

The level of the housefly resistance to several synthetic insecticides in Kochi Prefecture

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The development of resistance to insecticides has become one of the most important problems in relation to insect control and to conservation of nature in Japan. As for the housefly, for the first time a report was published by Yasutomi in 1960 on the resistance levels to γ -BHC and p,p'-DDT of housefly colonies collected at Hikone, Shiga Prefecture; their LD₅₀-values ($\mu\text{g}/\text{female}$) 1.260 for γ -BHC and 60 for p,p'-DDT were of noticeably high level from a world-wide view-point. And similar reports have been sporadically published by other researchers, but we have not met with any respective overall pursuits on the subject at various regions of Japan until resistant strains to malathion of the housefly at 44 places in Hokkaido is reported by Hayasi (1970). In particular, little attention has been paid to resistance of medical insects in Kochi. In 1971 to 1972, houseflies were collected by us from various places in Kochi, and their resistance levels to insecticides were evaluated and compared with those of housefly colonies in diverse localities of Honshu.

Tested insects and methods

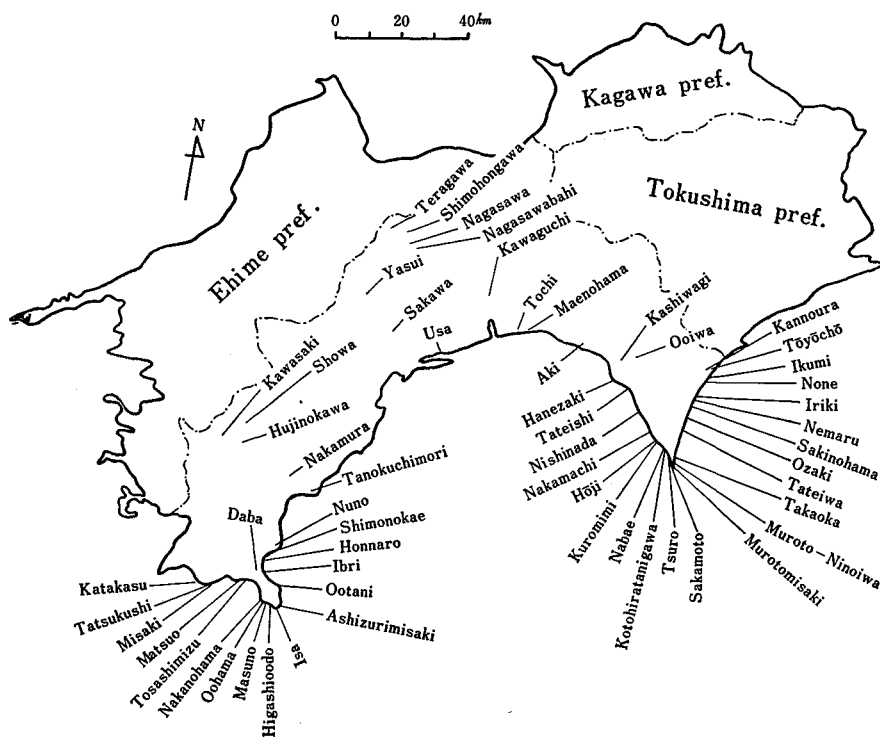


Fig. 1 Map showing the housefly collected at 57 stations in Kochi Prefecture from 1971 to 1972

Insects: Some couples of the housefly, *Musca domestica vicina* of 104 colonies, were collected from refuse cans, garbage dumping places or pig-pens at 57 places in Kochi, (Fig. 1) and the tests were made after breeding for three or four generations in the laboratory. Larvae were reared with the Oriental's animal food (Powder for the rearing of experimental animales, Oriental Yeast Manufacturing Co.,). Adults were fed with 2% sucrose solution. Of the adults, only females were made available for the tests 3 or 4 days after their emergence.

Some of the houseflies were collected for test of susceptibility to eight insecticides on 39 places at intervals of 100m in Tochi, Nangoku City, Kochi Pref.

Insecticides: Eight kinds of insecticides; lindane (γ -BHC), malathion, dichlorvos (DDVP), diazinon, fenitrothion (sumithion), bromophos, pyrethrins and allethrin were used as test chemicals. These chemicals were dissolved in acetone and applied to the insects.

Test method (Topical application): 0.5 μ l of serial dilution of the insecticides was applied topically onto dorsum of each fly using a microsyringe. Each dilution was tested on 20 flies and the experiment was repeated three times. After the treatment flies were transferred to containers in a constant temperature chamber held at 24 to 27°C, and fed with 2% sucrose solution, and the mortality was counted 24 hours after the treatment.

