THE EPIDEMIC OF MALARIAL FEVER IN NATAL, 1905.

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Natal, which has been considered of recent years to be a malaria-free country, has been visited in the past six months by an extensive epidemic of this disease.

Variations in the extent of the prevalence of malarial fever in different years, and the occurrence of epidemics in regions where the disease is known to be endemic, have been frequently observed in different parts of the world. Numerous instances are recorded of the extension of malaria beyond its normal endemic areas and also of its subsequent recession from districts in which it is not usually encountered. There are instances on record of the appearance of malaria in epidemic form in parts where it has almost certainly not existed before, the disease subsequently becoming established as a dominant factor in the pathology of the district. The most notable instance of such an occurrence is found in the history of the Island of Mauritius, regarding which information may be found in Clemow's *Geography of Disease,* Manson's *Tropical Diseases* and other works.

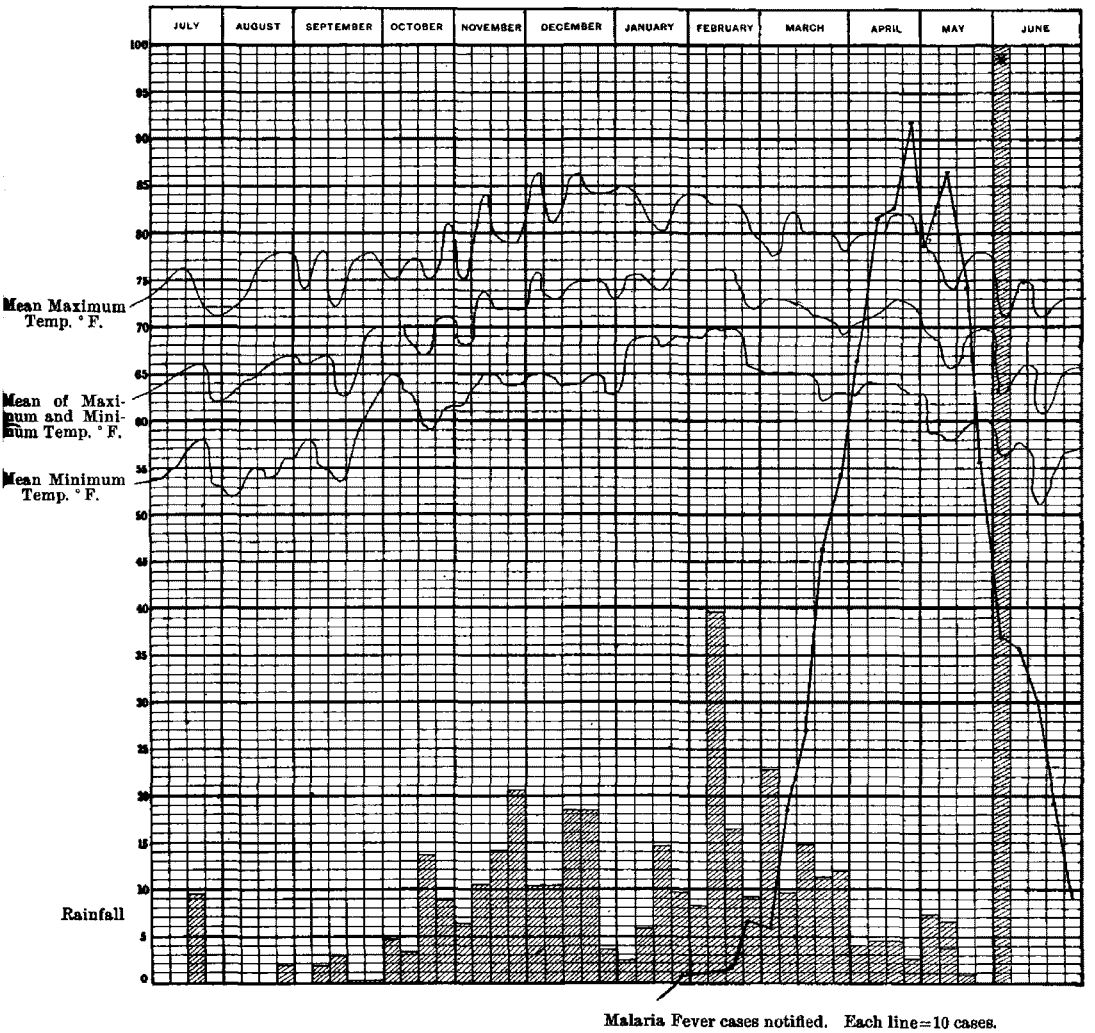
We are not however aware of any reports of important extensions of malarial fever beyond its established endemic areas since the part played by the mosquito in the spread of infection has been established. For the most part such instances in the past have apparently been associated with exceptionally wet seasons, whereas the Natal summer 1904—5 was not remarkable for any particularly lavish rainfall. Of four Districts in which the incidence has been most severe, in three the amount registered has varied during the past summer less than one inch

