# THE SURVEILLANCE OF RODENT POPULATIONS IN EAST AFRICA IN RELATION TO PLAGUE ENDEMICITY

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**Abstract**

Plague has been endemic in East Africa from very early times. The fact that the plague organism occurring in the area is mostly **Pasteurella pestis var. antiqua** which is said to have been associated with the Justinian pandemic of the 6th century A.D. would seem to support the contention that this endemicity was established during that pandemic. The maintenance of this endemicity has been made possible by the presence in the area of suitable rodent reservoirs, efficient flea vectors and favourable climatic and ecological conditions. The main reservoirs of plague in East Africa are **Rattus rattus, Praomys natalensis** and **Arvicanthis abyssinicus.** Because of their semi-domestic habits, **P. natalensis** and **A. abyssinicus** are usually responsible for carrying plague during plague epizootics from the field to the domestic environment where **R. rattus** plays a major role. In the plague areas investigated in Tanzania, **P. natalensis** and **A. abyssinicus** formed the bulk of the field rodent population. It is possible that **Tatera** species play some role in those endemic areas where they occur. However, the absence of these rodents from some of the plague areas would seem to suggest that their presence is not necessary for the maintenance of plague endemicity. The main flea vectors of plague in East Africa are **Xenopsylla cheopis, X. brasiliensis** and **Dinopsyllus lypusus.** The fact that in endemic areas all these three flea species occur commonly on the main rodent reservoirs **R. rattus, P. natalensis** and **A. abyssinicus** indicates the close association in which these three rodents live with one another. This close association is favourable for plague transmission.

## INTRODUCTION

Plague has been endemic in East and Central Africa for a very long time (Roberts 1935, Msangi 1968). Indeed some authorities believe that the original home of plague was in this area (Wu Lien-teh et al. 1936). This belief has however been disputed by many workers and it is now generally accepted that the original home of plague was a group of endemic foci in the Central Asiatic plateau which included Chinese Turkistan, Russian Turkistan, Inner and Outer Mongolia, Transbaikalia, Kurdistan

and the foothills of the Himalayas in Northern India. The Central African focus, though undoubtedly of very long standing, is now considered to have been an off-shoot of the Central Asiatic one, and to have been established during the Justinian pandemic in the 6th century A.D. (Roberts 1935, Davis et al. (1968). This view is supported by Devignat (1951, 1953), Heisch et al. (1953) and Davis et al. (1960), who found that **P. pestis var. antiqua,** which is said to have been associated with the Justinian pandemic, was present in Congo, Uganda, Kenya Tanzania and Zambia. After the focus was established its maintenance was assured by the existence in the area of suitable rodent reservoirs, efficient flea vectors and favourable climatic and ecological conditions.

The European missionaries and colonialists who came to East Africa in the late 19th and early 20th century found that many African tribes were familiar with plague and had vernacular names for the disease. Thus the Baganda called it "kampuli", the Wahehe called it "champafu", while the Swahili called it "tauni" (obviously from Arabic — "taun"). Some of these tribes, like the Wahehe of Tanzania, knew the connection between rodent plague epizootics and human plague epidemics and had developed efficient methods of plague control based on the killing of rats, the isolation of the sick and the burning of houses where plague cases had consistently occurred (Msangi, 1968).

In Uganda the first British and French missionaries are said to have encountered plague when they entered the country in 1877 and 1879 respectively. Simpson (1914) expressed the opinion that plague had existed in Uganda for many years and possibly for ages before the country became a British Protectorate in 1894. Hopkins (1949) reported that the endemic foci in Uganda were invariably situated in rural areas and not in towns. Since 1947 there have been no plague outbreaks in most parts of Uganda but the disease has remained active in the Lake Albert and Lake Edward foci on the border with Zaire up to the present time.

