FINAL REPORT ON A RAT-FLEA SURVEY OF THE CITY OF SAN JUAN, PORTO RICO

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We ([1-2-3]) have already presented the annual results of three consecutive years of work on a rat-flea survey of San Juan, Porto Rico. This survey was carried out by the Bureau of Plague Prevention of the Insular Health Department with the cooperation of the United States Public Health Service. The present report has been prepared as a general summary of that work taken as a whole.

Activities were initiated on July 11, 1926 and were continued till June 30, 1929. During this period cage traps were distributed at the rate of 205 per day among 39 premises. Rats were obtained from only 1.8 per cent of the localities trapped and it is estimated that a proportion of 4.2 rodents were caught per thousand traps set.

The total number of live rats captured reached 1,005. Of these 800 were adults and 205 either young or partially grown. The number of females exceeded that of males by 119. About 30 per cent of the females, or 168, were found pregnant bearing an average of 7.5 little ones each. The highest number of embryos observed in a single animal was 11.

The following table shows the distribution of the rats by zones:

TABLE No. 1

RATS CAPTURED IN DIFFERENT ZONES

Year	Zone 1 (Docks)	Zone 2 (Water-front)	Zone 3 (Commercial)	Zone 4 (Residential)	Total
1926-27	140	77	20	123	360
1927-28	151	58	29	158	396
1928-29	93	28	60	68	249
Total	384	163	109	349	1,005

It will be seen that Zones No. 1 and No. 4 supplied considerably higher numbers than Zones No. 2 and No. 3. This was probably due to the fact that trapping was more active at the former locations.

Table No. 2 has been prepared to demonstrate the actual concentration of the species in the different zones. In this table rat prevalence is represented by the average number of rats captured per 1,000 traps set.

TABLE No. 2 *

COMPARATIVE CONCENTRATION OF THE SPECIES IN DIFFERENT ZONES

	Zone 1 (Docks)	Zone 2 (Water-front)	Zone 3 (Com-mercial)	Zone 4 (Resi-dential)
Total traps set	83,762	14,873	33,973	34,625
Total rats captured	272	105	101	231
Average number of rats per 1,000 traps set	3.2	7	2.97	6.6

According to this table the rat population of the city would be more concentrated in the water front and residential sections, both of which show an index of approximately 7. In Zones No. 1 and No. 3 the degree of infestation appears to be about half as great.

Mus norvegicus has been the most prevalent species in practically all parts of the city, this variety alone representing about 72 per cent of the total catch (See Table No. 3). The rest of the rodents consisted of Mus alexandrinus and Mus rattus in almost equal proportions. Chart No. 2 shows more graphically the incidence of each species in the different zones.

TABLE No. 3

CLASSIFICATION OF RATS

	1926-27	1927-28	1928-29	Species Total	Species Percentage
Mus norvegicus	287	296	140	723	72
Mus rattus	41	45	49	135	13
Mus alexandrinus	32	55	60	147	15
Total	360	396	249	1,005	100

Fleas were found in only 57 per cent of the rats captured, the total number of parasites collected reaching 7,145. Of these, 4,029 were males and 3,116 females, a ratio of 13:10. Classification revealed the presence of five different species; but one of these alone, *Xenopsylla cheopis*, was found to represent 98.5 per cent of the total. (See Table No. 4.)

* The records available for this table cover almost, but not entirely, the three years period.

TABLE No. 4

TABULATION OF FLEAS AS TO SPECIES AND SEX

Species	Sex	1926–27	1927–28	1928–29	Total
Xenopsylla cheopis	Males	1,472	1,484	1,055	4,011
	Females	1,067	1,092	870	3,029
Echidnophaga galinacea	Males	4	1	5	10
	Females	31	18	34	83
Ctenocephalus canis or felis	Males	.....	1	2	3
	Females	1	1	2	4
Pulex irritans	Males	.....	.....	1	1
	Females	.....	2	1	3
Leptopsylla musculi	Males	.....	.....	.....	.....
	Females	.....	1	.....	1
Total		2,575	2,600	1,970	7,145

The highest number of fleas came from the docks which yielded 5,337 for the three years. Zone No. 4 furnished 793 specimens while the commercial and water-front districts followed respectively with 630 and 385. (See following table.)

