SPECIES-ERADICATION

The Eradication of Anopheles gambiæ from Upper Egypt 1942–1945

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Early in 1942, Egypt was threatened with two invasions—one from the west across the Libyan Desert, the other from the south from Wadi Halfa. The first invader was repulsed and thoroughly defeated at El Alamein. The second, *A. gambiæ*, was stopped at Asyût and eradicated by 19 February 1945.

A. gambiæ showed its devastating effect in Brazil in 1930, and a veteran malariologist, Dr. M. A. Barber [1] said of *A. gambiæ*, after a three-month survey of the infested region of Brazil in 1939,

> " There is no doubt that this invasion of *gambiæ* threatens the Americas with a catastrophe in comparison with which ordinary pestilence, conflagration or even war are but small and temporary calamities."

In this preliminary report, the important points in the history of *A. gambiæ* in Egypt are summarized and a description is given of the organization of the control measures taken in 1943, which

[1] BARBER, M.A. (1940) *Amer. J. trop. Med.* **20**, 249

resulted in its eradication in just over two years. It is to be hoped that this interesting chapter in the medical history of Egypt will not have to be rewritten.

Anopheles gambiæ is one of the most vicious vectors of malaria in the world. It is found everywhere in tropical Africa and in many of the adjacent areas. Periodically it extends into the temperate areas of South Africa, and wherever it goes there is malaria. The evil reputation of the Dark Continent as the white man's grave is in large part based on the exceptional activity of *A. gambiæ*.

Apart from its efficiency as a vector of malaria, there are two other things which characterize *A. gambiæ*. First, it is thoroughly domesticated and feeds with ease and luxury upon human beings in their dining-rooms and bedrooms; and secondly, it breeds in places not far from human habitations, preferably in shallow sunlit pools, free from vegetation. But it will also breed in other places when it is at its peak of abundance, and *gambiæ* have been repeatedly found in Egypt breeding in deep wells.

The same factors which make *A. gambiæ* such a dangerous vector of malaria—namely, its preference for breeding in shallow sunlit pools without vegetation and its tendency to rest and feed in human habitations, fortunately make it highly vulnerable to simple direct methods of attack which are not so successful against less dangerous anophelines. Paris green against the larval forms, and spray insecticides against the adults, together form an ideal combination for the eradication of *gambiæ*.

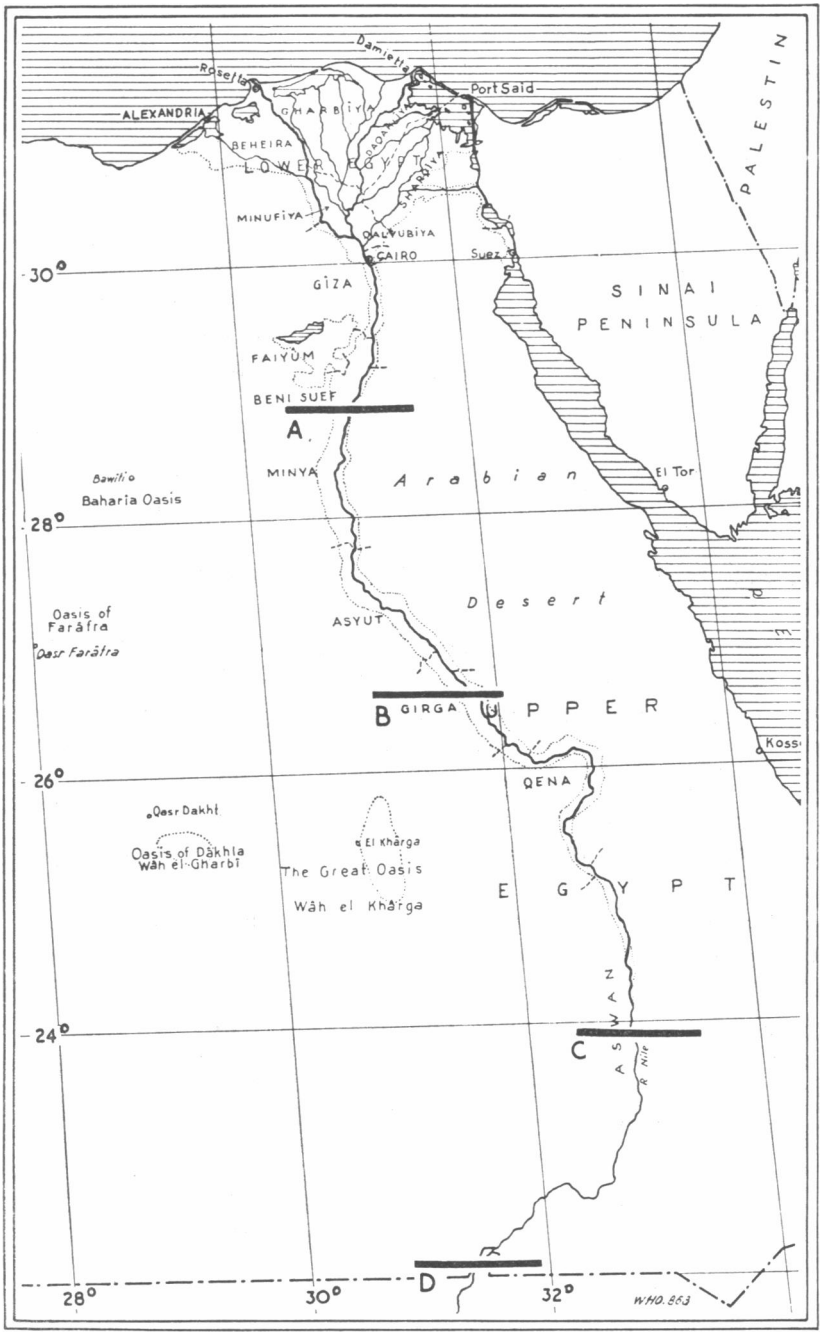
1. INTRODUCTION OF ANOPHELES GAMBIÆ INTO EGYPT

The possible introduction of *Anopheles gambiæ* into Egypt was foreseen by the Ministry of Public Health, and some measures were enforced to safeguard against such an event.

In a letter from the Fouad I Research Institute and Hospital for Tropical Diseases on 24 December 1938, to the President of the Quarantine Board Service, the following paragraph appears:

"With reference to your letter No. 4245 of 24 July 1938, I wish to draw your attention to the importance of examining not only mosquitos, but also flies and agricultural pests that may be introduced into Egypt through aeroplanes.

"This study is of great practical importance. In Brazil severe outbreaks of malaria, which occurred there lately have been attributed to the introduction of *Anopheles gambiæ* through aeroplanes.



The sections of the Nile Basin indicated by the letters A, B, C and D will be found in greater detail in fig. 2.

" Egypt is connected by airways with Palestine, Sudan and South Africa. This Ministry fears not only the introduction in Egypt of an infected yellow-fever mosquito, but also of *Anopheles elutus* from Palestine and *Anopheles funestus* and *Anopheles gambiæ* from the Sudan and South Africa. These species are notorious malaria carriers in their native countries and may cause severe epidemics of malaria if introduced in Egypt."

2. EFFECT OF THE INVASION OF GAMBIÆ

In March 1942, the Ministry of Public Health was informed of the occurrence of a severe epidemic disease in Abu Simbil and Ballana in the Lower Egyptian Nubia district adjacent to the Anglo-Egyptian Sudan. The medical entomologist of the Ministry of Public Health was sent on 30 April to inquire into the cause of this epidemic and to take immediate measures to control it. Arriving at Abu Simbil on 5 May 1942, he found the villages deserted and no human beings to be seen in the thoroughfares. All the inhabitants were ill and confined to their homes. They were suffering from severe headache, irregular intermittent fever, vomiting and diarrhœa. The spleen was slightly enlarged.

Two hundred thick-drop blood-films were taken and examined on the spot. All were positive for malignant malaria. Nineteen blood-specimens were sent for examination by Widal and Weil-Felix reactions, with negative results. Antimalarial drugs were distributed freely, and within a few days some of the inhabitants were able to go about in the villages. The villages were then divided into four sections and the drugs were distributed at four distributing centres.

The results of examination for malaria of blood taken from these villages are shown in table I.

Table I

Village	Population	Number of blood-films examined	Positive for *P. falciparum*	Percentage positive
Abu Simbil	3,481	972	842	86.6
Ballana	2,577	1,008	549	54.5
Qustul	855	412	334	81.1
Adindan	1,938	442	302	68.3
Total	8,851	2,834	2,027	71.5

The records of attendance of schoolchildren in the villages of this area were investigated and compared with the corresponding months of the previous year.

Table II

SCHOOL ATTENDANCE AT ABU SIMBIL, ADINDAN AND QUSTUL JANUARY-MAY, 1941 AND 1942

Month	Percentage of absentees			
	Abu Simbil school		Adindan and Qustul schools	
	1941	1942	1941	1942
January	1.5	1.3	6	5
February	3.5	12.0 [a]	2	8
March	6.5	16.0	4	12
April	2.1	40.0	7	37
May (till 19 May) .	4.2	100.0 [b]	5	37

[a] Measles outbreak
[b] School closed

From table II, it is evident that there was a marked rise in the number of absentees during March 1942, showing that the epidemic began during that month. An inquiry into the death-rate in these villages led to the results shown in table III. In Egypt, the normal average death-rate is 2.5 per thousand per month.

Table III

DEATH-RATE PER THOUSAND PER MONTH IN ABU SIMBIL AND BALLANA, JANUARY-MAY, 1941 AND 1942

Month	Abu Simbil		Ballana	
	1941	1942	1941	1942
January	3.1	3.4	1.9	1.5
February	2.3	1.4	1.1	1.9
March	1.7	13.1	1.9	1.1
April	1.1	18.3	1.1	4.9
May (till 19 May) .	2.0	34.1	2.3	9.1

It is evident from table III that during April there was an unusual rise in the number of deaths. This agrees with the conclusion, made from the number of absentees from the schools, that the epidemic started in March and affected the death-rate in April.

The economic loss due to this invasion in the estate of Kom-Ombo, which is about thirty thousand feddans of cultivated land situated 45 kilometres to the north of Aswan, was about £E.500,000 in 1943 and 1944, as shown in table IV. Such is the devastating effect of *A. gambiæ* whenever it invades a new territory.

When the epidemic which occurred in Southern Nubia in May 1942 was shown to be malaria transmitted by the new invader, *A. gambiæ*, the first thing that was done was to survey the Nile Valley from south to north to ascertain the scope of the problem. The medical entomologist of the Ministry of Public Health recorded the presence of *A. gambiæ* in Aswan in July 1942, at Daraw, Kom-Ombo and Idfu on 7, 8, 10 July respectively, at Luxor and Girga in August, and at Asyût in September. In November, an isolated focus was found in Manfalut, a town some 25 kilometres north of the city of Asyût. This was dealt with immediately, and in fact the species seems to have died out at Manfalut. The northward limit of *A. gambiæ* was therefore south of the city of Asyût in 1942, and thus Asyût became the " Alamein " of this campaign.