on the average of the nine preceding years, and in the fourth has been much below it, while the general character as shown by the number of days on which rain has fallen, affords no evidence of higher humidity. A careful comparison of the weekly rainfall in the summer months (November—March) of 1904—5 with that of the preceding three years, so far as records are available, on the higher lands near the coast (which would affect the dimensions of the smaller streams), shows a fall below the average in November and December, a rise above it in January, the rise being about double in February, and in March the point reached somewhat higher than usual. The epidemic reached its fastigium in April (see Chart), which bears the relation to maximum rainfall commonly observed; but in so far as any excess of rainfall might be thought to be a main cause, by increasing facilities for breeding of *Anophelina*, it is noticeable that although it was above the average of three immediately antecedent years, yet the monthly difference as against one or another of those years is hardly so remarkable as to produce such a result, although probably contributing to it; the epidemic had moreover attained considerable dimensions before the rainfall of February (the only marked excess) could have begun to take effect.

The malaria epidemic in Natal has been of notable proportions, and under the circumstances it appears to us desirable to publish this contribution to the epidemiology of the disease. We are unable to advance any sound reason to account for this epidemic, and propose only to set out such slender facts as we have, and to briefly draw attention to their bearings.

The territory of Natal lies between latitude 27° and 31° S., the northern part, still known as Zululand, occupying 27°—29° S. It is divided from Portuguese East Africa on the North by the Pongola River. Inland from the coast line the country rises rapidly to an elevation under the Drakensberg Range of some 5000 feet above the sea, to some degree in plateaux, the first being about a level of 2000 feet. The climate along the coast is sub-tropical, with a mean monthly temperature in the summer months of 70°—80° F., the mean maximum 80°—90° F., with a minimum 15° to 20° lower. The average rainfall in the Coast Districts for the sixteen years 1885—1900 has been 38·44 inches, the highest 71·27, and lowest 27·24, the great bulk of which falls between October and May, January and February being as a rule the wettest months. Thunderstorms are frequent. There is some but not very much marshy ground, mostly about the last few miles of the courses of rivers, which invariably terminate in a tidal lagoon, often sandlocked;

Chart showing weekly notifications of malaria, mean weekly temperatures recorded at Durban, weekly rainfall in district most affected, together with average of weekly rainfall recorded at three stations on the higher ground at the back of the district.



* An extraordinary storm : during 15 hours over 15 inches of rain fell in some parts.

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the river beds are much wider than is needed for the average flow, and intermittent streams, as would be expected in a broken country, are general. There is only one town on the coast line of two hundred and fifty miles, namely Durban, with a population of upwards of sixty thousand, composed of Whites, Indians, and Natives of South Africa, of whom the first form nearly half the total. There is a considerable area of marshy ground on one side of Durban, and some parts are low lying and favour the formation of pools. The most important country industry is sugar-planting, and some tea is grown, for the cultivation of which Indians imported under indenture are employed; there are also several thousand Indians composed of coolies who have remained in the country after expiration of their term of indenture, and in lesser number, of traders and artificers.

Malarial fever has always been considered an important disease in Portuguese territory and the northern parts of Zululand. It occurs mostly on the coast, but also extends a considerable distance inland in districts bordering the large rivers. Variations in prevalence from year to year are recorded, as elsewhere; for instance Clemow states that in 1893 malaria was prevalent throughout the Transvaal, but that in 1894 very few cases were recorded. In 1904 nearly all the persons working at a colliery in northern Zululand suffered, in 1905 nearly all escaped. These records however are generally based on the incidence on Europeans, and take little account of the immense Native population. In 1905 malarial fever appears to have been exceptionally severe at Dar es Salaam in German East Africa, as recorded in a local paper. The previous history of Natal in respect of this disease lacks the clearness which is desirable for the purpose of determining the causation of the epidemic of 1905. This is partly due to the want of medical evidence regarding some parts of the country, and partly to a conflict of medical testimony, which is further deficient, in that it is but rarely that the blood has been microscopically examined for purposes of diagnosis. According to popular repute, malarial fever was common in the town of Durban in the sixties and early seventies, indeed we are informed that some old colonists say it was as bad in the "early days" as Delagoa Bay has been considered within recent years, though the conditions there have very much improved of late. As to this we have been unable to obtain professional evidence, but in a volume of personal experiences entitled *Incwadi Yami* Dr J. W. Matthews (then holding a public appointment at Verulam, a coast village less than twenty miles north of Durban) relates that in 1869 malarial fever or bilious remittent

