

THE FLEAS FOUND ON RATS AND OTHER  
RODENTS, LIVING IN ASSOCIATION WITH  
MAN, AND TRAPPED IN THE TOWNS, VIL-  
LAGES AND NILE BOATS OF UPPER EGYPT.

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*Description of Methods of Collection.*

THE collections of fleas described in this paper were made during an enquiry into the plague conditions of Upper Egypt, carried out in 1912 and 1913 on behalf of the Egyptian Government. With few exceptions the fleas were taken from rats or other rodents trapped either in the native houses or in the Nile boats (native river craft), which were infested with rats.

The method of trapping was as follows: The trap used was the ordinary wire cage trap with two compartments separated by a partition into which fits a hinged platform with counterweight permitting ingress of the rats, but preventing their escape. The traps containing catches, before being brought from the houses to the laboratory, were enclosed in a black cloth bag to lessen the risk of fleas escaping. At the laboratory the bags were removed and the traps were placed in suitable boxes on the bottom of which were removable metal trays covered with white wax-cloth. Chloroform was poured into the boxes in order to kill the rats and fleas. A considerable number of the fleas were found to have dropped from the rats on to the white cloth, and thus could be easily seen and collected. The chloroformed rats were thoroughly searched for fleas upon a table covered with white cloth.

The most extensive collection in the series is that from Assiut (245 miles south of Cairo), for the reason that in this town trapping operations were carried out continuously during two years. With the idea that the flea population might show seasonal variations as regards species or proportions of species, collections of consecutive periods of two or three months were kept separate, and samples from each lot have been examined, without, however, revealing any seasonal difference.

*Comments on the Localities from which the Fleas were collected.*

The localities represented extend from Cairo to Komombo, an agricultural estate 460 miles south of Cairo, and 26 miles north of Assuan, and are indicated upon the sketch map in the text (p. 500).

With the exception of Cairo and Komombo the towns and villages from which fleas were collected may be regarded as typical for Upper Egypt in respect of the housing conditions. Most of the houses in an Upper Egyptian town or village are constructed of burnt bricks held together chiefly with clay (Nile mud), in which, when dry, rats make their burrows. The earth foundations of the walls are also riddled with rat burrows. As a result rodents infesting houses are in close association with the human inhabitants and with their domestic animals, *e.g.*, dogs, cats and fowls.

The conditions in the quarters in Cairo which yielded the fleas in our collections differ from the above description. The quarters trapped were the Mousky—the native bazaar quarter in the centre of the city, and Boulac, a quarter adjacent to the Nile and opposite to the island of Ghezireh. The houses in these quarters and in Cairo generally are more substantial than those in Upper Egypt, many of them being built of limestone from the neighbouring hills.

From the standpoint of rodent and flea infestation Komombo is of considerable interest. The Komombo estate is a cultivated area of 20,000 feddans (acres), scattered over which are a number (29) of small hamlets each with an average population of about 500 persons. The houses are built, some of stone, others simply of dried mud. The whole estate is of very recent origin, having been developed by means of irrigation from purely desert land only some ten or twelve years ago. *Arvicanthis niloticus* and *Mus norvegicus* are found in the houses and in the fields, but *Mus rattus* and *Acomys cahirinus* have not been met with.



The Nile sailing boats (feluccas) are built with inner and outer planking bolted to the cross-ribs, thus providing a hollow space in which the rats live. These boats carry cargo—grain, coal, etc.—but also passengers, and ply up and down the Nile from Rosetta and Damietta to Assuan. The rodent infestation on board consists chiefly of *Mus norvegicus*, differing in this respect from the rodent population ashore (Komombo excepted), where this species is, in our experience, a rare inhabitant of houses.

Meteorological data for Cairo, Assiut and Assuan are appended.

TABLE I<sup>1</sup>.

*Mean monthly meteorological observations recorded at 8 a.m., 2 p.m. and 8 p.m. at Gizeh (Cairo), for the years 1902–10, Assiut 1900–1910 and Assuan 1901–1910.*

	Mean temperature Centigrade.											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Gizeh near Cairo	10·8	12·3	14·7	19·1	23·1	25·4	26·7	26·5	24·4	21·7	17·0	12·6
Assiut	11·2	13·1	16·6	21·8	26·2	28·8	29·3	29·0	26·2	23·4	17·7	13·7
Assuan	14·5	17·1	20·3	25·4	29·5	32·0	32·6	32·2	30·3	27·4	21·2	16·3
	Relative humidity (Saturation 100).											
Gizeh near Cairo	80	72	68	60	56	57	62	67	71	75	78	82
Assiut	69	63	55	43	37	36	40	45	57	62	66	66
Assuan	52	45	40	34	36	34	30	30	35	38	45	49

