

CHANGES IN THE EPIDEMIOLOGY OF PLAGUE IN EGYPT, 1899-1951

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SYNOPSIS

The author of this article discusses the epidemiology of plague in Egypt from its reintroduction in that country in 1899 until 1951. Dealing first with the period 1899-1945, before the introduction of DDT, he notes that plague was first reported in the ports and then spread rapidly inland; in contrast with previous epidemics, the prevalence was greater in Upper than in Lower Egypt. By 1937 the whole of Lower Egypt had become free of the disease, which, however, persisted in endemo-epidemic form in Upper Egypt until 1941.

The reasons for the slighter severity of this third plague pandemic in Egypt compared with the previous history of the disease there are discussed, particularly in connexion with the role played by rodents. Details of the number of rats captured and of flea indices are given for the years from 1937 onwards.

In 1941 a scheme was introduced for the control of rats in river and canal craft in order to prevent the spread of plague inland from the ports. The details of this scheme are given, and the significant fact is noted that no case of plague was reported inland from 1941 to 1945 despite an outbreak during that time in the Suez Canal Zone.

Turning to the period 1946-51, after the introduction of DDT, the author discusses the Alexandria epidemic of 1946-47, giving rat and flea counts and describing the control methods adopted, which included the use of poison baits and DDT. Dusting both persons and rat burrows with DDT has clearly resulted in a sharp decrease in flea indices, and the periodical use of DDT and Gammexane in port areas since 1950 has been shown to yield good results.

THE PRE-DDT PERIOD (1899-1945)

A general review of the spread of plague during the 47 years from its reintroduction into Egypt in 1899 until 1945 (see Table I and Fig. 1) shows that the disease first established itself in the main ports: in Alexandria in 1899-1900 and in Port Said in 1900; it then dispersed inland with increasing speed and intensity, reaching its maximum during the period 1908-12.

