

FLEAS (SIPHONAPTERA) HARMFUL TO MAN IN ISRAEL

AMOS WILAMOWSKI

Laboratory of Entomology, Ministry of Health, Jerusalem, Israel

Abstract - The oriental rat flea, *Xenopsylla cheopis*, was considered the parasite of the two rat species in Israel, *Rattus norvegicus* and *Rattus rattus*, in their area of common distribution along the coastal plain. This flea does not exist on *R. rattus* which is found in the interior of the country. After *R. norvegicus* became dominant over all the coastal plain since the 1980s, *X. cheopis* became a parasite only of this species. The level of infestation of *X. cheopis* on rats was very high in the beginning of the 1950s and the number of murine typhus cases reached many hundreds per year. The distribution of this disease overlaps the distribution area of *Rattus norvegicus* and *X. cheopis*. Control operations against rats and fleas, which were carried out over many years and drastic urban changes, caused a continual decrease in the level of flea infestation of rats, down to extremely low levels. In parallel, there has been a decrease in the number of murine typhus cases to four cases or less per year in the 1990s. This low number supports our assumption that *X. cheopis* is very rare in Israel today. The urban changes also caused the disappearance of *P. irritans* from human habitations. The last case of a *P. irritans* infestation was recorded in the beginning of the 1990s. The cat flea, *Ctenocephalides felis*, is distributed throughout Israel except the desert city of Eilat. It is mainly a parasite on dogs and cats, but it is also found on large farm mammals. The increase in the standard of living, accompanied by a large increase in the number of household pets, is responsible for the very large populations of this flea in urban areas. There are serious difficulties controlling *C. felis*, particularly when a whole neighborhood is infested.

Key words - *Xenopsylla cheopis*, *Pulex irritans*, *Ctenocephalides felis*, murine typhus, *Rattus norvegicus*, *Rattus rattus*

INTRODUCTION

The plague outbreak in India in summer 1994 brought about a renewed interest amongst the health services and the public in Israel concerning fleas harmful to man in his home environment. In Israel, about 40 species of fleas are known (Costa, 1978), of which only 3 are parasitic on man as nuisance pests or vectors of disease. These are the oriental rat flea (*Xenopsylla cheopis* Rothschild), the human flea (*Pulex irritans* L.) and the cat flea (*Ctenocephalides felis* (Bouche)).

X. cheopis is parasitic on the roof rat (*Rattus rattus*) and the Norway rat (*Rattus norvegicus*) which are both common in Israel (Gratz, 1973) and may, under certain conditions, also attack man. *X. cheopis* is the vector of *Yersinia pestis*, which causes plague, and of *Rickettsia typhi*, which causes murine typhus. The plague was known in Israel, the last recorded cases being in 1947 in the area of Haifa port (Gratz, 1957a). Following these cases, a control operation of spraying was carried out using DDT (Pollock, 1948). This operation, which was continued for many years, using also additional insecticides, was thus one of the factors determining the level of *X. cheopis* for the future. At the beginning of the 1950s, hundreds of cases of murine typhus were recorded. Following this, Gratz (1957a,b) began a survey to determine the level of flea populations in the city of Haifa. From 1954 until 1980, the Entomology Laboratory of the Ministry of Health conducted monthly surveys of rat flea infestations in Tel Aviv and its surroundings.

Since 1981, continuous checking of rats from several areas and determination of the level of flea populations has been carried out in the Entomological Laboratory in Israel. The results of the survey and checks reported in this paper follow the changes in the distribution of the species of rats, the level of their infestations with fleas and the change in the number of murine typhus cases in Israel. Since the beginning of the 1950s, drastic changes in the urban areas took place. Urban districts were greatly expanded and large areas were covered with asphalt and concrete. Modern buildings were constructed and there was a significant increase in the standard of living of the inhabitants. Departments of sanitation were established in which pest control became an integral part. Using the information which was collected in the laboratory over many years and the results of the survey, we try to show in this

paper the profound influence of these processes on the distribution of the flea species which are known to be human pests.