Evaluation of the level of resistance: The dosage required to produce 50 % mortality (LD₅₀) was used as the basis for comparison of resistance level. The value of LD₅₀ for the Takatsuki strain, which has never been exposed to any insecticides, was used as the reference.

Results and discussion

Results of my tests for houseflies collected from Kochi Pref. and these of flies from Honshu reported by other researchers, are summarized in Tables 1 ~ 4. The comparative

Table 1 LD₅₀-values (μ g/♀) of seven insecticides for 20 colonies of housefly collected in Kochi Prefecture in 1971

Colony	Allethrin	Pyrethrin	Sumithion	Malathion	Diazinon	DDVP	Bromophos
1 Murotomisaki	1.104	0.444	0.369	68.821	0.763	0.095	0.838
2 Tsuro	0.886	1.088	0.307	1.141	1.195	0.085	0.571
3 Hoji	1.222	0.875	0.222	84.821	0.534	0.077	0.369
4 Aki	0.907	0.454	0.345	0.811	0.465	0.075	0.429
5 Maenohama	1.504	1.707	0.510	0.886	0.598	0.105	0.630
6 Tochi	0.859	0.728	0.247	1.168	0.575	0.053	0.326
7 Kawaguchi	1.030	0.886	0.449	0.848	0.465	0.091	0.424
8 Nagasawa-bashi	1.382	0.278	0.638	1.106	0.367	3.673	
9 Nagasawa	0.461	0.319	0.424	1.701	0.830	9.131	
10 Shimo-hongawa	2.196	1.084	0.550	3.853	0.253	6.301	
11 Teragawa	0.592	0.300	0.349	1.078	0.549	2.117	
12 Yasui	1.936	2.177	0.185	6.722	0.233	0.087	0.410
13 Sakawa	1.280	0.522	0.125	0.730	0.259	0.062	0.281
14 Shōwa	1.464	1.123	1.271	1.002			

15 Kawasaki	1.141	0.494	0.182	0.318			
16 Hujinokawa	0.925	0.655	0.347	1.211			
17 Nakamura	1.158	0.950	0.185	0.534	0.268	0.059	0.228
18 Ashizurimisaki	0.788	0.388	0.247	116.885			
19 Nakanohama	1.641	0.482	0.341	271.419			
20 Tosashimizu	1.728	0.950	0.268	0.630	0.505	0.070	0.401
Takatsuki	0.543	0.413	0.179	0.455	0.293	0.076	0.161

Table 2 LD₅₀-values ($\mu\text{g}/\text{♀}$) of eight insecticides for 45 colonies of housefly collected in Kochi Prefecture in 1972

Colony	Allethrin	Pyrethrin	Sumithion	Malathion	Diazinon	γ -BHC
1 Kannoura	0.813	0.388	0.555	0.267	0.187	2.801
2 Tōyōchō	0.724	0.959	0.400	165.416	10.060	2.699
3 Ikumi	1.433	0.866	0.352	189.249	8.643	9.379
4 None	0.842	0.825	0.183	21.119	0.508	5.346
5 Iriki	1.032	0.436	0.305	13.019	0.313	1.204
6 Nemaru	1.035	0.729	0.328	4.769	0.624	4.724
7 Sakinohama	1.441	1.233	0.147	144.768	10.181	18.912
8 Ozaki	1.185	0.361	0.299	150.114	0.793	28.129
9 Tateiwa	1.513	0.617	0.224	10.013	0.460	6.948
10 Takaoka	0.681	1.011	0.194	8.939	0.481	8.714
11 Muroto-Ninoiwa	0.862	0.374	0.412	11.804	0.454	3.837
12 Murotomisaki	1.104	0.444	0.369	68.821	0.763	5.708
13 Sakamoto	0.826	0.385	0.365	10.111	0.893	3.886
14 Tsurō	0.886	1.088	0.307	1.142	1.195	4.621
15 Kotohiratanigawa	1.001	0.874	0.245	18.265	0.434	2.813
16 Nabae	1.106	0.283	0.366	36.268	0.821	4.321
17 Kuromimi	0.513	0.298	0.323	41.311	0.571	9.478
18 Hoji	0.886	0.761	0.541	11.325	0.303	6.749
19 Nakamachi	0.426	0.263	0.623	49.736	0.508	8.463
20 Nishinada	0.582	0.381	0.327	20.261	0.821	5.125
21 Tateishi	0.731	0.195	0.335	28.314	0.267	2.652
22 Kashiwagi	0.981	0.935	0.418	1.449	0.399	11.216
23 Ooiwa	0.384	0.489	0.283	3.881	0.376	2.222
24 Hanezaki	0.963	0.273	0.275	88.271	0.613	5.151
25 Tōchi	1.629	0.660	0.545	1.698	0.388	4.350
26 Usa	0.809	0.465	0.194	124.683		
27 Tanokuchimori	0.469	0.412	0.797	14.650		
28 Nakamura	0.481	0.496	0.310	1.316		
29 Nuno	1.094	0.471	0.259	1.382		
30 Shimonokae	0.473	0.721	0.227	0.617		
31 Honnaro	0.514	0.369	0.232	0.847		
32 Iburi	0.555	0.268	0.356	0.761		
33 Daba	0.505	0.500	0.539	4.829		
34 Ootani	1.504	0.440	0.262	6.032		
35 Ashizurimisaki	0.848	0.456	0.316	5.318		
36 Isa	0.570	0.797	0.224	18.734		
37 Higashioodo	0.428	0.342	0.425	84.312		
38 Matsuo	0.449	0.354	0.351	128.421		
39 Oohama	0.851	0.736	0.211	6.102		
40 Nakanohama	0.455	0.223	0.272	11.441		
41 Tosashimizu	0.957	0.154	0.198	1.143		
42 Masuno	0.621	0.372	0.152	0.929		
43 Misaki	1.482	0.698	0.305	1.882		
44 Tatsukushi	0.859	1.318	0.224	0.609		
45 Katakasu	0.563	0.358	0.293	0.682		
Takatsuki	0.481	0.387	0.089	0.455	0.293	4.542