3. THE INVADED REGION

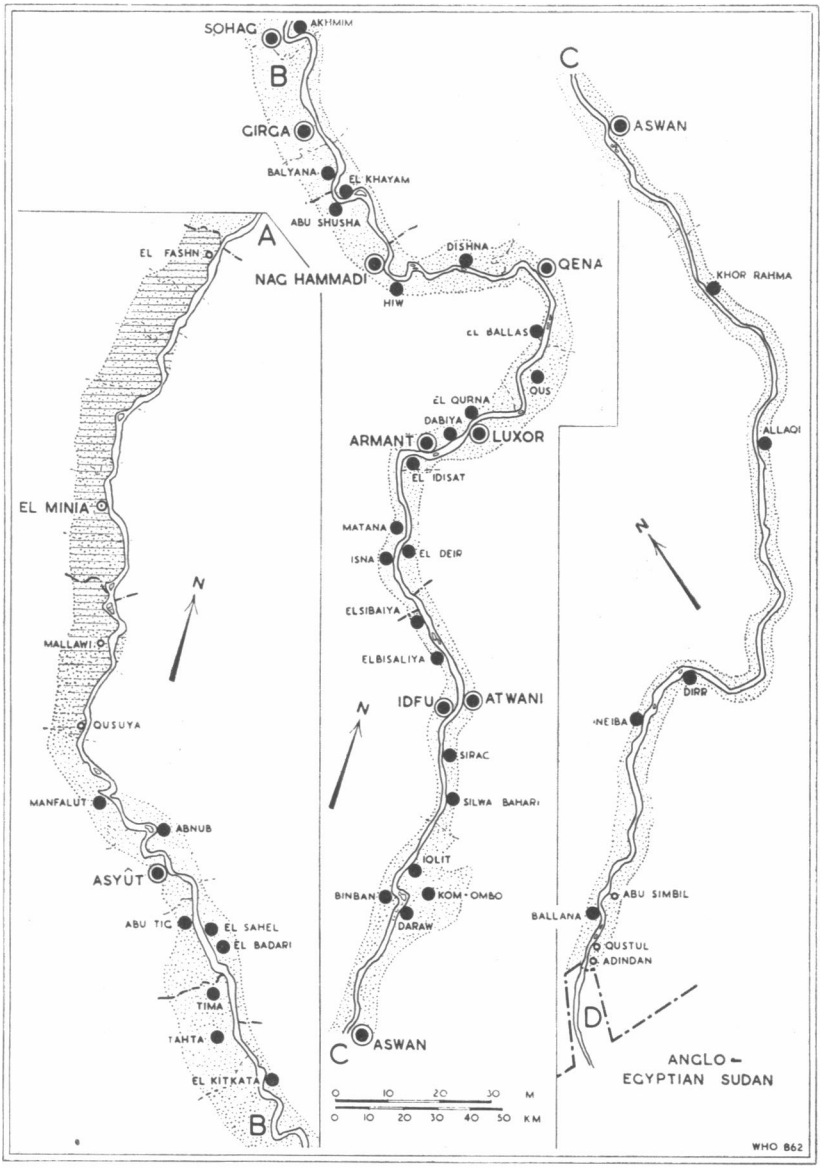
The region invaded extended from Ballana in the south to Asyût in the north, representing a narrow cultivated strip of land in the flood-plain of the Nile, with an area of 1,016,830 feddans or 4,270 square kilometres and a population of 3,000,000 people.

This represented a huge problem, especially because the Malaria Section was responsible both for the antimosquito measures and the treatment. Both control and treatment were gravely handicapped by lack of adequate automobile transport in 1942 and 1943, owing to the war. Paris green was not available, and reliance had to be placed on oil, with the serious transportation difficulties involved in the use of oil over a wide area. Antimalarial drugs, too, were scarce.

As is well known, crops are grown in Egypt only in land that can be irrigated. The flood-plain of the Nile in Upper Egypt is one of the flattest places in the world. While most of Egypt is now

FIG. 2

UPPER EGYPT SHOWING THE MANATEK (DIVISIONS) AND DAWAYER (POSTS) OF THE GAMBIÆ-ERADICATION SERVICE



◉ = Mantikah or division ● = Dairah or post

▨ = Barrier area where survey work only was carried out Active control measures were taken from Ballana in the south to Asyût in the north.

Table IV

LOSSES IN CROP-YIELD IN KOM-OMBO ESTATE DUE TO INVASION BY A. GAMBIÆ

Crop	Unit	Area cultivated 1943–1944 (in feddans) [a]	Mean annual yield per feddan		Decline of mean annual yield per feddan		Total decline of yield	Price per unit (£E.)	Total loss (£E.)
			Before *A. gambiæ* invasion 1937–1942	During *A. gambiæ* invasion 1943–1944	Units	Percentage			
Sugar cane	Kentar [b]	16,326	863	643	220	25	3,591,720	0.087	312,479
Wheat	Kadah [c]	17,288	494	291	203	41	3,509,464	0.039	136,860
Beans.	Kadah	.	455	229	226	50	.	.	.
Barley	Kadah	5,460	428	242	186	43	1,015,560	0.029	29,451

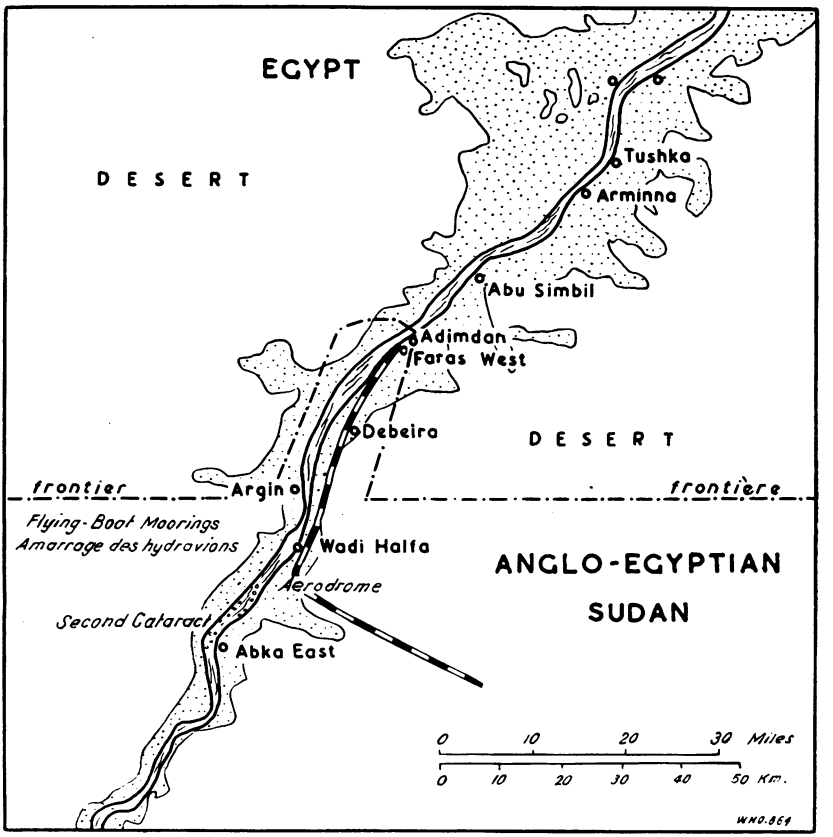
[a] 1 feddan = 1.038 acres, or 4.200 square metres
[b] 1 kentar = 44.52 kg.
1 kadah = 1.562 kg.

under what is called perennial irrigation, a sizeable part of Upper Egypt is still under basin irrigation, the method which has been used from time immemorial.

Looked at from the viewpoint of breeding places for *A. gambiæ*, Upper Egypt can be divided into three areas. These are : areas under perennial irrigation ; areas under basin irrigation, and the shore of the Nile itself.

In the areas of perennial irrigation, there is an abundance of breeding places at all seasons, and were it not for the low winter-temperatures, *gambiæ* could flourish all the year round. But in areas of basin irrigation there is very little water during most of the year. With the filling of the basins—to a depth of one to two metres—the conditions change completely, and there are unbroken sheets

FIG. 3
BOUNDARIES OF EGYPT AND THE ANGLO-EGYPTIAN SUDAN



of water all across the valley. The water remains in the basins for several weeks, and most of its surface is subject to wave action.

The net result of all these factors is that during most of the year there are relatively few breeding places for *gambiæ* in areas of basin irrigation. However, there are enough to produce a quantity of *gambiæ* sufficient to cause very serious epidemics of malaria.

There is, moreover, always the shore of the Nile. This is particularly dangerous during the weeks in which the flood of the Nile is receding, and the ground-water is seeping back into the river all along its course. But of greatest importance in respect of the Nile are the khors, or high-water channels. These have shelving bottoms, usually of sand, and they occur in such form as to produce shallow sunlit pools, regardless of the level of the river. Furthermore, there is often a village at the entrance to a khor—for the khors provide good anchorages for the river-boats. These two factors provide conditions which are very useful to *gambiæ* in the winter months when temperatures are distinctly unfavourable to the species. Shallow sunlit pools, near human habitations, form a combination which *gambiæ* prefers.

The rainfall in Upper Egypt is so small, and the rains occur so infrequently, that, in marked contrast with most other places in the world, rainfall can be almost completely disregarded in a consideration of the malariology of Upper Egypt.

However, even without rain, there are marked seasonal changes in relative humidity. In the autumn months, the prevailing north winds carry moisture-laden air far inland from the Mediterranean, and as the temperature drops the relative humidity increases rapidly.

The rise and fall of the Nile constitute the last of the factors of major importance in the malariology of Upper Egypt. Below Aswan Dam the river is at its lowest in April and May, and in flood from August to November.

The climate of Upper Egypt from Aswan to Asyût is not quite favourable for *gambiæ* during most of the year, but almost ideal for it during a few months in the autumn. From January to March, the weather, especially at night, is so cold, with mean minimum temperatures of 6° to 10° C., that the species is just able to survive.

Then in April to August, the temperature rises rapidly, but the relative humidity drops. As the mean monthly temperature increases to about 29° to 33° C., the relative humidity falls to 37% at Asyût and 27% at Aswan. In the absence of control measures, *gambiæ*

increases appreciably in abundance during these months, but possibly the average life of the adults is too short to cause much malaria.

September, October and November are the months which are almost ideal for *gambiæ*. The relative humidity increases to more than 60% at Asyût and the temperature to a range that is more favourable for *gambiæ*. By December, the temperatures are low enough to decrease breeding very appreciably. Much malaria has been observed in December, but this must be attributed to the " momentum " which the species had attained in the preceding months.

Thus, there are only three months during which *gambiæ* proliferates abundantly in Upper Egypt, while there are nine months during which it has a more or less difficult time, three months being especially difficult.

The weather in Cairo and the Delta is such that *gambiæ* could proliferate there during the summer and autumn just as well as in Upper Egypt. The Delta is slightly colder than the region around Asyût in winter, and there is no doubt that *gambiæ* would have reached Giza and Lower Egypt during the summer and autumn. It is certain that low temperature in winter cannot stop the spread of the species during summer, as is evident from the fact that *gambiæ* survived three winters at Asyût. The only thing that can stop the spread of *gambiæ* is active and widespread control measures during summer and autumn.

4. INCIDENCE OF MALARIA DURING THE EPIDEMIC, AND ORGANIZATION OF THE THERAPEUTIC SERVICE

Malaria was designated a notifiable infectious disease on 24 April 1930, by a Ministerial arrêté. Since that date, all primary cases of malaria were notified to the public-health offices, and the figures collected were published in the periodical returns. Before 1936, the control and treatment of malaria was the responsibility of the Epidemic Diseases Section of the Ministry of Public Health. In 1936, a separate Malaria Section was established. When the devastating epidemic of malaria caused by *A. gambiæ* broke out in Upper Egypt, the Malaria Section had only 19 malaria stations scattered over Lower Egypt, in the rice-cultivated areas, the Canal zone and Faiyûm. Upper Egypt had not been a malarious place, and no malaria stations were established there.

During the difficult days of 1942 and 1943, everything that was needed to control the epidemic of malaria caused by *A. gambiæ* was scarce. Antimalarial drugs, transport, and Paris green were difficult to secure owing to the war.

Notification of malaria cases was incomplete in 1942 and in 1943. In 1944, a special therapeutic service was established which was responsible for the treatment of the sick and the registration of all primary and relapse cases. Notification was greatly improved.

The organization of the therapeutic service was as follows :

The *gambiæ*-infested area was divided into 16 therapeutic divisions, with a chief malaria inspector at the head of each division. These divisions were further subdivided into 62 treatment dawayer or posts, with a treating doctor as the head of each dairah or post. The dairah was further subdivided into treatment zones.