MATERIALS AND METHODS

The information reported in this paper is from three sources: 1) A survey of the infestation of rats and house mice with fleas and other parasites. An annual survey was carried out by the Entomological Laboratory in Tel Aviv and its surroundings and in Eilat from 1954 to 1980, and in Jerusalem from 1981 to 1985 and during 1997-8. Occasional samples of rats and mice which were trapped in various urban areas were also checked for ectoparasites throughout the years. The rats and mice were trapped using cage-type live traps which were set before dusk and collected after dawn. The traps were placed in pathways where rats were known to be active according to various signs such as feces, gnawing marks etc. The rats were brought alive to the laboratory and anaesthetized with ether. The species of rat was determined and the fur was combed with a louse comb to remove all ectoparasites. The combed products were transferred to 70 % ethanol and examined under a stereo microscope. When relevant, the *X. cheopis* index (XCI) was determined. This is the average number of fleas per rat in a sample of rats caught at the same place and time. 2) Collection of fleas from human habitations where people had suffered from flea bites etc., in cooperation with pest control and sanitation workers. Fleas were also obtained from citizens who collected them from their homes and sent them to the laboratory for identification. 3) It is obligatory to report all cases of murine typhus to the health authorities. This data was given to us by the Epidemiology Department of the Ministry of Health.

RESULTS

Species of rats trapped during our surveys in the Tel Aviv area and Eilat are shown in Table 1. The level of *X. cheopis* measured in the area of Tel Aviv zoo is shown in Fig.1. This is one of the several areas surveyed by our laboratory between 1954 and 1980. The number of cases of murine typhus in Israel in the years 1950 to 1998 are from figures given by the Epidemiology Department of the Ministry of Health and are shown in Table 2 and Fig. 2. The flea species found on rats during the Tel Aviv survey were *X. cheopis*, *C. felis*, *Leptopsylla segnis* (Schoenherr) and *Echidnophaga murina* (Tiraboschi). The information on the number of control operations against fleas was recently reported by N. Felheim, a pest control operator (Fig. 3). In many of these cases, the identification of the fleas had previously been confirmed in the laboratory.

Table 1. Percentages of the two rat species found in the Tel Aviv area and Eilat.

Town	Year	<i>R. norvegicus</i>	<i>R. rattus</i>
Tel Aviv	1954 - 1955	73	27
	1956 - 1957	76.7	23.3
	1967 - present	100	—
Eilat	1958	17	83
	1959 - present	100	—

In Jerusalem, only *R. rattus* has been trapped.

In two towns northwest of Beersheba, only *R. norvegicus* was trapped (see Fig. 4)

Table 2. Number of cases of murine typhus in Israel between 1950 and 1969 as reported by the Department of Epidemiology, Ministry of Health

Year	Cases
1950	598
1951	793
1952	752
1959	173
1960	144
1969	88

DISCUSSION

It is known from Gratz's survey (1957a,b) and the laboratory survey that the oriental rat flea was parasitic on both *R. norvegicus* and *R. rattus* in their joint geographical area of distribution in the coastal plain in Israel. The Norway rat invaded Israel only in the 1920s or 1930s through the ports of Haifa and Jaffa (Gratz, 1973). There is evidence from several researchers that studied this process, that the Norway rat "took over" habitats around the ports which were previously occupied by the roof rat. Gratz's survey in the Haifa area and our survey up to the beginning of the 1980s shows that the Norway rat became the dominant rat in all the area of Haifa and greater Tel Aviv (Table 1). Other surveys show that the Norway rat was the only rat species found in the coastal plain since the mid 1980s (Lidror *et al.*, 1986; see Fig. 4). Likewise, the Norway rat is now the only rat species in the southern port of Eilat. A similar situation occurred in England where the Norway rat replaced the roof rat over a large area (Bentley, 1964). In all the surveys carried out in Jerusalem until the present time, and in other areas in the interior part of the country, in wooded and mountainous areas, only *R. rattus* has been caught (Wolf, 1982; Lidror *et al.*, 1986). *X. cheopis* was not found on *R. rattus* in these areas. *X. cheopis* is very rare on wild rodents (Theodor and Costa, 1967). Only two specimens of *X. cheopis* were found on a single *R. rattus* during all the survey carried out in Jerusalem. *X. cheopis* is not a parasite of *R. rattus* in the interior part of Israel and since the 1980s is common only on *R. norvegicus* in the coastal plain area (Fig. 4). It is noteworthy that the level of flea infestation of *R. norvegicus* was significantly higher than that of *R. rattus*. This phenomenon can be explained by the fact that the nesting sites of *R. norvegicus* are underground, while those of *R. rattus* are found above the ground in trees and buildings etc., thus less contact is created between the rats and the fleas. The extreme temperature changes occurring in the higher nests are unsuitable for fleas (Gratz, 1957a).