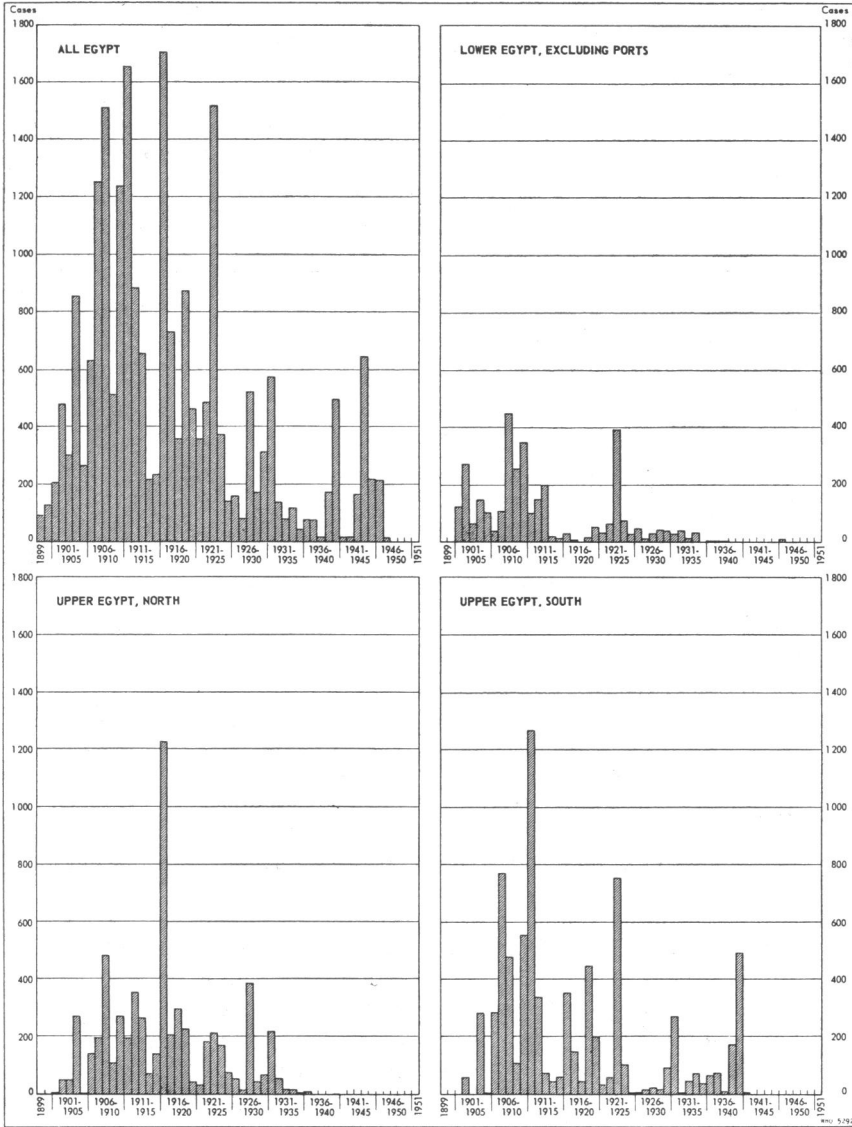
**TABLE I. ANNUAL NUMBER OF PLAGUE CASES RECORDED IN EGYPT.
1899-1951**

Year	All Egypt	Lower Egypt (excluding ports)	Upper Egypt		Frontier districts	Ports				
			north	south		Alexandria	Port Said	Suez	Is-mailia	Da-mietta
1899	93	0	0	0	0	93	0	0	0	0
1900	127	0	0	0	0	36	90	0	0	1
1901	205	122	5	0	0	52	26	0	0	0
1902	481	268	51	57	0	101	1	0	0	3
1903	303	63	51	0	0	129	33	0	0	27
1904	854	145	269	297	0	108	22	11	0	2
1905	266	100	2	1	0	127	14	21	0	1
1906*	631	34	140	281	0	99	14	62	0	0
1907	1 253	104	198	766	0	152	19	3	10	1
1908	1 511	442	480	476	0	100	13	0	0	0
1909	512	251	108	104	0	23	26	0	0	0
1910	1 238	344	269	550	0	45	28	0	1	1
1911*	1 656	99	194	1 266	0	52	42	0	1	0
1912*	884	147	352	335	0	33	12	0	0	0
1913	654	199	264	71	0	95	25	0	0	0
1914	219	18	69	39	0	43	50	1	0	1
1915	235	9	138	59	0	10	19	0	0	0
1916*	1 702	28	1 225	353	0	61	32	1	0	0
1917*	732	6	202	145	0	17	41	318	1	0
1918*	357	0	296	39	0	4	16	0	1	0
1919*	877	17	224	444	0	9	54	126	2	0
1920	462	53	43	198	49	13	19	87	0	0
1921	356	31	31	31	0	137	33	93	0	0
1922	487	63	182	58	0	71	54	58	1	0
1923	1 517	392	208	752	0	67	51	47	0	0
1924	373	73	170	99	0	2	8	20	1	0
1925	138	27	72	6	0	4	21	8	0	0
1926	154	48	51	6	23	8	0	18	0	0
1927	78	11	14	15	11	20	5	1	1	0
1928	519	32	382	21	38	5	1	40	0	0
1929	170	42	40	14	0	57	16	1	0	0
1930	311	40	68	87	1	109	6	0	0	0
1931	575	27	217	272	0	45	14	0	0	0
1932	134	39	54	7	0	34	0	0	0	0
1933	78	10	15	45	1	7	0	0	0	0
1934	115	31	13	70	0	1	0	0	0	0
1935	40	0	3	36	0	1	0	0	0	0
1936	77	1	9	66	0	0	0	1	0	0
1937	73	2	0	71	0	0	0	0	0	0
1938	11	1	0	10	0	0	0	0	0	0
1939	169	0	0	169	0	0	0	0	0	0
1940	491	0	1	489	0	0	1	0	0	0
1941	14	0	0	4	0	0	10	0	0	0
1942	15	0	0	0	0	0	14	0	1	0
1943	163	0	0	0	0	0	7	156	0	0
1944	644	0	0	0	0	0	72	163	409	0
1945	218	0	0	0	0	0	74	22	122	0
1946	211	10	0	0	6	124	15	24	32	0
1947	15	0	0	0	0	15	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0

* The numbers of cases recorded in Cairo during each of the following years are included in the total figures for all Egypt: 1906, 1; 1911, 2; 1912, 5; 1916, 2; 1917, 2; 1918, 1; 1919, 1.

Unlike previous epidemics, the prevalence was much greater in Upper Egypt than in Lower Egypt; thus, 6192 cases had been recorded in Upper Egypt by 1912 as against 2141 in Lower Egypt. The epidemic then fluctuated widely, although generally lessening, until 1925 when it began to

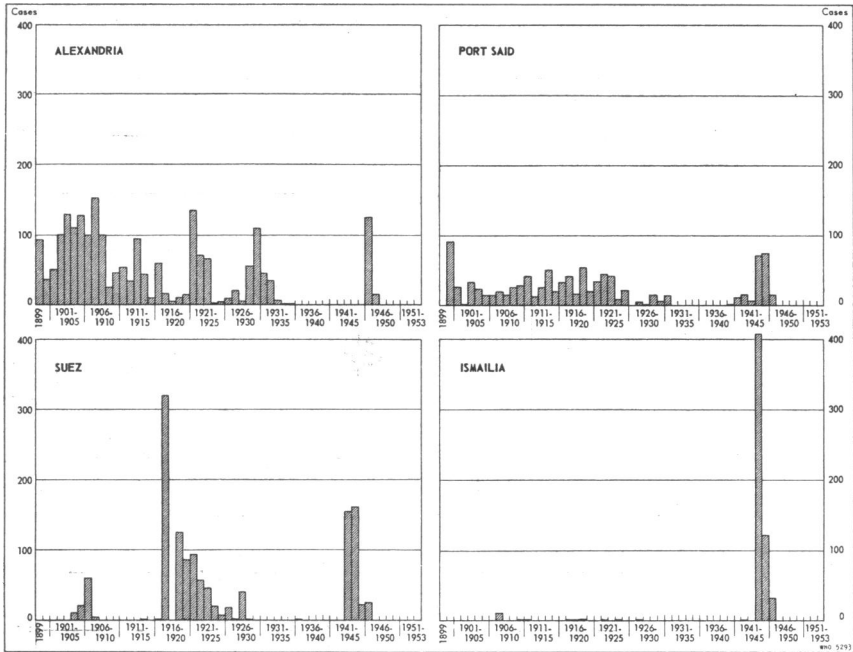
FIG. 1. ANNUAL CASES OF PLAGUE IN EGYPT, EXCLUDING MAIN PORTS, 1899-1951



All Egypt : Population 19 089 573 in 1947
 Lower Egypt, excluding ports : Population 8 205 744 in 1947 ; provinces of Beheira, Gharbia, Daqahliya, Minufya, Sharqiya, and Qalyubiya
 Upper Egypt, north : Population 3 168 161 in 1947 ; provinces of El Giza, Beni Suef, El Faiyum, and El Minya
 Upper Egypt, south : Population 4 061 450 in 1947 ; provinces of Asyut, Girga, Qena, and Aswan

show signs of abating. It disappeared from the ports particularly abruptly—from Suez in 1930, from Port Said in 1932, and from Alexandria in 1936 (Fig. 2)—and from the northern part of Upper Egypt (the provinces of El Giza, El Faiyum, El Minya, and Beni Suef) in 1937. The whole of Lower Egypt finally became free of plague in 1939.

FIG. 2. ANNUAL CASES OF PLAGUE IN MAIN EGYPTIAN PORTS, 1899-1953



Population in 1947: Alexandria, 928 237; Port Said, 178 432; Suez, 108 250; Ismailia, 32 296

In the southern part of Upper Egypt (Asyut, Girga, Quena, and Aswan provinces), and particularly in Asyut province, the disease continued to appear almost every year in endemo-epidemic form until 1941. From that year until 1946 the whole interior of the country, where never a year had passed without an outbreak of plague, remained entirely free of the disease. This followed directly from the application of the rat-control scheme for river craft in the early part of 1941, which will be discussed later (see page 37).

This phenomenon is particularly important in the recent history of plague in Egypt since it represents the first time since the reintroduction of the disease in 1899 that the interior of the country remained free of plague for five consecutive years, that is, until 1946, despite an epidemic in the Suez Canal Zone from 1941 to 1946.

Disappearance of Plague from Egypt in the 19th Century

Considering the earlier history of plague in Egypt, we find that it spontaneously disappeared for over half a century from 1844 until 1899;^{2, 4, 6} in that year the third pandemic reached Alexandria, having started in China, and having overrun Hong Kong in 1894, India in 1896, and Jedda in 1897.