was epidemic in the neighbourhood on the sugar estates. This followed a disastrous flood. In later years, Durban, the country to the south of it, and thirty miles to the north, were considered non-malarious by medical men with one or two exceptions. Where the disease was observed it occurred in persons who had been infected either in north Zululand or in other territories. From those who hold that these parts are not entirely free from malaria we learn that occasional cases, of what appeared to be malarial fever, have occurred during the last ten or twelve years in persons who could not have been infected elsewhere. These cases came to them for treatment. The diagnosis however was not confirmed by blood-examination. The Government Medical Officer of the District situated between Tongaat River (latitude 29° 33′ S.) and Tugela River (latitude 29° 14′ S.), who has held his appointment for over thirty years, assures us that malarial fever is and always has been indigenous in this region. He however states that since 1880 the cases have not been numerous, and the type has been mild. In respect of Zululand, the coast population consists almost entirely of aborigines, who do not to any extent seek medical advice. The Native Commissioner, whose experience of Natives is long and unique, informs us that north of the Umhlatusi River (latitude 28° 45′ S.) malarial fever prevails among them more or less all the year round: that they suffer to some extent in the summer in wet seasons, as far south as Matikulu River (latitude 29° S.): but that he is not aware of fever occurring further south. Within more recent years, several persons were treated for malaria in the Boer Refugee Camp a few miles from Durban, but we are unable to obtain any evidence which would enable previous infection elsewhere to be definitely excluded. In a midland district, one Government Medical Officer is of opinion that malaria occurs in a mild form among natives living along some of the river valleys. A number of cases of malaria are entered in the various hospital records, and since the disease was made notifiable in 1902 have also been notified. A good proportion of those treated in Durban have been sailors from ships in harbour. It may be taken that the majority of all cases notified have, within more or less recent times, been resident in, or visited territories in, parts of which malaria is known to be endemic. Thus Indian coolies and many Whites have admitted that they suffered from previous attacks elsewhere. It has therefore always been assumed that these persons were infected before arrival in Natal, but it is possible that this assumption may have been carried too far.

It has been suggested that the cases recorded in the sixties may, in

default of microscopical evidence, which was of course not at that time available, have been enteric fever. This possibility cannot be doubted, for in some parts where malaria is endemic, many cases of enteric have been classed with the former disease. Nevertheless any such argument necessarily cuts both ways, and is equally applicable to the numerous cases of miscellaneous febrile illness, which, as will be presently shown, have been entered on hospital records of late years.

It is now generally accepted that the diagnosis of malaria in individual cases where the classical signs of periodicity and ague are absent, cannot be satisfactorily made without an examination of the blood; this is particularly emphasised by Manson in *Tropical Diseases* in respect of pernicious fevers, because of the urgency of treatment; but apart from that it is equally applicable to relatively mild attacks such as may be frequently encountered. The diagnosis by clinical symptoms is certainly not always an easy matter. In the *Indian Medical Gazette*, February 1905, M. Watson of Selangor states that sixty per cent. of a series of cases of quartan malaria under his charge in the gaol, and therefore under fairly favourable conditions for observation, were clinically unrecognisable as such. This absence of any characteristic signs was found also in many very mild cases of benign tertian seen by us at the commencement of the epidemic, so much so, that some planters expressed surprise at the statement of the Medical Officers that malaria was assailing their employees. They stated that slight febrile illness of similar character occurred, to a greater or less extent, every year about January or February. Difficulties in diagnosis are naturally enhanced by the circumstances under which coloured persons are seen, especially when all conversation needs to be conducted through an interpreter, and the patient's own description is often the only basis on which it can rest. In such cases unless temperature records are accurately kept, in default of pronounced ague fits, the periodicity of an attack of short duration may readily be missed. In looking through the Annual Reports for past years of the different small hospitals maintained for the treatment of Indian immigrants, there were three points which particularly arrested our attention:—

(1) the large number of cases in some hospitals entered under headings of different febrile illnesses of no pronounced clinical characteristics, such as influenza, dengue fever, fever, febricula;

(2) the generally small number of entries under malaria, which was a little surprising in that among persons coming from various parts of India, a certain number of relapses might have been looked for;

(3) the difference in classification adopted in different hospitals, and in the same hospital in different years, generally concurring with a change in Medical Officers.

In a period of ten years, according to the record of one hospital, cases of malaria were treated every year, but of the other ailments mentioned none occurred excepting in one year, when the number of malaria cases was very small. In two hospitals malaria was never once entered, but in each hospital in one—but not the same—year 11 % of the cases were classed as fever or febricula. In one of these hospitals, in another year, just under 17 % of all cases were entered as febricula and dengue. In respect of fever and febricula, at any rate, it is admissible to say that the cause may have been malaria equally well with any other.