The personnel of the therapeutic service at the end of 1944 included 80 doctors, 117 morakebin or chief inspectors, and 856 inspectors. The headquarters of the therapeutic service was at Luxor.

During the difficult year of 1942, it was found that the number of cases and deaths notified to the public-health offices did not agree with the severity of the epidemic. An estimated incidence of malaria deaths was calculated on the basis of attributing the increased number of deaths in 1942 over 1941 as due to malaria in the infected area. The fatality-rate of malaria was estimated as 10% of the cases in that year.

In 1943, there was a better detection of early cases and a more liberal distribution of drugs, which had an effect in reducing the fatality-rate in 1943 to 5%.

In 1944, the therapeutic service was established. Notification was complete, and both new cases and relapses were notified.

Table V gives the notified and estimated malaria cases and deaths during 1942 and 1943 in the infested region—namely, Aswan, Qena, Girga and Asyût Provinces ; table VI, the primary and relapse cases and deaths during 1944-1946.

Table V

MALARIA CASES AND DEATHS AS NOTIFIED AND AS ESTIMATED, 1942-1943

Year	Cases		Deaths	
	Notified	Estimated	Notified	Estimated
1942	10,193	63,000	320	6,300
1943	9,430	76,000	1,221	3,800

Table VI

PRIMARY CASES, RELAPSES AND DEATHS FROM MALARIA, 1944-1946

Year	Cases		Deaths	
	Primary	Relapses	From primary cases	From relapses
1944	32,823	733,906	1,789	—
1945	28	138,150	7	18
1946	59	2,254	4	2

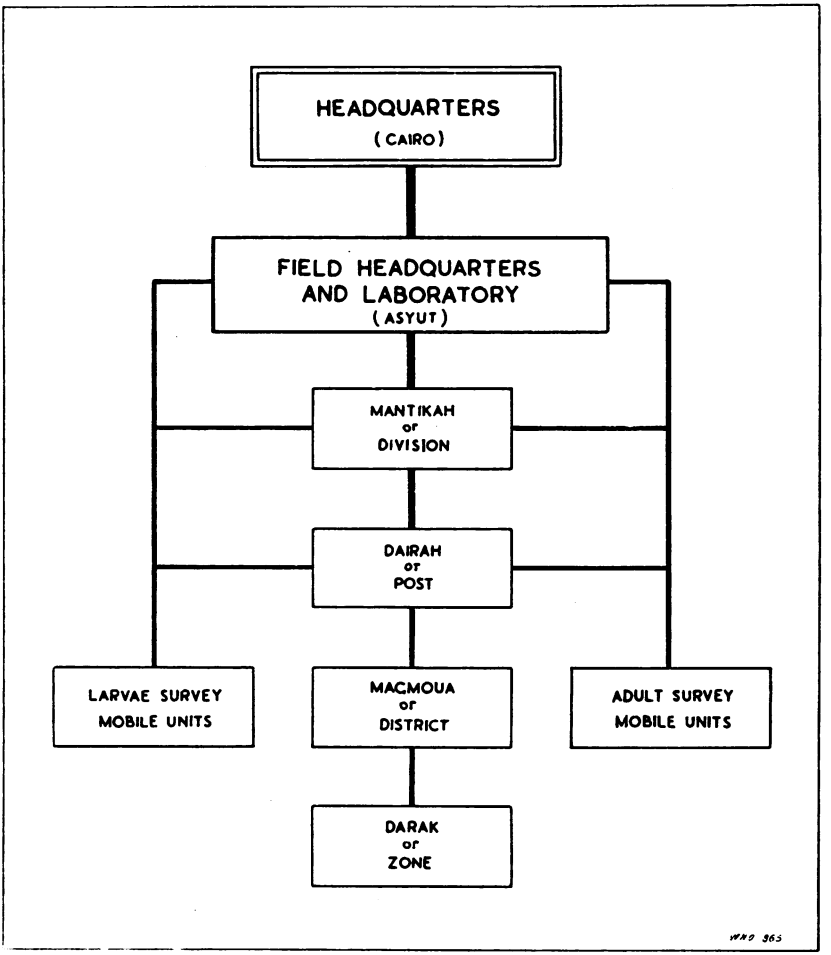
5. ORGANIZATION OF THE GAMBIÆ-ERADICATION SERVICE

The basic tenet of any mosquito-eradication service is to treat all potential breeding places as if they were actual breeding places. Operations had to follow a weekly cycle. There are many potential breeding places for *gambiæ* in Upper Egypt, but there is much available manpower. The method consists of dividing up the whole area into darakat or zones, the darak being the area which one man can cover in a week. The man must first be trained, and arrangements must be made for supervising and checking his work. This is an administrative task—large, to be sure, but not at all impossible.

The larvicide of choice in this work is Paris green, diluted one part in one hundred with whatever unsifted dust or sand is available

FIG. 4

ORGANIZATION OF THE GAMBIÆ-ERADICATION SERVICE



The unit in the organization is the darak or zone. The Gambiæ-Eradication Service comprised at its maximum 10 manatek (divisions), 44 dawayer (posts) and 641 darakat (zones), in which active control measures were taken. In addition, there were 4 other posts forming a barrier area in which mainly survey work was carried out (see fig. 2). Active control measures were taken in this area with a view to eradicating *A. pharoensis*, but by the end of September 1945 the idea was dropped.

Meticulous care was taken to study in detail the work of the Paris-green mulahezin and check the work done by each mulahez. Particular attention was paid to the following points:

1. The boundaries of each darak were defined.
2. Each mulahez was supplied with two flags, one to put in the place where he was actually working so as to enable the person checking his work to find him easily, the other to be placed on the main road where he left work on

near the breeding place. Its use obviates the enormous transportation problem involved when oil is used as the larvicide. While Paris green may not be quite as efficient as oil, when the latter is used under ideal conditions, there is no doubt that the net efficiency of Paris green under field-conditions is very much higher than that of oil.

The whole infested region was divided up into 641 serially-numbered darakat or zones, using the excellent maps which exist for all the cultivated portions of Egypt. In July 1944, the boundaries of these darakat were " frozen ", and the darak was used as the unit of place in all subsequent reporting. To provide the necessary leeway for the varying number of breeding places at different times of year, the field-workers were authorized to split any darak into as many parts as necessary, in order to enable one man to cover all of it each week.

Each darak, or sub-darak, is the responsibility of one man, assisted by one labourer. The man in charge of the darak is known as a mulahez, or overseer.

Every five darakat are grouped into a magmoua, or district, with a morakeb, or foreman in charge. A variable number of magmouat make up one dairah, or post, with a doctor or engineer in charge, and a variable number of dawayer, or posts, are grouped together to form a mantikah, or division, with an experienced malaria doctor in charge. The Gambiæ-Eradication Service had in 1945 to occupy 10 divisions and 40 posts, covering the whole area from Asyût to the southern boundary of Egypt.

In this way, there is a clear channel for the delegation of responsibility, and for the transmission of reports. All communications from headquarters go to the mantikah officers for transmission on down the line, and reports are forwarded from the mulahez to the morakeb, to the dairah, to the mantikah, to headquarters (see fig. 4). With the excellent mail service in Egypt, this system worked very well.

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the field. A small pocket was provided in this latter flag and the mulahez was instructed to slip into it a detailed itinerary of his work (see fig. 20).

3. Each mulahez was provided with forms on which to enter the amount of work done.
4. Checking and counter-checking of the work of the mulahez was carried out by the morakeb or chief inspector of the magmoua (district) and by the larval and adult survey unit of the dairah, mantikah and field headquarters.

Table VII

MANATEK (DIVISIONS) AND DAWAYER (POSTS) IN UPPER EGYPT

Mantikah (Division)	Dairah (Post)	Area (in feddans)			Area (in square kilometres)
		Perennial irrigation	Basin irrigation	Total	
	Ballana	2,200	—	2,200	9.2
	Ineiba	2,400	—	2,400	10.1
	El Dirr	600	—	600	2.5
	El Allaqi	1,880	—	1,880	7.9
Aswan	Khor Rahma	—	—	—	—
	Aswan	1,500	10,000	11,500	48.3
	Daraw	5,400	1,000	6,400	26.9
	Binban	4,600	500	5,100	21.4
	Iqlit	2,500	500	3,000	12.6
	Kom-Ombo	35,000	500	35,500	149.1
	Silwa	3,000	1,500	4,500	18.9
Atwani	Sirag	4,000	1,000	5,000	21.0
	Atwani	3,800	1,000	4,800	20.2
	Idfu	22,000	—	22,000	92.4
Idfu	El Bisaliya	9,000	—	9,000	37.8
	El Sibaiya	6,000	4,700	10,700	44.9
	Isna	—	17,000	17,000	71.4
	El Deir	—	4,000	4,000	16.8
	Matana	13,000	9,000	22,000	92.4
Armant	Armant El Wabourat	9,000	3,000	12,000	50.4
	Armant El Heit	4,000	4,000	8,000	33.6
	Dabiya	4,000	3,500	7,500	31.5
	El Qurna	—	10,000	10,000	42.0
Luxor	El Idisat	—	9,750	9,750	41.0
	Luxor	—	30,000	30,000	126.0
	Qus	—	41,000	41,000	172.2
Qena	El Ballas	—	33,000	33,000	138.6
	Qena	3,000	43,000	46,000	193.2
	Dishna	—	43,500	43,500	182.7
	Hiw	7,400	24,000	31,400	131.9
Nag	Nag Hammadi	38,000	—	38,000	159.6
Hammadi	Abu Shusha	25,000	—	25,000	105.0
	El Khayam	35,000	—	35,000	147.0
Girga	Balyana	34,000	—	34,000	142.8
	Girga	80,000	—	80,000	336.0
	Sohag	5,000	70,000	75,000	315.0
	Akhmim	17,000	—	17,000	71.4
Sohag	El Kitkata	18,000	—	18,000	75.6
	Tahta	—	45,000	45,000	189.0
	Tima	—	42,000	42,000	176.4
	El Badari	19,600	—	19,600	82.3
Asyût	Sahel Selim	13,500	—	13,500	56.7
	Abu Tig	—	79,000	79,000	331.8
	Asyût	—	56,000	56,000	235.2
10	44	429,380	587,450	1,016,830	4,270.7

The next important measure is that the mulahez dusts all potential breeding places with Paris green, but does not search for larvæ. He is not allowed to carry any equipment for dipping ; his sole job is to dust Paris green on all potential breeding places following a written itinerary.

His foreman, the morakeb, spends his time dipping for larvæ, and observing the way the mulahez works, correcting any faults which he finds. The morakeb does not apply Paris green. If he finds anophelines, he brings the mulahez of the darak back to the place and shows him the larvæ, and makes him dust the breeding place.

Both the mulahez and the morakeb are provided with forms on which to record, in full detail, all the work which they do. This enables their work to be checked at any time, and from these sheets, weekly summaries of the work are made quickly and easily, because each man summarizes his own work before he passes his report on to his immediate superior. These forms must be as simple as possible in view of the nature of the work which is to be done. Human nature being what it is, the trick is to design the forms in such a way that it will be easier for a man to be honest than dishonest.

The amount of dusting which is done is recorded in linear or square metres. This is convenient in assessing at the end of each week the total amount of work done by the whole service.

In recording the amount of searching which is done for larvæ, a different unit is used. Each five linear or square metres of breeding place, except in wells and other similar places, is recorded as one unit. By this system, a single larva found along one five-metre stretch of canal bank counts the same as 1,000 larvæ in the same length, but as the goal is eradication and not mere control, a place is not clean if there is even one *gambiæ* larva in it.

The results of the larvicide work must be checked still further. This is done in two ways, by two separate groups of men, known as kashshafin, or scouts. Each dairah chief (doctor or engineer in charge of a post) has a group of larva kashshafin directly under him. The number is usually six, which is about all that can be taken to the field by the doctor himself in his car each morning, and picked up again in the afternoon. These men search for larvæ, and have no responsibilities for larvicidal work. They provide an independent check on the work of the other men in the dairah.