TABLE No. 5

FLEAS COLLECTED IN DIFFERENT ZONES

Year	Zone 1 (Docks)	Zone 2 (Water front)	Zone 3 (Commercial)	Zone 4 (Residential)	Total
1926–27	2,014	212	123	226	2,575
1927–28	2,258	32	121	189	2,600
1928–29	1,065	141	386	378	1,970
Total	5,337	385	630	793	7,145

As already stated in a previous report, the absolute number of rat-fleas collected does not always indicate the degree of infestation in a given region. Such conditions as the extent of the surveyed area, the number of rats examined for parasites and the length of time covered by the work will promote great variation in the total number of insects and may lead to false conclusions as to their actual rate of concentratation among the local rats. At the present time flea prevalence is expressed in terms of fleas per rat. This ratio is generally known as the *flea index*. It is determined by dividing the number of fleas collected by that representing the total rats examined, this being independent of all other conditions.

The *flea index* of San Juan, taken as a whole, has been estimated at *7.1* which is almost identical with the *cheopis index*, represented by *7*. Table No. 6 records the index in the four zones considered separately, giving in addition the relative concentration of the rodents.

TABLE No. 6

GENERAL SUMMARY OF RAT AND FLEA CONDITIONS IN THE FOUR ZONES

	Zone 1 (Docks)	Zone 2 (Water front)	Zone 3 (Commercial)	Zone 4 (Residential)	Total
Total rats captured	384	103	109	349	1,005
Average No. of rats per 1,000 traps set	3.2	7	2.97	6.6	4.2
Total fleas collected	5,337	385	630	793	7,145
Percentage rats with fleas	85.4	33.7	73.4	31.2	56.9
Fleas per rat	13.9	2.4	5.8	3.5	7.1

It is evident from the above table that a high rat infestation does not always imply a corresponding hyperabundance of fleas. In Zone No. 2, for example, where the concentration of rodents appears to be highest (7 rodents per 1,000 traps set), the *flea index* is only *2.4*. In Zone No. 1, on the other hand, the flea-index is very high, almost 14 per rat, while the rodent index is slightly higher than 3.

The highest number of fleas in a single animal was obtained from an adult, female, *Mus alexandrinus* trapped in a fertilizer warehouse (Nitrate Agencies) located in the water-front section of the city. This rodent contained at least 303 parasites. It may be of interest to add that two other rodents yielding 124 and 111 fleas respectively were also captured in the water-front area.

The following table was prepared to determine any possible predilection of the insects for any particular species of rat.

TABLE No. 7

COMPARATIVE STUDY OF FLEA INDEX IN DIFFERENT SPECIES OF RATS

	Mus norvegicus	Mus rattus	Mus alexandrinus	Total
Total rats per species	723	135	147	1,005
Rats with fleas	345	112	115	572
Percentage rats with fleas	47.7	82.9	78.2	56.9
Total fleas per rat species	4,589	1,130	1,426	7,145
Fleas per rat	6.3	8.4	9.7	7.1

Although the index is evidently high for the three varieties of rodents, the above data would seem to point to the species Mus alexandrinus and Mus rattus as more desirable hosts. It must be admitted, however, that the number of rats examined is relatively too small and our field of observation too limited to warrant any final conclusion in this respect.

With a view to determining the relation of flea prevalence to atmospheric moisture and temperature we have carried daily weather records which were kindly furnished at the end of each month by the office of the United States Weather Bureau at San Juan. These records as well as the seasonal variations of the flea index for the three years have been carefully tabulated in Charts No. 4 and No. 5. In plotting out the curves for these charts it was deemed convenient to arrange the data by periods of three months.

As would be expected from our limited thermometrical changes, the temperature factor does not appear to have influenced flea prevalence to any appreciable degree during this period. On the contrary, a glance at Chart No. 5 will show, for most of the three years, a striking parallelism between the relative humidity curve and the line representing flea prevalence. The only marked deviation from this tendency took place toward the end of the survey during the months immediately following the cyclone of San Felipe. After the occurrence of this terrific phenomenon the whole city remained for some time under very abnormal conditions, our work was hindered in many ways and there are several other reasons for considering the data for this period as rather unrealiable. The favorable influence of a moist atmosphere on the different phases of flea breeding has been variously observed by different investigators. This particular weather condition is, indeed, one of the most important factors governing the prevailing degree of infestation in any given region. Our observations in San Juan, therefore, are only confirmatory.

SUMMARY

This survey includes three consecutive years of work. During this period a total of 1,005 live rats were captured. Of these 72 per cent were classed as Mus norvegicus, the rest of the rodents consisting of Mus rattus and Mus alexandrinus in proportions of 13 and 15 per cent, respectively. Fleas were obtained from almost 57 per cent of the animals and their total number for the three years was 7,145, giving an index of 7.1 fleas per rat for San Juan. Five different species of fleas were encountered but one of these alone, Xenopsylla cheopis, represented 98.5 per cent of the total catch. The concentration of rats is heaviest at the water front and residential sections while the flea index is highest at the docks (almost 14 fleas per rat) and commercial district (almost 6 fleas per rat).