As is well known, plague in the past used to spread in the trail of commercial caravans, particularly those carrying grain.^{3, 5} Thus it attacked one town after another and one country after another, occasionally leaving behind endemo-epidemic foci. In mediaeval times these foci existed in Uganda on the north-western shore of Lake Victoria, in the western regions of the Arabian Desert, along the Tigris and Euphrates rivers, in Central Asia, and in northern India, giving rise to epidemics or pandemics.^{3, 4} With the development of steam navigation and the use of ships rather than caravans, the means of transmission of plague changed; trade between Egypt and India was no longer carried on overland through Persia, Turkey, and Syria—then the chief centres of plague—but by direct sea communication. It is thought that the disappearance of plague in Egypt between 1844 and 1899 was due to this change in the trade routes at a time when India had been free of plague for some 200 years.⁶

The Third Plague Pandemic

The third pandemic of plague was much slighter than its precursors both in severity and in spread, which was so restricted that only a few European ports and towns were smitten. The fourteenth century epidemic, the "Black Death", on the other hand, was responsible for the death of nearly one quarter of the total population of Europe. The third pandemic in Egypt, although overrunning the whole country as far south as Aswan, took six years to do so and was responsible for far fewer cases than in the fourteenth century. Contrary to its experience in earlier epidemics—it is recorded that from 1142 to 1841 some 25 severe epidemics occurred in the city—Cairo has remained practically immune to plague throughout the third pandemic. As an example of the severity of the 1835 epidemic, Gaetani states that in Cairo alone, with a total population of 280 000, some 33 751 deaths from plague were recorded within six months.⁶ The difference in severity between that epidemic and the third pandemic becomes quite apparent when that figure is compared with the 10 131 deaths from plague recorded in the whole of Egypt between 1899 and 1928.

Although plague disappeared from many parts of the country after 1930, it persisted in Asyut province, reappearing year after year with occasional exacerbations. Some workers interpreted this fact as meaning that

plague had become endemic in the province. I believe that such an interpretation could not have been advanced, or would at least have been very doubtful, had the following facts been taken into account:

1. The changes in the epidemiological conditions affecting rodents took place much earlier in the ports and in Lower Egypt than in Asyut province.

2. The conditions prevailing in Asyut are very favourable to rodents and rodent migration. The system of irrigation in Asyut involves the use of shallow basins of fertile land which harbour enormous packs of the field rat *Arvicanthis niloticus*, particularly when the land lies fallow during the late spring and early summer before the flooding of the Nile. During periods of flood the rats withdraw to neighbouring dikes and villages. Asyut province is also a centre of commercial water traffic along the Nile, the Bahr Yusef Canal, and the Ibrahimiya Canal, which is navigable along its southern length from Asyut to Dairut.

3. Plague disappeared spontaneously from Asyut province as well as from the rest of Egypt for more than fifty years in the nineteenth century.

4. Plague appeared continuously in Europe for nearly a thousand years from the sixth to the seventeenth century and yet subsequently disappeared.

With all these facts in mind, it would seem more logical to attribute this annual appearance of plague to the continuous reintroduction of infection.

Spread of plague early in the third pandemic

Plague first broke out in Alexandria in 1899 and then attacked Port Said and Damietta in 1900. From these ports it began to invade the country (see Fig. 3), spreading throughout Lower Egypt in 1901-02, even extending as far southwards as El Minya province in Upper Egypt in 1901, where a few cases were detected in Minya town and the village of Kafr el Mansura, some 250 kilometres south of Cairo up the Nile. In 1902 it appeared in the village of Bayadiya in Mallawi district, Asyut province, and then spread further south to Dishna village, Qena province. In 1903 cases were recorded near Cairo in Mansuriya village, Giza province, and along the Nile. The following year plague appeared in Suez for the first time and in three Nile villages of Girga province—Awlad Yihya in Girga district, and Khiam and Nag-nag in Balyana district. The epidemic was well established by 1905 and extended as far south along the Nile as the town of Aswan, some 1000 kilometres south of Cairo. It thus took six years to extend as far south as Aswan, and it failed to spread further south into the Nubian region, which, as usual, has proved resistant to plague until the present time. It is interesting to note that, although plague later spread very generally throughout the country, almost all the towns and villages affected at the

beginning of the pandemic lie on the banks of the Nile or along navigable canals, a fact which implicates river craft in the spread of the disease.

Later epidemics

Plague broke out in Asyut province in 1939 and spread southwards to Girga province; in 1940 a severe epidemic flared up in those two provinces and 489 cases were recorded in the southern part of Upper Egypt as against 169 cases in 1939. In 1941 the epidemic abated and only four cases were notified. After that the disease disappeared.

At the same time several cases of rat plague were notified in 1940 in the Palestine ports, followed by one case of human plague in Port Said in the summer of that year. In 1941, 10 cases of plague were recorded in Port Said, and it was declared that plague had broken out at Casablanca in Morocco.

Several plague foci were thus established in important ports which were being very heavily used under war-time conditions by the Allied forces, so paving the way for a possible world-wide epidemic. The Egyptian Ministry of Health considered that unless adequate precautionary measures were taken a new epidemic might be expected to spread throughout Egypt. A plan for the protection of the whole country against a spread of plague inland from the ports was therefore drawn up during the first quarter of 1941 and put into operation in the second quarter of that year. This will be considered later in this paper.

In 1942 the disease reappeared in Port Said and 14 cases were reported, including several cases of pneumonic plague. Early in 1943 a severe epidemic was declared in the El Arbeen slum area of the town of Suez and soon overran all the neighbouring villages and the ports provisionally established by the British military authorities on the west bank of the Suez Canal and on the Bitter Lakes between El Qantara and Suez. Later in the same year plague appeared in Ismailia, at the junction of the Suez and Ismailia Canals. The situation then seemed particularly serious as the British military authorities were at that time using a large fleet of river craft for the transport of goods from ships in the Bitter Lakes and the temporary ports on the Suez Canal to the interior of the country along the Ismailia Canal. As a result of the efforts made by the Egyptian health authorities, however, it was ultimately possible to localize the epidemic in the Canal Zone and to prevent it from spreading inland, and this despite the fact that it maintained its severity throughout the Zone until 1945, the total number of cases there in 1943, 1944, and 1945 being 163, 644, and 218, respectively.

Although this epidemic was unusually severe, only four foci were infected—the word “focus” being taken as covering an administrative area. Taking the number of infected foci as a criterion of the extent of

spread of infection, we find that, as against 644 cases in four foci in 1944, there were 491 cases in 33 foci in 1940 and an annual average of 1238 cases in an average of 146 foci over the period 1908-12. It may be appropriate in this connexion to recall that plague is primarily a disease of rodents and that it affects man only in certain circumstances; it is what I may call an "underground" disease. Therefore no survey of the extent of infection will give a true picture unless it shows statistics for epizootic plague, which are at present lacking, in addition to the morbidity rate for man. As was so well illustrated by Greenwood³ in connexion with the plague outbreaks at Felixstowe, England, in 1906-18, an area may harbour a plague epizootic which remains undetected because no cases, or a few sporadic cases only, occur in man.

