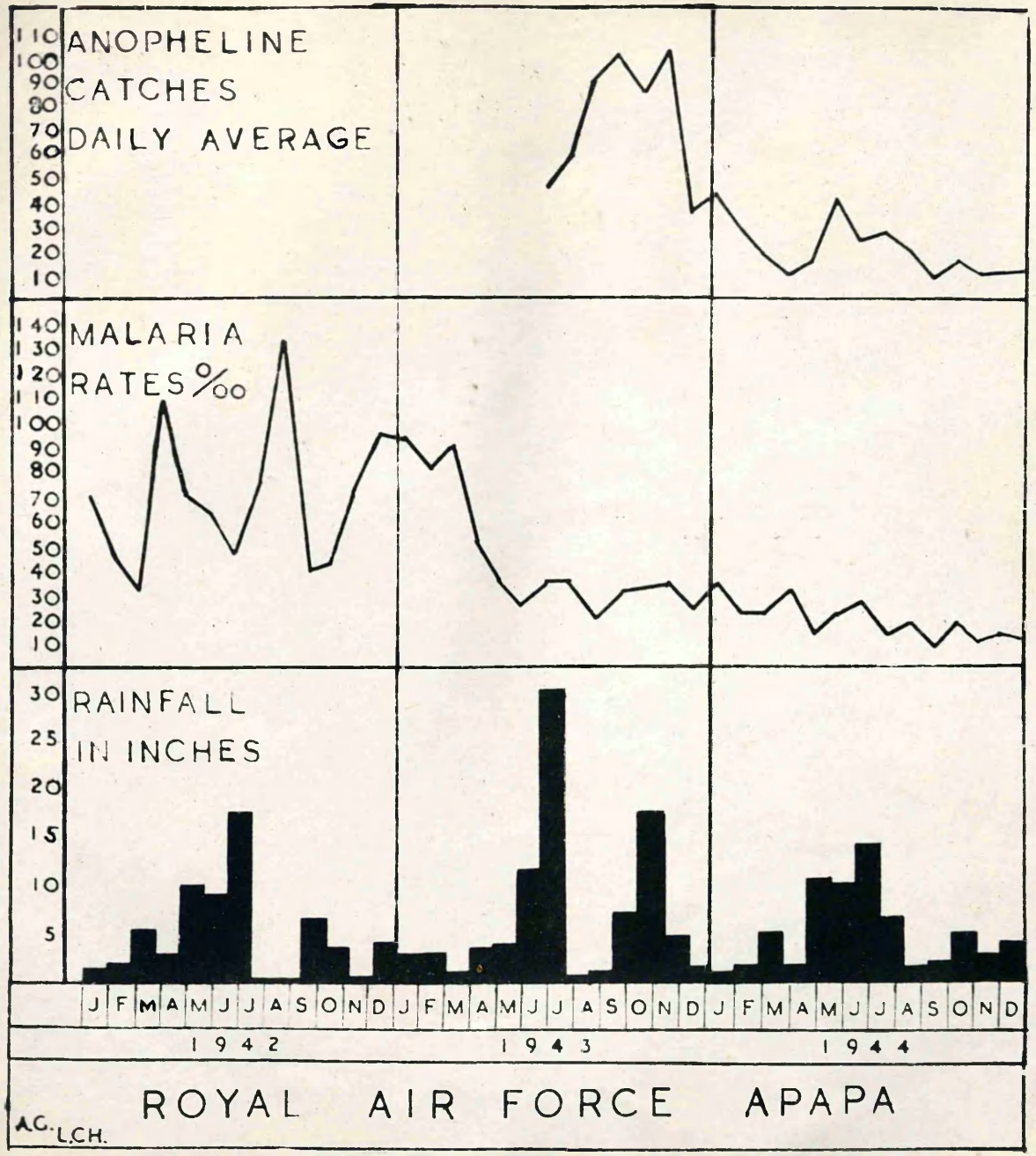
13.

NIGERIA - MALARIA ADMISSIONS
ARMY EUROPEANS



14.

4 - WEEKLY PERIODS

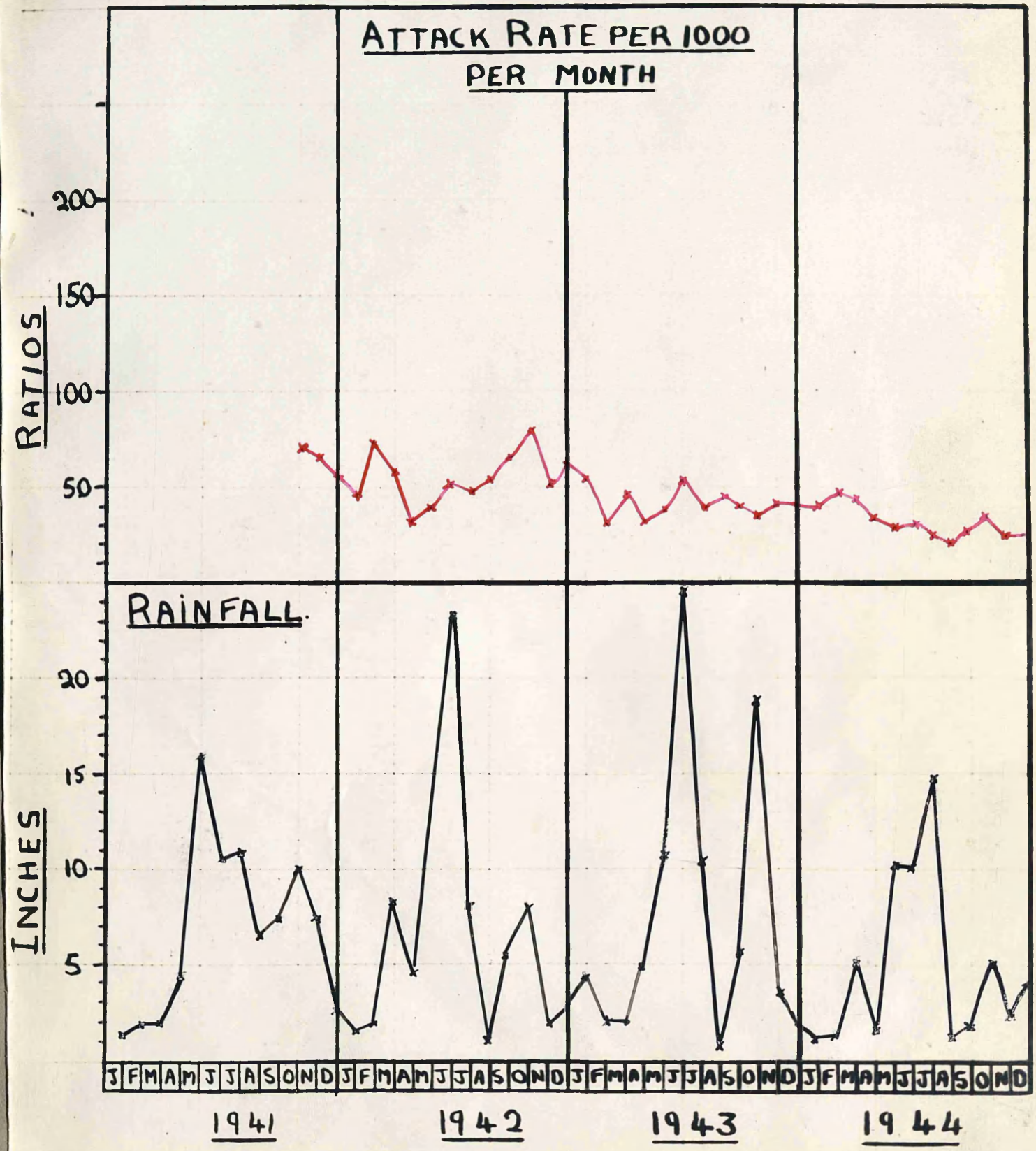


ROYAL AIR FORCE APAPA

A.C. L.C.H.

15.

MALARIA- EUROPEANS- LAGOS.