The hospitals above mentioned are managed under the orders of Medical Officers, by qualified "compounders," with coolies apportioned for hospital attendance. Temperature charts etc. are naturally not kept in most of these hospitals with the regularity and accuracy observed in modern institutions. In the Government Hospital in Durban, which is conducted in all respects in accordance with the best present day usage, it is most improbable that any but an occasional atypical case of malarial fever could be overlooked. It is not unreasonable in this instance to suppose, that although the disease occurred occasionally and sporadically on parts of the coast, there might be no malaria in the town itself.

It is not possible to say whether or no any of these cases were really malarial fever, or to pronounce definitely whether the country has been free as supposed, or whether the disease has been present all along though unsuspected. If the latter hypothesis be correct, the number of cases must have been relatively insignificant, the pathognomonic signs generally absent, and the type mild. The absence, or at any rate relative paucity, of cases of malarial fever in Natal for many years past, renders the epidemic of 1905 the more notable. Between the last week in January and the end of June 9106 new cases were notified, and 107 deaths registered as directly or indirectly due to malaria. Of these cases 4177, with 42 deaths, occurred in Durban. The racial distribution was as follows:—

	Cases notified	Deaths registered
White races	3234	21
Indians	5404	86
Natives	468	

In considering the incidence on populations living in the affected

districts, it is desirable to eliminate Natives, otherwise a false impression of relative racial immunity might be created; for two reasons:—

(1) the population can only be estimated by districts or counties, and whereas in the districts involved Europeans and Indians live mostly within a few miles of the coast line, and largely in or near the valleys, resident Natives have their kraals on the higher grounds and mostly on the top of knolls, where they are less exposed to attacks of *Anophelinae*. Native families moreover live apart, each in their own kraal, and do not congregate in villages;

(2) Natives working in towns are not prone to seek medical advice, and, not having their families with them, prefer if possible when ill to go home, and so they escape notification. The deaths among natives are fairly well registered, but the cause of death can rarely be determined.

In Europeans and Indians, the incidence of cases notified was reckoned as follows for the population of the districts in which malaria occurred:—

	Per 1000 Population	
	Cases	Deaths
Europeans	78	0·5
Indians	79	1·26[1]

Outside the Borough of Durban it was only possible to make blood examinations in a fraction of the cases. It is therefore possible that all cases notified were not really malarial, but considering the prevalence of the disease, and its typical character in a large proportion of the cases when the epidemic became well established, it is probable that the margin of error is not wide.

The first cases were notified in the last week of January in the town of Durban, but it was not until the beginning of March that notifications were received from the country districts. Further enquiry elicited the fact that an exceptional amount of minor febrile illness had occurred among plantation coolies, in January and February. Indeed when the occurrence was first reported to the Department of Public Health in the middle of February, and investigation was immediately instituted and blood films examined, the character of the illness in general was so mild, and the clinical symptoms so indefinite, that without blood examination

[1] The death-rate is probably much higher, because it is only the deaths of "Protected" Indians, entering under special conditions, which are systematically registered, and of 25 per cent. of the total Indians in the Colony, deaths are rarely registered.

a diagnosis of Malarial Fever would have been impossible. On blood examination the majority of these cases showed either malarial parasites (mostly benign tertian), or mononuclear leucocytosis (large mononuclear leucocytes over 16 %). Later, as the epidemic gathered force, the clinical symptoms increased in intensity, and severe tertian or quotidian agues became common.

Arranged according to notifications (see Chart, p. 462), the number of cases in February was small; the epidemic curve rose sharply early in March, and then with increasing rapidity to reach a fastigium at the end of April—920 cases being notified in the week ending April 29th. Beginning in the second week in May the number of cases rapidly diminished in this and the succeeding month.

The most southerly point from which notifications were received was Umzinto—latitude 29° 44′ S. The commencement of the epidemic, if the earlier cases of ephemeral fever are reckoned, was practically synchronous along the area of coast infected. The distribution of cases was at first patchy, and, although later the disease became fairly general, one district immediately south of Durban appeared throughout to enjoy a relative immunity.

The initial local outbreaks occurred mostly among persons resident along rivers, where the river-beds widen out in broader valleys. It was not until April that malaria crept as it were up the track of the smaller tributary streams. This was due no doubt to the heavy rainfall on the higher ground observed in February, which increased the area of water, and the number of sheltered pools in which *Anophelinae* subsequently bred. In many Indian villages nearly the whole population suffered at one time or another, and the death-roll grew to serious proportions. At the end of April and in May, four outbreaks were reported inland up river valleys as far as thirty miles from the coast. Three of these outbreaks were among Natives, who form almost the entire population in those parts. These outbreaks were traceable to men who had recently been at work near the coast, and had returned home ill. The people became alarmed, and reported that a fatal disease was attacking them. In two instances, the District Medical Officers sent in to the Department of Public Health blood films from persons whom they found actually suffering from fever. Malarial parasites were demonstrated in the films. As many as a score of deaths in one small area were attributed to malaria.

