A Survey on the Resistance of Vietnam Fleas to some Insecticides

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INTRODUCTION

Since the plague laboratory in the Pasteur Institute, Nhatrang was taken over by the KOPreM Team* from a team of the Walter Reed Army Institute of Research (WRAIR) in 1969, many tests have been performed by KOPreM members. Since there has been difficulty in feeding fleas and raising mice, due to a consistent lack of the necessary supplies, we have not been able to test fleas from all the provinces in the 2nd Military Region(MR-2). However, now AIK funds have been granted for purchasing cages and food for adult mice. We have been able to keep 40 pools which contain 1,277 fleas from 619 rats. These fleas and rats were captured from 32 hamlets in 12 provinces and one municipal city in this region which is located in the central parts of South Vietnam during a 3-month period from April to June 1971 (Table 1). All the pools were identified by host species and dusting history such as pre- or post-dusting. One hundred percent(100%) of the examined fleas (200 fleas) were *X. cheopis*, showing the sex ratio to be about 50. The insecticide suscep-

ptibility tests were carried out when the fleas had multiplied sufficiently, usually more than one month.

We are very appreciative that WHO and Ministry of Health, Vietnam have provided insecticide impregnated papers for the tests. Here, we compiled, analysed and evaluated all the data of tests performed in our laboratory in 1971.

Table 1. Flea Index by Province in 1971.

Province	No. of Rat	No. of Flea	Flea Index
Binh Dinh	67	104	1.6
Binh Thuan	34	192	5.6
Cam Ranh	23	68	2.9
Darlac	26	63	2.5
Khanh Hoa	151	316	2.1
Kontum	22	66	3.0
Lam Dong	52	88	1.7
Ninh Thuan	45	63	1.4
Phu Bon	32	11	0.3
Phu Yen	36	42	1.2
Pleiku	37	171	4.6
Quang Duc	46	77	1.7
Tuyen Duc	48	16	0.3
Total	619	1277	2.1

RESULTS AND DISCUSSIONS

Results of the tests which were performed

*KOPreM: Korean Preventive Medicine Team/US-AID/Vietnam.

Table 2. Percent mortality and LC by Rat Species, Malathion dusting history and flea index.

	Concentration of Malathion					LC ₅₀	LC ₉₀	Flea Index
	0.8	1.6	3.2	6.4	12.8			
<i>R. norvegicus</i>	6.0	25.0	52.7	75.4	100.0	2.5	6.4	3.9
<i>S. murinus</i>	8.3	21.0	56.4	81.9	100.0	2.5	5.8	3.6
<i>R. rattus</i>	5.7	17.1	50.0	74.3	95.7	3.2	10.0	2.3
<i>R. exulans</i>	6.7	22.1	63.3	84.0	98.7	2.7	7.2	1.2
Average	7.1	22.0	75.2	79.7	98.8	2.5	6.4	2.1
Pre-dusting	7.0	20.0	53.5	78.4	98.4	2.9	8.0	2.5
Post-dusting	3.3	26.2	58.1	81.4	100.0	2.6	5.8	1.6

Table 3. Percent mortality of Fleas after malathion Exposure for One hour.

Province	Percent mortality by concentration					LC ₅₀	LC ₉₀	No. of Flea tested
	0.8	1.6	3.2	6.4	12.8			
Binh Dinh	0	32	50	80	100	2.6	6.2	320
Binh Thuan	10	24	62	80	99	3.1	7.5	370
Cam Ranh	10	20	53	80	100	2.6	6.4	160
Darlac	3.3	25	67	90	100	2.7	5.6	230
Lam Dong	10	15	55	75	100	3.0	6.6	110
Khanh Hoa	0	22	60	84	100	2.6	6.2	250
Ninh Thuan	2.5	7.5	44	70	100	5.2	9.2	280
Phu Bon	0	30	90	100	100	1.8	3.5	60
Phu Yen	10	30	53	63	97	3.3	10.0	170
Pleiku	13	30	70	90	100	2.2	5.0	230
Tuyen Duc	0	10	60	90	100	3.2	5.4	60
Kontum	0	0	33	60	90	4.8	13.5*	170
Quang Duc	10	20	70	90	100	2.6	5.2	120
Total	7.1	22.0	75.2	79.7	98.8	2.5	6.4	2530

* indicates out of confidence limit.

in the plague laboratory in 1971 are compiled and tabulated (Table 3, 5 & 9). Each result of resistance and susceptibility test of fleas in the region to malathion, dieldrin and DDT was discussed separately as follows:

1) Malathion Test:

A total of 1,970 oriental rat fleas (*X. cheopis*) were contacted with malathion impregnated papers of 0.8, 1.6, 3.2, 6.4, and

12.8% concentration for one hour and the mortality was checked after 24 hours. The total average mortality percent by concentrations ranged from 7.1% to 98.8% showing LC₅₀ and LC₉₀ as 2.5 and 6.4 each (Table 2). The highest value of LC₅₀ is shown in the fleas from, Ninh Thuan Province indicating 5.2 and the second highest value from Kontum province indicating 4.8 (Table 3). Values of LC₅₀ and LC₉₀ which

Fig. 1. Percent Lethal Concentration and Flea Index by Rat Species.