COMMENT

From a considerable amount of previous work the author is led to the conclusion that the rat population of San Juan is much greater than would be expected from the data here given. The present work, however, is thought to give a fair idea of the comparative concentration of rodents in different parts of the locality. So far as the flea findings are concerned, there is every reason to believe that they represent in a general way the true prevailing conditions in San Juan.

If Zones No. 1 (docks) and No. 2 (water front) be considered as a single zone, and this is what they actually are topographically, this zone as a whole can evidently be declared more heavily infested with rats and fleas than any other portion of the city. It is important to add that *Mus norvegicus* is the prevailing rat species in the community and that *Xenopsylla cheopis* is practically the only flea encountered. In other words, the rat and flea conditions at the water-front area (indeed, all over the city) are particularly favorable for the development and spread of bubonic plague. This offers an explanation for the introduction of the disease into this port in 1912 and again in 1921 notwithstanding the most scrupulous precautionary measures taken by the United States Public Health Service at San Juan. Moreover, the fact that San Juan is frequently visited by ships stopping at the Canary Islands and other mediterranean and South American ports where plague is often endemically or accidentally present, renders this city particularly exposed to future infections. Under such circumstances, the observation of permanent preventive measures at San Juan should be considered as a fundamental and necessary public-health activity.

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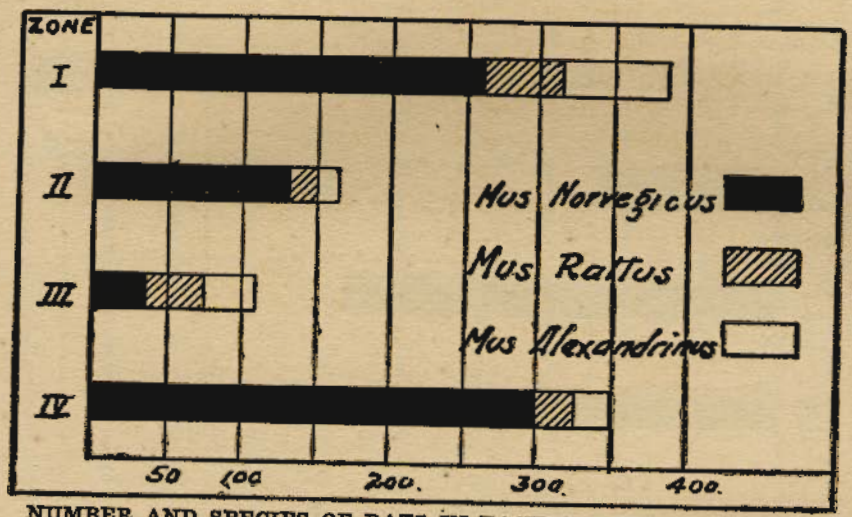
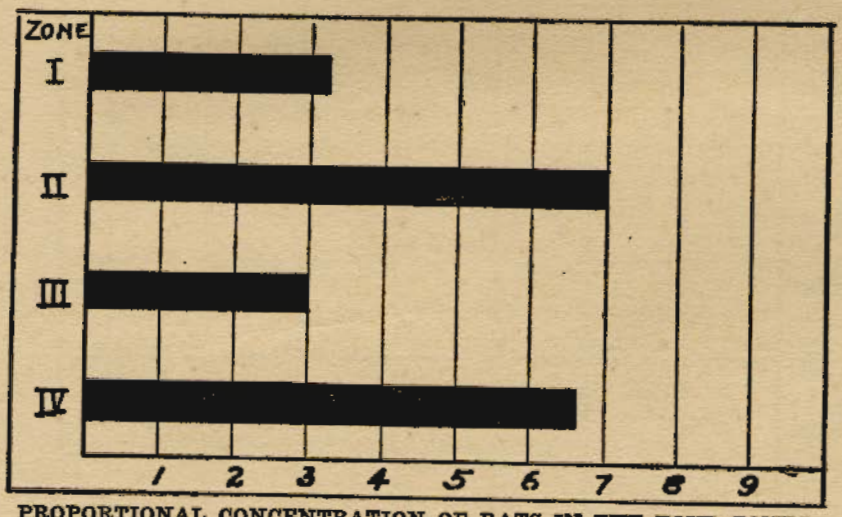
CHART I