In Kenya the earliest outbreak of plague recorded in the interior of the country was the Nairobi epidemic of 1902 which was believed by Roberts (1935) to have originated from Kikuyu country in the hinterland of Nairobi. However, it has been said that plague was known in Kisumu on Lake Victoria for generations before the coming of Europeans to Kenya (Thornton 1930) and epidemics are believed to have occured towards the end of the last century on the Sagala Hills (1892-93), at Machakos (1895) and Taveta (1897). At present the main endemic foci in Kenya are in the Rift Valley around Rongai, on the foothills of Mount Kenya and on the eastern slopes of the Aberdares. Although the results of extensive serological surveys of rodents would seem to indicate that enzootic plague is widespread in the country, human plague epidemics have been few and far between.

In Tanzania plague has figured as an important human disease since the beginning of German colonial administration towards the end of the last century, and from that time to the present many foci of endemic plague have been discovered in the country. The earliest foci to be recorded

were those of Kiziba in Bukoba (1897), Shirati in Mwanza (1901), Iringa (1903) and Rombo in East Kilimanjaro (1912). Later, other foci were discovered at Mbulu (1917), Singida (1918), South Pare (1951) and Arusha (1970). Most of these foci are still active but the Bukoba and Iringa ones have been quiescent since 1903 and 1937 respectively.

The spread of plague and the establishment of new endemic foci in East Africa was facilitated by the slave trade caravan routes from the interior of the country to the coast. Many of these caravan routes started from the Buganda Kingdom in Uganda where plague was endemic and went through Kenya and Central Tanzania. The main areas of endemic plague in East Africa today are :—

| | |
|---|---|
| Kenya : | Rift Valley, foothills of Mt. Kenya, eastern slopes of Aberdares. |
| Tanzania : | Mwanza, Singida, Mbulu, Arusha, Kilimanjaro, Pare and Kondoa. |
| Uganda : | Lake Albert and Lake Edward foci on border with Zaire. |

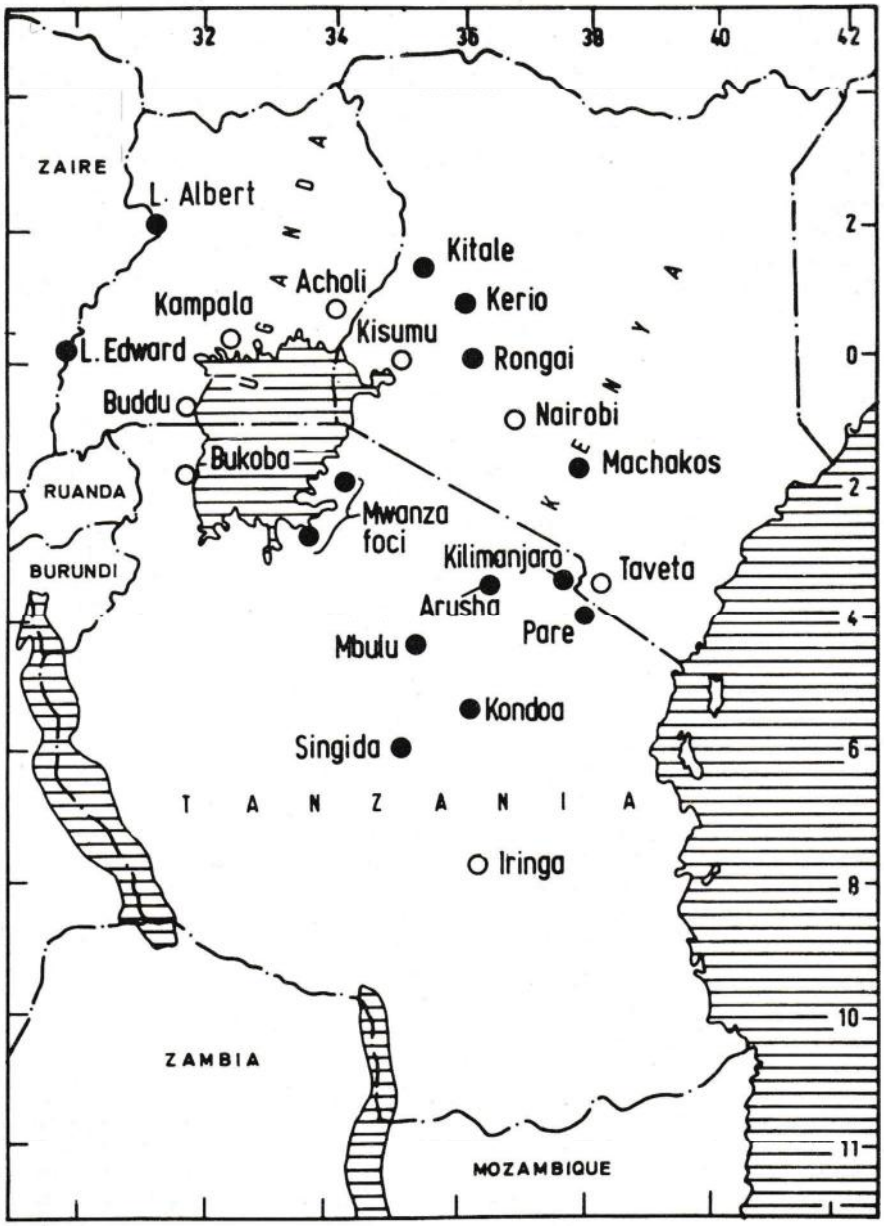
The active and quiescent foci of plague in East Africa are shown on the map opposite.

