THE INHERITANCE OF RESISTANCE TO PLAGUE IN PALLASIOMYS MERIDIANUS

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 56, No. 7,
pp. 75-79, July, 1963
Original article submitted September 19, 1962

In comparitive experiments, we succeeded in establishing essential differences in the degree of resistance to plague within pallasiomys meridianus inhabiting the left and right banks of the Volga, and also, related differences in the pathogenesis of the infection [2,5]. Using the subcutaneous method of inoculation, the LD_{50} for the left-bank animals exceeded the LD_{50} for the right-bank animals by several tens or hundreds of thousands of times. There can be no doubt as to the geographical isolation of the right-bank and left-bank pallasiomys meridianus.

In this work, we studied the effect of genetic factors on the formation of resistance to plague in the left-bank pallasiomys meridianus.

EXPERIMENTAL METHOD

First, the conditions of reproduction of the animals in captivity were elucidated [4]. The wild animals reproduced well in concrete vol'ery. For nourishment of the animals we used a special nutritive ration. Under strict control conditions, we carried out cross breeding of the animals in two lines. In the first line, we crossed left-bank females and right-bank males, while in the second line – left-bank males and right-bank females. The crossing was successful, and the obtained progeny were fertile. In the first and second generations the progeny of each line were mated with males and females within the line. The work was carried out from the middle of 1960 until May of 1962.

A total of 3 experiments were set up for inoculation of the animals with a virulent strain of the plague bacteria (strain No. 1230 of the pallasiomys variety), studied earlier in detail [8]. In the first experiment, the parent generation underwent inoculation, in the second experiment – the progeny of the first generation, and in the third experiment – the progeny of the second generation. Along with inoculation of the progeny of both lines, the same doses were injected simultaneously into right-bank and left-bank animals caught in the steppes, left-bank animals reared in captivity, and white mice. At the same time, we carried out seedings of the inoculate doses on nutrient agar. Doses for the inoculation were the following: 0.1, 1, 10, 100, 1000, 10,000, 100,000, 1000,000, 10,000,000 and 100,000,000 microbial bodies; each dose was injected subcutaneously into both males and females of each group of animals, weighing approximately the same amount (8 animals per dose).

When animals died they were autopsied, and seedings were made to nutrient agar and bouillon using material taken from the site of injection, from regional lymph nodes, the spleen, liver, lungs and blood. In half the animals, from the moment of inoculation up to the 10th day, every 8 hours we studied the quantitative concentration of plague bacteria in the peripheral blood, drawn from an incision in the tail, by seeding it onto hard nutrient media. All the surviving animals were sacrificed 21 days after the inoculation for bacteriological investigation, and the serum was investigated in the reaction of passive hemagglutination with formalinized sheep erythrocytes, sensitized to fraction 1, for demonstration of antibodies to the plague microbe. Details of the experimental method were presented in a report by M. I. Levi [6].

Along with the experiments for determining the resistance to plague in the progeny of these animals, we carried out biometric measurements of their bodies and heads.

TABLE 1. Resistance of the Generation Obtained from Crossing Right-Bank and Left-Bank Pallasiomys Meridianus (LD_{50} in Microbe Bodies)

Characterization of the animals	Experiment No.		
	1	2	3
White mice	316	558	48
Right-bank pallasiomys meridianus	4	216	2
Left-bank pallasiomys meridianus	3937000	>10000000	39400000
First generation of the first line		1000	14920
Second generation of the first line			170000
First generation of the second line		131000	
Second generation of the second line			56200