Because *gambiæ* is a house-frequenting species there is another group of checkers. These are called imago kashshafin ; they spend their whole time searching for adult mosquitos. They, too, report directly to the chief of the dairah. Each kashshaf has one labourer to help him. Pyrethrum insecticide is used to facilitate the capture of such anophelines as may be present. But the purpose of the insecticide is not to kill the anophelines which may be resting in the house ; it is merely to facilitate their capture.

Other mobile survey-teams operate from the field headquarters of the service, and are responsible to the field director of the service. These mobile survey-teams have men who search for larvæ, and others who search for adults.

Such then, is the organization which has been developed for the killing of the larvæ of *A. gambiæ* and for checking the work. At the end of August 1945, there were 612 kashshafin engaged in checking the work of the 1,000 Paris-green mulahezin.

Mention should be made of the status of systematic weekly disinsectization of houses for the control of *gambiæ* in Egypt. When an anopheline is in the habit of resting inside human habitations as does *gambiæ*, it can be attacked very effectively in its adult stage, with pyrethrum, as well as in its larval stages.

For the control of malaria, in contradistinction to the control of anophelines, the method of choice depends upon the relative abundance of breeding places, and of human habitations ; or, to provide a common denominator, it depends upon which requires the lesser number of man-hours : either weekly disinsectization of houses, or weekly application of larvicide to the breeding places of anophelines within flight-range. When the population is sparse and the breeding places abundant, house disinsectization is obviously the method of choice. But that is not the situation in Egypt. Breeding places are very numerous, but so are houses, because of the very dense rural population.

Pyrethrum being in very short supply, and the quantities needed being vast, house disinsectization has not been used as a routine measure in Upper Egypt. However, it was held in reserve in case an epidemic of malaria did occur, because of the failure of the Paris-green work to control *gambiæ*. This occurred in El Badari, with a population of about 100,000 people. Weekly disinsectization of all the 18,000 houses in the area was organized. It took seven weeks to

complete this organization, and, with the equipment which was available, small hand-atomizers, it required appreciably more man-hours of work to " flit " all the houses once each week than it did to dust all the potential breeding places once each week.

All of the foregoing is based on pyrethrum insecticide ; if DDT had been available, then the situation would have been very different.

Mention may be made of the measures which were taken to prevent the spread of *gambiæ* from the infested area to the uninfested area to the north. These were simply the routine disinsectization of all vehicles leaving the infested area for the non-infested one. The vehicles in question were : trains, automobiles, boats and aeroplanes. Trains and automobiles were " flitted " at Asyût, the northern limit of the infested area, but boats were treated when they passed through the locks of the Aswan Dam and of each of the three barrages between Aswan and Asyût. Planes were " flitted " at the airport in Asyût. While *gambiæ* was abundant, the trains were " flitted " four times between Aswan and Cairo, and automobiles once after leaving Asyût.

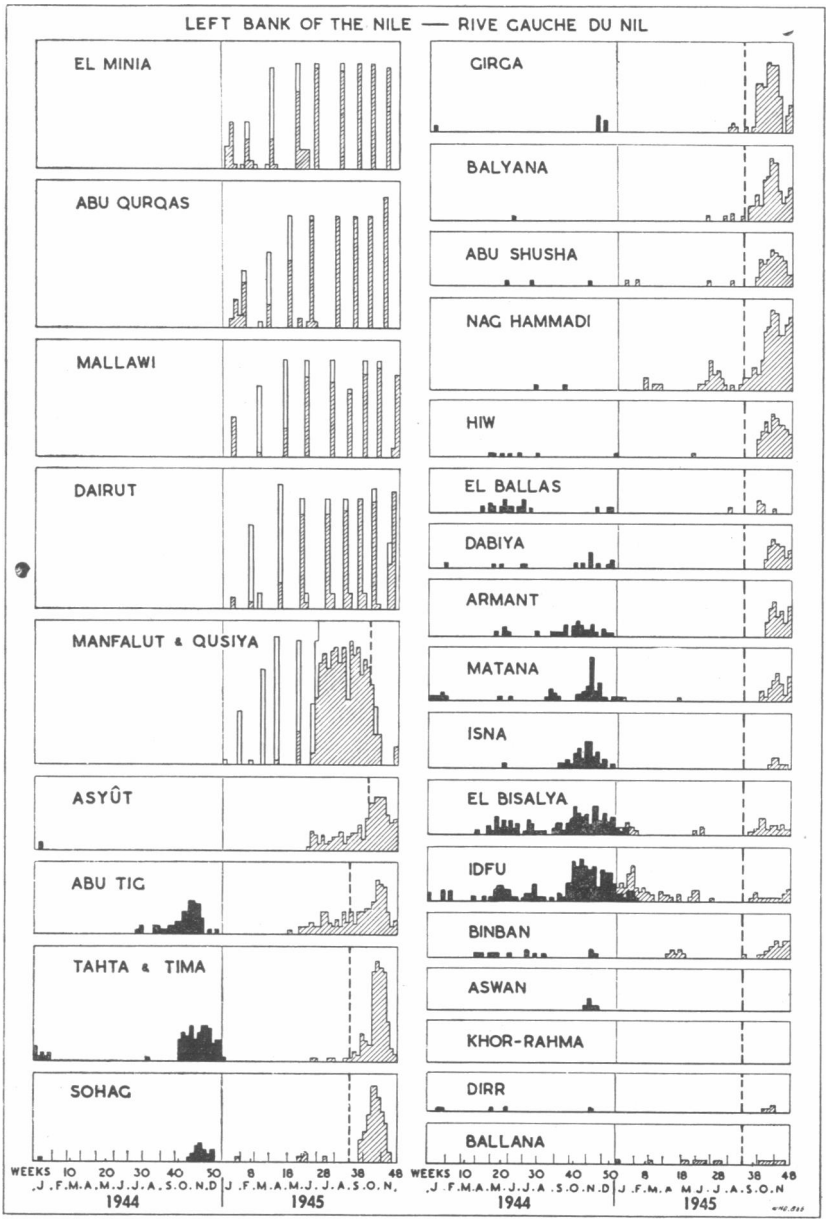
A small amount of DDT was available, and it has been used to spray-paint the interior of the passenger wagons used on the line of the Egyptian State Railways in Upper Egypt. The residue of DDT which remains in the walls and ceilings of the wagons may be expected to act on any mosquitos which chance to enter the coaches at any place along the journey, while the effect of the pyrethrum insecticide could, at best, have been only temporary.

Known Prevalence of Anopheles gambiæ by Months

It may be remembered that the unit of place is the darak, and that there are 641 darakat in the infested portion of Upper Egypt. The number of positive darakat depends a good deal upon the amount of search which is done. It makes an important difference whether 50 or 200 men are spending their time searching for larvæ. Nevertheless, the figures on record in table VIII give an indication of the prevalence of *Anopheles gambiæ* in 1943, 1944 and 1945. But it should be understood that the figures in 1945 give a more precise picture of the situation, as more men were set to search for the larvæ.

FIG. 5

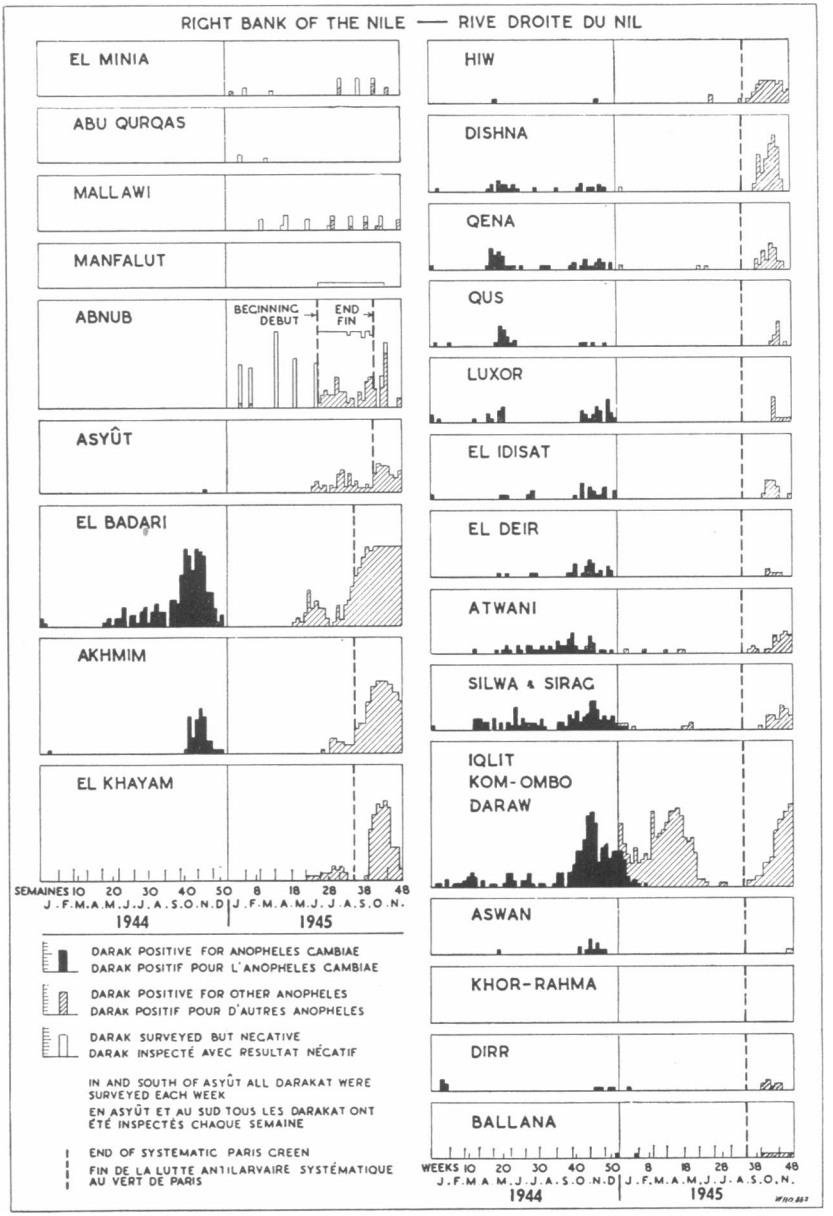
DISTRIBUTION OF A. GAMBIÆ AND OF OTHER SPECIES OF ANOPHELES IN THE DARAKAT OF UPPER EGYPT, 1944-1945*



* For a fuller explanation of this figure, see p. 346.

FIG. 5

DISTRIBUTION OF A. GAMBIÆ AND OF OTHER SPECIES OF ANOPHELES IN THE DARAKAT OF UPPER EGYPT, 1944-1945*



* For a fuller explanation of this figure, see p. 346.

Table VIII

MONTHLY NUMBER OF DARAKAT (ZONES) POSITIVE FOR GAMBIÆ

(Total number of darakat : 641)

Month	1943	1944	1945
January . . .	—	42	37
February. . . .	—	8	3
March	14	13	0
April	27	23	0
May	67	79	0
June	60	49	0
July	46	49	0
August	35	34	0
September . .	44	60	0
October	90	177	0
November . . .	142	242	0
December . . .	111	141	0

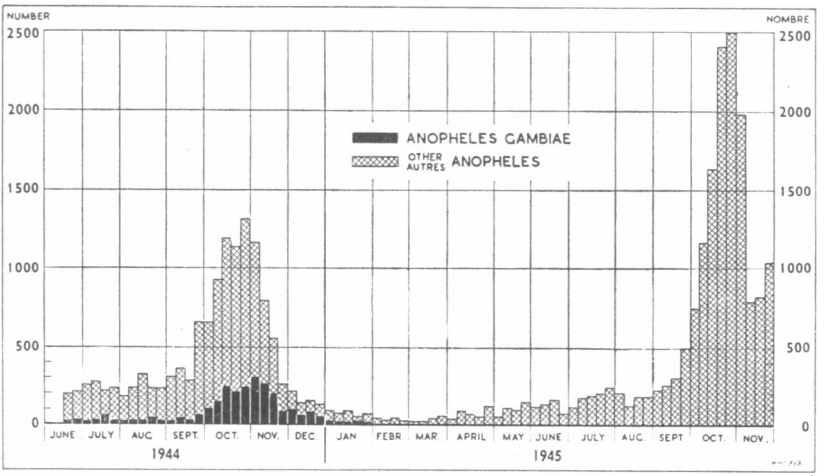
The low figures in February, March and April 1944 result from a combination of unfavourable temperature and a small amount of search. The increase to 79 in May is a result of increased search and hotter weather ; but the drop to 34 in August is due to energetic work, with oil, particularly in the Province of Qena. The rapid rise from 34 in August to 242 in November is a direct result of the inadequacy of the Paris-green work which was done during the period of the year when the climate was most favourable for *gambiæ*.