The type of fever has generally been benign tertian, but malignant, or sub-tertian, formed a substantial percentage. In the Government

Hospital, Durban, where over 600 cases were observed, the percentages of each type of infection were determined approximately as follows :—

	Malignant %	Tertian %
White races	20	80
Natives and Indians	8·5	91·5

The apparent racial difference may be due to the different sources of the original mosquito infection; persons infected in various parts of the world constantly arriving in the town of Durban.

In 100 cases of malaria in Indians in country places, we found malignant parasites in 14·4 per cent., the majority towards the end of the epidemic. In the remainder the benign tertian parasite was found. Since no microscopic examination was made in fatal cases the malignant tertian parasite may have been more common. The thin and oily nature of the blood of many Indian patients towards the end of the epidemic, especially in the sub-tertian cases, was very marked.

The causes of the epidemic cannot be determined with any precision for want of accurate data. Since the connection of the mosquito with the life cycle of the malarial parasite has been established, it is evident that the appearance of malaria in a country or region previously exempt from it, may be attributable (*a*) to the introduction of the requisite species of mosquito, not previously existent in the region, (*b*) to the introduction of the parasite in the persons of human beings infected elsewhere, or to both (*a*) and (*b*) together. The occurrence of an epidemic in a region where the disease is sporadic, though indigenous, would be in the main due to the presence of an increased number of suitable mosquitoes, and this again in general would be the result of increased facility for breeding, owing to a difference in the amount and character of the rainfall. Without reverting to the question of the possible existence of endemic malaria in Natal prior to 1905 (see p. 470) it is reasonable to suppose that a number of persons (12,000 or more) imported annually from various parts of India, would harbour malarial parasites capable of infecting suitable mosquitoes. Few cases of malarial relapse have however been recorded in Indians.

Granting that malaria was endemic prior to 1905 then it necessarily follows that suitable mosquitoes must likewise have existed in Natal. Christophers and Stephens[1] have brought forward evidence indicating

[1] *The Practical Study of Malaria.* London, 1904.

that all of the *Anophelinae* are not equally good hosts for malarial parasites and that some species may not act as hosts at all. They believe that the relative prevalence of the disease may depend on the species present in corresponding regions. The Natal epidemic may have been due to the introduction and successful establishment of an Anopheles more favourable to the sexual phase of the protozoon than those previously present. The epidemic may also have been due to a greater number of infected persons recently entering the country, thus increasing the chances of infection in the indigenous species of mosquitoes. The season may moreover have especially favoured the breeding and multiplication of these mosquitoes. Any or all of these hypothetical causes may have operated in this instance.

Mosquitoes found.

From the first, attention was directed to ascertaining what species of *Anophelinae* were principally active in transmitting the disease, but owing to limited time and opportunity and the difficulty in obtaining any material assistance in the collection of live mosquitoes, much less was done than was desired. The majority of those examined were captured by ourselves, and, seeing that all were taken in the daytime, our collection was very probably not representative. We confined our search to habitations in or near which cases of fever had recently occurred, and it is somewhat significant that of more than one hundred and fifty captured, all with two exceptions corresponded, in respect at least of palpal bandings, costal spots, and leg markings, viewed through a hand lens, with Theobald's description of *Pyretophorus costalis*. The exceptions were *Myzorhynchus*, of which the last two and a half hind tarsi were white. No sporozoites were found in the salivary glands of one of the latter examined.

Satisfactory dissection was made of ninety-one of the specimens of *P. costalis*. Eleven of these were brought to us from a house in Durban in which no cases had occurred, although in the vicinity several were reported, and in none of them were sporozoites found. Eighty specimens, for the most part filled with blood, were captured in habitations in the country wherein cases had recently occurred, or wherein persons were at the time lying sick, and sporozoites were demonstrated in thirteen, or 16·2 per cent. (see Plate XV). This cannot be regarded as the actual "sporozoite rate," because many of the insects were kept alive as long as possible after capture, under the most favourable conditions which we were able to devise (see further under *Sporozoites*, p. 482).

As to the part played by any other species of mosquito under natural conditions, we are unable to bring forward any evidence, and opportunity for feeding experiments was not found. The evidence certainly points to *Pyretophorus costalis* as the chief agent.