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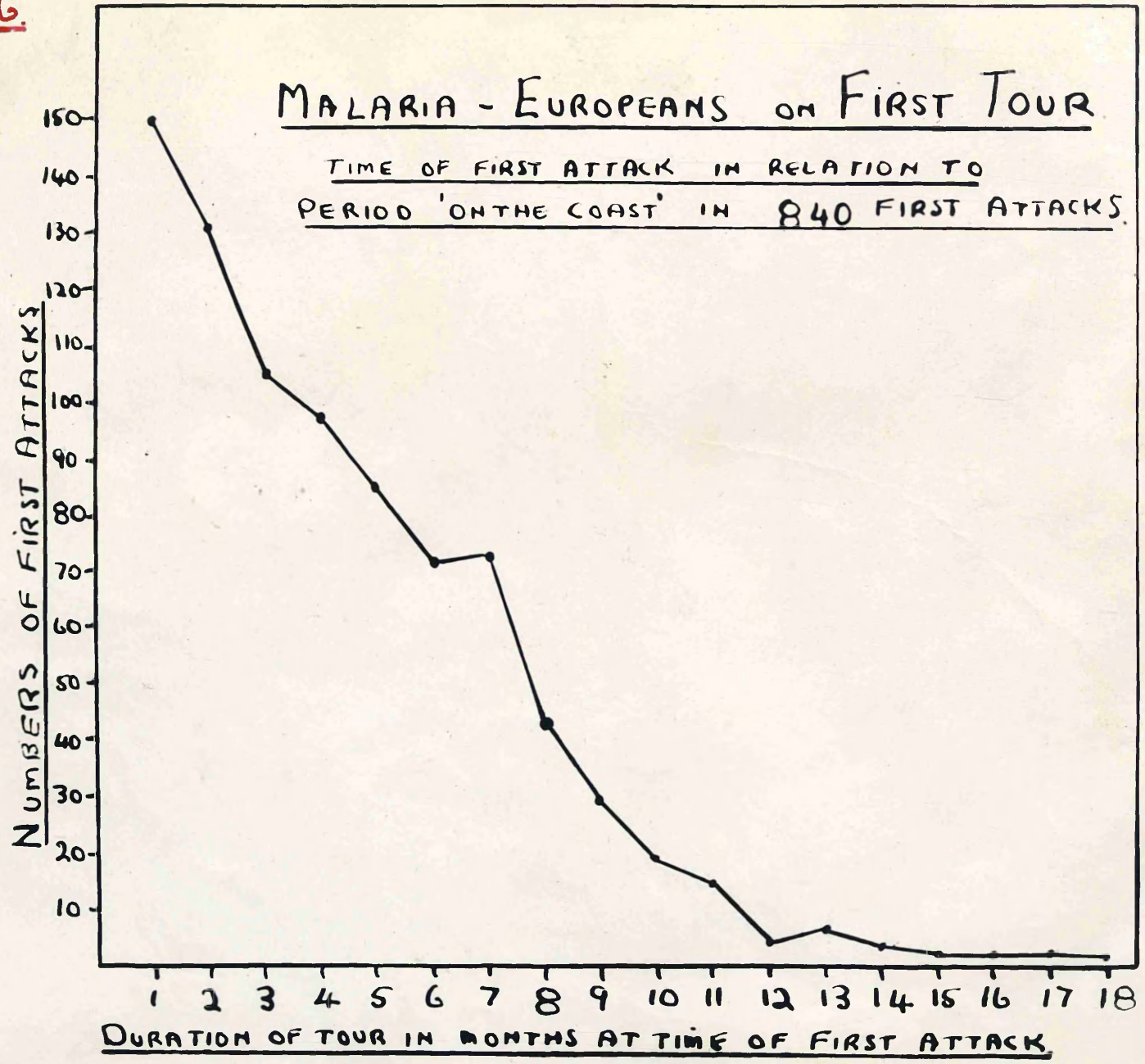
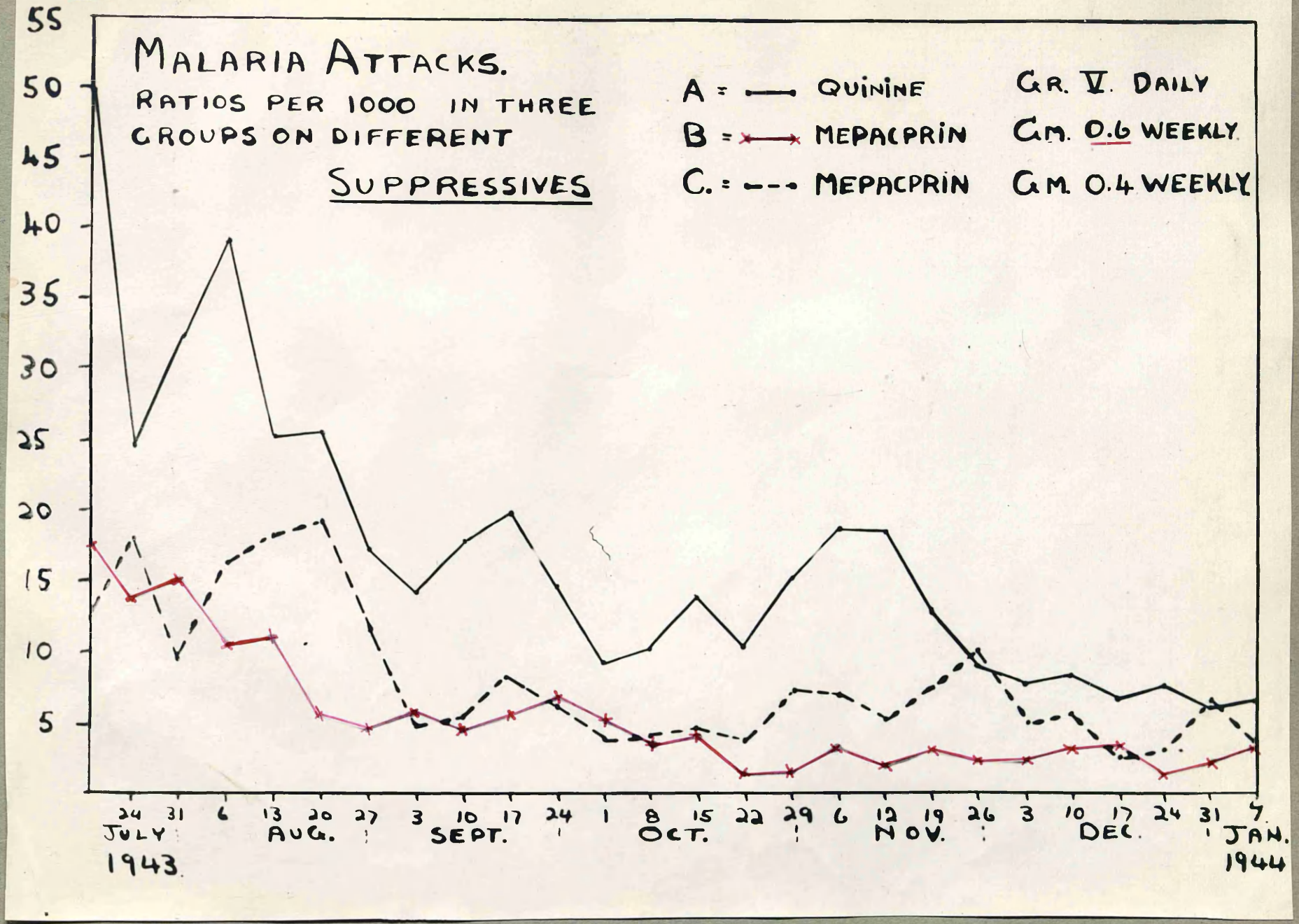

MALARIA - EUROPEANS ON FIRST TOUR
TIME OF FIRST ATTACK IN RELATION TO
PERIOD 'ON THE COAST' IN 840 FIRST ATTACKS.
NUMBERS OF FIRST ATTACKS
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
DURATION OF TOUR IN MONTHS AT TIME OF FIRST ATTACK

17.

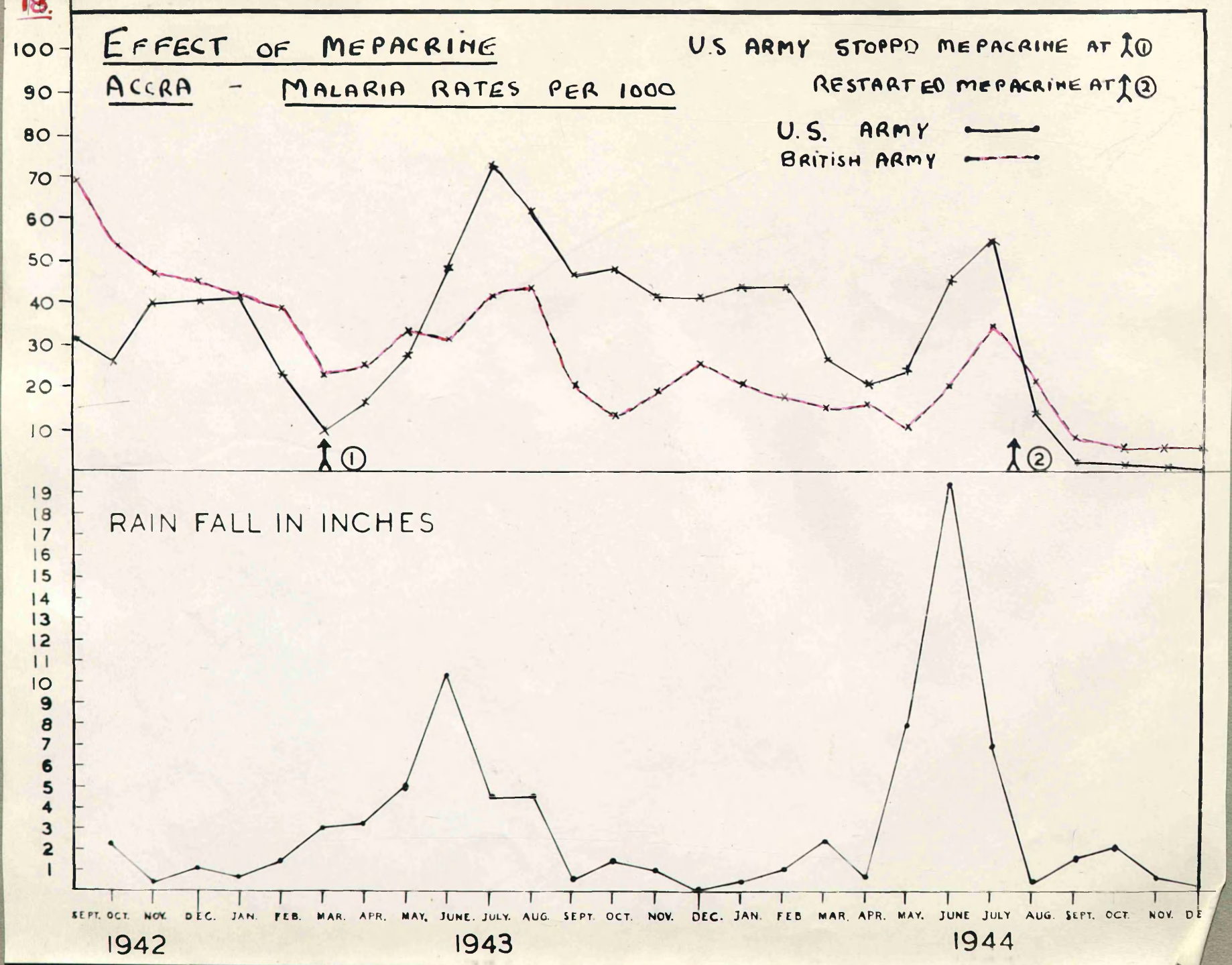

MALARIA ATTACKS.
RATIOS PER 1000 IN THREE GROUPS ON DIFFERENT
SUPPRESSIVES
A = QUININE GR. V. DAILY
B = MEPACRIN GM. 0.6 WEEKLY
C. = MEPACRIN GM. 0.4 WEEKLY
55
50
45
40
35
30
25
20
15
10
5
24 31 6 13 20 27 3 10 17 24 1 8 15 22 29 6 12 19 26 3 10 17 24 31 7
JULY AUG. SEPT. OCT. NOV. DEC. JAN.
1943 1944

18.