Only about 40% of the total of 641 darakat were positive for *gambiæ* at the peak in November, and in many of the positive darakat there were very few *gambiæ*. The indices used are qualitative rather than quantitative, and they are expressly designed for the use of an eradication service, where one *gambiæ* is almost as important as 1,000. There was transmission of malaria in many darakat, but the amount of malaria was not sufficient to interfere with the normal economy of the region as it had in many places in each of the previous two years.

The change from oil to Paris green as larvicide was made in August and September. It takes time for the men to learn how to use Paris green and for the supervisors to learn how to train their workmen and check their work.

FIG. 6

NUMBER OF ANOPHELINE LARVÆ IDENTIFIED MICROSCOPICALLY AT THE GAMBIÆ-ERADICATION SERVICE LABORATORY JUNE 1944-NOVEMBER 1945 (in weeks)



Note the complete absence of *gambiæ* larvæ after January 1945, despite the very great increase in the other species of anopheles later in 1945.

Returning to the 1945 figures, the large drop to 37 in January is the result of the unfavourable weather, plus the lethal effect of about 15 tons [2] of Paris green a month. Even when not applied with full efficiency, this amount of Paris green has a cumulative effect which is decidedly discouraging to any anopheles. The further drop to three in February was expected.

Anopheles gambiæ was last found on 19 February 1945. Nevertheless, intensive dusting with Paris green was continued for another six months, or until the end of August. During this period, from 10 to 15 million metres of breeding places were dusted with Paris green, about 250,000 units of breeding places were surveyed for larvæ and about 60,000 houses were searched for adult anophelines, each week, with negative results.

At the end of August, all control measures were stopped in order to allow the mosquito to multiply unhampered—if it were still present—during the time of the year which is exceedingly favourable to it.

[2] ton = 1,016 kg.

Table

MONTHLY SUMMARY OF THE WORK OF THE

Month	Number of darakat positive for *A. gambiæ* [a]	Insecticides used				Eradication work		
		Paris green (tons)	Malariol (tons)	Pyrethrum extract (litres)	DDT solution (litres)	Units [b] dusted with Paris green	Houses sprayed with pyrethrum extract	Transport disinsectized
1944								
July	49	small quantities	326	1,669	—	No records	—	19,480
August . . .	34	4.0	139	1,664	—	» »	—	21,707
September. .	60	7.2	81	1,245	—	» »	—	19,424
October. . .	177	14.8	47	5,823	—	» »	12,614	20,569
November. .	242	15.0	67	17,100	—	» »	78,236	22,750
December. .	141	14.3	31	14,991	615	» »	80,807	16,929
1945 [d]								
January. . .	37	12.0	5	6,021	619	26,961,852 [e]	21,750	18,143
February . .	3	10.6	1	3,293	443	14,523,516 [e]	—	11,251
March . . .	0	9.4	1	9,529	—	26,688,858 [e]	—	11,846
April	0	8.9	0	11,433	1,644	53,396,864	—	13,693
May	0	9.2	0	9,571	779	44,558,271	—	12,241
June	0	10.0	0	10,285	—	57,572,134	—	8,112
July	0	11.1	0	10,475	201	78,155,192	—	10,037
August . . .	0	8.4	0	10,755	—	60,297,490	—	7,715
September. .	0	1.7	0	12,798	302	7,600,204	—	7,521
October. . .	0	0.2	0	12,226	124	1,682,934	—	11,379
November. .	0	0.0	0	7,297	45	—	—	8,695

[a] Out of 641 darakat constituting the area infected with *gambiæ*, which is 1,600 square miles or 4,270.7 square kilometres

[b] Linear or square metres except for wells which are counted as one unit

[c] Each unit equals 5 linear or square metres

IX

GAMBIÆ-ERADICATION SERVICE, 1944-1945

Survey work		Personnel										
Units [c] surveyed for larvæ	Houses searched for adults	Doctors	Engineers	Mushefin (chief sanitary inspectors)	Morakebin (foremen)	Paris-green mulahezin	"Flitting" mulahezin	Larvæ kashshafin (scouts)	Imago kashshafin	Office clerks	Labourers and others	Total
No records	—	43	10	—	91	653	59	34	—	58	2,900	3,848
» »	—	41	14	—	107	546	60	46	—	64	2,393	3,271
» »	Few	48	14	4	155	767	60	105	—	71	2,036	3,260
» »	»	48	17	5	173	804	150	128	—	136	1,861	3,322
» »	410	52	19	6	189	900	191	147	—	133	2,121	3,758
» »	7,087	52	22	6	200	889	141	210	—	141	1,909	3,571
403,296	54,913	43	23	11	203	869	41	180	84	139	1,745	3,338
347,961	79,143	44	23	14	207	869	58	205	130	141	1,718	3,409
713,202	173,357	45	22	16	229	823	43	247	276	156	1,840	3,697
1,226,704	297,664	44	34	23	237	828	39	254	282	136	1,896	3,783
783,917	207,337	44	31	23	254	876	39	272	304	139	1,961	3,943
907,429	248,301	44	32	22	281	983	37	301	308	142	1,985	4,135
1,256,286	323,717	42	43	25	287	1,012	37	314	302	172	1,946	4,180
892,751	234,244	40	42	26	302	1,015	36	331	294	174	1,932	4,192
1,452,449	240,213	39	37	24	300	315 [f]	36	352	336	172	1,127	2,738
2,102,257	330,433	36	35	23	291	181	32	363	324	166	1,049	2,500
1,191,996	205,400	30	34	22	290	180	31	365	320	163	1,014	2,449

[d] The monthly records are for 4 or 5 weeks and not for a calendar month
[e] Records not complete
[f] At the end of September, almost all Paris-green mulahezin were transferred to survey work

During the test-period of 3 months—*i.e.*, September, October and November—1,200 men were engaged in survey work. The number of breeding places surveyed for larvæ each week increased to about 400,000 units in addition to about 60,000 houses each week—and yet no *gambiæ* was found. This constituted the test of eradication.

6. SUMMARY OF THE WORK OF THE GAMBIÆ-ERADICATION SERVICE DURING THE PERIOD FROM JULY 1944 TO NOVEMBER 1945

The summary begins in July 1944, because in that month the Gambiæ-Eradication Service was created as an entity separate from the Malaria Section of the Ministry of Public Health. In July 1944, the Gambiæ-Eradication Service was made responsible for only one thing: the control and eventual eradication of *Anopheles gambiæ*.

Larvicides used

The quantity of larvicides used is a useful index of the amount of antilarval work done, especially during the period before the detailed system of record-keeping was in operation. The service considered that the larvicide of choice for the eradication of *gambiæ* from Egypt was Paris green, one part of Paris green diluted with 100 parts of whatever unsifted dust or sand was most conveniently available. Oil was used only until it could be replaced by Paris green, supplies of which were at first not sufficient for the whole area.

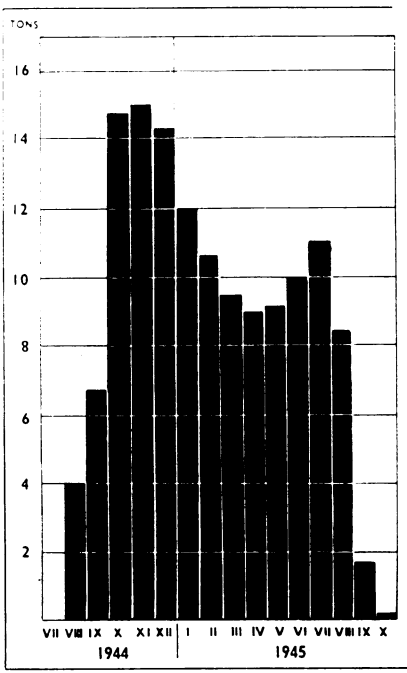
Paris Green

The amount of Paris green—pure Paris green and not the 1% mixture—used each month rose rapidly to a peak of 15 tons in November 1944, in which month the service kept no records of the number of breeding places treated with Paris-green dust. The change from oil to Paris green was begun in July 1944, but was not completed until January 1945.

The drop in the consumption of Paris green from the peak in November 1944 to 8.9 tons in April 1945 reflects the very great decrease in the number of potential breeding places which took place with the passing of the 1944 flood of the Nile.

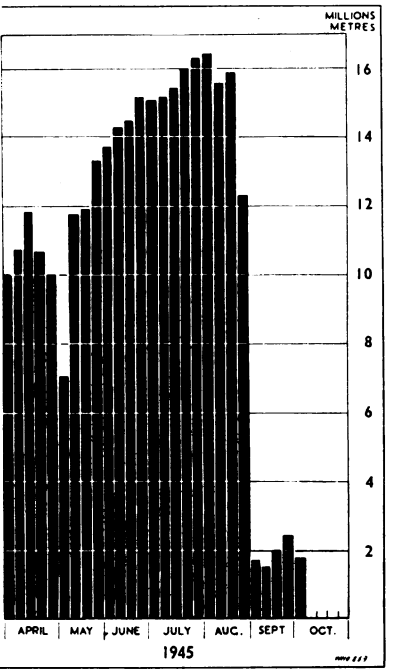
The increase to 11.1 tons of Paris green in July 1945 represents the intensification of its use with the onset of hot weather, plus the extension of its systematic application to the *pharoensis* barrier-area north of Asyût.

FIG. 7
PARIS-GREEN CONSUMPTION PER MONTH, AUGUST 1944-OCTOBER 1945



Total consumption : 138 tons

FIG. 8
LARVICIDE WORK OF THE GAMBIÆ-ERADICATION SERVICE, APRIL-NOVEMBER 1945



Number of linear and square metres of breeding space dusted with 1% Paris green (in millions of metres)

During the flood season of 1945, the systematic application of Paris green had been stopped everywhere except in the *pharoensis* barrier-area north of Asyût. This area was small in comparison with the whole of the so-called *gambiæ* area, so that the figure of 1.7 tons for September cannot properly be compared with the larger quantities used in previous months.

The total quantity of Paris green used during the whole campaign was 138 tons. The amount of Paris green still in stock at the end of the work in November 1945 was 134 tons. The estimates made in July 1944 of the total amount of Paris green which would be needed for the eradication of *gambiæ* proved to be considerably greater than the amount which was actually required (see table IX).

Malariol

The total quantity of Malariol which was used during the period was 718 tons, 326 tons of which were used in July 1944. No Malariol at all was used for any purpose after March 1945. For lack of adequate supplies of Paris green during the last three months of 1944, Malariol was used in the large mantikah (division) of Girga, as it was then constituted, until the end of 1944. This accounts for most of the appreciable consumption of Malariol in the months of October, November and December 1944.

Pyrethrum

The total consumption of pyrethrum insecticide during the period was 146,173 litres. The concentration of pyrethrins in the insecticide varied with the purpose for which it was used. For all vehicle disinsectization, the preparation was extra-strong, with 0.15% pyrethrins, while for ordinary use as an adjunct to the work of surveying for adult *gambiæ*, the pyrethrins were at only 0.07%. In the systematic disinsectization of houses, preparations of various strengths were used, most of them containing about 0.1% pyrethrins. All the pyrethrum insecticide was procured through the Middle East Supply Centre and the British Army.