Role of rodents in the evolution of plague in Egypt

The most important rodent closely connected with the spread of plague in Egypt is the black or house rat, *Rattus rattus*. However, early in the eighteenth century a great change took place in the rodent population, which affected the spread of plague and contributed to its gradual decline and final disappearance from many parts of the world. This was when the brown rat, or grey rat as it is sometimes called, *Rattus norvegicus*, which had until then lived in north-west Asia, for some reason invaded Europe. It is thought that this invasion was prompted partly by famine in India and the neighbouring countries and partly by earthquakes in Persia and along the Caspian coast. In 1727—the "rat year" as it became known in Europe—hordes of brown rats invaded Astrakhan in Russia, crossed the River Volga, and headed westwards devastating everything in their way until they reached the British Isles in approximately 1731. Establishing themselves there, they began to invade other parts of the world on board the numerous British ships, and reached North America in about 1735.¹ Although the exact date of the brown rat's arrival in Egypt is not known, it had certainly settled there by the latter part of the nineteenth century. A survey made early in the twentieth century by Petrie & Todd⁶ showed that *R. norvegicus* was well established in Lower Egypt and the Egyptian ports but that *R. rattus* still predominated in Upper Egypt until 1913. This explains the lesser extent of plague in Lower Egypt already mentioned. The same survey also revealed that *R. norvegicus* had reached Nile villages in Asyut province in 1912 and the Kom Ombo estate in Aswan province in 1911. Surveys made in 1928 and 1934 by the Department of Public Health show that *R. norvegicus* was by then well established throughout Egypt.

It is interesting to note that in Egypt *Xenopsylla cheopis* has remained the most constant rat flea, in contrast to Europe and America where *Ceratophyllus fasciatus* has largely supplanted it.⁷

Another change of great importance is the natural decline in the flea infestation of rats since the survey by Petrie & Todd in Asyut in 1912; this has been attributed to the influence of certain insects (*Staphylinida*, *Leptothorax*) which feed on flea larvae. The maximum flea count during a normal period in the town of Asyut in March 1912 was 11.2 per *R. rattus* and 1.2 per *Acomys cahirinus*; there was also considerable flea infestation of *Arvicanthis niloticus* and *R. norvegicus*. The average flea count for the whole of that year in Asyut town was 8.6 per *Arvicanthis niloticus*, 10 per *R. norvegicus*, and 6.6 per *R. rattus*. Similar findings were made in many other towns and villages in the course of this investigation.⁶ Since then the flea counts have steadily decreased. Investigations by the Department of Public Health in 1928 and 1934 showed that the count had by then fallen to 2.6 in Asyut district and 2.7 in Fashn district in El Minya province. In Alexandria the flea count fell as low as 0.95 and 0.81 per rat in 1937 and 1938, respectively (see Table II).

The following tabulation shows the trends of the flea index in Alexandria and Port Said from 1937 to 1945 :

<i>Alexandria town</i>		<i>Port Said town</i>	
<i>year</i>	<i>flea index</i>	<i>year</i>	<i>flea index</i>
1937	0.95 *	—	—
1938	0.81 *	—	—
1939	1.03 *	—	—
1940	6.64 *	—	—
1941	3.45	1941	3.00
1942	5.64	1942	2.05
1943	1.88	1943	0.90
1944	1.69	1944	1.00
1945	2.02	1945	1.71

* Port area included

It will be noticed that the flea index in Port Said was relatively high from 1941 to 1945. This rise, however, is very small when compared with the counts made during epidemics in the first part of this century; thus, the flea index varied between 14 and 33 on the Kom Ombo estate, Aswan province, and in other places in Upper Egypt in 1911-12.⁶

The rise in the flea index for Alexandria will be discussed later.

Mildness of the third pandemic

The causes of the mildness of the third plague pandemic may perhaps be summarized as follows:

1. The house rat, *R. rattus*, has been progressively supplanted by the fiercer, outdoor-living, brown rat, *R. norvegicus*.

2. There has been considerable progress in environmental sanitation, housing, and town planning.

TABLE II. TOTAL NUMBER OF RATS CAPTURED AND FLEAS REMOVED IN ALEXANDRIA, 1937-45, AND AVERAGE NUMBER OF FLEAS PER RAT

Year	Alexandria city										Alexandria port									
	rats					fleas					rats					fleas				
	total number captured	percentage of total captured			number removed	average number per rat	total number captured	percentage of total captured			number removed	average number per rat	total number captured	percentage of total captured			number removed	average number per rat		
		<i>R. norvegicus</i>	<i>R. rattus</i>	<i>Acomys cahirinus</i>				<i>Leptopsylla muscui</i>	<i>Xenopsylla cheopis</i>	<i>R. norvegicus</i>				<i>R. rattus</i>	<i>Acomys cahirinus</i>	<i>Leptopsylla muscui</i>			<i>Xenopsylla cheopis</i>	<i>R. norvegicus</i>
1937*	4 999	96.1	2.3	1.5	945	3 804	0.2	0.8			1 314	6.4	92.5	1.5	3 409	7 749	2.6	5.9		
1938*	4 375	95.6	2.4	2.0	1 001	2 534	0.2	0.6			488	13.5	86.3	0.2	954	1 240	1.9	2.5		
1939*	5 543	93.3	4.4	2.3	1 246	4 458	0.2	0.8			652	11.0	88.5	0.5	1 168	3 792	1.8	5.8		
1940	4 170	84.4	13.8	1.8	3 695	23 944	0.9	5.8			721	20.8	78.9	0.3	590	722	0.8	1.0		
1941	1 626	65.0	33.7	1.3	2 389	3 223	1.5	2.0			577	24.1	75.7	0.2	253	967	0.4	1.7		
1942	2 354	73.3	23.5	3.2	3 536	9 748	1.5	4.1			522	24.7	75.1	0.2	639	1 249	1.2	2.4		
1943	1 309	64.3	34.5	1.2	1 015	1 450	0.8	1.1												
1944	1 024	55.2	43.4	1.5	691	1 046	0.7	1.0												
1945	7 457	78.3	18.1	3.7	3 539	11 557	0.5	1.6												

* The figures shown in respect of the years 1937-39 are combined figures for the city and the ports

3. The quarantine health services have been greatly developed, and there has been greatly increased international co-operation in fulfilling sanitary agreements, particularly against the epidemic diseases.