## THE MAIN RODENT RESERVOIRS OF PLAGUE IN EAST AFRICA

One of the most important factors favouring the establishment and maintenance of endemic plague in a locality is the presence in that locality of species of rodents which can act as reservoirs of plague infection. Individuals of such species survive plague epizootics and carry **P. pestis** in their blood while they remain in an apparently healthy condition. Such individuals serve as sources of enzootic plague which keeps smouldering at a low ebb among the wild rodent population during plague epidemic off seasons. When conditions become favourable, viz. a build-up of the susceptible rodent population, an increase of the flea index and suitable climatic and ecological conditions, the enzootic plague flares up to become an epizootic when large numbers and many species of susceptible rodents over a much wider area become involved. It is usually during such an epizootic that plague spreads from the wild rodent reservoirs through field and domestic rodents to man, causing human plague epidemics.

It is now known that although rodent reservoirs of **P. pestis** form the main factor in the maintenance of enzootic plague, certain species of fleas. e.g. **Xenopsylla cheopis** and **X. philoxera** which can harbour **P. pestis** and remain infective for several months in burrows that have been vacated by rodents. can also act as reservoirs of plague (Girard 1936, 1937, 1940, 1943; Robio 1937 and Davis 1953, 1964). Furthermore many workers including Baltazard **et al.** Karimi, Mollaret **et al.** (1963) and Devignat (1964). have shown that the plague bacillus **P. pestis** can remain viable and infective in the soil of unoccupied rodent burrows for long periods of time. Such soil can act as a source of infection when these burrows come to be occupied during a build-up of the rodent population after an epizootic.

## THE MAIN PLAGUE FOCI IN EAST AFRICA




● Active plague focus

○ Quiescent plague focus

The surveillance of rodent populations for plague infection or "plague experience" has been greatly facilitated by the introduction of the passive haemagglutination test for antibody against the Fraction 1 antigen of **Pasteurella pestis** described by Chen, Quan and Meyer (1952) and Chen and Meyer (1954). This test has enabled retrospective diagnosis of plague in man and rodents. Using this method or its paper-disc modification described by Trainer **et al** (1963) extensive rodent surveillance work was carried out in Kenya by Davis **et al.** (1968) and in Tanzania by Msangi (1968), with the co-operation of F. K. Meyer of the George Williams Hooper Foundation, University of California. This work has indicated that the most important rodents so far as plague endemicity in East Africa is concerned are **Rattus rattus, Praomys natalensis** and **Arvicanthis abyssinicus.** Species of **Tatera,** e.g. **T. robusta** may also be playing some role in certain plague endemic areas where they occur.