From July to September 1944, all the insecticide used was used in vehicle disinsectization. The peak consumption in November 1944 of 17,100 litres was in connexion with the systematic disinsectization of houses. In 1945, the increasing amounts of insecticide used were all used as an adjunct to the searching of houses for adult *gambiæ*.

Except for about 40,000 litres of prepared insecticide supplied by the Shell Company upon the authorization of the British Army, all the insecticide was prepared by adding the proper amounts of pyrethrum extract to ordinary kerosene. The concentrated extracts which were used contained either 2.5% or 10% pyrethrins.

DDT

DDT solution was used to spray-paint railway passenger wagons, aeroplanes and boats. The great bulk of the total of 4,773 litres was used in the railway wagons of the Egyptian State Railways on the line from Upper to Lower Egypt. DDT was used in both 5% and 10% solutions, on the usual weight-volume basis ; and it was applied in quantities sufficient to leave a residue either of one or two grams per square metre of surface treated.

Eradication Work

Number of Units dusted with Paris Green

No data are available for the number of units (linear or square metres) dusted with Paris green in 1944 ; and the data for the first three months of 1945 are incomplete, because the complete system of record-keeping was not in operation everywhere until the beginning of April.

The month in which the largest amount of Paris-green dusting was done was July 1945, when over 78,000,000 units of breeding places were dusted, an average of over 15,000,000 units per week.

A large drop from 60,297,490 units dusted in August 1945 to 7,600,204 in September reflects the discontinuance of the systematic application of Paris green south of Asyût at the end of August. The figure for September includes the systematic work in the *pharoensis* barrier extending north from Asyût, plus the " spot " Paris-greening done in the places south of Asyût in which *pharoensis* occurred.

In October, 1,682,934 units were dusted, but this represents only the work of the first week of that month, after which application of Paris green was stopped everywhere.

The total number of Paris-green mulahezin at work reached a maximum in August 1945 with 1,015 men.

House Disinsectization

The systematic disinsectization of houses was done only from October 1944 to January 1945, and then only in El Badari and El Idisat. In all, 193,407 house-disinsectizations were done, much the greater part of these in El Badari. This special measure was undertaken in order to stop the epidemic of *gambiæ*-transmitted malaria which was occurring there.

Vehicle Disinsectization

The number of vehicles disinsectized averaged about 20,000 per month during 1944. The reductions which occurred in 1945 were mainly due to the discontinuance of the train-" flitting " stations, first at Idfu and Girga, and then at Beni-Suef, until finally only the station at Asyût remained. This station was continued until the end of the field-work. The four boat-" flitting " stations were maintained until the end, as were the several automobile-" flitting " stations on the outskirts of Asyût, and the one at Dishna.

Survey Work

Larvæ

During 1944, no records were kept of the number of units (of 5 linear or square metres) of potential breeding places searched by the larvæ kashshafin ; and until the end of March 1945 the records were incomplete. From April to August, the monthly totals of units surveyed ranged between 783,917 and 1,256,286, the variation being

FIG. 9

UNITS[a] OF BREEDING PLACES SURVEYED WEEKLY FOR ANOPHELINE LARVÆ BY THE GAMBIÆ-ERADICATION SERVICE, APRIL-NOVEMBER 1945

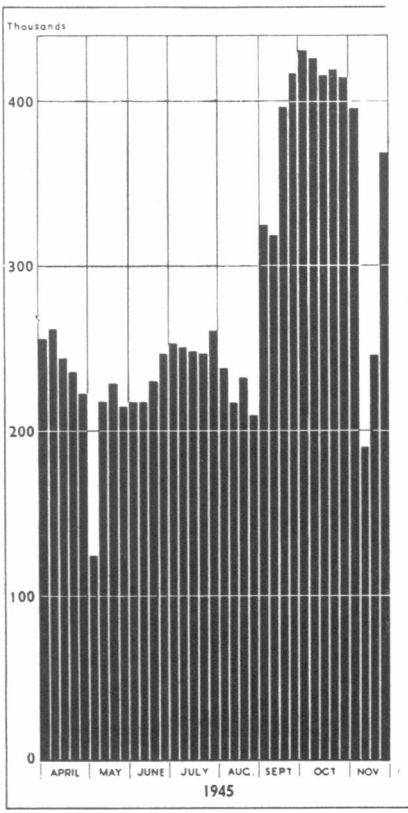
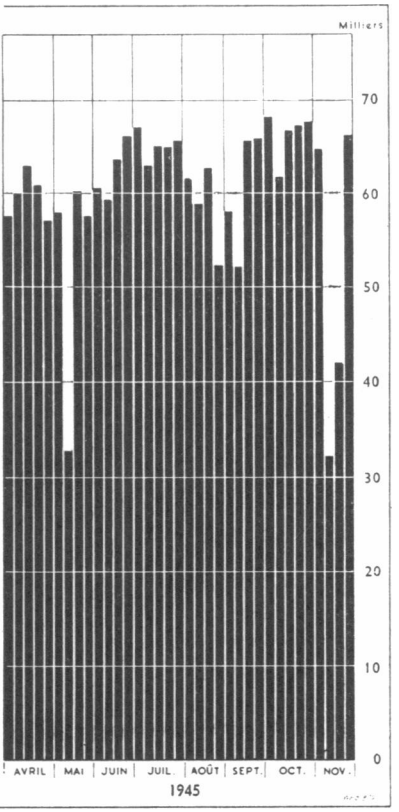


FIG. 10

NUMBER OF HOUSES SEARCHED WEEKLY FOR ADULT ANOPHELES BY THE GAMBIÆ-ERADICATION SERVICE, APRIL-NOVEMBER 1945



[a] Each unit = 5 linear or square metres

mainly due to the fact that the monthly totals are for four- or five-week periods, and not for calendar months.

After the discontinuance of the systematic application of Paris green south of Asyût, the number of men assigned to larva survey work was greatly increased, so that the totals for the last three months of work were much higher than previously. In November 1945, the figure was relatively low because of the Qurban Bairam holidays, which caused the loss of five working days. Reporting was incomplete up to March, but from April to August the number of units surveyed each week ranged between 200,000 and 250,000. In September, October and November, the weekly figure averaged nearly 400,000, about double what it had previously been. This was due, of course, to the much larger number of men assigned to the larva survey work during the period of the test for the eradication of *gambiæ*. The number of men engaged in the survey work increased steadily during the year.

Adults

The reporting of the number of houses searched for *gambiæ* adults is reasonably complete even during the early period of this work. The relatively small monthly totals for January, February and March 1945, are more or less proportional to the smaller number of imago kashshafin at work during those months. From April to November, the monthly totals vary between 205,400 and 330,433, but it must be remembered that these are four- or five-week periods and not calendar months. During the last six months of work the number of imago kashshafin at work averaged just over 300.

7. DISCUSSION

As pointed out by Soper & Wilson,[3] " It will be argued by many that species eradication is an expensive luxury and that funds for this type of work could never be gotten in the districts in which they work." However, it is well to consider that when a dangerous insect like *A. gambiæ* with its devastating effect can be eradicated, great economies can be effected, for the cost of an eradication campaign is basically a capital expenditure which, though large, makes it unnecessary to spend appreciable sums of money each year in control.

[3] Soper F. L. & Wilson D. B. (1943) Anopheles gambiæ *in Brazil, 1930-1940,* New York

As stated earlier, although the last *gambiæ* was found on 19 February 1945, intensive control measures were continued for a further six months. All control measures were then stopped in order to allow the mosquito to multiply unhampered—if it were still present—during the time of the year which is exceedingly favourable for it—namely, the months of September, October and November. During those three months, the search for *Anopheles gambiæ* was still further intensified.

All the 1,200 men engaged in survey work during this period were daily-paid workers, and if one larva or adult *gambiæ* were found it meant they would keep their job for another year. This constituted the test for the eradication of *A. gambiæ*.

At the end of November, the Gambiæ-Eradication Service was liquidated. In January 1946, a small Sentinel Service was established. The service had only to survey the area from Abu Simbil to Asyût once every month. During 1946, all control measures were stopped. The Sentinel Service surveyed 1,284,100 units for larvæ; 143,982 houses were searched for adults, with negative results for *A. gambiæ*.

The importance of negative results in an eradication campaign is self-evident, and this explains the great amount of work that was carried out after the last positive finding of *A. gambiæ* at Kom-Ombo on 19 February 1945.

At the end of 1946, the work of the Sentinel Service was handed over to the Malaria Section of the Ministry of Public Health with the recommendation that periodic surveys for *A. gambiæ*, both larvæ and adults, should be carried out four times each year in Nubia, until such a time as it is definitely known that *A. gambiæ* does not exist in the northern portion of the Anglo-Egyptian Sudan. Even then, it would be wise to maintain some vigilant measures in Nubia.

As to the introduction of *A. gambiæ* into Egypt, the only direction from which this could occur is from the south, and while it is almost certain that *gambiæ* was not introduced into Egypt in 1942 by aeroplane, the hazard of reintroduction on aeroplanes arriving in Cairo from the south is a constant one. The indicated measure is the routine disinsectization of all aircraft. This will be useful for pests other than *gambiæ* which are of medical, veterinary and agricultural importance.

According to Evans,[4] *A. gambiæ* is probably almost universally distributed in tropical Africa except in desert regions and in the high mountains. In the north, there are numerous records from the southern Sudan and the Nile Valley, the most northerly being Zeidab (north of Khartoum), that the species does not occur in Egypt. In his observations on mosquitos at Wadi Halfa, Lewis [5] records the following:

"In the area between Wadi Halfa and a point just south of Faras, the first anopheline larva found in 1942 was obtained in an irrigation channel near Ashkeit on 19th April and the last on 9th December in a similar breeding place at Dubeira. In 1942 and 1943 no anopheline larvæ were found in January, February or March in this area. Breeding appears to cease for some 4 months, from about the middle of December till the middle of April, presumably because pools do not exist for long enough. Since it is unlikely that the few adults present in December could live for 4 months in the dry desert air it is probable that the species normally dies out in this period in the area named.

"Breeding begins in April with the rising temperature and tends to increase greatly in May, when the falling river leaves many pools. It is curtailed in July by the rising flood and continues, to only a limited extent, on irrigated land where water sinks rapidly into the porous soil.

"The source from which *A. gambiæ* comes in April appears to be the Second Cataract. Anopheline larvæ have been reported from pools in the Cataract in December and March, and the writer found a third stage larva of *A. gambiæ* in filamentous algæ in an inlet among the rocks on 12th April, 1943, a month that was about as cool as a normal March. It is likely that larvæ exist in these large pools throughout the winter."

The Second Cataract is about ten kilometres to the south of Wadi Halfa, and it is very likely that *A. gambiæ* has invaded Wadi Halfa from the south as a natural infiltration of an insect, by the drifting of the larvæ along the course of the Nile, or transported to Wadi Halfa by rail or motor-cars. Its northward spread from Wadi Halfa to Abu Simbil is likely to be by boat transport, which was increased to a great extent during the war, or by wind.

It is of interest to compare the conditions in Egypt with those in Brazil, where eradication of the same species was obtained, after about the same amount of work. There are many similarities between the Nile Valley and the portion of north-east Brazil which was invaded by *gambiæ*, but there are also certain important differences. The most important of these differences is the mean monthly temperatures in the coldest months of the year. In Brazil, they

[4] EVANS, A. M. (1938) *Mosquitoes of the Ethiopian Region, II*, London
[5] LEWIS, D. J. (1944) *Trans. R. Soc. trop. Med. Hyg.* **38**, 215

are 19° to 20° C. ; while in Egypt they are, in the infested area, 8° to 10° C. Furthermore, the absolute minimum temperatures are of importance. In Egypt these are commonly 0° C., while in Brazil they were rarely less than 10° C. These tend to make the eradication of *gambiæ* easier in Egypt than it was in north-east Brazil.