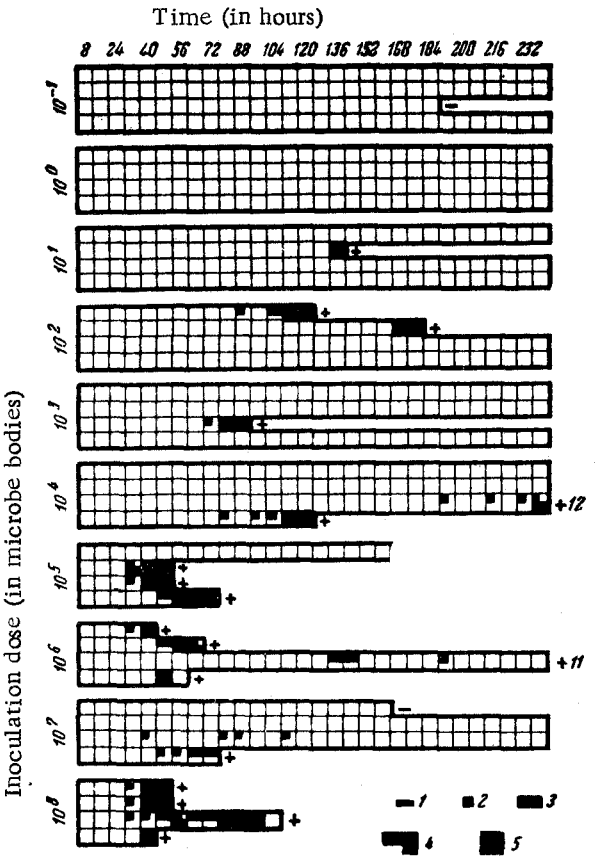

Fig. 1. Bacteremia in animals from the second generation of the first line (F_2-1). Experiment No. 3. + plague bacteria isolated from the deceased rodent; + 12 days on which the rodent died; 1) plague bacteria not isolated; 2) from 1 to 10 colonies isolated; 3) from 11 to 50 colonies; 4) from 51 to 100 colonies; 5) more than a hundred colonies.

EXPERIMENTAL RESULTS

The results of all the experiments with inoculation of the pallasiomys meridianus of both lines were shown to be monotypic (Table 1). While the dose that caused death of 50% of the animals was ten or a hundred microbes for the white mice, one, ten or a hundred microbes for the right-bank pallasiomys meridianus, and one or ten million microbes for the left-bank pallasiomys meridianus (both for wild animals, trapped on the steppes, and those reared in the laboratory), for the progeny of both lines, in the two generations, it ranged within the limits of one, ten and a hundred thousand microbe bodies. Thus, the LD_{50} in the progeny was approximately the mean figure between the LD_{50} for the right-bank animals and the LD_{50} for the left-bank animals. Calculation of the LD_{50}'s shown in Table 1 was done from observations on wild animals in which we did not perform the tail incisions for studies of the bacteremias.

As an example, we present the results of studying bacteremias in one group of the animals (Fig. 1). Corresponding with the principles specified earlier, bacteremia arose in the right-bank animals after inoculation with minimal doses, and was agonistic in character; a huge amount of bacteria was observed in the blood. In the left-bank animals, bacteremia appeared as a result of large doses; along with agonistic bacteremia, we encountered an infectious type, where only a few bacteria were found in a cubic millimeter of blood. In the progeny of the crossed lines the bacteremia possessed properties characteristic for the bacteremia of both the right-bank and left-bank rodents (Fig. 2 and 3). The bacteremia indices, which were computed according to the method recommended by M. I. Levi [6], are represented by mean figures for each group of animals.

TABLE 2. A Comparative Morphological Characterization of Two Populations of Pallasiomys Meridianus and Progeny (Age of the Animals 7-10 Months)

Group of pallasiomys	Number of individuals undergoing measurement	Mean indices				
		weight (in grams)	length of the tail without end hairs	length of the posterior foot without claws	height of the ear	total length from the end of the muzzle to the end of the tail without hairs
			in mm			
Left-bank animals, caught in nature	50	36	95	27	14	216
	51	39	95	27	14	216
The same	40	38	92	27	14	208
	40	46	93	27	14	209
Left-bank animals, reared in a nursery	8	36	91	26	14	205
	11	38	93	26	14	207
Right-bank animals, caught in nature	35	40	102	27	14	226
	63	44	102	28	15	228
The same	26	41	98	27	14	214
	23	51	97	27	14	224
First generation of the first line	20	45	94	26	14	212
	18	55	93	26	14	218
First generation of the second line	40	35	92	27	14	207
	30	41	93	28	15	210
Second generation of the second line	28	40	95	27	14	211
	30	49	94	28	14	216

Note. First figure – females, second – males.