**Rattus rattus**

This domestic rodent which is commonly known as the black rat or roof rat is now the commonest house rat in East Africa. Hopkins (1949) has put forward an argument that **R. rattus** was introduced into the inland areas of Kenya and Uganda early in the present century through the Kenya and Uganda Railway built between 1896 and 1901. It is probable that this rodent was introduced into the interior of Tanzania at about the same time via Kenya and Uganda and through the Central and Tanga railway lines which were also built early in the century. In human plague epidemics in Kenya, Tanzania and Uganda, **R. rattus** plays a central role (Hopkins 1949; Roberts 1950; Pollitzer 1954; Msangi 1968).

The importance of **R. rattus** in human plague epidemics in East Africa lies in the fact that it is the rodent living in closest association with man, it is highly susceptible to plague infection and its flea fauna includes the efficient plague vectors **Xenopsylla brasiliensis** and **X. cheopis.** During a rodent survey in areas of endemic plague in Tanzania, Msangi (1968) reported that of the 203 rodents of this species tested serologically for plague antibodies by the paper-disc method, none was found positive. However, Meyer (1964), found that 14% of 646 sera specimens of **R. rattus** from Kenya were positive for plague antibodies. The difference in the two results could possibly be explained by the difference in the sensitivity of the two methods of testing (dried up blood on filter paper discs as opposed to sera specimens) and by the fact that Msangi's observations were carried out during a plague off-season period when most rodents would have had no experience of plague.

In his field observations Msangi (1968) found that in plague areas the flea indices of both domestic and wild rodents were higher than in non-plague areas and that **X. brasiliensis** and **X. cheopis** formed 80% of the fleas collected from **R. rattus** (see table 1). The other fleas collected from this rodent were **Echidnophaga gallinacea, Ctenocephalides felis, Leptopsylla aethiopica, Xenopsylla debilis** and **Dinopsyllus lypusus.** The last three species which are typical wild rodent fleas were only found on this rodent in plague areas. This would seem to indicate the close association in which **R. rattus** lives with wild rodents in areas of endemic plague.

TABLE 1

FLEAS OF RATTUS RATTUS

(collected from 816 specimens in plague and non-plague areas)

| Species | No. collected | % of collection |
|---|---|---|
| Xenopsylla brasiliensis | 988 | 58.6 |
| Xenopsylla cheopis | 335 | 19.9 |
| Echidnophaga gallinacea | 321 | 19.0 |
| Ctenocephallides felis | 10 | 0.6 |
| Leptopsylla aethiopica | 26 | 1.4 |
| Xenopsylla debilis | 6 | 0.4 |
| Dinopsyllus lypusus | 2 | 0.1 |

**Praomys natalensis (Rattus natalensis)**

This rodent is commonly known as the multimammate rat or shamba rat. It is by far the commonest field rodent in East Africa. In his field observations Msangi (1968) found that of all the rodents caught in the field more than 50% were of this species. Its great abundance seems to be due to its great adaptability as regards its habitat and food requirements and its high fecundity. It is found in practically every type of open country whether cultivated or uncultivated, from sea level to 6000 feet altitude and above. It occurs in large numbers in cultivated fields around human dwellings and feeds on all types of food crops and on grass. The average number of young per litter was found to be 11 and the maximum 17.

So far as its role in the transmissions of plague is concerned the most important characteristic of P. **natalensis** is its semi-domestic habit. Msangi (1968) found that 16% of all the rodents caught in houses in a plague area in Tanzania were P. **natalensis**. Hopkins (1949) expressed the opinion that before **Rattus rattus** was introduced to Uganda **"Rattus coucha" (Praomys natalensis)** was the house rat in the whole of the country and that it was still abundant in houses in all the areas where **R. rattus** had not penetrated. Pollitzer (1954) stated that in the Lake Albert and Lake Edward foci of plague **P. natalensis** formed 98% and 32% respectively of the rodents found in human habitations. Ansell (1960) reported that **P. natalensis** was the common house rat of Northern Rhodesia (Zambia). The fact that **P. natalensis** which in many parts of East Africa is primarily a field rodent, can readly enter and inhabit human dwellings, means that it lives in close association with the typical domestic rodent **Rattus rattus** on the one hand and with typical field rats such as **Arvicanthis abyssinicus** and **Tatera robusta** on the other. This is clearly shown by its flea fauna which is a mixture of typical domestic rodent fleas such as **X. cheopis** and **X. brasiliensis** and typical field rodent fleas such as **Dinopsyllus lypusus, Leptopsylla aethiopica** and **Ctenophthalmus calceatus.**, (see table 2).