Table 3 LD₅₀-values ($\mu\text{g}/\varphi$) of eight insecticides for the 39 colonies of housefly at the stations situated at intervals of 100m in Tochi, Nangoku City, Kochi Pref. in 1972

Colony* No.	Allethrin	Pyrethrins	Sumithion	Malathion	Diazinon	DDVP	Bromophos	γ -BHC
1	1.560	1.015	0.597	1.367	0.433	0.198	0.443	2.490
2	2.094	2.147	0.330	1.319	0.351	0.208	0.586	2.642
3	2.549	0.360	0.330	1.493	0.558	0.143	0.631	4.120
5	1.627	0.660	0.545	1.698	0.388	0.237	0.489	4.350
6	3.930	1.257	—	—	0.645	—	0.617	—
7	3.625	1.243	0.295	2.159	0.512	0.398	1.411	1.947
8	2.341	0.645	0.660	2.368	1.257	0.398	9.707	12.437
9	2.498	1.218	0.752	5.009	0.734	0.483	1.463	23.820
10	2.567	1.624	0.530	4.460	0.639	0.325	0.913	9.426
I 11	1.339	1.114	0.490	1.500	0.518	0.107	0.462	5.006
12	1.067	1.033	0.388	1.939	0.421	0.244	0.389	3.911
13	0.989	2.159	0.402	3.003	0.550	0.350	0.807	1.664
14	1.150	0.531	0.337	2.905	0.703	0.159	0.663	7.302
15	1.522	0.489	0.516	4.047	0.641	0.243	0.591	11.033
16	1.470	0.774	0.534	4.116	0.488	0.300	0.437	8.091
17	1.626	0.922	0.675	5.814	0.579	0.277	0.477	6.633
18	1.901	0.825	0.268	3.719	0.852	0.400	0.566	5.590
19	2.033	0.728	0.309	1.562	0.769	0.291	0.800	2.808
20	1.980	0.660	0.444	1.783	0.770	0.317	0.714	3.256
1	2.062	0.870	0.528	3.384	0.810	0.234	0.508	3.764
2	2.459	0.884	0.594	4.458	0.344	0.212	0.464	2.525
3	2.146	1.015	0.597	3.393	0.621	0.216	0.818	6.466
4	3.701	0.870	0.441	1.463	0.568	0.151	0.597	10.197
5	2.280	1.357	0.461	1.519	0.633	0.154	0.605	2.744
6	3.973	1.386	0.516	3.660	0.563	0.296	0.713	28.150
7	2.047	1.739	1.624	8.531	0.435	0.457	1.177	36.118
8	1.585	1.735	0.528	4.899	0.292	0.263	1.486	4.899
9	2.191	0.976	0.363	3.086	0.850	0.231	1.591	2.027
10	1.485	1.077	0.368	2.191	0.418	0.191	0.435	4.695
II 11	1.349	0.744	0.471	4.043	0.558	0.107	0.544	5.115
12	1.715	0.907	0.314	2.589	0.515	0.226	0.496	10.904
13	1.501	1.031	0.298	1.980	0.400	0.403	0.407	3.313
14	2.004	1.402	0.375	5.211	0.471	0.197	0.399	7.500
15	1.803	0.699	0.414	5.432	0.339	0.161	0.502	9.421
16	1.913	0.911	0.502	3.118	0.318	0.242	0.451	6.137
17	1.009	1.395	0.221	1.037	0.511	0.303	0.439	4.808
18	1.278	1.008	0.407	1.792	0.461	0.215	0.807	2.249
19	1.490	0.881	0.359	2.020	0.299	0.386	0.383	3.617
20	1.555	0.905	0.450	4.001	0.490	0.299	0.777	2.999
Takatuki	0.481	0.387	0.089	0.455	0.293	0.076	0.161	4.542