4. In Europe and America the flea *X. cheopis* has been supplanted by *C. fasciatus*.

5. There has been a steady natural decrease in the flea infestation of rats.

It may be pertinent to add here some of the factors which may have been partly responsible for the immunity of Cairo during the third pandemic; these are:

(a) the relative scarcity of *R. rattus* and the predominance of *Acomys cahirinus*, which carries few or no fleas;

(b) the comparatively low number of rats in the city, which may to some extent be due to the presence of great numbers of weasels (*Mustela africana*);

(c) the very general use of stone for building.

Control of Rats in River Craft

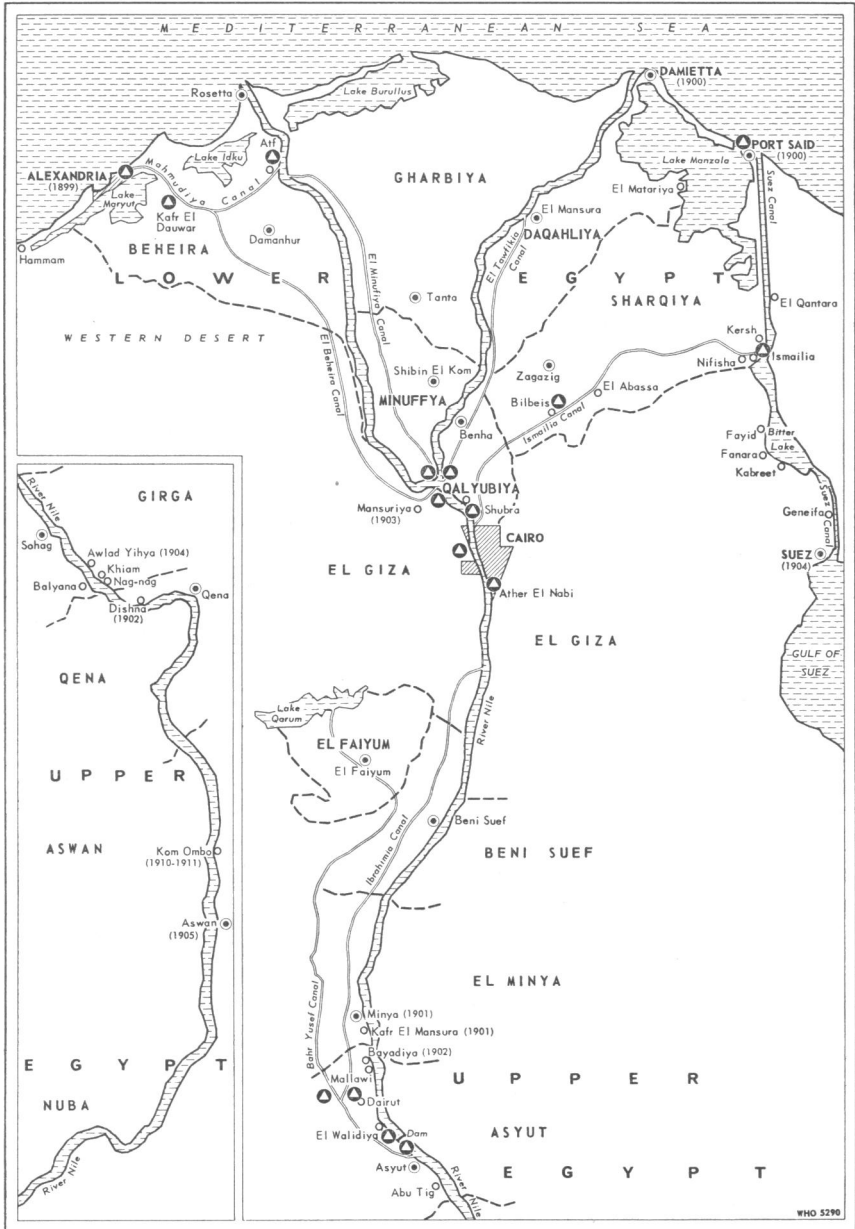
In 1941, as Director of the Epidemic Section of the Ministry of Public Health, I was responsible for the introduction of a scheme for the control of rats in river craft in order to protect the country against the spread of plague from the Suez Canal Zone. Fifteen rat-control stations were set up near canal locks, at the principal dams and bridges on the Nile, and alongside canals connected with the ports (see Fig. 3). These stations were provided with the necessary equipment for trapping or poisoning rats on board craft using these waterways, and the results achieved during 1941 were so encouraging that it was decided to apply the scheme on a wider scale. A draft law was prepared requiring the owners of all river craft to rid their vessels of rats by trapping; in view of the emergency, this law was promulgated in 1942 in the form of a military order, and it was passed as an Act of Parliament soon after the Second World War.

The owners of river craft co-operated heartily in this campaign, particularly since it was designed to exterminate a pest which gnawed at their vessels and attempted to eat the little amount of food they kept on board.

During 1943 a total of some 100 000 rats were trapped and approximately 5000 poisoned rats were collected from a small number of craft which put up at the rat-control stations. Nearly a million poisoned baits had been placed in these vessels.

From the introduction of this scheme early in 1941 until 1945 not a single case of plague was reported inland. The scheme may therefore be said to have stood the particularly rigorous test to which it was subjected by the unprecedented severity of plague in the Canal Zone and the great volume of river traffic, particularly military vessels.

FIG. 3. PLAGUE AREA OF EGYPT, 1899-1951



▲ Station for control of rats in river craft

Dates of the first recorded cases of plague in the third pandemic are indicated in parentheses for various localities.

DDT PERIOD (1945-51)

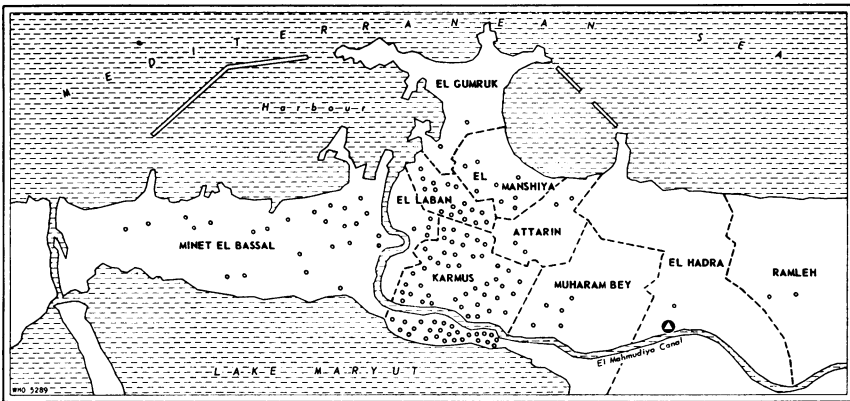
The plague epidemic that had raged in the Suez Canal Zone since 1941 ceased in 1945 except in Port Said, Suez, and Ismailia, where a mild flare-up in 1946 resulted in 15, 24, and 32 sporadic cases, respectively. Since then plague has disappeared from the Canal Zone.