TABLE 2

FLEAS OF MASTOMYS COUCHA

(collected from 770 specimens in plague and non-plague areas)

| Species | No. collected | % of collection |
|---|---|---|
| Xenopsylla brasiliensis | 776 | 59 |
| Dinopsylla lypusus | 225 | 17 |
| Xenopsylla cheopis | 196 | 15 |
| Xenopsylla debilis | 43 | 3 |
| Leptosylla aethiopica | 42 | 3 |
| Ctenophthalmus calceatus | 36 | 3 |
| Nosopsyllus fasciatus | 3 | – |
| Ctenocephalides felis | 2 | – |

Many workers have reported **P. natalensis** to be an important reservoir of plague in many parts of Africa. Thus Vinke and Devignat (1937) pointed out that in the Lake Albert plague focus the disease occurred where **"Rattus coucha Ugandae" (P. natalensis)** was the principal if not the only reservoir of the disease and where **R. rattus** was absent. Hopkins (1949) while considering the role of **P. natalensis** in plague in Uganda came to the conclusion that before the arrival of **R. rattus** early in the present century **P. natalensis** was responsible for carrying plague and was probably still playing a minor role in the spread of plague in that country. Heisch (1952) during a study of wild rodent reservoirs in the Rongai endemic area of Kenya proved the presence of **P. pestis** in **P. natalensis.** Msangi (1968) reported that of the 603 specimens of this rodent tested for plague antibodies by the paper-disc method, 5 were positive. Perhaps the most important part that **P. natalensis** plays in plague epidemics in endemic areas is in conveying the disease from the wild to the domestic environment. This is made possible by its semi-domestic tendencies which enable it to act as an intermediary between wild and domestic rats. This role of **P. natalensis** was emphasised by Davis (1948, 1964) who pointed out that in the endemic areas of South Africa **P. natalensis** was the intermediary between primary gerbil reservoirs and man.

**Arvicanthis abyssinicus**

This rodent, commonly referred to as the unstriped grass mouse, was found by Msangi (1968) to be the second most abundant field rodent in the interior of Tanzania, forming 31% of all the rodents collected from the field in those areas. Swynnerton (1951) recorded it from most parts of the interior of Tanzania and Hopkins (1949) stated that **Arvicanthis** formed a large portion of the field rat population of Uganda. Where it occurs it seems to have habitat and food requirements similar to those of **P. natalensis.** It is however diurnal in its habits in contrast to **P. natalensis** which is largely nocturnal. Its geographical distribution in East Africa seems somewhat patchy; in Tanzania it was reported absent from the coastal lowlands (Msangi 1968) and in Uganda (Hopkins 1949) it was said not to occur in high elevations and in forests.

There is strong evidence that **A. abyssinicus** plays an important role in plague transmission and plague endemicity in East and Central Africa. Heisch (1952) found it naturally infected with plague in the Rongai area of Kenya and Pollitzer (1954) reported that it was one of several wild rodent species found naturally infected with plague in the Congo. In his field observations Msangi (1968) reported that 5 out of 339 specimens of this species were found positive for plague antibodies by the paper-disc method. The same author found that **A. abyssinicus** had a flea fauna very similar to that of **P. natalensis,** i.e. being composed of a mixture of the typically domestic rodent fleas **X. cheopis** and **X. brasiliensis** and the typically wild rodent fleas such as **Dinopsyllus lypusus** and **Ctenophthalmus calceatus** (see Table 3). Like **P. natalensis, A. abyssinicus** has semi-domestic tendencies and within its range it occurs in great abundance in the vicinity of human dwellings. Hopkins (1949) stated that though not a truly domestic rat **Arvicanthis** was very common in the neighbourhood of dwellings and often foraged for food in huts. He found that in those areas where **R. rattus** did not occur, as in the Mubende District of Uganda **Arvicanthis** entered houses to a much greater extent than in those areas where **R. rattus** was established. Pollitzer (1954) reported that in the Lake Edward and Lake Albert plague foci **A. abyssinicus** was regularly caught indoors and formed 14% of the rodents found in huts in the latter focus.