* Nos. 1—20 are arranged from west to east within each area of the two groups (I, II) of stations; I is along the mountain, II is along the coast.

Table 4 LD₅₀-values ($\mu\text{g}/\varphi$) of eight insecticides for 5 colonies of housefly collected by Hayashi in Honshu and Hokkaido in 1970

Colony	Malathion	Dichlorvos	Diazinon	Bromophos	Lindane	Allethrin	Pyrethrins
Hachimantai	51.589	0.068	0.359	0.123	3.432	0.839	0.297
Aomori	4.926	0.085	0.502	0.238	3.292	1.126	0.767
Morioka	58.025	0.083	0.233	0.124	3.627	0.751	0.321
Sapporo	213.388	0.058	0.134	0.318	0.741	0.730	0.379
Takatsuki	0.454	0.076	0.293	0.161	4.547	0.481	0.387

resistance of each colony to respective insecticides is explained as follows ;

Lindane : The considerable departure in LD₅₀-value from that of Takatsuki strain for γ -BHC was not observed in any colonies of Kochi, except for some colonies from Sakinohama, Ozaki, and Tashiwagi at Murotomisaki.

Then it follows that many colonies of houseflies in Kochi Pref. are no less susceptible to γ -BHC than the Takatsuki strain.

Malathion : Almost all the samples of flies collected in Kochi Pref. with not a few exceptions (Tosashimizu area at Ashizurimisaki and areas in the east of Murotomisaki) were proved to show LD₅₀-values 1.5~5 times as high as that of Takatsuki strain, whereas the exceptional colonies were of wonderfully higher resistance to malathion than the Takatsuki strain. LD₅₀-values of Japanese houseflies for malathion reported by several researchers are estimated at nearly 0.5 μ g per female fly, strictly speaking, 0.52 μ g in the RP strain and 0.589 μ g in the Denken and Hokota strains (Suzuki et al. 1961 ; Yasutomi, 1961). Recently, Hayashi reported that the high resistance in houseflies to malathion was found at Sapporo,

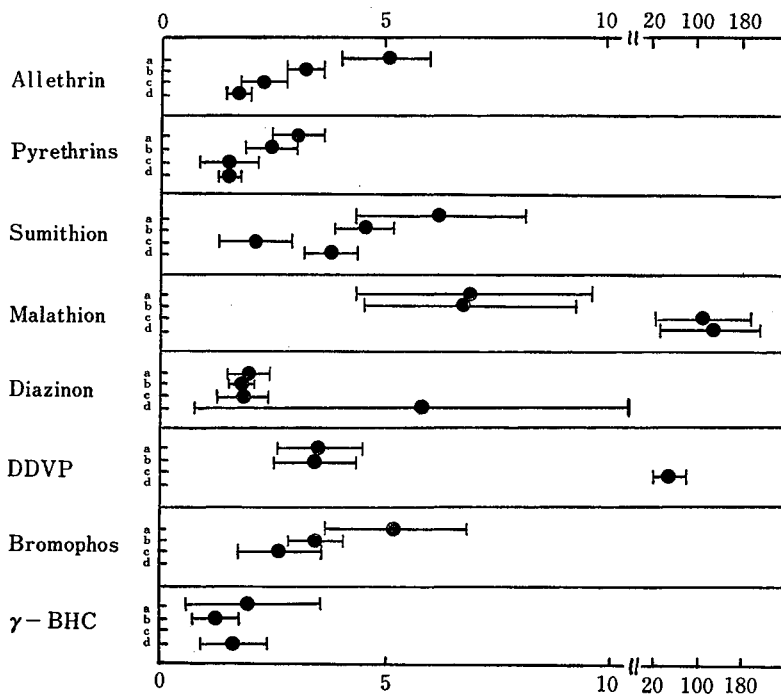


Fig. 2 Mean LD₅₀ with 99% confidence intervals of relative resistance rates as compared with that of Takatuki for eight insecticides applied topically of the colonies corrected from each station along the coast and the mountain in Tochi, developed in vinyl-house horticulture, in Kochi Prefecture in 1972 and of colonies from localities other than Tochi in 1971 and 1972

a: Samples collected in the west of Tochi, b: those collected in the east of Tochi, c: those at the locality other than Tochi in 1971, d: those at the locality other than Tochi in 1972