It must not be forgotten, however, that *gambiæ* survived three winters in Egypt, and that these winters were of about average severity. There seems to be little doubt that, if the eradication measures had not been put into effect, the species would have spread still farther north, carrying epidemic malaria with it.

The time to eradicate *Anopheles gambiæ*, or any other insect pest, is at the time of year when conditions are least favourable for it ; but to have a service to operate efficiently at this critical time, it must have begun work some time previously. Now *gambiæ* is a tropical species, and therefore vulnerable in Egypt, a subtropical country. Nevertheless, it had established itself in the country, and the lives saved by the eradication of the species amply justified the money spent.

Whenever a species invades a new region, as *gambiæ* invaded Brazil and Egypt, the question becomes not of its being an exotic species, but whether or not the region offers entirely suitable ecological conditions for the species. The situation in Brazil is essentially different from that in Egypt. In Brazil, conditions were fully favourable for the species, and quite comparable to those in its home in tropical Africa, while in Egypt in the winter they were on the borderline of what *gambiæ* could tolerate.

There has been considerable discussion of the possibility that *gambiæ* may have invaded Upper Egypt on one or more occasions prior to 1942. The building of the Aswan Dam, and the two heightenings of it, have changed conditions in Nubia, which are more favourable for *gambiæ* than those previously existing.

The observation which leads some people to think that *gambiæ* had previously invaded Egypt is the outbreaks of malaria which occurred at Nag Hammadi, Armant and Kom-Ombo about thirty years ago. These epidemics were all associated with the extensive cultivation of sugar-cane, which was a new crop in Upper Egypt. Thus, a new set of ecological conditions was produced. The epidemics were characterized by large numbers of reported cases, but few or no reported deaths. As time went on, malaria became less and less

of a problem in the sugar-cane areas, until by 1942 there was no problem at all.

In Lower Egypt, especially around rice-fields, *Anopheles pharoensis* causes widespread malaria, and it seems justifiable to consider that the vector of the malaria in the sugar estates was *pharoensis* rather than *gambiæ*.

Another recorded episode is of interest. It occurred at El Dirr, in 1919–1920. El Dirr is in Nubia, about 80 kilometres down river from the southern border of Egypt. In July 1919, a most unusual event occurred ; heavy rain fell over a wide area in the desert around El Dirr. For several months water seeped from the desert into the Nile. This would provide ideal breeding places for *gambiæ* and *pharoensis*.

An epidemic of malaria occurred in and around El Dirr which is reported to have killed a thousand people. No collections of anophelines were made at the time, but the history of the epidemic, especially the large number of deaths, indicates that *gambiæ* rather than *pharoensis* was probably the vector. For whenever *gambiæ* invades a place in which the human population has little group immunity to malaria, it always causes a devastating epidemic of malaria.

But whether or not *gambiæ* ever invaded Egypt before 1942 is rather beside the point. It did so then, and it can do so again, unless adequate protective measures are put into force.

I am pleased to be able to report that the Medical Service of the Anglo-Egyptian Sudan has installed anti-*gambiæ* measures, apparently with entire success in the stretch of the Nile around Wadi Halfa, and extending 58 kilometres from the border to the Second Cataract.

ACKNOWLEDGEMENTS

In this report, it is fitting that acknowledgement should be given to the persons and entities who made the campaign a success.

First and foremost was the visit of His Royal Majesty King Farouk to the infested area in Luxor on his birthday, 11 February 1944. His Royal Majesty set the good example for the 4,182 employees of the Gambiæ-Eradication Service. Efforts were doubled, and *Anopheles gambiæ* began to feel the brunt of the attack and was finally eradicated in February 1945.

Special mention should be made of the Ministers of Public Health during 1942 to 1945, who gave the service their full, continuous and unstinting support.

The campaign against *Anopheles gambiæ* is like war, the success of which depends on equipment, transport and able leadership. As to equipment and transport, special mention should be made of the Egyptian Army and Middle East Supply Centre. The Egyptian Army placed at the disposal of the Gambiæ-Eradication Service 55 cars, with a driver for each. The Middle East Supply Centre supplied Paris green as well as 50 cars.

As to the technical men and matters, the Gambiæ-Eradication Service is greatly indebted to the representatives of the Rockefeller Foundation, to the medical corps and advisers of the Egyptian and British Armies, and to the members of the Combined Malaria Committee who placed their knowledge and experience of malaria in different parts of the world at the disposition of the service.

The representatives of the Rockefeller Foundation, Dr. F. L. Soper, Dr. J. A. Kerr and Dr. D. Bruce Wilson, are the very same men who developed the technique and organization which finally eradicated *Anopheles gambiæ* in Brazil. Dr. Soper visited the *gambiæ*-infested area more than once, and his advice and criticism were greatly appreciated. Dr. Kerr became Director of the Gambiæ-Eradication Service in July 1944, and Dr. D. Bruce Wilson became Field Director in October 1944.

The Egyptian Medical Corps supplied the necessary staff for one antimalaria control unit at El Idisat, and the British Royal Army Medical Corps supplied the staff for two antimalaria units at Luxor and Asyût, in addition to a mobile survey-unit which surveyed parts of the *gambiæ*-infested area. These inspections constituted an independent check on the progress of the eradication work which was very valuable to the Ministry of Public Health.

As to matters relating to succour of patients, special credit should be given to the Ministry of Social Affairs, the Ministry of Supplies, the Ministry of Public Works and, last but not least, to the ladies of the benevolent society of Mohamed Aly El Kebir and ladies of the Red Crescent Society.

Appendix

SPECIES AND DISTRIBUTION OF ANOPHELES IN EGYPT

1. Species other than Gambiæ found in the Gambiæ-infested Area

The other anophelines found in the area which was invaded by *A. gambiæ* are *A. pharoensis*, *A. multicolor*, *A. coustani* and *A. d'thali*.

A. pharoensis

A widely distributed species, throughout the Delta, especially in rice-growing districts. It is also found in burrow pits, pools of all sizes, drains, and irrigation channels where there is a growth of weeds or reeds.

Since *A. pharoensis* was found infected with malaria in nature, [6] an attempt was made to eradicate it in the so-called *gambiæ*-infested areas. A very good start on *A. pharoensis* eradication has been made as a by-product of the *gambiæ*-eradication work. First, it was necessary to isolate the "*gambiæ*-area" from the heavy *pharoensis*-producing area to the north of Asyût. To this end, an attempt was made to set up a "*pharoensis*-barrier" north of Asyût City, beginning at Asyût and extending north of it for about 50 kilometres.

Systematic application of Paris green was continued in the posts of Asyût, Abnub, Manfalut and Quseya after 30 August, the date on which it was stopped in the whole area from Asyût to Ballana.

When *A. pharoensis* was found south of Asyût, "spot" application of Paris green was instituted in the places where *pharoensis* was found and in circles within a radius of 100 metres around the breeding places. Two weeks later it was found that this system did not work for the eradication of *pharoensis*, and by the end of September it was abandoned and orders were given to stop all control work with Paris green in the barrier area, as well as the previously *gambiæ*-infested area, as a test of the eradication of *gambiæ*.

A. multicolor

One of the commonest Egyptian anopheles, widely distributed all over Egypt. The preferred breeding place is salty water in small pools with or without vegetation. *A. multicolor* appears to be a truly endemic species in Egypt and to be very well adapted to surviving in Upper Egypt.

According to Kirkpatrick [7] *A. multicolor* is considered to be a "proved carrier of malaria". It is probably the cause of most if not all the malaria in Egypt, except in those few localities where *A. sergenti*, *A. rhodesiensis* and *A. superpictus* occur.

[6] Madwar, S. (1936) *J. Egypt. med. Ass.* **19**, 616

[7] Kirkpatrick, T. W. (1925) *The Mosquitoes of Egypt*, Cairo

It may be pointed out that, hitherto, *A. multicolor* has not been found infected in nature in Egypt.[8]

A. coustani

Not an abundant species. Found more in the northern part of the Delta, very rare in Upper Egypt and certainly of no importance as a vector of malaria.

A. d'thali

This species resembles *A. rhodesiensis*. It had been recorded from the Anglo-Egyptian Sudan, Port Sudan, Red Sea hills towards Eritrea, Aden, etc. Available information indicates that *A. d'thali* is not unimportant as a vector of malaria. *A. d'thali* was found in September 1945 in very small numbers from Asyût to Nag Hammadi. Early in October it was also found in Nubia.

* * *

Table X gives the number of larval and adult collections examined each month from July 1944 to November 1945.

2. Distribution of Gambiæ and of other Species of Anopheles in Upper Egypt, 1944–1945

In fig. 5, the horizontal scale represents weeks, and the vertical scale darakat (zones). Thus the height of the space in each dairah (post) is proportional to the number of darakat in it. Only the total number of darakat positive each week is shown, no attempt being made to show exactly which darakat are positive. The data are for larvæ only.

A glance at fig. 5 reveals that in 1944 *gambiæ* was present from Ballana, on the southern border of Egypt, all the way north to Asyût, a distance of some 850 kilometres along the course of the Nile. This region comprises the so-called "*gambiæ* area" with an area of just over one million feddans, or about 4,200 square kilometres.

From a maximum of 242 darakat positive for *gambiæ* in November 1944, the species decreased rapidly so that in January 1945 it was found in only 37 darakat, these being in the dawayer (posts) of Tahta-Tima, Matana, Bisaliya-Sibaiya, Idfu, Atwani, Kom-Ombo-Iqlit, Ineiba-El Dirr, and Ballana. In February it was found in only three darakat, located in Kom-Ombo and in Idfu. After February, *gambiæ* was not found, either as imago or as larva.

The findings regarding other species of anopheles are not shown for 1944, but they are given in full detail for 1945 because they are of interest and importance. This is particularly true of *A. pharoensis*, the breeding habits of which are sufficiently similar to those of *gambiæ* to provide a very useful index—when *gambiæ* is not found—of the efficiency of the anti-*gambiæ* measures which are being used.

Fig. 5 gives the combined picture of all four of the other species of anopheles, but the data for *pharoensis* alone give almost the same picture.

In the first four months of 1945, all anophelines were exceedingly rare, except, of course, in Kom-Ombo and Idfu. In the next four months—from May to August

[8] Madwar, S. (1938) *Acta Conventus Tertii de Tropicis atque Malariæ Morbis*, 2, 222

Table X

LARVAL AND ADULT ANOPHELINES EXAMINED, JULY 1944-NOVEMBER 1945

Month	Number of darakat[a] positive for *A. gambiæ*	Larvæ					Adults				
		Total collected	Species				Total collected	Species			
			gambiæ	*pharoensis*	*multicolor*	Other species		*gambiæ*	*pharoensis*	*multicolor*	Other species
1944											
July	49	936	103								
August . . .	34	1,187	102								
September. .	60	1,581	155								
October. . .	177	5,145	924								
November. .	242	2,757	1,467								
December . .	141	668	280								
1945											
January . .	37	300	45				9	6			
February . .	3	111	2				5	1			
March . . .	0	130	—				665	—			
April	0	348	—				733	—			
May	0	311	—	277	33	1	74	—	8	66	—
June	0	439	—	417	—	22	11	—	9	1	1
July	0	833	—	813	—	20	12	—	2	10	—
August . . .	0	650	—	645	2	3	16	—	6	10	—
September. .	0	1,276	—	1,216	44	16	107	—	94	13	—
October. . .	0	8,420	—	7,422	874	124	2,115	—	1,914	199	2
November. .	0	4,595	—	3,985	477	133	1,274	—	1,009	248	17

[a] The zones into which the *gambiæ*-infested area was divided

inclusive—they disappeared from Kom-Ombo and Idfu, but they appeared in moderate numbers in several places, especially Asyût, Abu Tig, El Badari, Akhmim, Nag Hammadi and El Khayam.