The area of distribution of murine typhus clearly overlaps the distribution of the Norway rat and of *X. cheopis*. According to the information of the Epidemiological Department, all cases of this disease up to 1960 were reported from the areas of Haifa and of Greater Tel Aviv (Gratz, 1973). Moreover, all cases up to 1998 are reported from the distribution area of *R. norvegicus* and *X. cheopis*. There is no evidence that murine typhus is transmitted by fleas other than *X. cheopis* nor that there is any other vector or reservoir apart from domestic rats (Theodor and Costa, 1967). The level of infestation of rats with *X. cheopis* has decreased steadily throughout the years in Greater Tel Aviv (Fig. 1), from 10 to over 20 fleas per rat in the summer months in the 1950s to 0 - 1 fleas per rat in 1980. There was a single increase in the level *X. cheopis* infestation of *R. norvegicus* in Eilat in 1982, and in Netivot in 1983, following a drastic increase in the numbers of *R. norvegicus* in these towns. Since 1983, only very few specimens of the oriental rat flea have been found.

In parallel with the decrease in infestation of *R. norvegicus* with *X. cheopis*, there has also been a dramatic decrease in the number of cases of murine typhus, from hundreds of cases per year in the

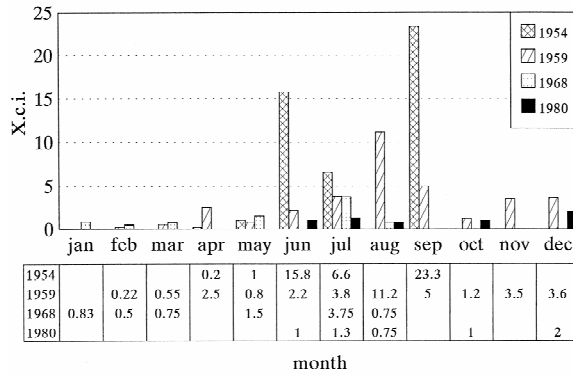


Figure 1. *X. cheopis* index (X.c.i.) Zno area of Tel Aviv

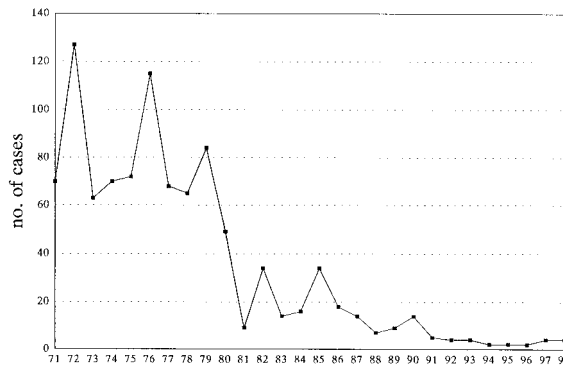


Figure 2. Murine typhus in Israel 1971-1998

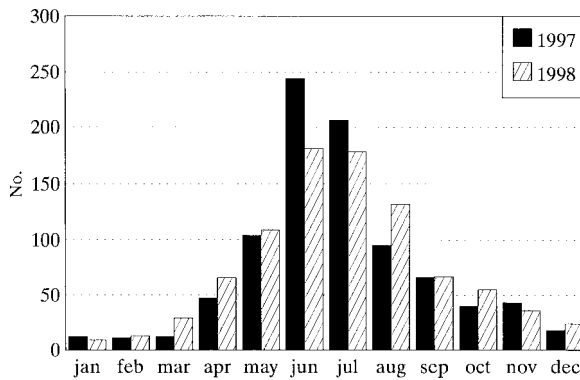
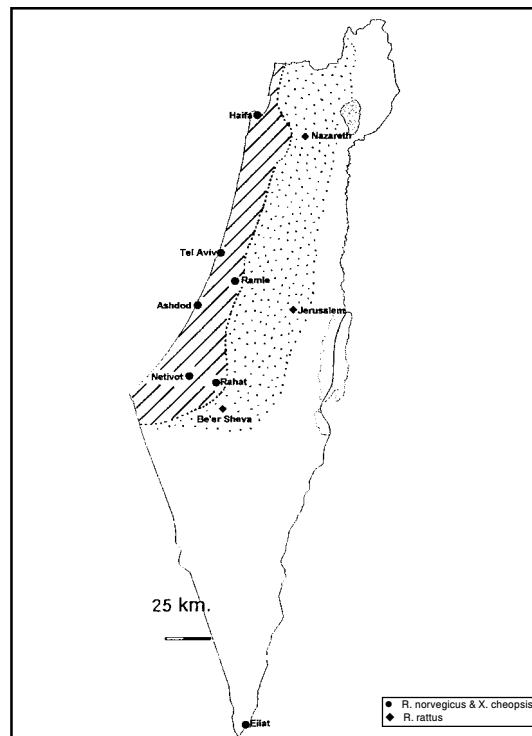


Figure 3. Control operation against fleas, Tel Aviv and surroundings



After Lidror et al. (1986)

Figure 4. Rat species and *X. cheopis* distribution in Israel.