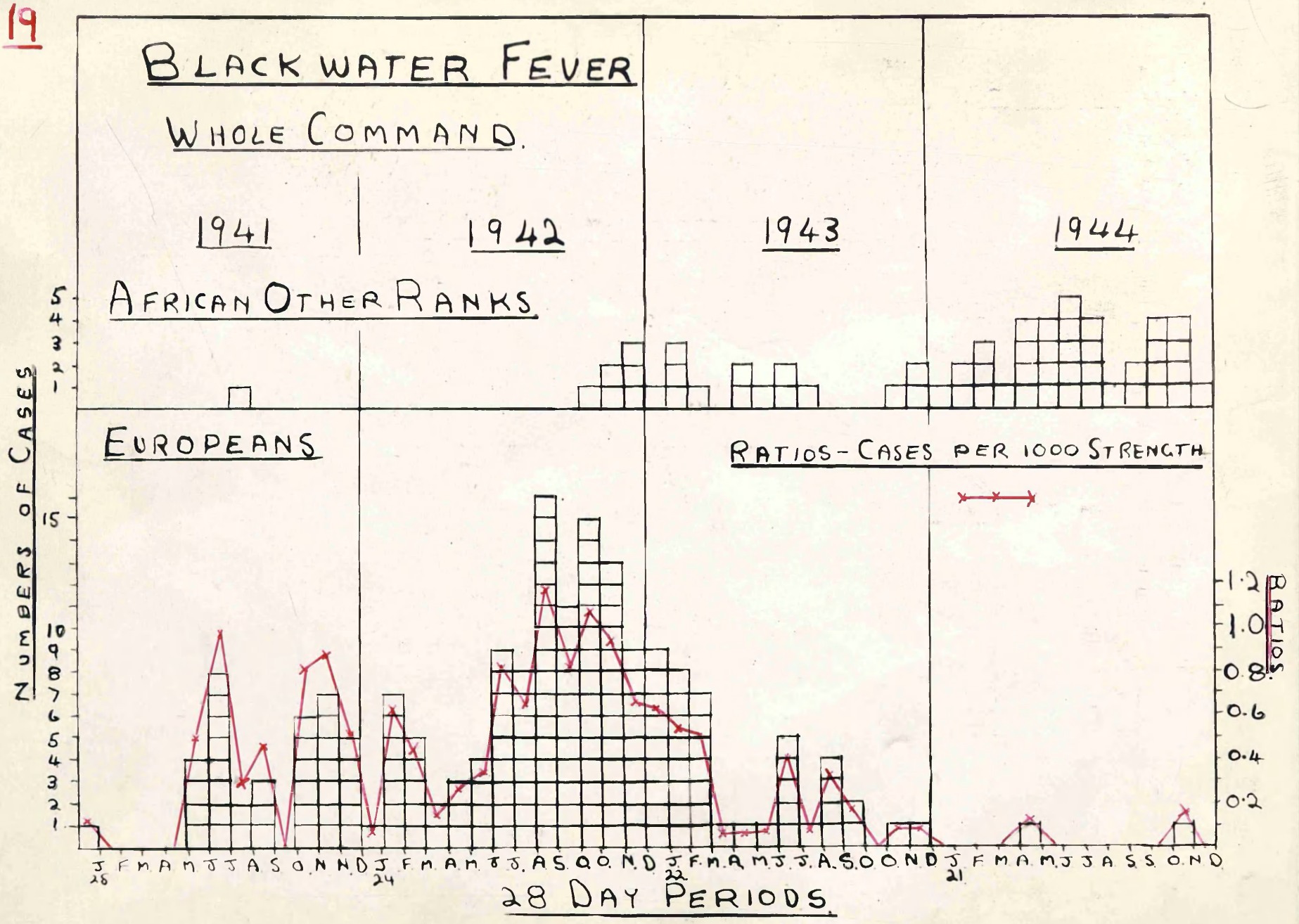
EFFECT OF MEPACRINE

ACCRA - MALARIA RATES PER 1000

U.S ARMY STOPPD MEPACRINE AT ① RESTARTED MEPACRINE AT ②



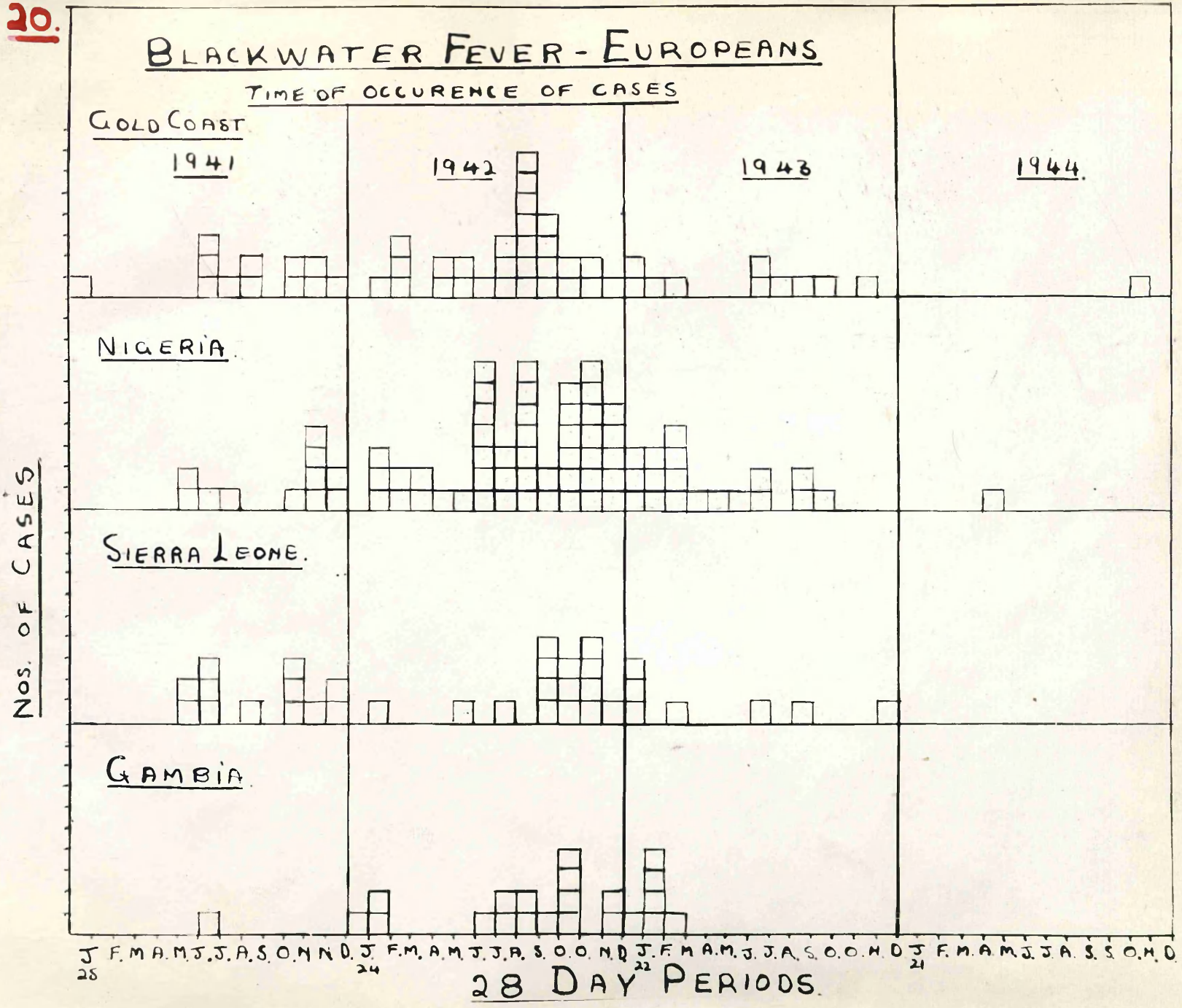
19


BLACK WATER FEVER
WHOLE COMMAND.
1941
1942
1943
1944
AFRICAN OTHER RANKS
EUROPEANS
RATIOS - CASES PER 1000 STRENGTH
NUMBERS OF CASES
RATIOS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
28 DAY PERIODS.

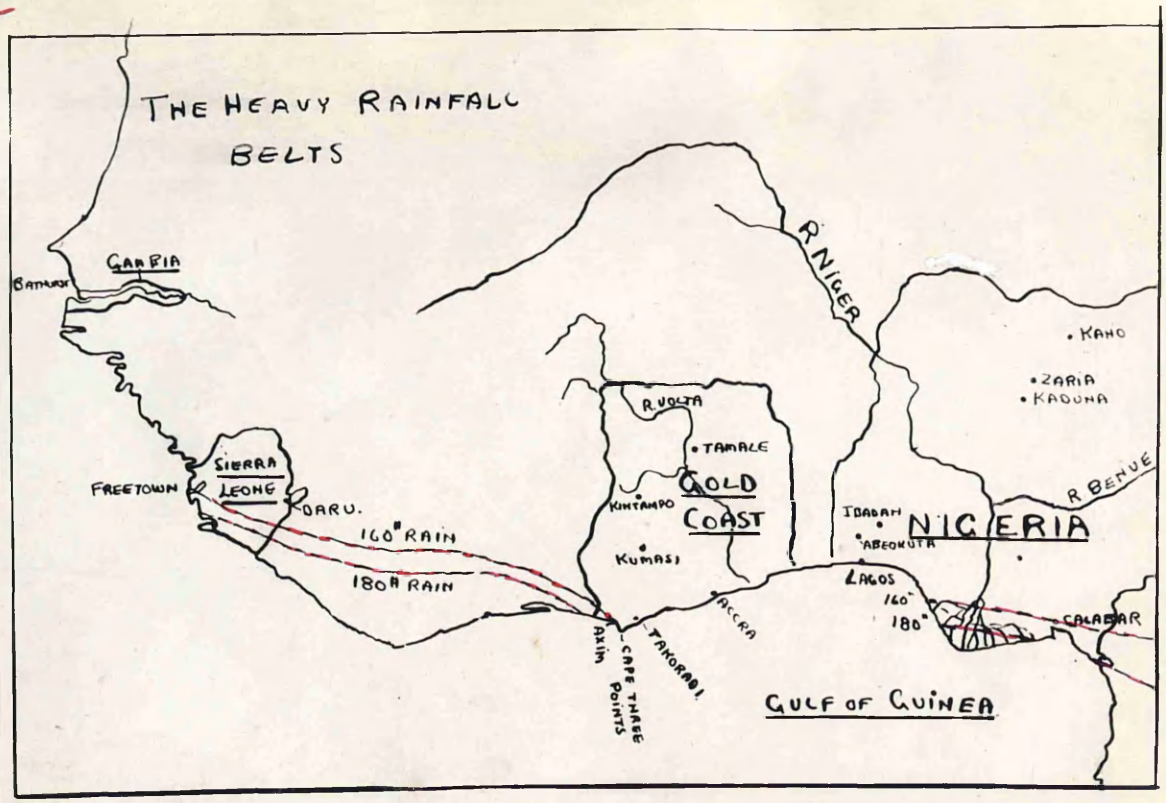
20.