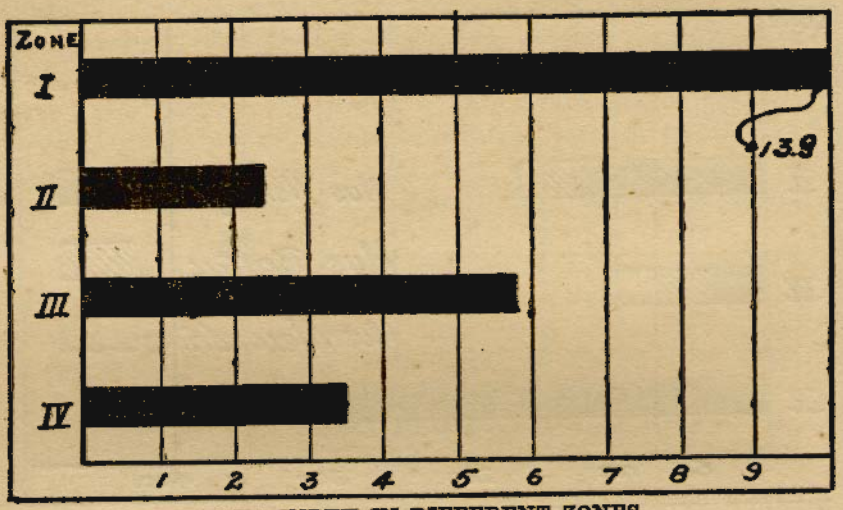
NUMBER AND SPECIES OF RATS IN EACH OF THE FOUR ZONES

CHART II



PROPORTIONAL CONCENTRATION OF RATS IN THE FOUR ZONES
(Average Number of Rats Captured per Thousand Traps Set)