1950s, to single cases in the last few years (Table 2, Fig. 2). These facts supports our assumption that, in Israel, *X. cheopis* is a rare species. The decrease in the level of the *X. cheopis* population is the result of a massive control operation against rats and fleas, beginning in the 1950s and continuing for many years, and the drastic urban changes already mentioned which reduced the possible nesting sites of the fleas, as well as the awareness of the health authorities in controlling rats and fleas. Among the fleas found on the rats, other species apart from *X. cheopis* were found. These were *Leptopsylla segnis* and *Echidnophaga murina*, which were only found in very low numbers on the rats. *L. segnis* may attack man (Gratz, 1983), whereas there is no indication that *E. murina* bites man. Since the survey of 1980, neither species has been found. It is worth noting that several specimens of the flea *Leptopsylla algira costai* Smit, were identified on two specimens of *Mus musculus* and one of *Crocidura russula*, which were trapped in a building in the middle of Jerusalem. This flea is known from feral *Mus musculus* (Theodor and Costa, 1967), but this is the first record from an urban area.

The main flea species bothering citizens in urban areas in Israel today is *Ctenocephalides felis*. More than 70% of the complaints of flea infestations recorded in the laboratory were from urban areas. *C. felis* is very common in all parts of Israel except the desert area of Eilat, where it has never been identified. In Eilat, the temperature is very high during most of the year and the relative humidity is very low. These conditions are unsuitable for the development of young stages of the cat flea (Dryden and Rust, 1994). Veterinarians and pest control operators report that they have not recorded any *C. felis* infestations in this city.

In urban areas, the cat flea is a parasite mainly on dogs and cats which are foci for infestation. In the past, *C. felis* was also found on domestic rats, but the flea numbers decreased steadily. In 1959, 73 specimens were found on rats in one of the neighbourhoods in Tel Aviv. In the same area in 1968, only five specimens were found and in 1980, none were recorded. *C. felis* has not been found on *R. rattus*

in Jerusalem. In nature, *C. felis* is a parasite on a number of animals (Costa, 1979). It is the only flea species found on sheep and cattle and other farm animals. Cats and dogs are also foci in such rural areas (Yeruham *et al.*, 1989). *C. felis* develops both outside and inside buildings where suitable conditions are present. The larval stages developing inside houses exploit food remnants and other organic matter under carpets and furniture and in the corners of rooms (Gratz, 1983). In summer time the population levels are very high, and in the winter, suitable conditions are found only inside heated houses, but the population levels decline significantly (Fig. 3).

With the increase in the level of living standards, there has also been a prominent increase in the number of household pets, mainly dogs and cats. This is the reason for the very great increase in the population levels of *C. felis*. This increase is in contrast to the decrease in numbers of *X. cheopis* and *P. irritans* in urban areas. It is difficult to estimate the population levels of cat fleas. However, the infestations are heavy in all urban areas. Fig. 3 shows the number of control operations carried out against fleas in the Tel Aviv area by a single pest control officer over two years and there is no doubt that these numbers are a clear indication of the generally high infestation levels. The control of *C. felis* is particularly difficult when a whole neighborhood or settlement is infested. In such cases, a cycle of infestation occurs between street cats and dogs and those owned by people, when they come together in public gardens and other open areas, causing the infestations to continue inside houses. In such cases, flea control inside houses and of the pets is not sufficient; control of the whole neighborhood is essential. A very acute focus of flea infection is the sand-pit in children's playgrounds which are frequently visited by dogs and cats. Adult fleas attach to the children and so enter their homes or kindergartens. In 1998, a single pest controller treated more than 60 such sand-pits (Della Rocca, pers. comm.). *C. felis* is a potential vector for murine typhus (Farhang-Azad *et al.*, 1984). One case is known in Israel of a cat breeder, who had murine typhus. *C. felis* was identified from his cats.

The human flea, *Pulex irritans*, is very rare in Israel in human habitations. Since 1971, only 12 cases have been reported of this flea as a human pest. Three of these cases were from urban areas. The last case was identified in 1992. *P. irritans* in Israel is a parasite mainly of large mammals. Single specimens have been found on *Erinaceus europaeus* and *R. rattus* (Costa, 1979). This flea has disappeared from the urban areas due to the changes in urbanization which eliminated their breeding sites. The few cases in which *P. irritans* was recorded from houses in rural areas, are probably result of fleas dropping off wild mammals passing near the houses.

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