BLACKWATER FEVER - EUROPEANS

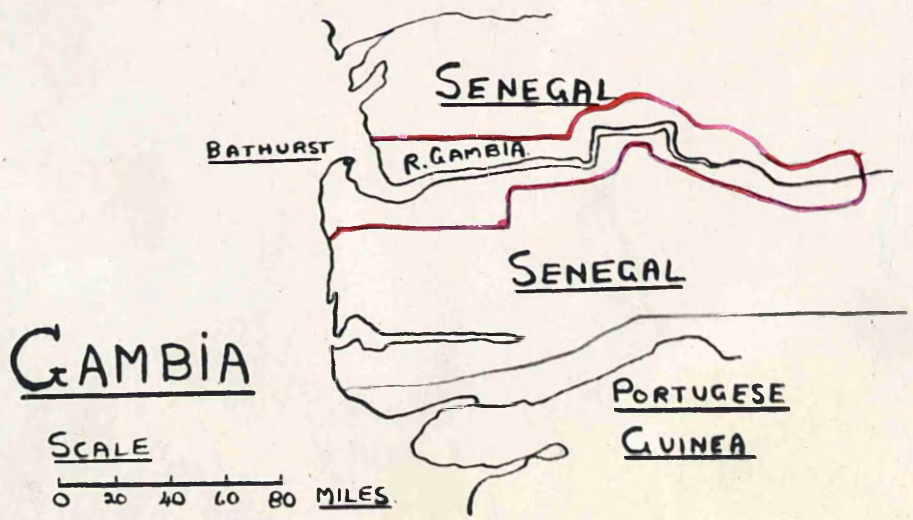
TIME OF OCCURENCE OF CASES



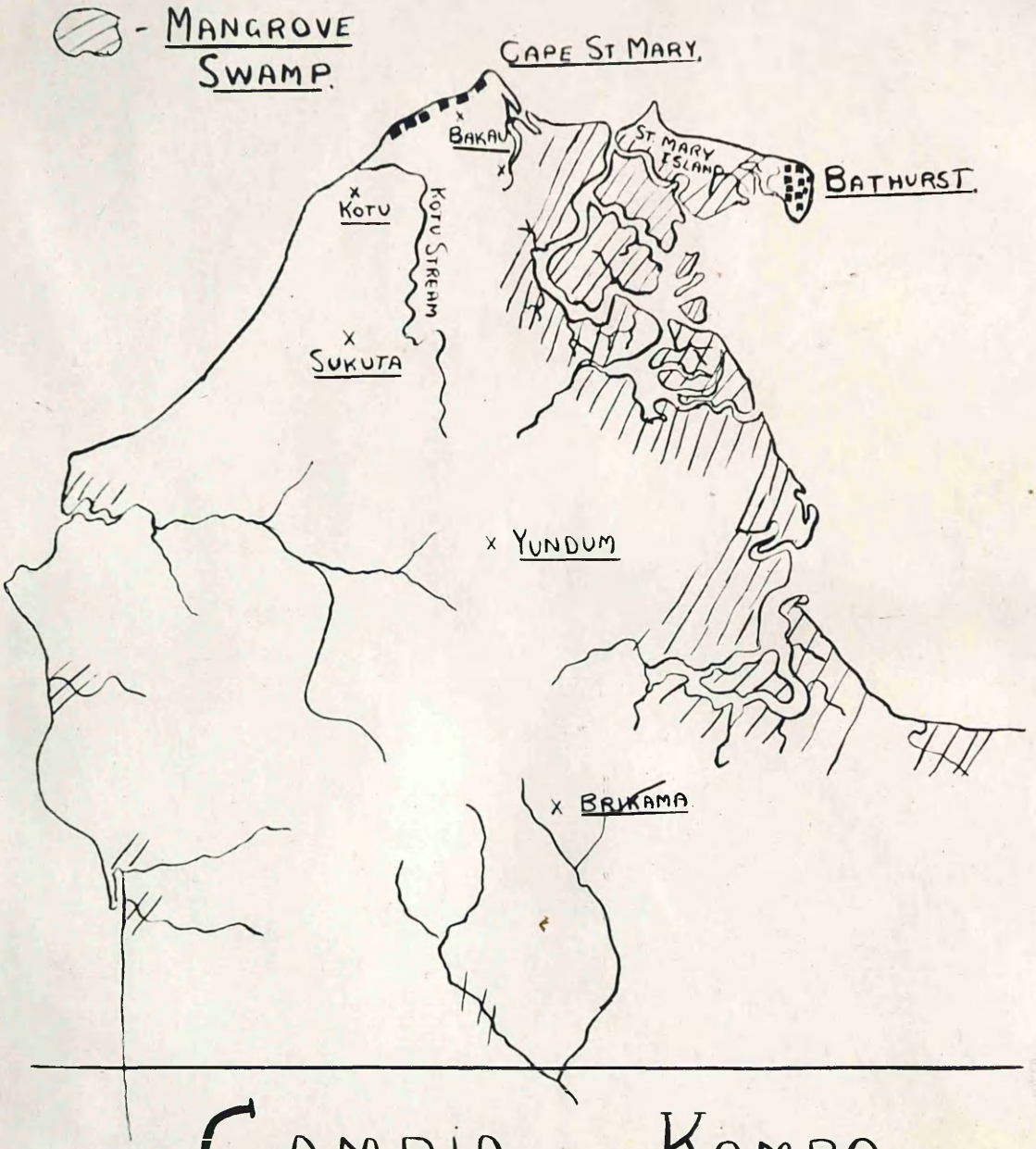
1


THE HEAVY RAINFALL BELTS
GAMBIA
BATHURST
SIERRA LEONE
FREETOWN
DARU.
160" RAIN
180" RAIN
R. NIGER
R. VOLTA
TAMALE
GOLD COAST
KINTAMPO
KUMASI
AXIM
CAPE THREE POINTS
TAKORADI
ACCRA
KANO
ZARIA
KADUNA
R. BENUE
IBADAN
ABEOKUTA
NIGERIA
LAGOS
160"
180"
CALABAR
GULF OF GUINEA

2.


SENEGAL
BATHURST
R. GAMBIA
SENEGAL
GAMBIA
PORTUGESE GUINEA
SCALE
0 20 40 60 80 MILES

3.



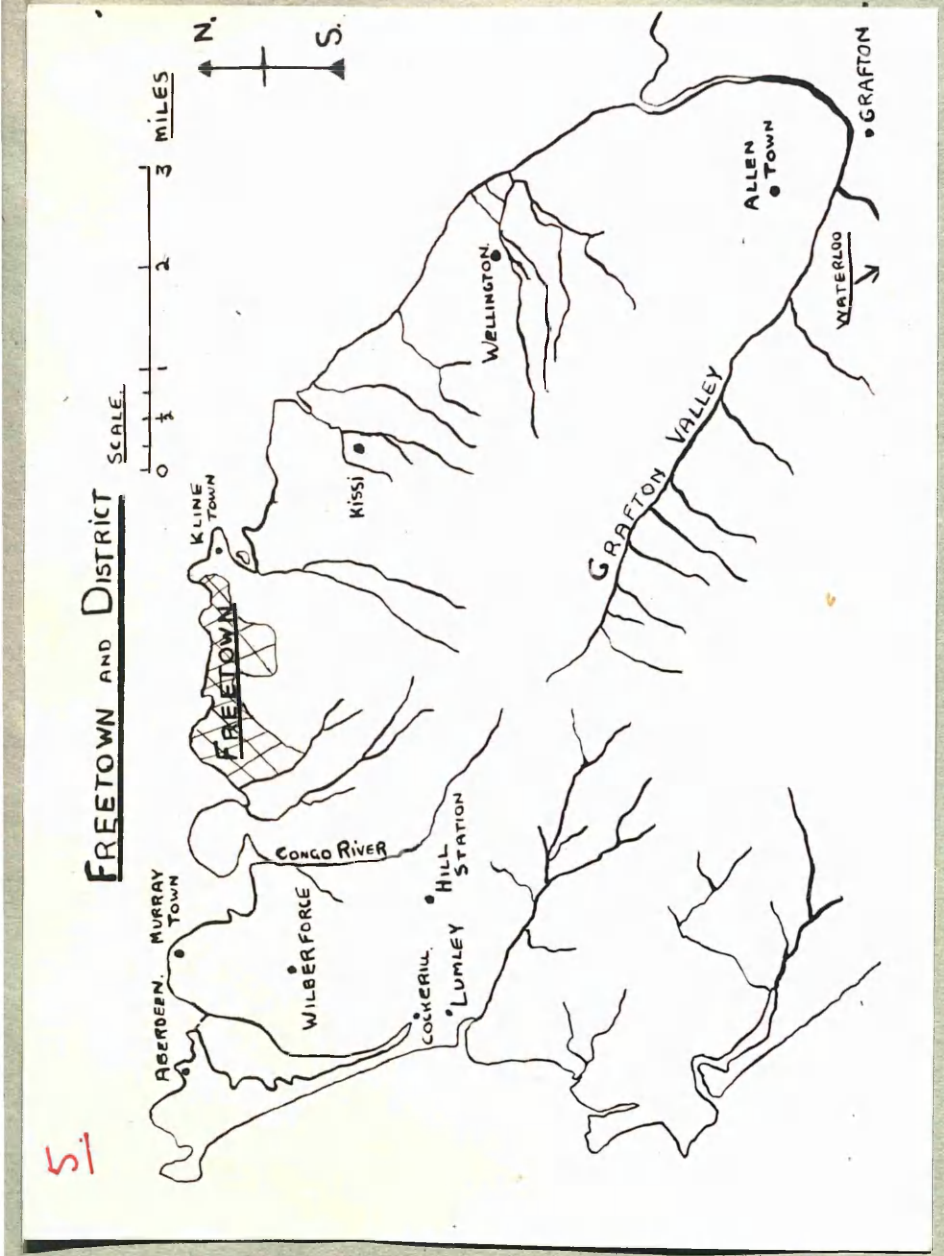
GAMBIA - KOMBO

SCALE.

0 1 2 3 4 MILES.