The very close similarity between the habits of **P. natalensis** and **A. absyssinicus** as regards habitat prefences and semi-domestic tendencies and the similarity of their flea fauna make it most probable that the two rodents play similar roles in plague transmission and endemicity.

TABLE 3

FLEAS OF ARVICANTHIS ABYSSINICUS

(collected from 339 specimens in plague areas)

| Species | No. collected | % of collection |
|---|---|---|
| Xenopyslla cheopis | 1,056 | 80 |
| Xenopsylla brasiliensis | 110 | 8 |
| Dinopsyllus lypusus | 72 | 5 |
| Ctenophthalmus calceatus | 83 | 6 |
| Xenopsylla debilis | 4 | – |
| Ctenocephalides felis | 3 | – |
| Echidnophaga gallinacea | 1 | – |

**Tatera spp. (Gerbils)**

The role played by gerbils in plague transmission in South Africa has been well described by Davis (1948, 1953, 1964). This author has established that in South Africa two species of gerbils **Tatera brantsi** and **T. leucogaster** form the primary plague reservoirs in the endemic areas of that country and that the multimammate rat **Praomys natalensis** acts as a link between these gerbils and the domestic rat **Rattus rattus.** So well

established is this picture of the nature of plague endemicity in South Africa that in attempting to study the problem in other parts of Africa where these rodents occur one strongly expects to find a similar situation. Thornton (1930) expressed the belief that gerbils were important in plague transmission in Uganda. However Hopkins (1949) disagreed with Thornton on the grounds that according to his own observations the gerbil flea **Xenopsylla nubica,** an efficient vector of plague in West Africa, was rare or absent from the plague areas of Uganda. Davis **et al** (1968) in an extensive serological survey of plague in rodents in Kenya were unable to come to any definite conclusion concerning the role played by gerbils in plague endemicity in Kenya. However the finding of positive sera in **Tatera** in some areas in that country indicated that in those areas these rodents may be important reservoirs of plague. Msangi (1968) observed that in endemic areas in Tanzania where **Tatera robusta** was found its flea fauna was very similar to that of **P. natalensis** and **Arvicanthis abyssinicus** (see Table 4). The four species of fleas found on **T. robusta — X. debilis, X. Cheopis, X. brasiliensis** and **D. lypusus** were also found on **P. natalensis** and **A. abyssinicus.** This common flea fauna would seem to indicate that these three species of rodents meet frequently in the field and exchange fleas. The fact that **T. robusta** harbours flea vectors of plague and the fact that it seems to come in frequent contact with **P. natalensis** and **A. abyssinicus** which are important in plague transmission and endemicity, would seem to suggest that it also plays a part in plague endemicity. However since Msangi (1968) found that **Tatera** was absent from some endemic areas, such as the South Pare mountains, he concluded that plague endemicity could be maintained without the presence of this rodent.

TABLE 4

FLEAS OF TATERA ROBUSTA

(collected from 99 specimens in plague and non-plague areas)

| Species | No. collected | % of collection |
|---|---|---|
| Xenopsylla debilis | 152 | 77 |
| Xenopsylla cheopis | 24 | 12 |
| Xenopsylla brasiliensis | 18 | 9 |
| Dinopsyllus lypusus | 4 | 2 |

**Other possible rodent reservoirs of plague in East Africa**

Specimens of the following rodents have been found at one time or another to be serologically positive for plague antibodies. They therefore probably play some role in the maintenance of plague in endemic areas where they occur :