Fig. 2. LC_{50} and LC_{90} of malathion in some area.

were higher than the average are shown in the Figure 2.

Those of LC_{50} are much higher than that of the past. The values were 0.2, 0.3 and 0.38 in MR 1 in 1970 and 0.023 in Nhatrang in 1966 (Table 4).

Reviewing the above data, the higher values of LC_{50} , more than ten times than in the past, from several areas of the region indicated that the fleas of the areas had resistance to malathion and possibly to diazinon already. The fleas from the rest of the

Table 4. LC of Malathion by Year and Area.

Area	Year	LC_{50}	LC_{90}
MR*—1	1970	0.38	0.75
"	"	0.3	0.65
"	"	0.2	0.5
Nha Trang	1966	0.023	
Dalat	1969	4.5	7.0
MR 2(Average)	1971	2.5	6.4

* MR : Military Region

areas which have high value of LC_{50} also, seem to be on the verge of becoming resistant to the insecticide (Fig. 2). For further confirmation, several retests are needed. There are some differences of LC_{50} from 2.5 to 3.2, according to the rodent species such as *Rattus norvegicus*, *Suncus murinus*, *Rattus rattus*, and *Rattus exulans*. However, the difference is due to a prominent mortality rate of fleas from a certain area such as Trung Thanh Hamlet. The difference of LC_{50} is not significant to evaluate the difference of the resistance of fleas according to their host, rodent species. And also, it is known that the value of LC_{50} is not related to the flea index, and dusting, that is, pre- and post-dusting with a single field test (Fig. 1).

Table 5. Percent mortality of Fleas after Dieldrin Exposure for one hour.

Province	Percent mortality by concentration				LC ₅₀	LC ₉₀
	0.4	0.8	1.6	0		
Binh Dinh	10	90	100	0	0.62	0.88
Binh Thuan	50	50	100	0	0.56	1.00
Cam Ranh	80	90	100	0	(0.30)	0.64
Darlac	50	70	100	0	0.50	0.88
Kanh Hoa	40	70	100	1	0.53	0.90
Kontum	20	80	100	0	0.55	0.90
Lam Dong	40	60	100	0	0.55	0.95
Ninh Thuan	70	80	100	0	(0.30)	0.79
Phu Bon	50	70	100	0	0.50	0.88
Phu Yen	30	70	100	0	0.55	0.90
Pleiku	90	100	100	0	(0.35)	0.56
Quang Duc	60	100	100	0	(0.26)	0.48
Tuyen Duc	40	60	100	0	0.55	0.95
Total	48.5	76.1	100		0.47	0.81

* note: A total of 520 *X. cheopis* were used for the above tests, and data in ( ) indicates "out of confidence limit".

2) Dieldrin Test:

A total of 390 fleas were contacted with dieldrin impregnated paper for one hour for 3 different concentrations of 0.4, 0.8 and 1.6% and mortality percent was checked after 24 hours. The total average mortality percent was 48.5, 76.1 and 100% showing LC₅₀ and LC₉₀ as 0.47 and 0.81 each (Table 5 and 6). The highest value of LC₅₀ is shown in the fleas from Binh Dinh Province indicating 0.62, the second highest values are from Binh Thuan Province and some others showing a range from 0.5 to 0.56 (Table 5 and 6). As for the LC 50 of the recent past, the values varied from 0.1 to 0.2 as shown in Table 6. Reviewing the data, the value shows up as more than double what it was. This increase indicates that some portion of the flea population have a resistance to dieldrin and

possibly to lindane also.

It was also known that mortality at 0.8% was down from 99.5% in 1967 to 76.1% in 1971. However, the mortality at 1.6% of dieldrin was still 100% (Table 7 and 8). This indicates that the resistance of fleas to dieldrin appears to be at a lower concentration first, though the fleas are still susceptible to a high concentration.

3) DDT Test:

A total of 360 oriental rat fleas (*X. cheopis*) were contacted with DDT impregnated papers for 24 hours in three different concentrations of 1%, 2%, and 4%. Mortality was checked at the end of the contact and the average mortality percent at the maximum concentration of 4%, was 30.0%. It was of no use to figure out LC 50, because the value of LC 50 was much higher than the 4% concentration which lies far outside

Table 6. Percent of mortality by dusting history (Dieldrin).

	0.4	0.8	1.6	LC ₅₀	LC ₉₀
No. of death/Total	63/130	99/130	130/130		
Total average	48.47	76.1	100.0	0.47	0.81
Pre-dusting	48.75	76.25	100.0	0.47	0.81
Post-dusting	48.0	76.0	100.0	0.47	0.81

Table 7. LC of Dieldrin by year and by area.