*Determination of the Species.*

In the case of small collections every individual flea in the tube was separately examined under a compound microscope, but of the large collections, comprising from 2000 to 10,000 fleas in a single tube, a sample only was examined. These samples consisted of at least 500, and in some instances of 1000 to 2000 specimens, each of which was identified. The number of specimens noted in the Tables as examined must not be taken as affording any guide to the relative numbers captured on the various individual hosts mentioned, nor as evidence of a seasonal or geographical prevalence. The statistics relating to

<sup>1</sup> In tabulating our results we have followed on the lines laid down by Chick and Martin (1911), the present paper forming an addendum to their work and filling the gap caused by the fact that there were no figures relating to Egyptian fleas available at the time they wrote.

this side of the research are in course of arrangement and will be published later.

We take this opportunity of recording our thanks to Dr Harriette Chick for assistance with the earlier consignments, and to the Hon. N. Charles Rothschild for his kindness in checking some of our determinations of species, especially in regard to *Xenopsylla chephrenis* and *X. cleopatrae*.

*Notes on the Species represented in the Collections.*

*Xenopsylla cheopis*, as was to be expected, makes up by far the greatest bulk of the collections as a whole. When the animals from which the fleas were taken were trapped on land the percentage of this species normally present varies from 90 % to 100 %.

The few exceptions to this general rule are afforded by such hosts as *Gerbillus pyramidum*, a specimen caught wild, yielding a high percentage of *Xenopsylla cleopatrae*, a species of hedgehog which showed a distinct preponderance of *Ctenocephalus felis*, a weasel carrying *Echidnophaga gallinaceus* and *Acomys cahirinus* from Cairo, which had a marked infestation of *Xenopsylla chephrenis*. On hosts trapped in the Nile boats the relative numbers of *X. cheopis* declined, their place being occupied by *Leptopsylla musculi*.

*Leptopsylla musculi*. It is remarkable how dependent the occurrence of this species in the collection is upon the trapping of rodents from the Nile boats (feluccas) during the cooler season of the year.

The percentage captured upon animals in dwellings is infinitesimal, whereas in the collections from feluccas it sometimes exceeds that of *X. cheopis*, rising in one instance to 85 %.

It is no easy matter to disentangle and assess correctly the various factors which may contribute to this result. As already pointed out in our remarks on localities, *M. norvegicus* is the dominant rodent on the Nile boats.

Further, from a considerable mass of data relating to the rat and rat flea infestation of Lower Egypt collected by Professor Bitter<sup>1</sup> and Dr Charles Todd of the Hygienic Institute in Cairo, it would appear that *M. norvegicus* occurs much more commonly as a house-rat in Lower Egypt than in Upper Egypt, and also that *L. musculi* is a much more

<sup>1</sup> We desire to acknowledge the courtesy of Professor Bitter and Dr Charles Todd in permitting us the privilege of becoming acquainted with their observations.

TABLE II.  
Showing species of Fleas found on various Hosts trapped in Houses.