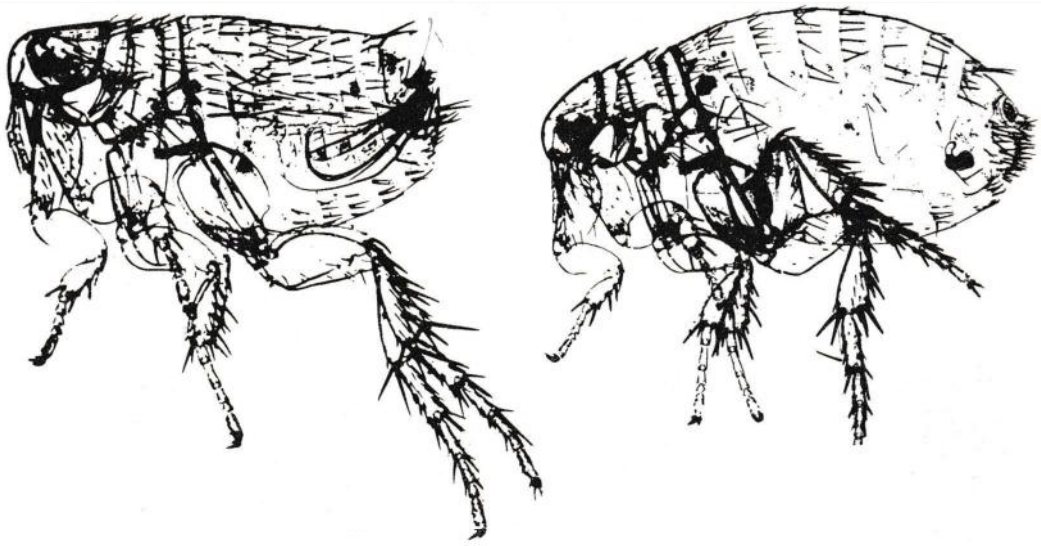
**Acomys. sp.** — Mombasa, Kombeni, Taveta, Rimo Valley, KENYA (Davis et al 1968)

**Aethomys kaiseri** — Rimo Valley, Rongai, Kombeni, KENYA (Davis et al 1968)

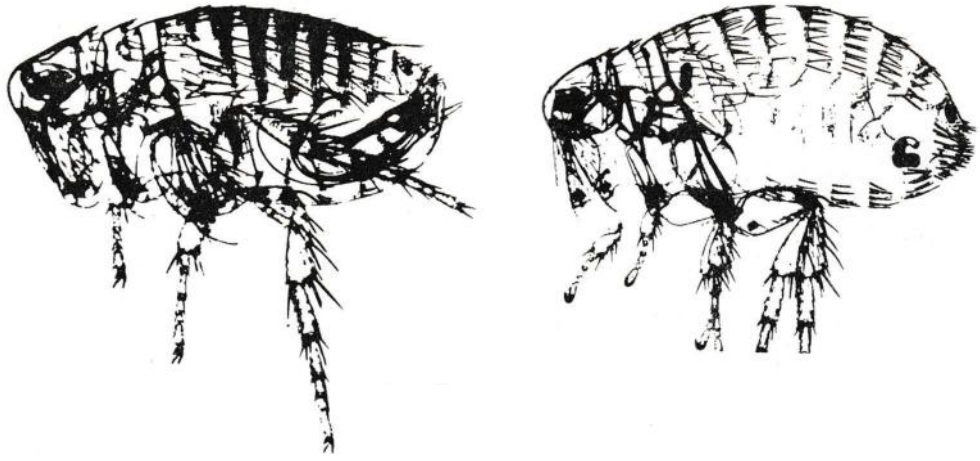
**Lemiscomys striatus** — Karen, KENYA (Davis et al 1968)