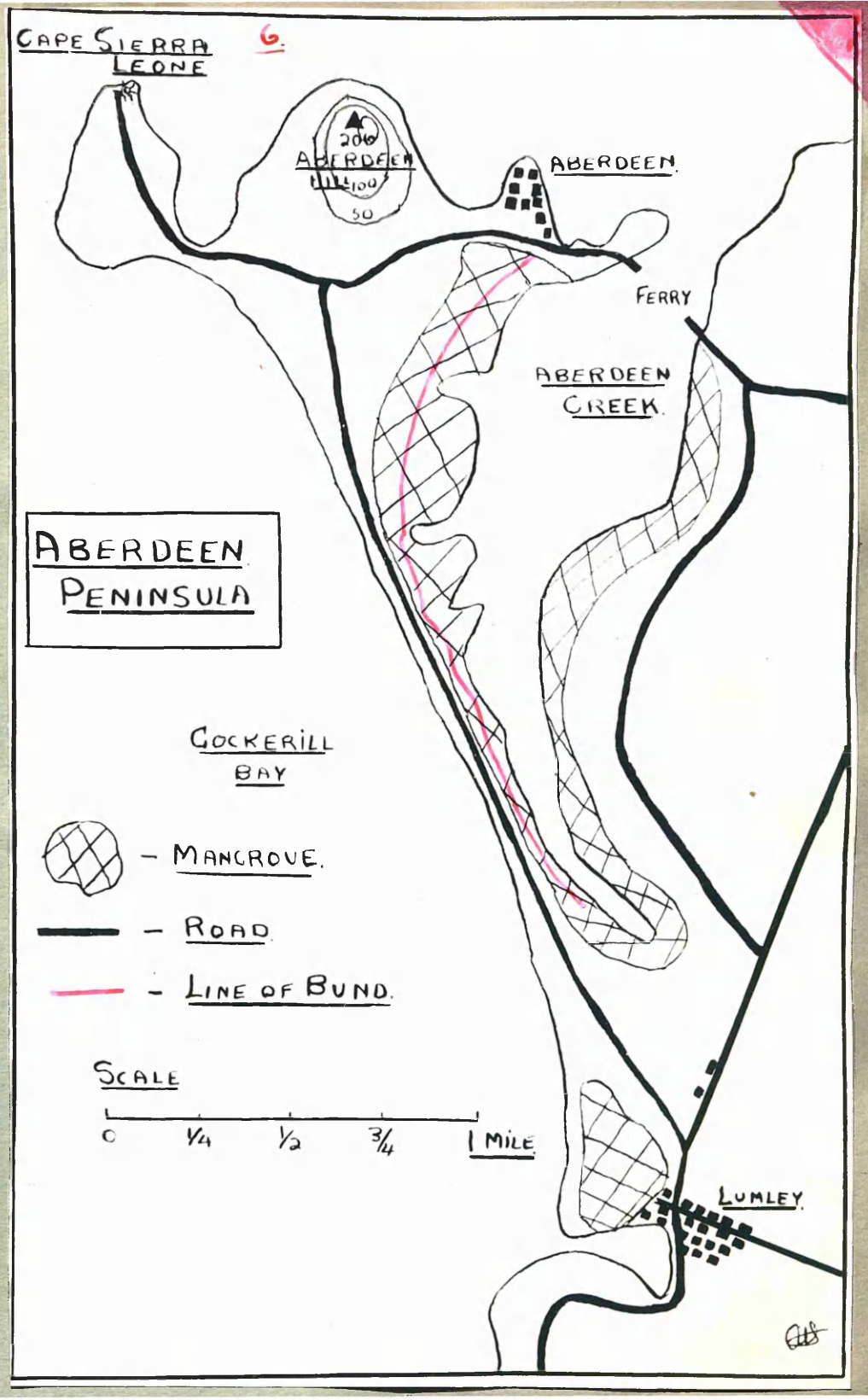
4

SIERRA LEONE

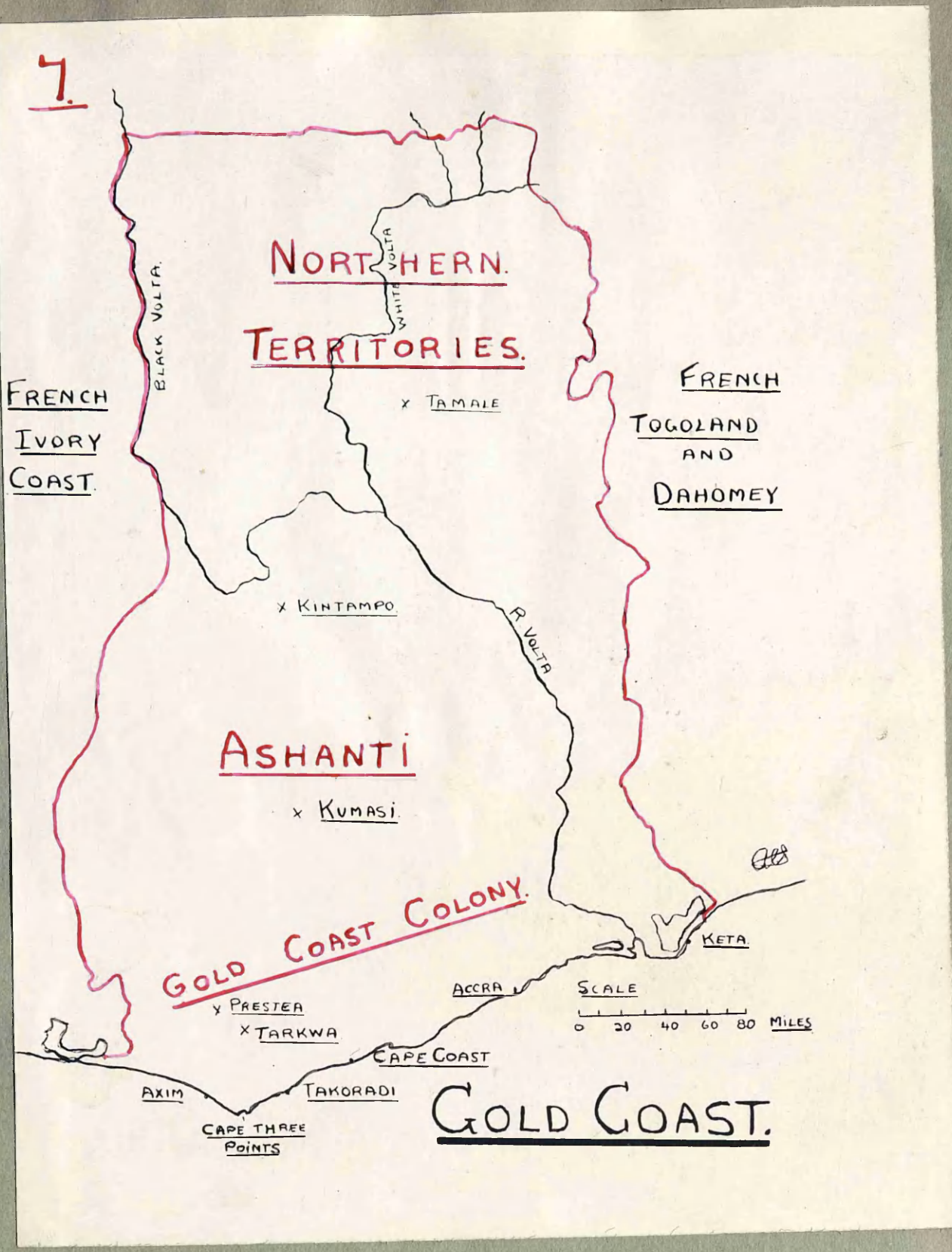

FREETOWN AND DISTRICT
SCALE.
0 ½ 1 2 3 MILES
N.
S.
KLINE TOWN
KISSI
WELLINGTON
ALLEN TOWN
GRAFTON
WATERLOO
GRAFTON VALLEY
FREETOWN
CONGO RIVER
MURRAY TOWN
ABERDEEN.
WILBERFORCE
COCKERILL.
HILL STATION
LUMLEY

5/

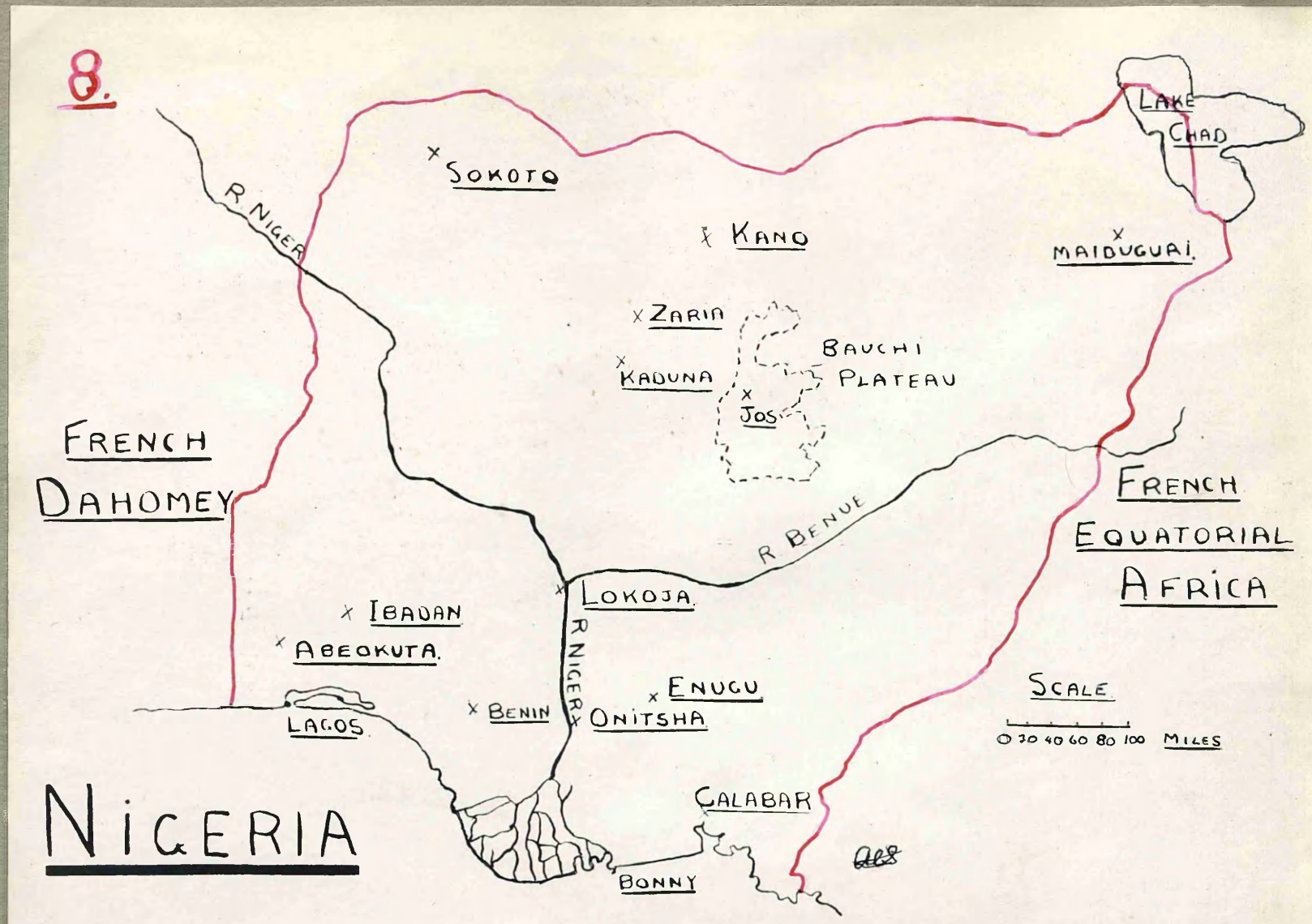
6.