There is no clear evidence regarding the recent introduction of an increased number of infected persons from India into the country. It is worthy of note that it was found on enquiry that during the previous year a certain number of persons had been drawn from the Malabar Coast, which had not previously been the case. We have some reason to believe that the rate of malarial endemicity is higher on the Malabar Coast than it is in the parts from which the majority of such immigrants come. We have however no evidence that any such persons were infected, and practically no malaria has been reported in any since their arrival. The distribution of these immigrants was investigated, and it was found that in parts of the coast districts to which 72 per cent. of all persons, and 66 per cent. of the children were allotted, malarial fever in this year was severely epidemic and in some places almost pandemic. On the other hand in parts to which 28 and 34 per cent. respectively were assigned, very few cases were notified.

It may be that the opening of the railway line to the area of high endemicity in Zululand has caused a greater influx of Native infected persons to southern parts. For reasons previously stated, there is no reliable evidence as to sickness among Natives. Assuming that Natives from Zululand accounted for the occurrence of malaria in the town of Durban where the majority of such Natives would obtain work, this would not account for the outbreak in country districts where very few, if any, Natives from Zululand are employed. Any hypothesis to be entertained must be capable of accounting for a widespread epidemic commencing synchronously at many different centres separated by considerable distances. For this reason, any suggestion that Chinese immigrants destined for the Transvaal mines were in any way the cause can be immediately rejected. A few have suffered from recurrences of malarial fever after arrival, but the situation of their Depot, by its distance and isolation from any considerable population, precludes the possibility of these having been the origin of the epidemic in the town of Durban, even without considering for the moment more distant places.

With regard to the possibility of the recent introduction of *Pyretophorus costalis* or other *Anophelina* into Natal no judgment can be arrived at for the reason that our knowledge of the mosquitoes of this

country is very scanty. Systematic observations have only been made of recent years, and in certain limited areas, by Mr H. S. Power. It is however worthy of note, that in considering the origin of the epidemic in Mauritius in the late sixties, Giles concludes that the rapidity of extension precludes the supposition that it is attributable to the introduction of a new mosquito. It has been contended that a malaria-bearing Anopheles has been recently introduced into Natal from northern Zululand, where malaria among Natives is severe in parts, especially near the coast. It has been further stated that no *Anophelinae* existed in Durban, until after the railway had been carried north of the Umhlatusi River (latitude 28° 45′ S.). The observations made in this respect have, however, been neither numerous nor systematic, and although occasional search for larvae has not been successful, it may well be that the actual breeding places of the mosquitoes have been missed. We, for instance, have on more than one occasion failed to find larvae where fever was epidemic. The date of opening the railway for traffic from Umhlatusi River (latitude 28° 45′ S.) was July, 1902, but construction trains had been running for some time previous.

We are greatly indebted to Mr H. S. Power, a keen and painstaking observer, for the following information regarding the *Anophelinae* found :—

Year	District	Malaria	Genus and Species
1903	Zululand, 80 miles from rail	Endemic and severe	Pyretophorus cinereus. ,, pitchfordi. Myzorhynchus mauritianus. Cellia squamosa. Nyssorhynchus pretoriensis. ,, maculipalpis. Myzomyia rhodesiensis. ,, funesta.
December	Illovo, 45 miles from coast, 25 miles from rail. Altitude 2300 feet	Not recognised	Pyretophorus costalis.
1903—1904	Inanda, 6 miles from Durban on coast.	Not recognised	Pyretophorus costalis. ,, cinereus. ,, new species. Myzorhynchus mauritianus. ,, paludis Myzomyia funesta.

In nearly all these mosquitoes classification was confirmed by Theobald or Giles.

It is rather remarkable that in careful observations carried over several months, in a part of Zululand having a bad reputation among Natives for fever, the *Pyretophorus costalis* was not found. Anopheles were found many miles to the south of Durban by Mr Power in 1901, but were not classified, and specimens of these are not now available.

In the year 1905, careful and systematic search was made for mosquitoes, and the following *Anophelinae* were identified, captured as imagines, or bred from larvae :—

District	Malarial prevalence	Genus and Species
Coast	Epidemic	Pyretophorus cinereus. ,, costalis. Cellia squamosa. Myzorhynchus mauritianus.
Inland 30 miles; deep valley	2 per cent.; small village	Cellia squamosa. *Pyretophorus cinereus.
Inland 45 miles	Doubtful, probably among Natives	Pyretophorus costalis.
Pietermaritzburg, 45 miles from coast, 2200 feet elevation	Absent	*Pyretophorus cinereus. Nyssorhynchus pretoriensis. Myzorhynchus mauritianus.