## Common Fleas of Domestic and Wild Rodents in Tanzania

MALE FEMALE

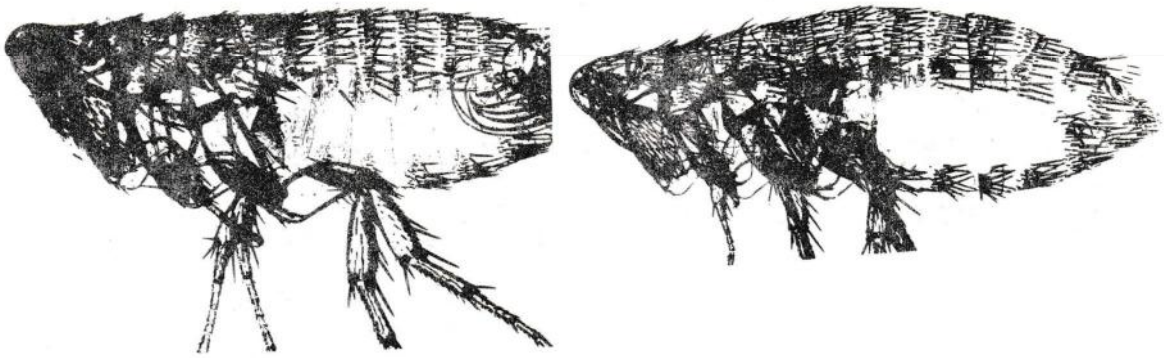


*Xenopsylla brasiliensis*

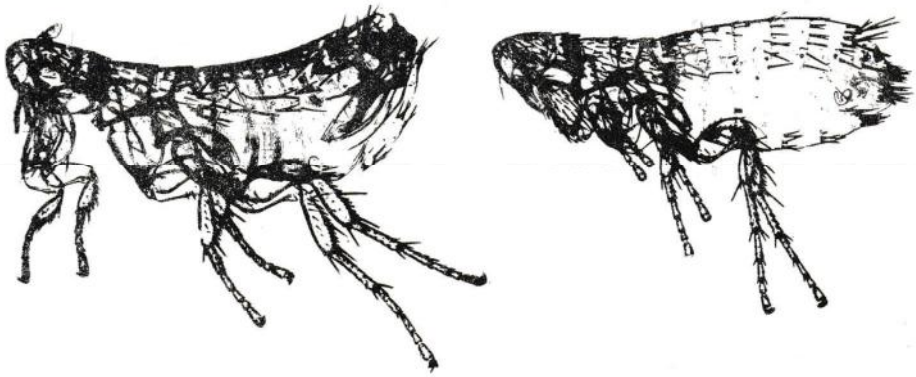


*Xenopsylla Cheopis*

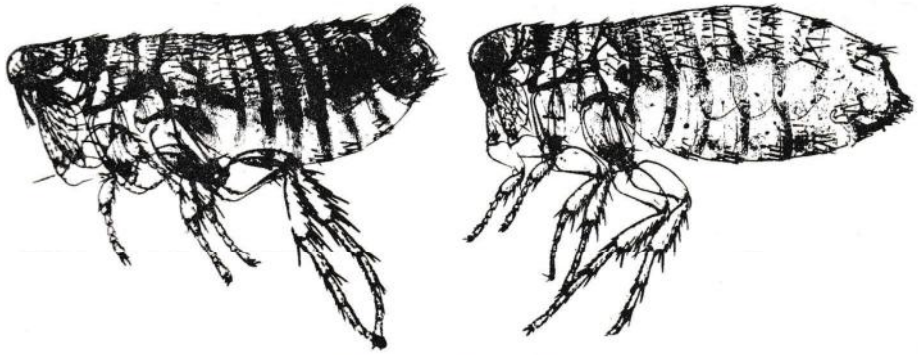
MALE FEMALE



*Dinopsyllus lypusus*



*Leptopsylla aethiopica*



*Ctenophthalmus calceatus*

**Otomys angoniensis** — Kiambu, Machakos, KENYA (Davis et al 1968)
**Rhabdomys pumilio** — Rongai, KENYA (Davis et al 1968)
**Thallomys paedulcus** — Rongai, KENYA, (Davis et al 1968)
**Thamnomys (Grammomys) dolichurus** — Taveta, KENYA (Davis et al 1968)
East Kilimanjaro, Singida, TANZANIA (Lurz 1913, Msangi 1968)
**Praomys morio** — Singida, TANZANIA (Msangi 1968)

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