The Alexandria Epidemic, 1946-47

In Alexandria, a British soldier residing in the Minet El Bassal quarter contracted plague on 11 January 1946; this was the first case in that city since 1936. On 19 February a second case was notified in a workman living in the Karmus quarter; on 18, 21, and 23 February four more cases occurred south of the El Mahmudiya Canal in the same quarter, and another in Minet el Bassal. As the number of cases grew, they were seen to be dispersed throughout the town with a certain concentration in the Karmus, Minet El Bassal, and El Laban quarters (see Fig. 4). The epidemic reached its peak in June, one month earlier than is usual, and then gradually waned, ceasing in the week ending 9 September. The total number of cases in 1946 was 124 with 34 deaths—a case-fatality of 27%, which compares favourably with the average of 54% in previous epidemics. This reduction in the fatality rate is attributed to the introduction of treatment with the sulfo-namides.

In July 1946, six cases occurred in the village of Hammam, some 100 kilometres west of Alexandria on the railway line to Marsa Matruh in the Western Desert. No cases have been reported there since then. The source

FIG. 4. DISTRIBUTION OF PLAGUE CASES IN ALEXANDRIA, 1946-47



- Cases of plague
- Station for control of rats in river craft

of infection was traced to an Alexandria flour mill which supplied Hammam and in the neighbourhood of which several cases of plague had occurred.

In 1947, plague reappeared sporadically in Alexandria, a total of 15 cases with five deaths being reported. From then until 1953 no further cases occurred.

Predisposing factors

Although almost all epidemics in Alexandria since 1899 began in El Manshiya and El Laban quarters, that of 1946-47 started in Minet El Bassal and Karmus quarters, which are situated on opposite sides of the El Mahmudiya Canal. Epidemiological investigations showed this change to be due to the fact that the port area adjoining Minet El Bassal, which had previously been used only for export, was being used intensively by the British military authorities for the import of goods, which were then stored in warehouses and stores in these two quarters. On account of the shortage of storage space, sacks of wheat awaiting milling were also stacked in the town at various places on both sides of the El Mahmudiya Canal.

At the same time piles of rubble and debris resulting from air raids in the quarters bordering the harbour gave shelter to great numbers of rats. Moreover, the fact that most buildings in the slum areas were directly connected with very old sewers without intermediary traps or flushing appliances gave sewer-rats free access to those houses. It should be noted in passing that a plan for the repair and improvement of the whole sewage disposal system was put into operation shortly after the Second World War and is still in progress.

Rats and rat fleas

Statistical analysis of rats captured in Alexandria since the beginning of the Second World War shows that there appears to have been a change in the ratios of different species of rats from those before the war. Thus, while before the war, about 95% of rats captured in the town proper were *R. norvegicus*, with some 2% of the house rat, *R. rattus*, in 1944 *R. norvegicus* made up 55.2% and *R. rattus* 43.4%. A contrary reversal took place in the port area. *R. rattus* made up about 93% of the rat population and *R. norvegicus* about 6% in 1940, while in 1945 *R. norvegicus* had increased to 24.7% and *R. rattus* had decreased to 75.1% (see Table II, page 36).

A sudden acute rise in the flea count also occurred at the beginning of the Second World War. Whereas, for the whole of Alexandria, the monthly flea index for November and December 1938 had been 0.8 and 0.7 respectively, the corresponding figures for November and December 1939 were 1.8 and 3.7. In the town proper the annual flea index rose to 6.6, 3.5, and 5.6 in 1940, 1941, and 1942 respectively, from 0.9, 0.8, and 1.0 in 1937, 1938, and 1939, respectively (see Table III). In the port

TABLE III. FLEA INDICES FOR ALEXANDRIA CITY AND PORT, 1937-51

Year	City			Port		
	total number of rats captured	total number of fleas removed	flea index	total number of rats captured	total number of fleas removed	flea index
1937*	4 999	4 749	0.9			
1938*	4 375	3 535	0.8			
1939*	5 543	5 704	1.0			
1940	4 170	27 689	6.6	1 317	11 158	8.5
1941	1 626	5 612	3.5	488	2 194	4.5
1942	2 354	13 284	5.6	652	4 960	7.6
1943	1 309	2 465	1.9	721	1 312	1.8
1944	1 024	1 737	1.7	577	1 220	2.1
1945	7 457	15 096	2.0	522	1 888	3.6
1946	20 926	15 693	0.8	3 056	4 419	1.5
1947	29 449	5 608	0.2	6 025	2 246	0.4
1948	29 405	1 699	0.1	5 373	629	0.1
1949	28 953	1 800	0.1	6 474	465	0.1
1950	26 913	1 417	0.1	8 371	265	0.0
1951**	30 741	3 182	0.1	5 716	348	0.1

* The figures shown in respect of the years 1937-39 are combined figures for the city and the port.

** Up to the end of October 1951

area the annual flea index was as high as 8.5, 4.5, and 7.6 in 1940, 1941, and 1942, respectively.

It should be noted that this rise in the flea count was particularly noticeable for the rat *Acomys cahirinus*, which usually harbours very few fleas. The average count for this species suddenly rose to 14.3 fleas per rat in November and 20.5 in December 1939 and continued at levels higher than those before the war until September 1940, when it reverted to zero, its normal level, at which it has continued ever since.

The sharp rise in the flea counts in Alexandria after November 1939, which came to my notice in 1946 as I reviewed the statistical data on rats and rat fleas, had apparently remained unnoticed until then, as there had been no human plague. The rise itself and the changed relative number of rats were largely due to a high mortality among rats, which, in view of the concomitant heavy flea infestation of *Acomys cahirinus*, was probably caused by some such epizootic disease as rat typhoid rather than plague.

Alexandria rat-control scheme

Trapping and poisoning. In 1946 the number of traps in Alexandria was increased from 2500 to 4000 so as to provide at least one trap for every 250 persons. Trapping was carried out by 30 gangs, each consisting of one overseer and two men, who began operations in the non-infected areas and followed in the trail of the rat-poisoning gangs to the infected localities. Altogether 20 926 rats were trapped in Alexandria in 1946 as against 7457 in 1945.