CAPE SIERRA LEONE
200
ABERDEEN
100
50
ABERDEEN.
FERRY
ABERDEEN CREEK.
ABERDEEN PENINSULA
COCKERILL BAY
- MANGROVE.
- ROAD.
- LINE OF BUND.
SCALE
0 ¼ ½ ¾ 1 MILE
LUMLEY.

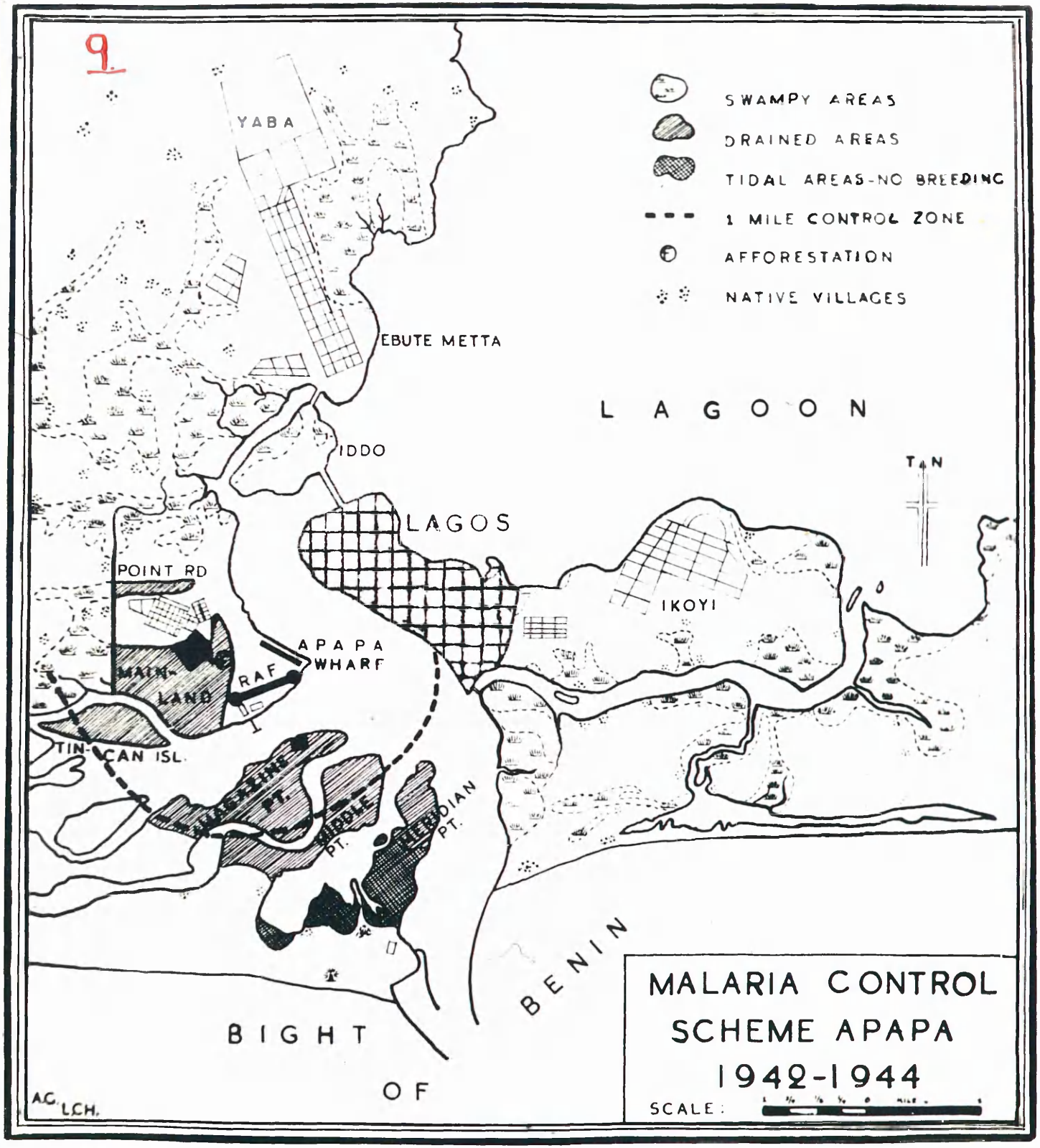
7.


NORTHERN
TERRITORIES.
BLACK VOLTA.
WHITE VOLTA
FRENCH
IVORY
COAST.
FRENCH
TOGOLAND
AND
DAHOMEY
x TAMALE
x KINTAMPO
R VOLTA
ASHANTI
x KUMASI
GOLD COAST COLONY.
KETA
ACCRA
SCALE
0 20 40 60 80 MILES
x PRESTEA
x TARKWA
CAPE COAST
AXIM
TAKORADI
CAPE THREE
POINTS
GOLD COAST.

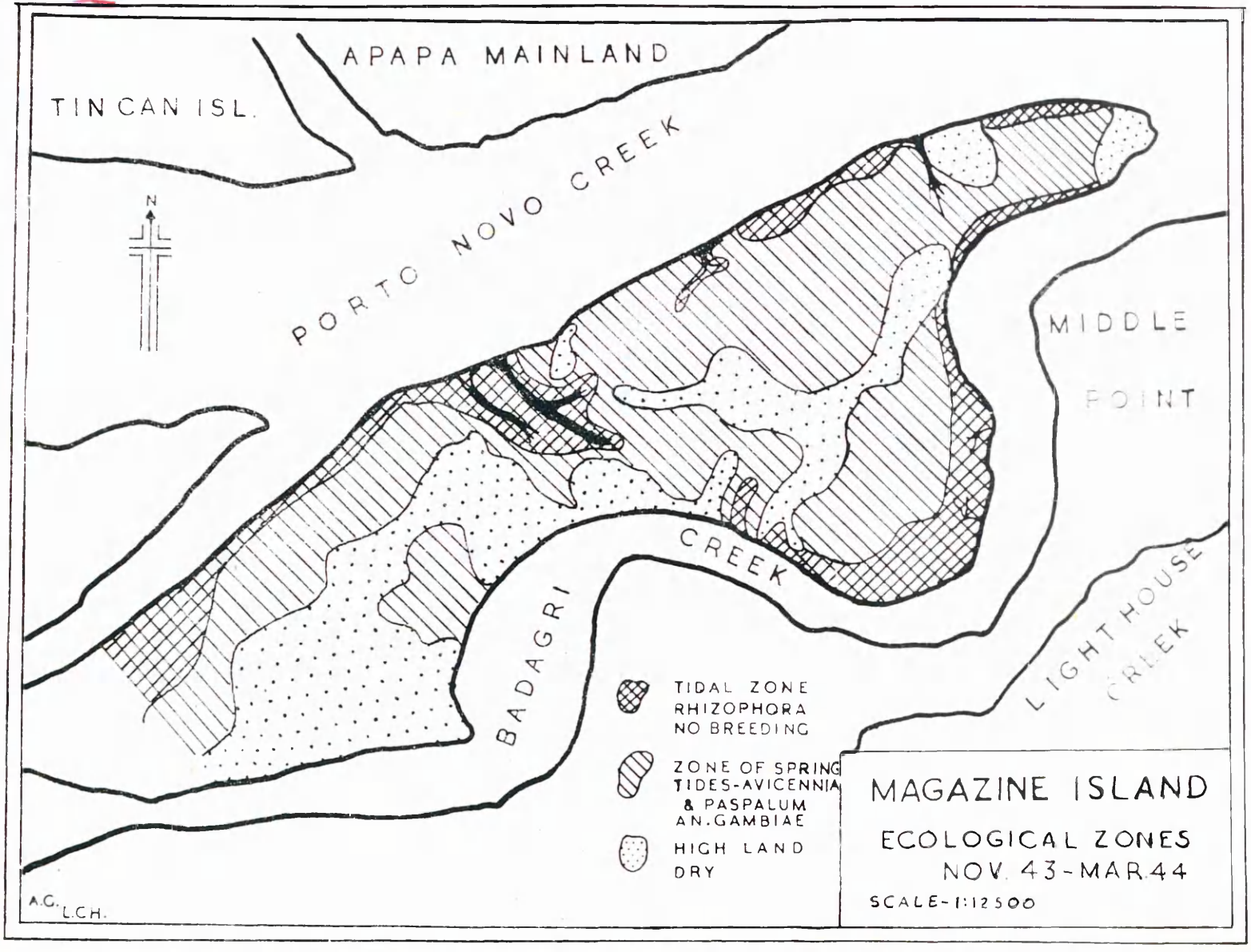
8.