Locality			Date of Collection	Species of Animal	Number of specimens examined	Percentage of each species of Flea									
Town or Village	District (Markaz)	Province (Madina)				<i>Pulex irritans</i>	<i>Echidnophaga gallicornis</i>	<i>Xenopsylla cheopis</i>	<i>Ceratophyllus fasciatus</i>	<i>Ctenocephalus felis</i>	<i>Lepto-psilla musciti</i>				
Cairo			Nov. 1913	<i>Mus rattus</i>	208	—	—	91.8	8.1	—	—	—	—	—	—
			Nov. 1913	<i>Acomys cahirinus</i>	212	—	—	3.3	96.2	—	—	—	—	—	—
			May-Aug. 1913	Weasel	45	—	—	—	—	—	—	—	—	—	—
Kafr-el-Mansura	Minia		Dec. 1911	<i>Mus rattus</i>	114	—	—	99.1	—	—	—	—	—	—	—
El Hassalba	Deirout	Assiut	Sept. 1913	<i>Mus rattus</i>	540	—	—	100	—	—	—	—	—	—	—
				<i>Mus norvegicus</i>	89	—	—	94.3	—	—	—	—	—	—	—
Abnoub	Abnoub	Assiut	Jan. 1912	<i>Mus rattus</i>	1058	0.7	—	98.9	—	—	—	—	—	—	—
				<i>Mus norvegicus</i>	1	—	—	1 flea only	—	—	—	—	—	—	—
Assiut	Assiut	Assiut	Dec. 1911 to Jan. 1913	<i>Mus rattus</i>	13,131	0.35	—	98.95	—	—	—	—	—	—	0.68
				<i>Mus norvegicus</i>	2664	0.37	—	97.94	—	—	—	—	—	—	1.50
				<i>Acomys cahirinus</i>	5839	0.47	—	98.25	0.74	—	—	—	—	—	0.52
				<i>Arvicanthus niloticus</i>	2060	0.09	—	98.8	—	—	—	—	—	—	0.04
				<i>Crocidura olivieri</i>	5	—	—	(5)	—	—	—	—	—	—	—
El Filia	Aboutig	Assiut	July, Aug. 1913	<i>Mus rattus</i>	623	—	—	100	—	—	—	—	—	—	—
				<i>Acomys cahirinus</i>	196	—	—	100	—	—	—	—	—	—	—
Edfa and Kelfaw	Sohag	Girga	July 1912	<i>Mus rattus</i>	185	—	—	100	—	—	—	—	—	—	—
				<i>Acomys cahirinus</i>	125	—	—	100	—	—	—	—	—	—	—
				<i>Arvicanthus niloticus</i>	32	—	—	96.8	—	—	—	—	—	—	—
				<i>Crocidura olivieri</i>	11	—	—	100	—	—	—	—	—	—	—
Kous and neighbouring villages	Kous	Kena	April to June 1912	<i>Mus rattus</i>	845	0.1	—	99.8	—	—	—	—	—	—	—
				<i>Mus norvegicus</i>	325	—	—	100	—	—	—	—	—	—	—
				<i>Acomys cahirinus</i>	424	0.9	—	99	—	—	—	—	—	—	—
				<i>Arvicanthus niloticus</i>	738	0.4	—	99.5	—	—	—	—	—	—	—
Komombo	Assuan	Assuan	Nov. 1911 to Feb. 1912	<i>Mus norvegicus</i>	932	—	—	99.9	—	—	—	—	—	—	0.1
				<i>Arvicanthus niloticus</i>	1754	—	—	99.9	—	—	—	—	—	—	0.05
				<i>Gerbillus pyramidum</i>	14	—	—	100	—	—	—	—	—	—	—
				Mouse	12	8	—	91.6	—	—	—	—	—	—	—

The number in brackets records the actual specimens and is not a percentage.

TABLE III.

Showing the number and species of Fleas taken from Rodents trapped on Feluccas (Nile boats) at Abnoub, Assiut and Komombo.

Locality	District (Markaz)	Provinces (Mudiriya)	Date of Collection	Species of Animal	Number of specimens examined	Percentage or number of each species of Flea								
						<i>Pulex irritans</i>	<i>Echinophaga gallinacea</i>	<i>Xenopsylla cheopis</i>	<i>Xenopsylla chephrenis</i>	<i>Xenopsylla cleopatrae</i>	<i>Ceratophyllus fasciatus</i>	<i>Ctenocephalus felis</i>	<i>Leptopsylla muscui</i>	
Abnoub	Assiut	Assiut	Jan. 1912	<i>Mus norvegicus</i> and <i>rattus</i>	32	3.1	—	56.2	—	—	—	—	6.2	34.3
				<i>Acomys cahirinus</i>	5	(1)	—	—	—	—	—	—	—	—
Assiut	Assiut	Assiut	Feb. 1912 to Jan. 1913	<i>Mus rattus</i>	585	0.8	—	69.2	—	—	—	—	0.1	29.9
				<i>Mus norvegicus</i>	3261	0.1	0.1	49.3	0.03	—	—	0.06	—	0.1
Komombo	Assuan	Assuan	Nov. 1911	<i>Acomys cahirinus</i>	79	3.7	—	78.4	—	—	—	—	—	17.7
				<i>Mus rattus</i>	143	—	1.4	97.9	—	—	—	—	0.7	—
				<i>Mus norvegicus</i>	478	—	—	98.7	—	—	—	—	—	1.2

Numbers in brackets record the actual specimens, not percentages.

TABLE IV.

Showing that *Leptopsylla muscui* is relatively more numerous than *Xenopsylla cheopis* during the cooler months of the year.

Fleas taken on Rodents trapped on Feluccas (Nile boats) at Assiut.