Poisoning was carried out by 30 gangs of one overseer and three men using altogether 300 bait-boxes. The poison used was white squill, and the baits were tested daily, before distribution, on captured rats. The poisoning was arranged to cover the whole town three times a year. Some 30 000 baits were distributed every day, with a minimum of 20 baits per building.

The following three compositions of bait were used :

<i>Flour bait</i>	<i>Tallow bait</i>	<i>Herring bait</i>
60 g white squill	60 g white squill	60 g white squill
240 g flour	180 g flour	180 g flour
25 g sugar	60 g tallow	60 g herring
	0.5 g salt	

In each case the ingredients should be well mixed with a sufficient quantity of water and divided into 300 baits.

During the campaign, 28% of the flour baits distributed disappeared, 71% of the tallow baits, and 51% of the herring baits, clearly showing the greater effectiveness of the tallow baits. It was, moreover, observed that the addition of tallow kept the bait wet for more than seven days; it was therefore used on a large scale, since it meant a considerable saving of time and labour over the flour bait, which had to be changed daily.

Rat-control of river craft

In 1941 three rat-control stations had been set up on the El Mahmudiya Canal near bridge-locks outside the town in order to prevent the spread of plague inland. As the risk of spread increased in 1946 it became necessary to take additional precautions, and it was decided to fumigate with sulfur gas every craft leaving Alexandria. Seven Clayton gas apparatuses were used, and about 25 craft were fumigated daily. No river craft was allowed to leave Alexandria without producing a fumigation certificate.

Use of DDT

DDT was first used for the control of plague in Egypt in 1946, when it was applied in Alexandria, Suez, Port Said, and the village of Hammam, the only remaining foci. It had also been used earlier in the year when the

whole population of the country was dusted as part of a campaign against an epidemic of relapsing fever which swept Egypt during the spring. The disinfection of houses was, and continues to be, of the utmost importance to the population, who are much troubled by flea bites. In order to ensure the fullest co-operation, the general delousing programme with DDT against relapsing fever, and later against typhus, was carried out in such a way that rodents were disinfested of fleas at the same time as the people were deloused. The inhabitants of each house were dusted in batches with DDT, each batch in a different room, so that the powder falling to the ground during the delousing process would be dispersed throughout the house.

The scheme for the use of DDT against plague in Alexandria was carried out by 30 gangs of one overseer and 10 workmen, each gang being responsible for :

- (a) dusting infected houses with 5% DDT solution,
- (b) dusting the inhabitants of infected areas and their bedding with 10% DDT powder,
- (c) dusting rat-burrows in the infected areas with 10% DDT powder before filling in the holes, and

TABLE V. MONTHLY AVERAGE NUMBER OF FLEAS PER RAT IN ALEXANDRIA CITY AND PORT, 1946-51

Month	1946		1947		1948		1949		1950		1951 *	
	city	port	city	port	city	port	city	port	city	port	city	port
January	2.4	4.1	0.2	0.7	0.1	0.4	0.1	0.3	0.1	0.0	0.1	0.0
February	2.3	2.0	0.4	0.6	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0
March	2.2	3.7	0.3	0.3	0.1	0.1	0.2	0.2	0.1	0.0	0.1	0.0
April	1.3	2.5	0.1	0.4	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0
May	0.9	2.6	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1
June	0.8	3.8	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
July	0.7	2.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
August	0.4	1.5	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2
September	0.1	0.6	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
October	0.1	0.5	0.4	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0
November	0.2	0.7	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	—	—
December	0.1	0.4	0.1	0.1	0.0	0.1	0.1	0.2	0.2	0.0	—	—
Total	0.7	1.4	0.2	0.4	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1

* Figures are not available for November and December 1951

TABLE VI. MONTHLY AVERAGE NUMBER OF FLEAS PER RAT IN SUEZ TOWN AND PORT (PORT TEWFIK), 1946-49 AND 1951

Month	1946		1947		1948		1949		1951 *	
	town	port	town	port	town	port	town	port	town	port
January	1.8	1.6	0.7	0.7	1.0	0.2	0	0	0	0
February	1.4	1.6	0.6	1.4	0.9	0.2	0	0	0	0
March	0.9	0.8	0.6	0.4	1.2	0.6	0	0	0.5	0
April	0.6	0.7	1.2	1.1	0.9	0.4	0	0	0.3	0
May	1.0	1.5	2.4	0.2	1.9	0	0	0	0	0
June	1.6	1.3	1.2	0	0.3	0	0	0.1	0	0
July	1.2	0	1.1	0.1	0.0	0	0	0	1.6	0
August	0.9	1.3	0.1	0.1	0.2	0.2	0.3	0	3.1	0
September	0.6	0.6	0	0	0.5	0	2.6	0	1.9	0
October	0.9	0.5	0	0	1.1	0.2	0.2	0	1.8	0
November	0.6	0.3	1.2	0.7	0.7	0.1	0.7	1.0	1.6	0
December	0.4	0.2	0.1	0.0	1.0	0	0.1	0	—	—
Total	0.9	1.0	0.9	0.3	0.6	0.2	0.2	0.0	1.2	0

* Figures are not available for December 1951.

(d) ensuring the general cleanliness of houses outside the infected areas, in accordance with the existing sanitary regulations.

In order to obtain the best results in the shortest possible time, 20 of these gangs were detailed to disinfest the slum areas of fleas and to delouse the inhabitants with DDT in the manner provided for in the regulations governing the control of relapsing fever.

It will be seen from the accompanying tables that the slow natural decrease in the flea counts up to 1946 has since that date accelerated sharply. At the same time, the general prevalence of plague in the country had been lessening, and by 1947 the disease had vanished from the ports, its last stronghold. Table III (page 41) reflects that trend in the flea indices for Alexandria from 1937 to 1951. Table IV shows the monthly flea count for the period 1937-39 according to the species of rat and of flea in Alexandria for comparison with the corresponding figures for the post-DDT years 1946-51 in Table V. Table VI shows similar figures for the town of Suez and its port (Port Tewfik). Table VII gives the number of rats caught monthly in Cairo from 1947 to 1951 and the remarkably low flea count for 1951, giving a flea index of 0.00.