In June, the attempt to set up a " *pharoensis* barrier " was begun with the northward extension of systematic Paris-greening to the dawayer of Abnub, Manfalut and Qusiya. It is important to remember that north of Qusiya *pharoensis* was breeding unhampered by any control measures, except around the town of El Minia ; and the prevailing wind is from the north.

The foregoing facts are of importance in connexion with the stoppage of the systematic application of Paris-green dust everywhere south of Asyût at the end of August to begin the test for the eradication of *gambiæ* ; and with the abandoning at the end of September of the attempt to maintain the *pharoensis* barrier north of Asyût.

The findings in the months of September, October and November may now be discussed. The very rapid increase everywhere of the other species of anopheles is immediately apparent. But *gambiæ* did not reappear, at any time, or at any place, during the entire period of three months.

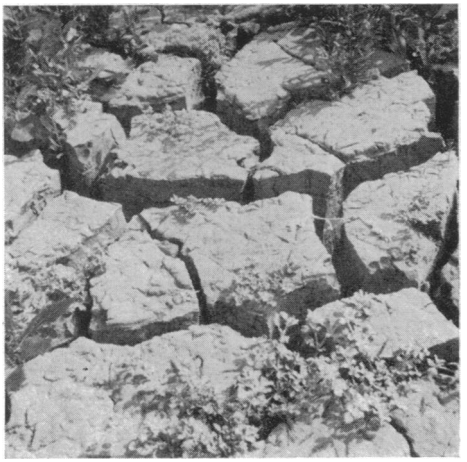
The behaviour of other anophelines during the three-month period in which the " test " for the eradication of *gambiæ* was carried out constitutes an index of what *gambiæ* would have done if it had previously been overlooked in any one of the million feddans which comprise the previously infested area. The significance of the negative findings regarding *gambiæ* is enormously enhanced by the positive findings regarding the other species of anopheles.

Finally, it is apparent that during November there was an important decrease in the abundance of the other anophelines. This decrease was entirely due to natural causes, because no Paris green was used anywhere after the first week in October.

By the end of November, the weather in Upper Egypt is much too cold, especially at night, to be favourable for anophelines, especially for *gambiæ*. The optimum period for *gambiæ* passed, without its reappearing, making it unnecessary to continue the test for the eradication of the species for a longer time.

The prevalence of *gambiæ* and its disappearance can be portrayed in another way, by charting the number of collections of the larvæ of *gambiæ*, and other anophelines which were collected each week and identified in the laboratory of the service at Asyût. This has been done in fig. 6, which shows very strikingly the complete absence of *gambiæ* larvæ after January 1945, in spite of the very great increase in the abundance of the other species of anopheles late in 1945. The last two *gambiæ* found were adults, which are not shown in the figure ; but they were found in February 1945.

It will be noted that in 1944 the largest number of collections in any week was 1,300 and that these were made in the last week of October, when more than 200 of the collections contained *gambiæ*. On the other hand, in 1945 the peak number of collections, again in October, was 2,500—nearly twice as great. The smaller totals in 1944 were due in part to the antilarval measures which were in effect, and in part to the much smaller number of men who were searching for larvæ.



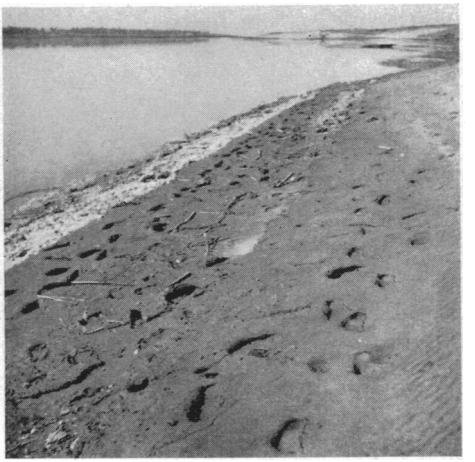
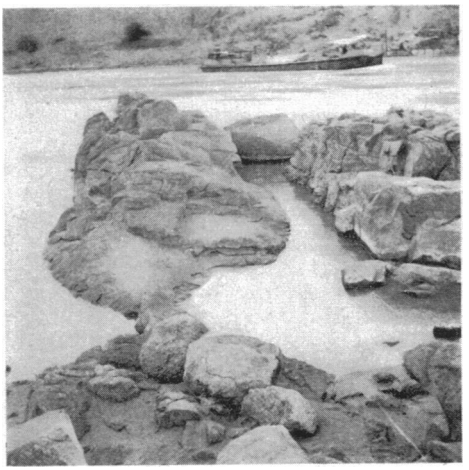


FIG. 11. DRIED AND CRACKED MUD FLATS ON THE SHORE OF THE NILE. These blocks of mud are very hard, but water remains for long periods in the cracks. *Gambiæ* larvæ have been found breeding in such water, but collection of the larvæ is difficult because of their inaccessibility.

FIG. 12. INLET OF A LARGE IRRIGATION CANAL. As the Nile rises, water flows into the canal and is carried to basins downstream. The soil in the bottom of the canal is a mixture of mud and sand. In many such canals, *gambiæ* has been found breeding, often prolifically.

FIG. 13. HUMAN FOOTPRINTS ON THE SHORE OF THE NILE. Footprints containing water form ideal breeding places for *gambiæ*.

FIG. 14. THE NILE, LOOKING NORTH FROM ASWAN DAM (January 1945). The Nile is very low below the dam and the rocky stretch forming the First Cataract is exposed. There are thousands of small rock-pools on the innumerable islands, which are ideal breeding places for *gambiæ*. Before control work was started in May 1943, *gambiæ* larvæ were abundant in these pools. The current in the channels between the islands is swift, increasing the difficulty of reaching them.



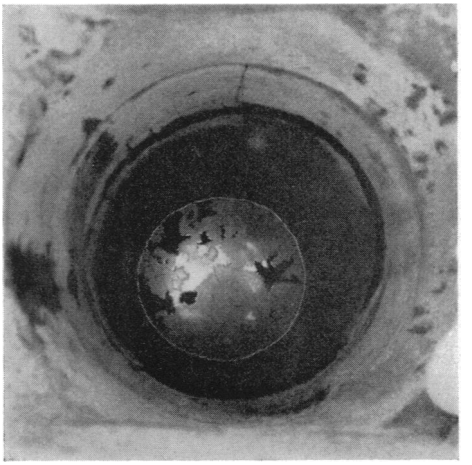
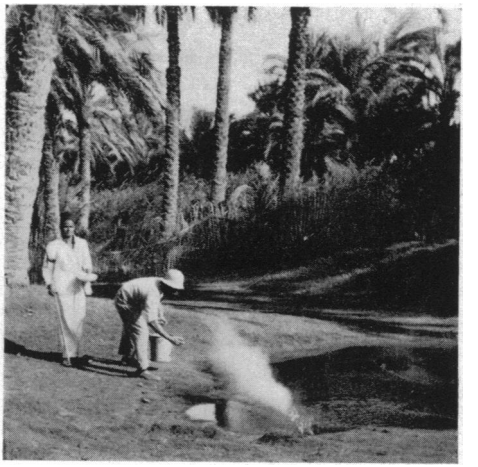


FIG. 15. POOL IN ROCKS AT THE EDGE OF AN ISLAND IN THE NILE. Note that the water is still.

FIG. 16. BIRKA (PIT) AT THE EDGE OF A VILLAGE. The earth has been removed to make bricks. This birka is not entirely typical as it is rather shallow. *Gambiæ* larvæ have been found several times in it, although birkas are relatively unimportant breeding places. This birka, at the village of El Luka, between Asyût and El Sahel, was the last place at which *gambiæ* was found in Asyût mantikah (in 1944).

FIG. 17. CONCRETE PITS OF HYDRANTS FOR RAILWAY LOCOMOTIVES. Iron covers to the pits besides the hydrant were defective at several stations, and *gambiæ* larvæ were found in the water. This tended to occur only when *gambiæ* was breeding profusely in the vicinity.

FIG. 18. WELL IN THE GROUNDS OF THE ANCIENT TEMPLE OF KARNAK. The diameter is about 3 feet (0.9 m.) and the depth to the water about 20 feet (6 m.). *Gambiæ* were found in this well. Note that the oil has not spread evenly on the surface of the water.



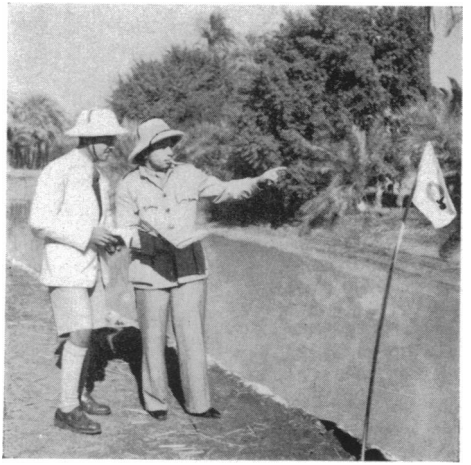


FIG. 19. MAGMOUA (DISTRICT) OFFICE, KARNAK. This is a much better office than is usual.

FIG. 20. DAIRAH (POST) CHIEF AND CHIEF INSPECTOR. The chief is a doctor or an engineer. Note tin folder to keep field-records and small notebook for the chief inspector's instructions. Small white flag attached to the stick bears the Red Crescent, and is used to indicate place where subordinate personnel are working. Thefts of flags were a problem until it was found that flags with holes were not stolen. Holes are now cut in all flags before use.

FIG. 21. MULAHEZ APPLYING PARIS-GREEN DUST, WHILE MORAKEB WATCHES. The dust is thrown by hand and carried by the wind. Note mulahez unencumbered by equipment except bucket containing dust. The morakeb carries equipment for dipping for larvæ. He searches for larvæ, teaches the mulahez how to apply Paris green, observes his work and checks results.

FIG. 22. DISINSECTIZATION OF RIVER BOATS, ASYÛT. Mulahez working with a small hand-atomizer in the hold. The holds of many boats are quite roomy, dark and moist, and provide a good resting place for adult *gambiæ*.

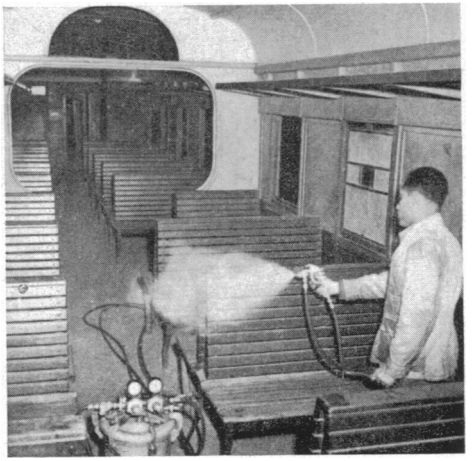


FIG. 23. SPRAY-PAINTING RAILWAY COACH WITH DDT. The bucket contains DDT solution (10% DDT in ordinary kerosene) from which two tubes lead to the pistol. DDT solution is carried into cracks of the seats and thus the residue cannot easily be removed.

FIG. 24. LARVÆ KASHSHAF AT WORK. Note long-handled dipping net to skim the surface of the water, shallow pan for contents of net, and canvas bag containing rest of kit—tin folder, daily work-sheet, and glass tubes for any larvæ found.

FIG. 25. DISINSECTIZATION OF AUTOMOBILES. The car is covered with a large sheet held close to the car, while the mulahez sprays the insecticide. After spraying, the sheet is retained for 5 minutes.

FIG. 26. IMAGO KASHSHAF AT WORK, ASYÛT. Each imago kashshaf has one helper. The kashshaf is working in a room with a thatched roof. While he sprays the insecticide, his helper holds a square of cloth to collect the insects knocked down. The pyrethrum insecticide used for this work contains only 0.07% pyrethrins.