* There was some considerable variation in the markings of different specimens, and it is possible that this includes another species. The differences are not yet fully worked out.

We are indebted to Mr C. Fuller, Government Entomologist, for time and trouble spent in examining mosquitoes, and to Mr H. S. Power for information as to the presence of *Pyretophorus cinereus* on the coast, where it was not found by us, and of *Pyretophorus costalis* in an inland district.

From the incomplete knowledge of Anophelinae of different parts of the country, no definite statement can be made, as to whether any particular species was previously present in the area of recognised endemicity, and absent from other areas. Attention may again however be drawn to the observations on *Pyretophorus costalis* as the apparent principal agent in the epidemic, and its absence from a severely affected area in Zululand. It is also worthy of note that this mosquito was found more than a year before cases began to be notified, in an inland district, to reach which from Zululand a change of trains at Durban and a journey by road of certainly not less than twenty-five miles is neces-

sary. In view of the fact that only *P. costalis* was found by us in houses, it seems very improbable that any other species has been the chief agent. It is probable that any new species introduced would become gradually established, at first in some one or two places, and, having become infected, it would at first make its influence felt locally, and not at once over a wide tract of country. The view that newly introduced Anopheles were the agents in this epidemic appears to us scarcely tenable.

If Anopheles were not introduced and there was no notable increase in the number of malarial subjects entering the district during the year 1904 to what was the epidemic in 1905 due? It appears to us that there is but one hypothesis, which, if tenable, would satisfactorily explain the matter; namely a very marked increase in the prevalence of one or more species of *Anophelinae* in the present year, with perhaps somewhat greater opportunity for their infection, by reason of the advent in recent months of somewhat larger numbers of persons harbouring the malarial parasites in latent form. It is worthy of mention that it has been a matter of common repute that "mosquitoes" have been unusually prevalent in the past summer.

In respect of other insects than mosquitoes, great variations in prevalence are observed from year to year, without any assignable cause. It cannot be claimed that meteorological conditions have been especially favourable for mosquito larvae in the past summer.

Observations on Anophelina.

From the beginning of April to the end of June mosquito larvae were collected from a small stream about 18 inches wide running through private grounds belonging to one of us and situated outside Pietermaritzburg. *Nyssorhynchus pretoriensis* predominated in April, but was not found after this month until the end of June, when it was again met with. *Pyretophorus cinereus* was found throughout the period mentioned, but larvae of *Myzorhynchus* were not found, although several imagines were captured at the end of May on the banks of the stream, one being caught in the house. Neither flood nor frost (lowest temperature 30° F.) appeared to greatly affect the number of larvae, although fewer were found in June than in the early part of May. The stream is not more than one hundred yards from the house, but though careful watch was kept, only about one dozen Anopheles were seen indoors, principally in May.

When a visit was made to an inland village to investigate a report of malaria—five cases had occurred—a few pupae and numerous larvae were collected from rock pools and the edges of the river. All the pupae, and 6—8 larvae which developed into imagines in the first ten days after collection, proved to be *Cellia squamosa.* Afterwards, *Pyretophorus cinereus* alone developed, the last hatching out on June 22nd. *Pyretophorus costalis* was not found here, though it may have been present earlier in the year.

Larvae were obtained from the following situations:

Genus and Species	
Pyretophorus costalis	Roadside puddles; cattle footmarks; edge of small marshes; shallow running streams of slow current.
Pyretophorus cinereus	Eddies; under overhanging banks of streams; residual pools.
Cellia squamosa	Residual pools.
Myzorhynchus mauritianus	Pools; dams; edges of small marshes.
Nyssorhynchus pretoriensis	Eddies; pools in streams, and under overhanging banks of faster running brooks; frequently with Pyretophorus cinereus.

Sporozoites.

At first we examined the mosquitoes as soon after capture as convenient, but in the first thirty so examined sporozoites were only found once. It was then decided to keep the captive mosquitoes as long as possible, and dissect such as died, or became very weakly, from day to day. Sporozoites were demonstrated in the salivary glands of 12 per cent. of those examined within the first seven days, and in 30 per cent. of those kept for a longer period[1].

[1] The most suitable diet appears to be sliced apple, with water available for drinking. Apple is preferable to banana, which is apt to entangle the legs. *Pyretophorus costalis* if left undisturbed in the dark thrives well enough in captivity, and feeds freely on human blood if opportunity is afforded; females in captivity occasionally deposited eggs in the drinking troughs, and the eggs hatched out in about forty hours at laboratory temperature in April. The food which suited the larvae best appeared to be dry lean meat, pulverised.

Table showing relative numbers of Pyretophorus costalis examined in which sporozoites were and were not found.