TABLE VII. NUMBER OF RATS CAPTURED MONTHLY IN CAIRO, 1947-51, AND NUMBER OF RAT FLEAS COUNTED IN 1951

Month	1947	1948	1949	1950	1951	
					rats	fleas
January *	2 971	2 716	2 939	2 418	2 634	--
February *	2 544	2 748	2 492	2 545	2 293	—
March	3 455	2 808	2 532	2 676	2 408	0
April	2 680	2 555	2 569	2 638	2 315	1
May	2 771	2 423	2 519	2 709	2 937	2
June	2 797	2 473	2 613	2 287	2 655	0
July	2 444	2 665	2 802	2 348	2 516	0
August	2 288	2 419	2 470	2 325	2 939	0
September	2 687	2 598	2 527	2 263	2 832	0
October	2 809	2 601	2 592	2 142	2 847	0
November	3 069	2 752	2 470	2 289	2 280	0
December	2 659	2 814	2 475	2 116	—	—
Total	20 203	31 582	30 950	28 756	28 656	3

* No flea count was done until March 1951.

In view of the results obtained with DDT, the public health authorities drew up a plan for its use in preventing any further outbreaks of relapsing fever or typhus, which had been very prevalent during the Second World War, by dusting the entire population with DDT three times a year. This was begun in 1946 and continued, with some interruptions due to shortage of DDT, until 1950, when the plan was revised. For a number of reasons, including the fact that some insects were beginning to show signs of resistance to DDT, it was then decided that the general delousing of the population should be carried out only once each year, but that any village or part of a village or town might be given a general dusting if circumstances required.

Since July 1950, owing to the shortage of DDT consequent upon the outbreak of hostilities in Korea, Gammexane has been used as well.

The explanation of the great drop in the number of rat fleas since 1946, concomitantly with the generous application of DDT against relapsing fever and typhus, is that rat fleas and their larvae lying outside rat-holes on the floors of rooms are directly affected by the DDT dust settling on the floors, while those inside the burrows are affected by the dust brought in by rats from outside, or by the direct dusting of burrows such as was carried out in 1946-47.

CONCLUSION

When the natural decrease in the flea count was noticed in 1945 the question was asked whether it would continue to the point at which plague epidemics would no longer occur. Whatever results natural processes alone might have produced, that point now seems attainable by the use of DDT.

In order to consolidate the advance made with the help of that insecticide, I was responsible, as Minister of Public Health, for the passing of regulations in 1950 providing that DDT was to be periodically dusted in all rats-burrows and on walls and floors of all stores and warehouses in port areas. From Table VI (page 45) it will be seen that there was a considerable rise in the average number of fleas per rat in the town of Suez in 1951, although not in Port Tewfik. Inquiries revealed that this rise had occurred in the El Arbeen quarter, a slum area noted for the severity of its plague epidemics. It was soon disinfested by the application of the regulations concerning port areas.

Eight years^a have passed since the last case of plague was notified in Egypt, and it may now be stated with confidence that this ancient scourge has been eradicated from the country. The experience gained during the 50 years that were needed to achieve this gives hope that plague may one day be made to disappear from the face of the earth.

RÉSUMÉ

Cet article est consacré à l'épidémiologie de la peste en Egypte, de 1899 à 1951, c'est-à-dire depuis sa réapparition dans le pays, après un demi-siècle d'absence. La troisième pandémie, venant de Chine en passant par Hong-Kong, l'Inde et Djeddah atteignit Alexandrie en 1899, puis Port Saïd en 1900. En 1905, elle parvint à Assouan, puis se répandit dans l'ensemble du pays. Au début de la pandémie, les villages riverains du Nil ou des canaux furent atteints les premiers, ce qui indique le rôle joué par les embarcations fluviales dans la dissémination de l'infection. A partir de 1925, la maladie faiblit. La peste disparut de Suez en 1930, de Port Saïd en 1932 et d'Alexandrie en 1936. Toute la Basse-Egypte était indemne en 1939.

Dans la partie sud du pays, la maladie reparut périodiquement jusqu'en 1941. Dès lors et sans doute à la suite de la campagne de dératisation entreprise cette année-là, la peste disparut de l'intérieur du pays jusqu'en 1946. Cette période de cinq ans est la première depuis 1899 durant laquelle la peste ne fut pas signalée dans l'intérieur du pays.

La bénignité de la troisième pandémie peut être attribuée à diverses causes : le remplacement progressif de *Rattus rattus*, espèce domestique active dans la transmission de la peste à l'homme, par *R. norvegicus*, fréquentant moins les maisons ; l'amélioration des conditions de salubrité, l'assainissement des habitations et la construction en pierre ; l'application plus stricte des mesures de quarantaine ; l'infestation moindre des rats par les puces ; la destruction d'une certaine proportion des rats urbains par les furets (*Mustela africanus*).

^a Up to the time of going to press, no new cases have been notified.

En 1941, fut élaboré un programme de dératisation des embarcations fluviales, afin de protéger le pays contre l'infection provenant de la zone du Canal de Suez où divers foyers de peste étaient réapparus. En 1943, quelque 100 000 rats furent capturés par piégeage et des milliers empoisonnés. De 1941-45, aucun cas de peste ne fut signalé à l'intérieur du pays, ce qui prouve l'efficacité des mesures prises.

L'auteur analyse ensuite les conditions qui accompagnèrent l'épidémie qui sévit à Alexandrie en 1946-47 (15 cas avec 5 décès en 1947).

En 1946, le DDT a été utilisé pour la première fois dans la lutte antipesteuse en Egypte, à Alexandrie, Suez, Port Saïd, Hamman, c'est-à-dire dans les seuls foyers pesteux qui subsistaient. La même année, la population entière du pays avait été soumise à des poudrages de DDT, dans le cadre d'une campagne contre la fièvre récurrente.

La diminution naturelle lente du nombre des puces s'est brusquement accentuée depuis 1946. Parallèlement, la fréquence générale de la peste dans le pays a diminué et, en 1947, la peste avait disparu des ports, ses derniers retranchements. Les résultats obtenus avec le DDT engagèrent les autorités à élaborer un plan de lutte contre le typhus et la fièvre récurrente, en soumettant la population à des poudrages de DDT trois fois par an. Pour diverses raisons, en particulier l'apparition d'une résistance au DDT chez certains insectes, les poudrages furent limités à un par an, sauf circonstances particulières exigeant une intervention immédiate.

Afin de consolider les résultats obtenus, un règlement fut promulgué rendant obligatoire le traitement périodique au DDT des terriers de rats, des planchers et parois des magasins et entrepôts des zones portuaires. Plus de neuf ans ont passé sans qu'un seul cas de peste ait été signalé en Egypte et l'on peut considérer la maladie comme ayant disparu du pays.

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