Hokkaido; the LD₅₀-values being 213.388 μ g, and on the other hand Yasutomi reported that such high resistance as ranks second to that observed in Hokkaido to malathion in

houseflies was found at Yumenoshima Island, the 15th dumping island in Tokyo Bay and Matsudo dumping site in Chiba, the LD₅₀-values being 18.51, 25.26 and 10.35 μg respectively. The high resistance has been recognized on the fly colonies in Hokkaido, Tokyo, Chiba and Kochi regardless of whether this insecticide has been used scarcely or usually, and then it is conceivable that inheritance factor operates strongly. In the flies collected at the seaside places in Kochi such as Toyocho, Ikumi, Sakinohama, Ozaki, Matsuo, Ashizurimisaki and Nakanohama, the highest resistance colonies were observed; the LD₅₀-values for malathion ranged between 116.885 and 271.419 μg , being 256.890 to 596.525 times as high as that of the Takatsuki strain (Fig. 2).

Allethrin: The LD₅₀-values 0.384 to 2.196 of the flies in Kochi are not so higher as those of Takatsuki (0.543) and Honshu (0.751 to 0.859 μg). But in 39 stations at the vinyl-house horticultural area in Tochi of Nangoku City, the LD₅₀ values, being 0.989 to 3.973 μg , 2.056 to 8.26 times as high as that of the Takatsuki strain, are of high level relatively to those elsewhere in Kochi as shown in Fig. 2.

Pyrethrins: The LD₅₀-values of the flies in Kochi were not so higher than that of Takatsuki strain, and it is rather susceptible colony; Yasui (2.177), Sakinohama (1.233), Takaoka (1.011), Tochi (2.159 μg) were of high level colony in LD₅₀.

Diazinon: The LD₅₀ values of the flies from Toyocho (10.060) and Sakinohama (10.181 μg) were higher than that of the Takatsuki strain, but the other colonies in Kochi Pref. were not so high for diazinon. Sumithion: Every colony of the housefly collected in Kochi except for a colony at Tochi, tended to be slightly more resistant to sumithion as compared with the Takatsuki strain.

DDVP: It was observed that all samples of flies collected in lowlands and seashores were of lower resistance level than any strains at Takatsuki and other places in Honshu for DDVP, whereas for the colonies of Nagasawabashi, Nagasawa and Shimohongawa in highlands in Kochi Pref., the LD₅₀-values were of higher level, i.e. 3.673, 9.131, and 6.301 respectively. In spite of the situation, DDVP seems to be a promising insecticide, because the LD₅₀-value is low universally in Kochi Pref., especially in Tochi where the housefly has been increased so much in numbers within horticultural vinyl-houses at present.

Bromophos: The susceptibilities of flies in Kochi to this insecticide were similar to those observed in the test with DDVP.

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Conclusion

Houseflies of 104 colonies were collected from 57 places in Kochi, and their resistance

levels to lindane, malathion, allethrin, pyrethrins, diazinon, sumithion, DDVP, and bromophos were assessed. It was found that many housefly colonies in Kochi were no more resistant to these insecticides than the Takatsuki strain. Nevertheless, it was proved that some strains at seashores of the Muroto- and Ashizuri-points are more resistant to malathion; especially notably high LD_{50} -values were obtained in the flies from Tōyōchō (165.416), Ikumi (189.249), Sakinohama (144.768), Ozaki (150.114), Matsuo (128.421), Ashizurimisaki (116.885) and Nakanohama (271.419 μ g). These LD_{50} -values being of such high level as ranks second to that in Sapporo, Hokkaido, were much higher than the LD_{50} -value of 25.26 μ g obtained in the 15th dumping island (Yumenoshima, Tokyo). In Kawaguchi, Nagasawabashi, and Shimohongawa, the remote and isolated places in highland, these LD_{50} -values of several strains were clearly higher than the values of the other strains.

These results establish that resistance to malathion is developed in the observed areas but tolerance to allethrin, sumithion and bromophos are done especially in the west of Tochi.

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