Number of days after capture before examination	Number examined	Sporozoites found	No Sporozoites found
2 and under	44	4	40
3	6	0	6
4	2	0	2
5	6	1	5
6	1	1	0
7	5	2	3
9	8	2	6
10	3	1	2
11	4	2	2
14	1	0	1
Total	80	13	67

This table only shows those which were captured in habitations in which malarial fever had recently occurred.

The method of displaying the salivary glands, attached to the head, by gentle traction on the nape of the neck while the thorax is held stationary, seems only to be satisfactory in mosquitoes just killed. If they have lain some little time, either dry, or in salt solution, the glands appear to become friable, and need to be expressed or dissected out from the thorax. The appearance of the glands when copiously infected differs considerably, even under the half-inch objective, from healthy glands, in that the former are less transparent and rather sticky. In making permanent stained preparations, the method described by Christophers and Stephens of drawing the coverslip along the slide, leaves the sporozoites rather widely scattered. We were able to obtain fuller fields for photographic purposes, by gently lifting the coverslip with a needle, and allowing the salt solution containing the gland tissue to accumulate in a big drop, and then dry. Leishman's stain, about nine days old, gave the best results.

Larvicidal Measures.

In the town of Durban, vigorous action was taken continuously from the end of February by the Medical Officer of Health, in the direction of clearing away vegetation, and the application of kerosene and other materials to all accessible pools, streams, and accumulations of water; but the weekly number of cases continued to increase till the end of April. It may be that *Anophelinae* were breeding in the less accessible parts of the larger swamp, but seeing that this is on the

outside of the town, it is difficult to understand why mosquitoes should travel from there to the centre, in which the natural breeding-places lent themselves well to the successful application of such measures. The water of the harbour abutting on the town contains probably too high a proportion of sea-water to serve as a breeding spot, and there are few rain-water tanks, the town having an abundant water supply. Possibly there were other breeding-places which were not detected, or the duration of life of the average imago is longer than is generally supposed. In the country districts, there were neither legal powers for enforcing necessary measures, nor any adequate staff to carry them out if there had been, and all that could be done was to issue leaflets of advice, and in some instances give more detailed recommendations to sugar planters and other employers of coloured labour. Partly from apathy, and partly from lack of intelligent appreciation of the necessity of attending to minutiae, little was effected, but from observation of the varied character of the water in which larvae were gathered, the prospects of success, where communities are small and water abundant, would not appear very hopeful. In some places the barracks and huts occupied by Indian labourers are undoubtedly much exposed to danger by reason of their proximity to water; in other places they are situated on rising ground, some four or five hundred yards from the nearest water. This of course is well within the flight of mosquitoes, and it would appear advisable to place habitations at a greater distance, but difficulties arise, in that it is repugnant to Indians to dwell, when they can avoid it, otherwise than near to a water supply. It can be readily understood that at the end of a day's work no man wishes to convey his water for domestic purposes from a distance of a mile or so. The provision of mosquito-proof dwellings for these people is clearly impracticable. Under these circumstances only the prophylactic use of quinine appears to give promise.

EXPLANATION OF PLATE XV.

PHOTOMICROGRAPHS.

No. 1. × about 500. Sporozoites free of gland.

No. 2. × about 1000. Sporozoites issuing from cells of salivary gland. In this specimen the protoplasm of the organism stained very faintly, in consequence of which only the chromatin nucleus is shown in the photograph.

Nos. 3 and 4. × about 1000. Sporozoites free of gland substance.

All specimens stained with Leishman's modification of Romanowsky stain.

Fig. 1.

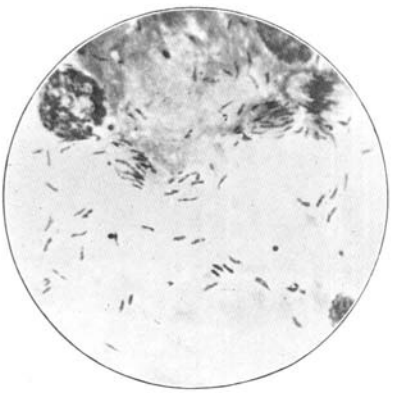

Fig. 2.

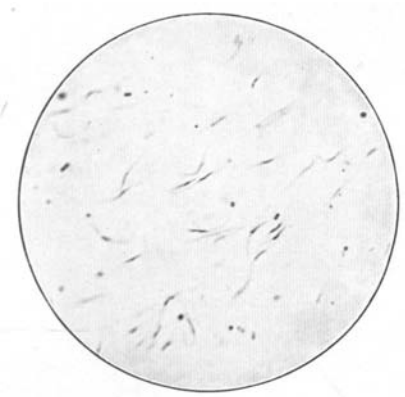

Fig. 3.

Fig. 4.

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