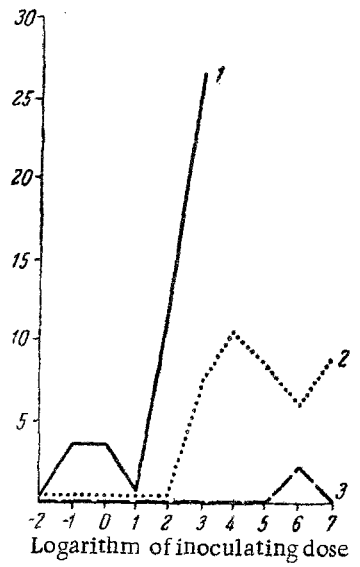

Fig. 2. Curve of the bacteremia indices. Experiment No. 2. 1) Right-bank pallasiomys meridianus; 2) progeny F_1-2; 3) left-bank pallasiomys meridianus.

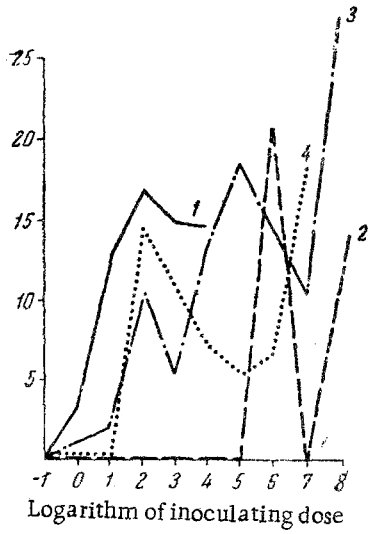

Fig. 3. Curve of the bacteremia indices. Experiment No. 3. 1) Right-bank pallasiomys meridianus; 2) left-bank pallasiomys meridianus; 3) progeny F_2-1; 4) progeny F_2-2.

In the serum of the right-bank animals that survived the inoculation, antibodies against the plague microbe appeared rarely and in low titer, while they were detected in a number of cases in the left-bank animals and the progeny of the crossed lines, in titers from 1:40 to 1:5120. We also noted that the highest antibody titers were recorded not so much in the animals in which we observed bacteria in the blood (but that survived), as in the animals in which an abscess formed at the site of injection, containing living bacteria 3 weeks after the inoculation.

Biometric measurements established that the features characteristic for the offspring of the crossed lines may be qualified as intermediate for left-bank and right-bank pallasiomys meridianus (Table 2).

On the basis of the fact that differences in the resistance of the right-bank and left-bank pallasiomys meridianus were established only as pertains to the plague pathogen, but not for other pathogenic microorganisms, and also because of the leading role played by the left-bank pallasiomys meridianus in supporting the existence of the plague microbe in nature (the right-bank animals have essentially no significance for the existence of the natural pool), it was postulated [5] that resistance of the left-bank animals to plague is a result of an unusual implication of these animals in an epizootic process. E. S. Biryukova [1] maintains a similar point of view. A similar possibility is recognized by L. A. Zil'ber, who believes that, in this manner, natural species immunity can arise [3]. At the same time, Yu. M. Elkin regards this hypothesis as incompetent. We note, here, that similar facts were observed from studying the resistance to plague in Persian pallasiomys. Baltazar (1953) found that Persian pallasiomys, inhabiting the mountainous region of the Iranian Kurdistan, where they play a leading role in supporting the natural pool of plague, are quite resistant to experimental inoculation with plague, However, U. A. Mamed-zade, working with Persian pallasiomys living in the borders of the Azerbaidzhan SSR, a total of 100 km more to the north, where these animals do not have any significance for supporting the existence of the plague microbe, showed that they do not possess resistance to plague [7].

SUMMARY

Pallasiomys meridianus, a habitant of the left bank of the Volga river is highly resistant to plague, whereas the same animals living on the right bank of the river are highly sensitive to experimental plague infection. The right-bank and the left-bank animals were interbred in strictly controlled conditions. The parents, the progeny of the first generation and the progeny of the second generation were experimentally infected. Along with plague resistance a study was made of bacteremia and blood antibody content of survived animals along with biometric measurements. As proved by direct experiments, plague resistance was inherited by Pallasiomys meridianus; crossing of genetic material of both populations led to the appearance in the progeny of properties characteristic of both the left-and the right-bank animals.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