LAKE CHAD
SOKOTO
R. NIGER
KANO
MAIDUGUAI
ZARIA
KADUNA
BAUCHI PLATEAU
JOS
FRENCH DAHOMEY
FRENCH EQUATORIAL AFRICA
R BENUE
LOKOJA
IBADAN
ABEOKUTA
R NIGER
ENUGU
ONITSHA
BENIN
LAGOS
CALABAR
BONNY
SCALE
0 20 40 60 80 100 MILES
NIGERIA

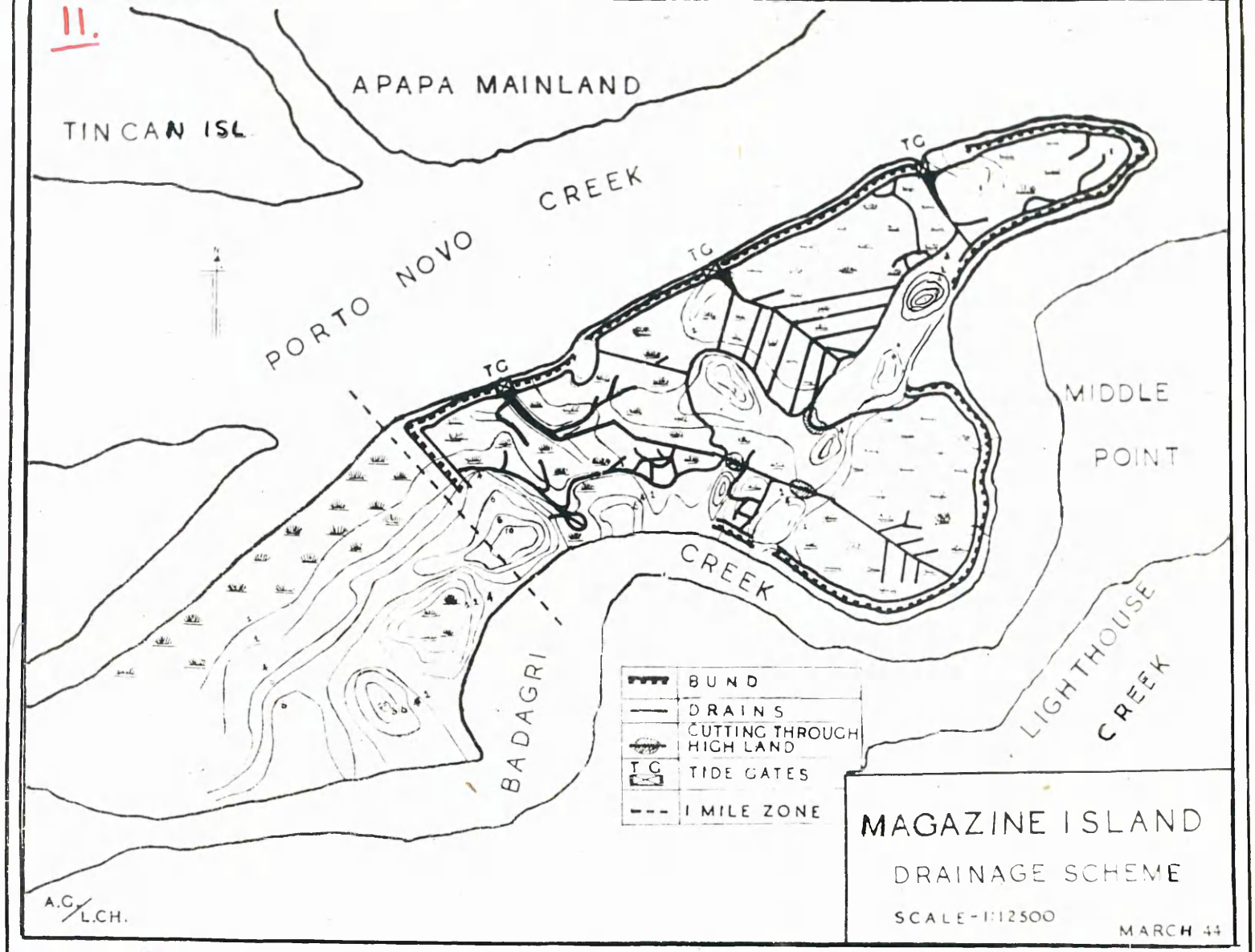
9.


SWAMPY AREAS
DRAINED AREAS
TIDAL AREAS-NO BREEDING
1 MILE CONTROL ZONE
AFFORESTATION
NATIVE VILLAGES
YABA
EBUTE METTA
LAGOON
IDDO
LAGOS
IKOYI
T N
POINT RD
APAPA WHARF
MAIN-LAND
RAF
TIN-CAN ISL.
PT.
PT.
PT.
BENIN
BIGHT
OF
A.G. LCH.
MALARIA CONTROL SCHEME APAPA 1942-1944
SCALE:

10.


APAPA MAINLAND
TIN CAN ISL.
PORTO NOVO CREEK
N
MIDDLE
POINT
BADAGRI
CREEK
LIGHT HOUSE
CREEK
TIDAL ZONE
RHIZOPHORA
NO BREEDING
ZONE OF SPRING
TIDES-AVICENNIA
& PASPALUM
AN. GAMBIAE
HIGH LAND
DRY
A.G.
L.C.H.
MAGAZINE ISLAND
ECOLOGICAL ZONES
NOV. 43-MAR. 44
SCALE-1:12500

11.


APAPA MAINLAND
TIN CAN ISL
PORTO NOVO CREEK
TG
TG
TG
MIDDLE POINT
CREEK
BADAGRI
LIGHTHOUSE CREEK
BUND
DRAINS
CUTTING THROUGH HIGH LAND
TG TIDE GATES
1 MILE ZONE
MAGAZINE ISLAND
DRAINAGE SCHEME
SCALE - 1:12500
MARCH 44
A.G.
L.CH.

1.

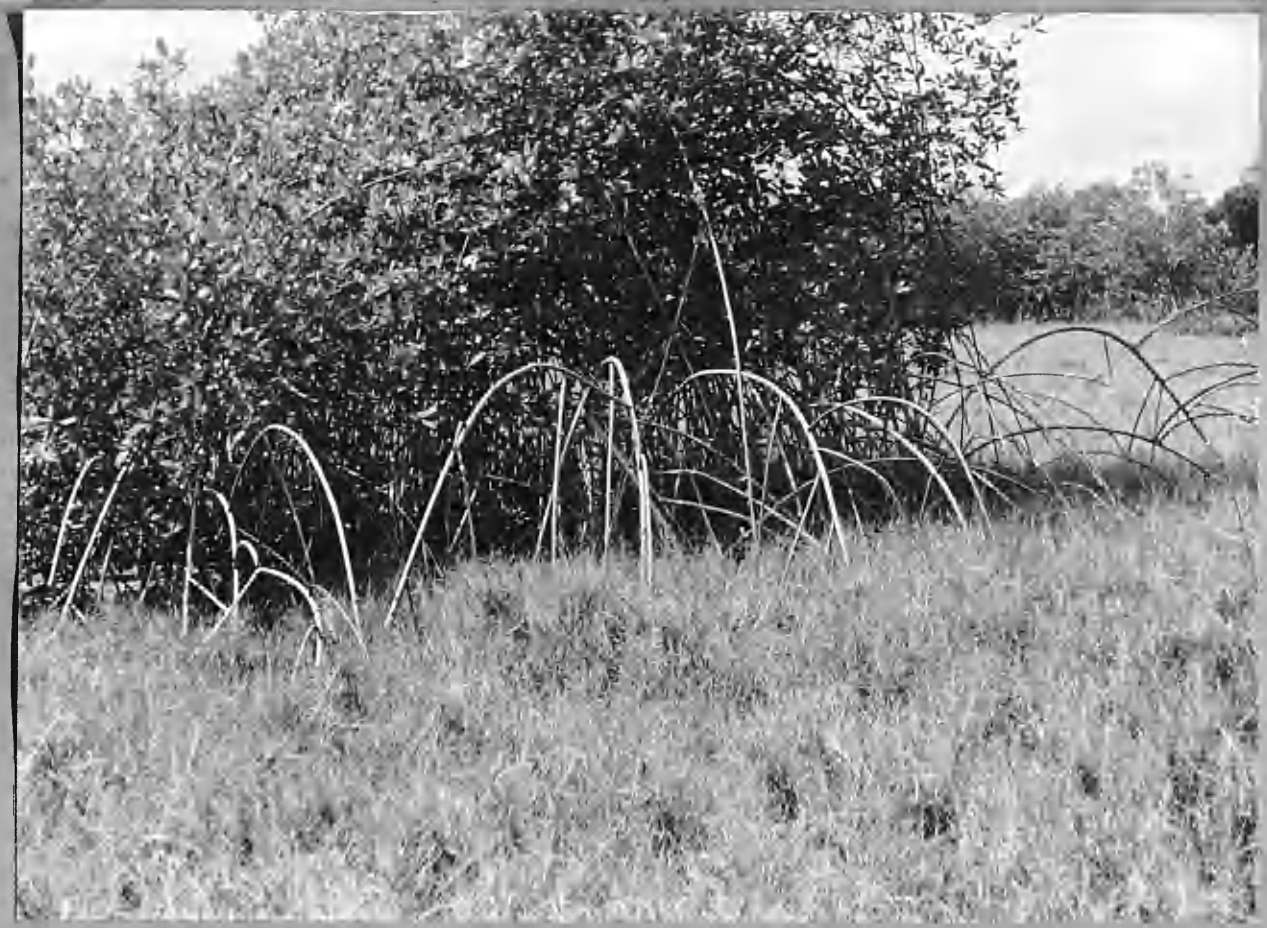
RHIZOPHORA

AVICENNIA

2.

AVICENNIA

3.



RHIZOPHORA

4.

AVICENNIA.

5.

BATHURST. Drains in a main street three months after the last rainfall.

BATHURST. Photographs 6 and 7 are two views of the refuse disposal area one quarter of a mile from the town. A huge source of mosquito breeding.

6

7.

8.

CAPE ST.MARY. GAMBIA. Typical mangrove swamp. The hut is the end of an Army Camp.

9.

10.

Photographs 9, 10 & 11 are of a concrete channel laid in 1942 in Freetown and smashed by heavy scouring.

GOLD COAST. The effect of three inches of rain on one day on a well cut drain.

13.

The bund at ABERDEEN. The sea is on the right in both photographs. (13 & 14).