Area	LC ₅₀	Year	Area	LC ₅₀	LC ₉₀	Year
Saigon	0.11	1965	Nha Trang	0.37	1.0	1969
Nha Trang	0.1	1966	Qui Nhon	1.0	2.02	"
"	0.125	1967	"	0.7	1.0	"
Bien Hoa	0.2	1968	Pleiku	1.0	2.02	"
MR 2	0.47	1971	Bao Loc	0.96	1.7	"

Table 8. Percent of mortality and LC by year (Dieldrin).

Conc. & LC Year	0.1	0.2	0.4	0.8	1.6	LC ₅₀	LC ₉₀
1967	27.9	76.7	95.4	99.5		0.125	0.32
1971			48.5	76.1	100.0	0.47	0.81

Table 9. Percent mortality of Fleas after D.D. T. exposure for 24 hours.

Province	% mortality by concentration			
	1	2	4	0
Binh Dinh	10	20	50	0
Binh Thuan	10	20	20	0
Cam Ranh	0	20	30	0
Darlac	0	0	10	0
Khanh Hoa	20	50	50	10
Kontum	0	10	30	0
Lam Dong	0	20	30	0
Ninh Thuan	0	0	0	0
Phu Bon	10	20	40	0
Phu Yen	10	40	50	0
Pleiku	0	10	30	0
Quang Duc	0	10	20	10
Tuyen Duc	—	—	—	—
Total	5.0	18.3	30.0	1.6

* note: A total of 480 *X. cheopis* were used for the above tests. All the data of LC₅₀ and LC₉₀ are out of confidence limit.

the range of confidence limits of the LC₅₀ of the normal colony. An analysis of world wide data by WHO showed LC₅₀ for DDT to range from 0.27 to 0.7% for one hour exposure. As many investigators already reported, fleas in Vietnam have been resistant to DDT since a report of the confirmation in 1965. But DDT has been used continuously in several areas. And so the resistance has become greater and greater until seventy percent of the fleas survived after 24 hours contact of 4% DDT impregnated papers (Table 9 and 10).

CONCLUSIONS

The results of the tests carried out in 1971 strongly suggested that a considerable portion of the flea population in MR 2 had developed resistance not only against DDT but also malathion and dieldrin. There is

Table 10. Percent mortality of Fleas after DDT exposure.

Locality	Year	Concentration of DDT					LC ₅₀	Exposure hours
		0.25	0.5	1.0	2.0	4.0		
Bangkok(Klong Toey)	1966	4	4	6	24	47		1 hr
	1969		0	0	6.6	13.3		"
	1971	0	0	0	0	40		"
	1972	0	0	0	0			"
	1966	5	24	60	91	98	0.83	24 hrs
	1969		33	70	86	86	0.7	"
	1971	0	30	50	80	80	1.0	"
	1972	0	10	40	70	80	1.3	"
Saigon	1965	20.9	45.9	37.5	58.4	58.4	1.3	1 hr
MR-2, VN(Nhatrang) area	1966	7.9	24.9	34.3	52.0	71.0	1.8	1 hr
	1967		9.3	16.3	20.9	28.0		"
	1969	0	0.9	0	1.3	2.5		"
	1971	0	0	0	0	0		"
	1969	0	0	2.2	12.2	33.3		24 hrs
	1971	0	0	5.0	18.3	30.0		"

also the possibility of the fleas developing a resistance to diazinon and lindane. Thus careful consideration should be given to the continuous use of diazinon. In areas where fleas had developed a resistance to malathion, further tests should be conducted continuously to confirm the possible development of resistance. Other insecticides which have not been used in Vietnam for any purpose should be ready to be substituted, if the development of resistance is confirmed,

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＝國文抄録＝

越南産 벼룩(*X. cheopis*)의 殺虫劑에 對한 抵抗 및 感受性 調査

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人體傳染病을 媒介하는 여러가지 昆蟲이 汎世界的으로 DDT 等の 殺虫劑에 抵抗을 나타내고 있으나 이에 對한 實際의 測定値는 몇몇 地域에서의 모기에 對한 것 以外에는 資料가 거의 없으며 더구나 代置殺虫劑로 쓰이고 있는 malathion 및 dieldrin, diazinon, lindane 에 對한 抵抗如否의 調査結果는 더욱더 없는 實情이다. 이에 對하여 著者が 越南에 있는 동안 一次調査로서 越南産 벼룩(*X. cheopis*)을 이용하여 DDT 및 malathion, dieldrin 에 對한 抵抗性 및 感受性을 WHO 推薦方法에 依해 實施하였다. 即 越南中部地方 12個省의 31個村落을 對象으로 169마리의 쥐에서 1277마리의 벼룩을 採集하여 40個 pool을 만들었다. 위의 資料를 充分히 繼代培養하여 WHO가 위의 殺虫劑를 浸潤시켜 만든 濾過紙에 24時間 接觸하여 얻은 死亡率을 調査分析한바 대부분의 벼룩이 DDT에 強力히 抵抗을 나타냈고 상당수의 벼룩이 malathion 및 dieldrin에 抵抗을 나타냈다. 따라서 malathion 및 dieldrin에 各各 相應하는 diazinon 및 lindane에 對한 抵抗의 可能性도 豫測할수 있었다.