Date of Collection	Species of Animal	Number of specimens examined	Percentage of each species of Flea							
			<i>Pulex irritans</i>	<i>Echinophaga gallinacea</i>	<i>Xenopsylla cheopis</i>	<i>Xenopsylla chephrenis</i>	<i>Ceratophyllus fasciatus</i>	<i>Ctenocephalus felis</i>	<i>Leptopsylla muscui</i>	
Feb., March 1912	<i>Mus rattus</i>	319	1.5	—	48.5	—	—	—	0.3	49.5
June, July, Aug. 1912	<i>Mus rattus</i>	206	—	—	99.5	—	—	—	—	0.4
Sept., Oct. Nov., Dec. 1912	<i>Mus rattus</i>	60	—	—	73.3	—	—	—	—	26.6
Feb., March 1912	<i>Mus norvegicus</i>	1458	0.1	0.06	13.4	0.06	—	0.06	0.2	85.9
April, May, June 1912	<i>Mus norvegicus</i>	536	0.1	0.1	74.8	—	—	0.1	—	24.6
July, Aug., Sept. 1912	<i>Mus norvegicus</i>	262	0.3	0.3	99.2	—	—	—	—	—
Oct., Nov., Dec., 1912	<i>Mus norvegicus</i>	902	—	0.1	79.7	—	—	—	0.1	20.0
Jan. 1913	<i>Mus norvegicus</i>	103	—	—	73.3	—	—	—	—	26.6
Feb., March 1912	<i>Acomys cahirinus</i>	32	(1)	—	(18)	—	—	—	—	(13)
April, May, June, 1912	<i>Acomys cahirinus</i>	34	(2)	—	(32)	—	—	—	—	(1)
July, August, Sept. 1912	<i>Acomys cahirinus</i>	3	—	—	(3)	—	—	—	—	—
Oct., Nov., Dec. 1912	<i>Acomys cahirinus</i>	10	—	—	(9)	—	—	—	—	(1)

TABLE V.  
Showing species of Fleas obtained from a variety of sources not included in the previous Tables.

Locality		Province (Markaz)	Date of Collection	Host or Source from which Fleas were obtained	Number of specimens examined	Percentage or number of each species of Flea								
Town or Village	District (Markaz)					<i>Pulex irritans</i>	<i>Echinopsylla gal-tinae</i>	<i>Xenopsylla cheopis</i>	<i>Xenopsylla cheppirens</i>	<i>Xenopsylla cleopatrae jasciatus</i>	<i>Ceratopsylla phippsii jasciatus</i>	<i>Ctenocephalitis felis</i>	<i>Leptopsylla muscaut</i>	
Assiut	Assiut	Assiut	May 1913	Dog	284	4-9	—	—	—	—	—	—	—	—
Assiut	Assiut	Assiut		Human host on clothing	538	100	—	—	—	—	—	—	—	—
Abnoub	Abnoub	Assiut	Jan. 1912	<i>Mus rattus</i> and mouse	4	—	—	(4)	—	—	—	—	—	—
Abnoub	Abnoub	Assiut	Jan. 1912	<i>Mus rattus</i> and <i>norvegicus</i>	431	0-6	—	93-7	—	—	—	—	—	5-5
Abnoub	Abnoub	Assiut	Jan. 1912	Clothes of plague patient	44	(43)	—	(1)	—	—	—	—	—	—
El Motiaa	Assiut	Assiut		Hedgehog	18	(1)	—	—	—	—	—	—	—	(17)
Kous	Kous	Kena	May 1912	Clothes of plague patient	1	(1)	—	—	—	—	—	—	—	—
Komombo	Assuan	Assuan	Nov. 1911	<i>Acomys</i> from Nile bank	14	—	—	(14)	—	—	—	—	—	—
Komombo	Assuan	Assuan	Feb. 1912	<i>Gerbillus pyramidum</i>	20	—	—	(2)	—	—	—	—	—	—
Komombo	Assuan	Assuan	Feb. 1912	Rats' nests in houses	121	—	—	100	—	—	—	—	—	—
Komombo	Assuan	Assuan	Feb., Mar. 1912	Plague infected houses	2821	—	—	100	—	—	—	—	—	—
Komombo	Assuan	Assuan	Feb. 1912	Clothes of rat catchers in infected houses	193	4	—	96	—	—	—	—	—	—
Komombo	Assuan	Assuan	Feb. 1912	Clothes of plague patients	15	(2)	—	(13)	—	—	—	—	—	—

Numbers in brackets record actual specimens, not percentages.

prevalent species of flea on house-rats in Lower Egypt than in Upper Egypt.

From these considerations it might be inferred that the occurrence of *L. musculi* and of *M. norvegicus* are inter-related, but on the other hand this view is not supported by any evidence that *L. musculi* favours *M. norvegicus* rather than *M. rattus*, whether the animals are trapped in feluccas in Upper Egypt or in the native dwellings of Lower Egypt.