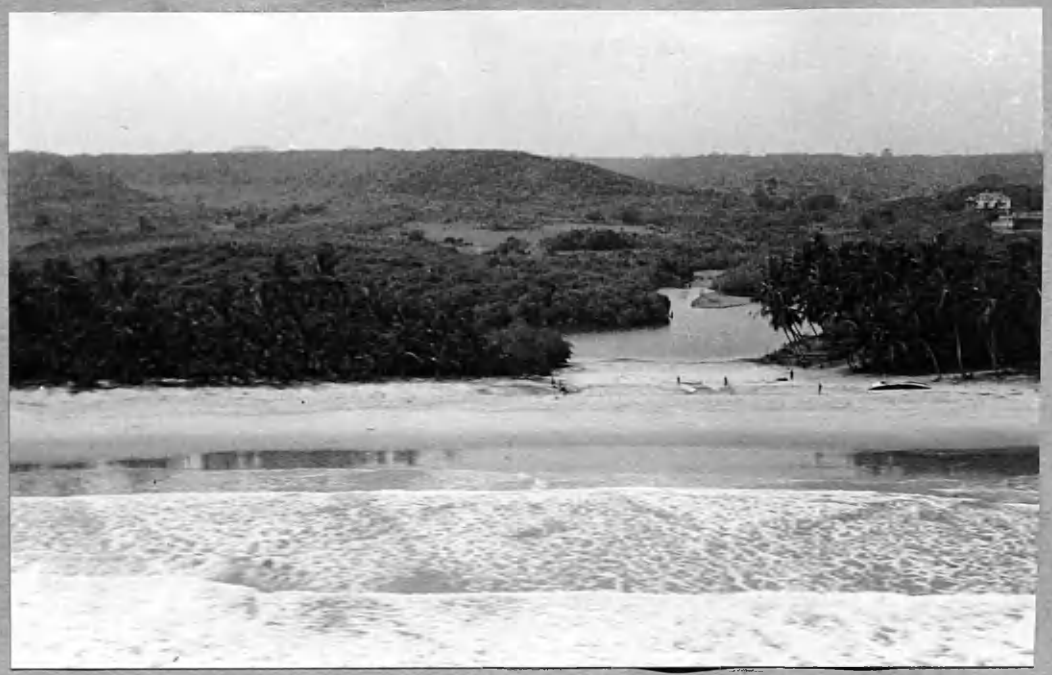
14.

15.

KINTAMPO. Canalisation of a stream and grass planting of the banks. In tsetse fly country.

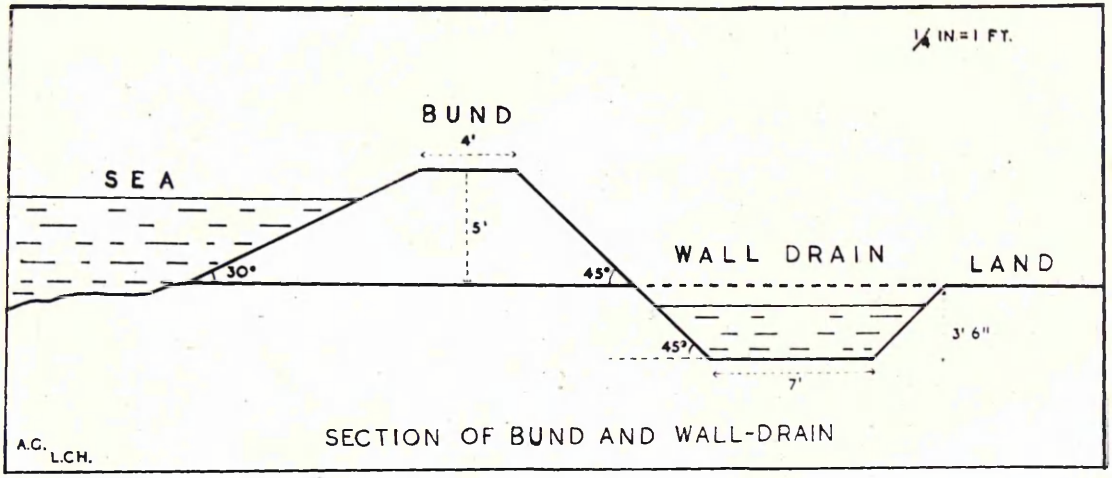
KINTAMPO. A stream passing underground in eroded limestone.

16.



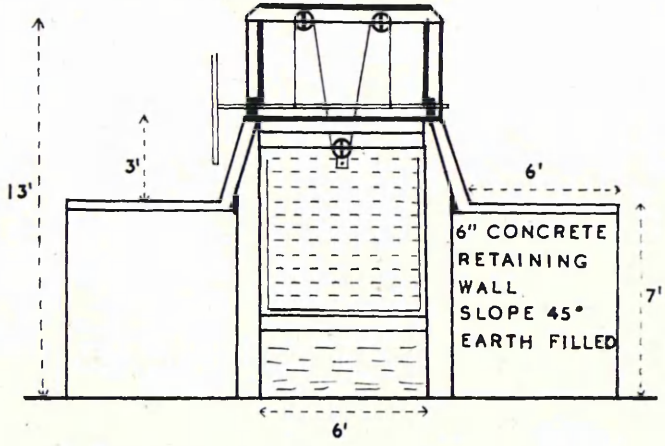
Photograph from the air of the mouth of a small river in Gold Coast terminating in a lagoon with a sand bar between the surf and the lagoon.

1.



SECTION OF BUND AND WALL-DRAIN

2.

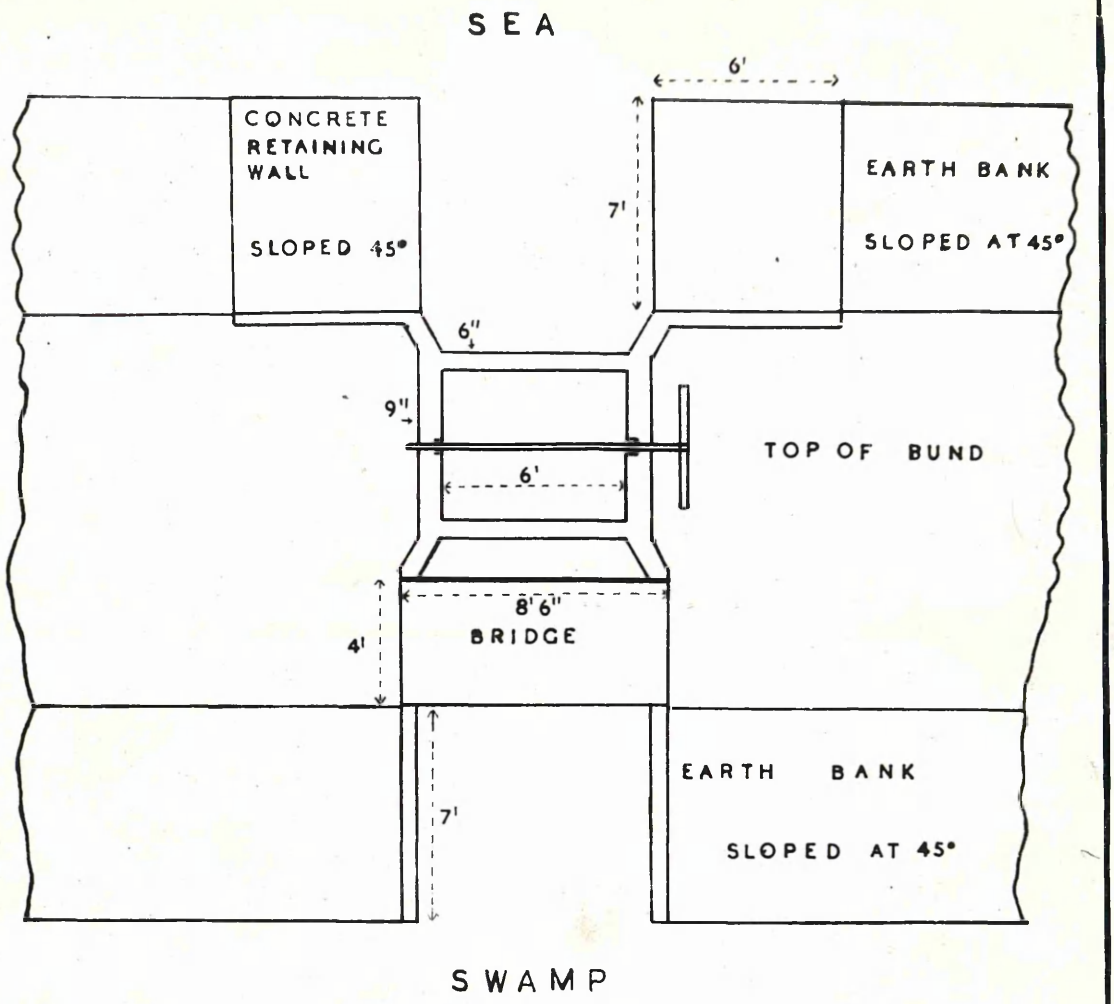


CONCRETE TIDE-GATE

ELEVATION FROM SEA. GATE OPEN

A.G.
L.C.H.

3.



1/4 IN = 1 FT

PLAN OF CONCRETE TIDE-GATE

A.G.
L.C.H.

4.

STANDING ORDERS FOR MOSQUITO-PROOFED BUILDINGS.

An Officer will inspect every mosquito-proofed building once each week.

The Officer will ensure :—

(i) That there is no damage or structural defect in the mosquito-proofing.

(ii) That no article of any kind is placed against the gauze.

(iii) That no nails or screws are driven into the supporting framework, and that nothing is tied to the gauze.

(iv) That all doors are close fitting and that the automatic closing device is working correctly.

(v) That under no circumstances doors are propped or tied open, and that a prominent notice to that effect is posted in every "lock".

(vi) That under no circumstances are both doors of a mosquito lock opened at the same time.

The inspecting Officer will arrange for all defects found by him to be remedied forthwith. Assistance from the R.E. will only be asked for when major structural work is necessary or the gauze has deteriorated through climatic conditions.

Damage by neglect or misbehaviour will be charged to the Unit or individual.

The senior occupant of any mosquito-proofed building will report at once any damage to doors and gauze.

No structural alterations will be made in any mosquito-proofed building without the approval of the A.D.M.S.

All buildings will be sprayed each day with an approved insecticide, during the hour after dawn and the hour before dark.

Existing Orders on the taking of suppressive mepacrine, the wearing of protective clothing, and the use of mosquito nets, will be *strictly* complied with, even though a building be mosquito-proofed.

A copy of these instructions must be displayed in a prominent position in all mosquito-proofed buildings.

LPS-LP1298-1000