CHART III



FLEA INDEX IN DIFFERENT ZONES

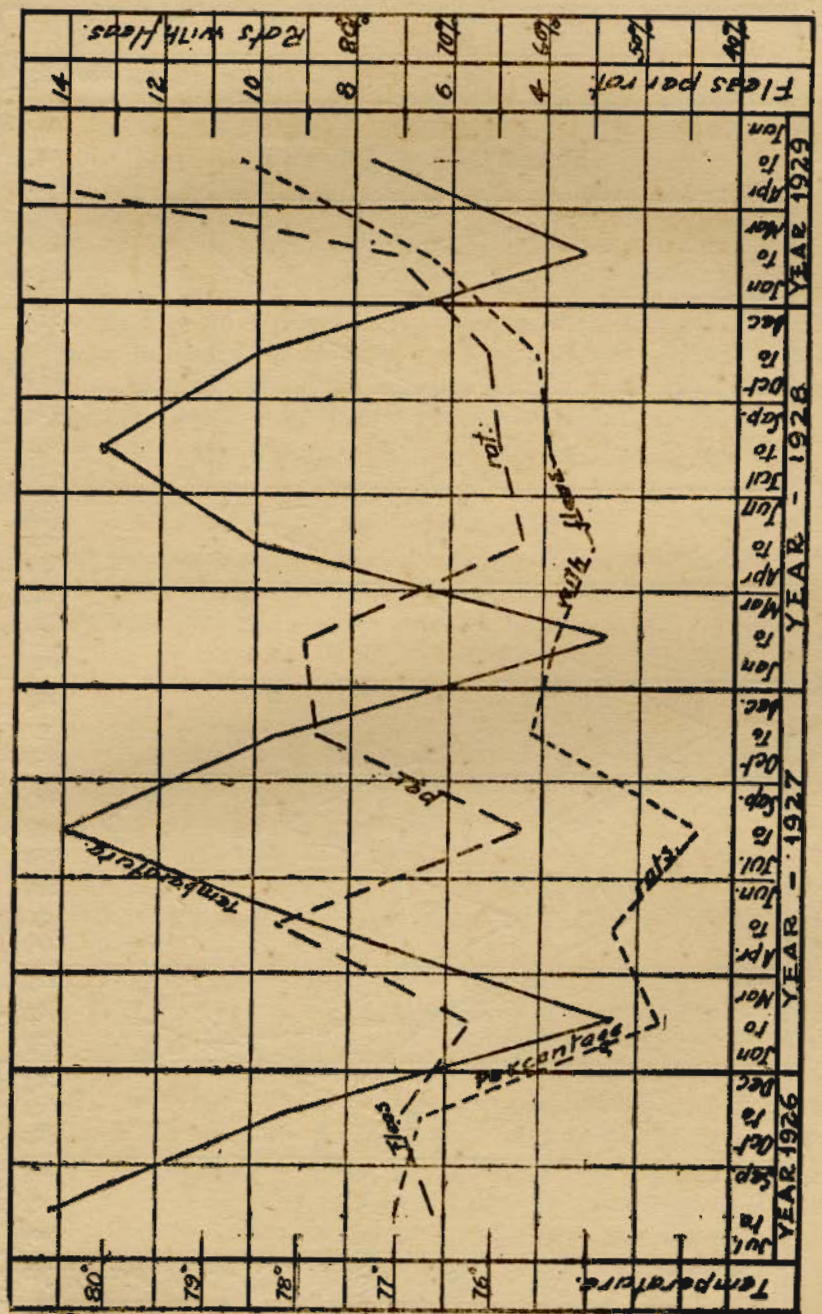


CHART IV

RELATION OF TEMPERATURE TO FLEA PREVALENCE

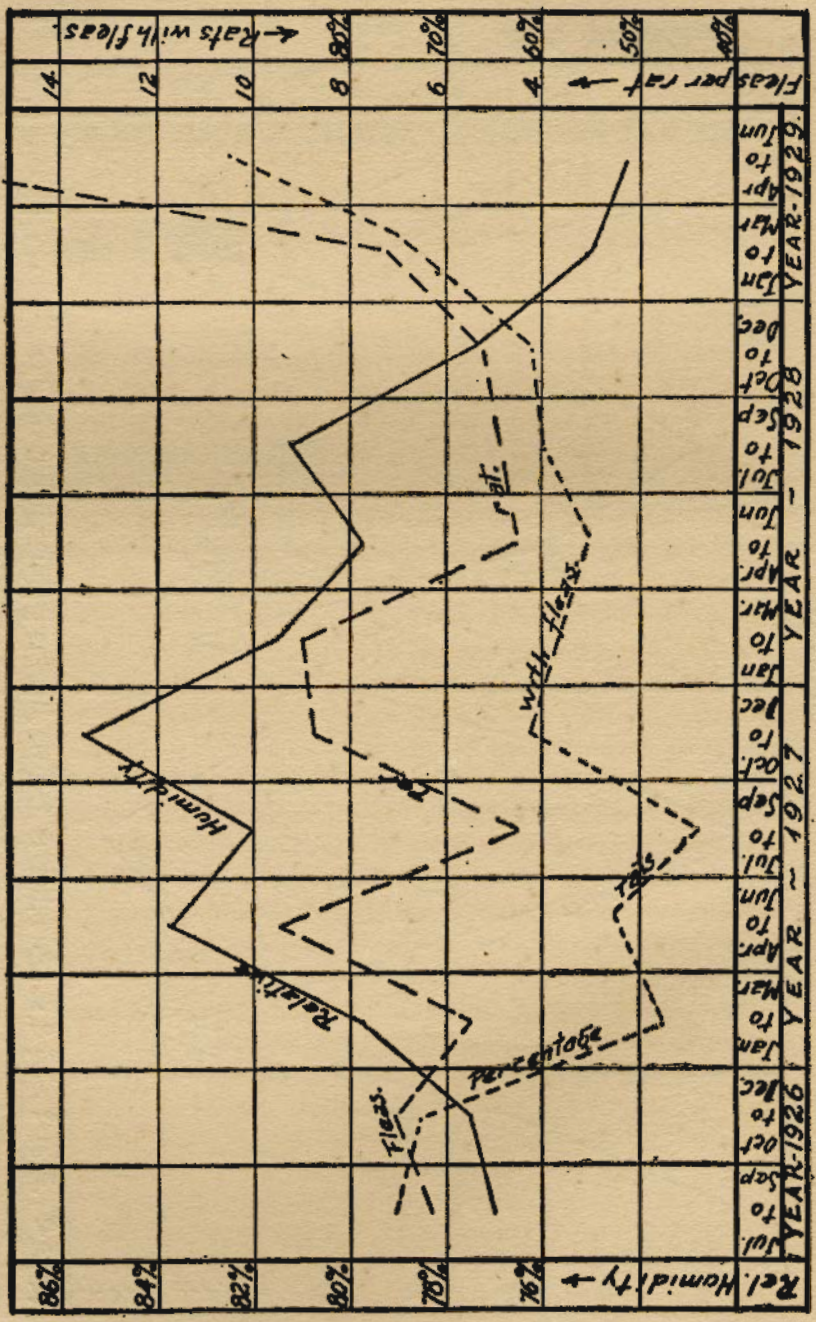


CHART V

RELATION OF ATMOSPHERIC HUMIDITY TO FLEA PREVALENCE