The two most plausible solutions are either that *L. musculi* is a species mainly restricted to Lower Egypt and that the feluccas are infested from this source or that the conditions on the Nile boats are more favourable for it than those in the rat-nests on land in Upper Egypt.

It seems definite, however, that the land conditions in Upper Egypt are unfavourable to the continued existence of *L. musculi*, though whether because of a small mouse population, or owing to the climatic conditions or for some other reason, is not clear.

*Ceratophyllus* is represented in these collections by three specimens of *fasciatus*, all taken from *M. norvegicus* trapped on feluccas during the first half of the year. From these circumstances and the fact that the species is present in small numbers on rats captured in Lower Egypt, we again get a suggestion of importation from the North, but curiously it is *M. rattus* which carries the larger number of specimens according to the unpublished data we have been privileged to see.

*Xenopsylla cleopatrae* was found only on one occasion, the host being a *Gerbillus pyramidum* captured in February, 1912, at Komombo. This flea would appear to be in no way associated with the usual rodent population of inhabited districts.

*Xenopsylla chephrenis*. Of the 265 specimens of this flea found in these collections, by far the larger number (221) are from Cairo; the remainder (44 specimens) were captured at Assiut. Of these latter 43 were on *Acomys* trapped in houses and one from a *M. norvegicus*, caught on a Nile boat at that town. The distribution on the hosts of the species trapped at Cairo is also significant; 204 of the fleas being found on *Acomys*, the remaining 17 on *M. rattus*. See Table II.

*Ctenocephalus felis*. Of the genus *Ctenocephalus*, *Ct. felis* alone is present in these collections, and although the percentage is low in comparison with that of *Xenopsylla cheopis* or *Leptopsylla musculi*, the actual number of specimens is large enough to justify the expectation of finding *Ct. canis* also, if this species occurs in Egypt. Probably,

as in other tropical countries, *Ct. felis* does duty for both feline and canine animals in Upper Egypt.

*Echidnophaga gallinacea* is rare considering the probable chances of intercourse between rats and fowls.

*Pulex irritans*. In view of the close association obtaining between rats and man under the conditions in which a large section of the human population of Egypt live, the percentage of this species found on trapped rats must be considered as extremely small, especially as human infestation with *Pulex irritans* is sometimes very heavy (Table V).

SEX PROPORTIONS. The very marked discrepancy between the number of male and female specimens of *Xenopsylla chephrenis* caused us to keep a record of the sexes of other species in the tubes that had not previously been examined when this discrepancy was first noted. The results set forth in the following table show that some difference in the proportion of the sexes is also present in *X. cheopis*, although to a much slighter extent, the difference only amounting to 7 %.

TABLE VI.

*Proportion of sexes in fleas captured on Rats and other Rodents, and on Man.*

Species	Number examined	Males	Females	Excess
<i>Xenopsylla cheopis</i>	8498	3948 (46.5 %)	4550 (53.5 %)	602 (7 %)
<i>Xenopsylla chephrenis</i>	259	36 (13.9 %)	223 (86.1 %)	187 (72.2 %)
<i>Pulex irritans</i>	547	329 (60.1 %)	218 (39.9 %)	111 (20.2 %)

As the numbers dealt with in arriving at this conclusion are considerable, over 8000 specimens from 18 parcels collected either at different seasons or in separate localities, it is probably justifiable to suppose that this want of balance is general and implies some variation in the habits of the sexes. With regard to *X. chephrenis*, although the number of specimens is not large, the discrepancy is so striking that there seems no doubt that some deep-seated divergence in the habit of the sexes is indicated. The explanation we would suggest is that the males wait in the nest to fertilize the females as they emerge from their cocoons, while the instinct of the female is to attach herself more closely to the host and feed as continuously as possible, as by this procedure egg development will be more rapid, and the chances of founding new colonies when the young of the host scatter will be enhanced.

In the terms of such a theory the position of *X. cheopis* is either that of a species in which the ancestral habit (possibly originating in a desert habitat) is waning with its adaptation to semi-domesticated hosts, or, which seems a less plausible proposition, that *X. chephrenis* is developing to excess the ancestral habits of the group which are retained by *X. cheopis*.

In the case of *P. irritans* it is doubtful as to how far the excess of males is a chance phenomenon, as the numbers, which are not large, relate to two parcels only.

#### REFERENCE.

- CHICK, H., and MARTIN, C. J. (1911). The fleas common on rats in different parts of the world and the readiness with which they bite man. *Journ. of Hygiene*, XI. 122.