References

1) Masuda, T., H. Fukuda: *Botyu-Kagaku*, 35, 134 (1970).
2) N. Sethunathan, Susan Caballa, M. D. Pathak: *J. Agr. Food Chem.*, 61, 571 (1971).
3) Yakumaru, K., N. Usuda: *Noyaku-Siken-Seiseki*, Zennō Nōgyō Gizyutu Center, 233 (1973).
4) Coffin, D. E., W. P. Mckinley: *J. A. O. A. C.*, 47, 632 (1964).
5) Nose, K.: *Pesticide and Technique*, 22, 49 (1970).
6) Kanazawa, J.: *Bulletin of the National Institute of Agricultural Sciences*, C, 25, 109 (1971).
7) Miyamoto, J.: *Botyu-Kagaku*, 36, 189 (1971).
8) Getzin, L. W., Rosefield, I.: *J. Econ. Entomol.*, 59, 512 (1966).
9) Getzin, L. W.: *J. Econ. Entomol.*, 61, 1560 (1968).
10) George W. Snedecor, William G. Cochran: *Statistical Method*, 6th edition, Iwanami (1972).

Laboratory Evaluation of Effectiveness of Some Insecticide Emulsifiable Concentrates for the Immature Stage of the Mediterranean Fruit Fly, *Ceratitis capitata* (Wiedemann)

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27. チチュウカイミバエの幼虫に対する殺虫乳剤有効度の評価法 長沢純夫 (FAO 在ブラジルサンパウロ生物学研究所) 49. 9. 20 受理

コーヒーの実を加害して，成長，脱出するチチュウカイミバエの幼虫の分布は，切れたポアソン系列に近似できた．この知見にもとづいて，殺虫乳剤に浸漬処理した実から脱出する幼虫数と，薬液の濃度の関係を Wadley の方法によって解析し，その適用の可能性を証明した．併せて数種市販乳剤の有効度の検定結果を例示した．

Laying aside the economical problems, insecticide spray tests in the field are undoubtedly a big task for experimenters. In spite of their hard operations, the results of experiments sometimes leave much to be desired, largely due to the complex environmental factors and technical problems involved. If it were possible to bring the test materials into the laboratory under the same condition of infestation in field, the field evaluation test of insecticide formulations could be satisfactorily replaced with laboratory scale test with no big difference in results.

For example, the control test of immature stage of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), growing on coffee berry usually would be carried out by spraying or dusting on the infested berries following an appropriate experimental design. After several days the counts would be made of the numbers of flies which survived and developed from randomly sampled berries. But the total number of flies treated could be discovered only by laborious counts on the dissected berries. If the infested berries are at first randomly collected from the field and assigned to some levels of dosage of insecticide, and then spraying, dusting or dipping treatment is made in the laboratory, the effectiveness of test insecticide could more precisely be determined statistically from counts of surviving flies only by the standard probit method of parameters of tolerance distribution (Wadley 1949, Finney 1949). A method of effectiveness evaluation of insecticide emulsifiable concentrates for the immature stage of the Mediterranean fruit fly will be discussed in the present paper.

Spatial distribution of the Mediterranean fruit fly on coffee berries

The fitting of an appropriate mathematical model to the spatial distribution of insects per unit of area, host or time is essential for

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evaluating the effectiveness of insecticides in field applications. Even in laboratory tests, when it is impossible to count the initial number of insects beforehand due to their living inside host plants or animals and the effectiveness of insecticides is evaluated by the number of non-responsive insects after treatment, the determination of the type of spatial distribution of test insects per unit of host would be necessary for the further statistical analysis of experimental data.

Host preference of the Mediterranean fruit fly covers a wide range including cultivated or wild fruits and vegetables. The number of larvae found per unit of fruit or vegetable varies markedly depending upond the size of host unit. The maximum number of larvae grown on a coffee berry, mulberry, olive, cherry, etc. of comparatively smaller size is about 10 individuals.

The simplest hypothesis to account for the variation in insect counts is that represented by the Poisson distribution, and the distribution of larvae of the fruit fly growing on coffee berry is assumed to followed the Poisson distribution since the number of larvae grown in any given coffee berry seems to be independent of that in any other berry and all coffee berries are equally exposed to the chance of oviposition of the fruit fly.

When the sampling units are sufficiently numerous and not too heavily infested, the units would be scored into an observed frequency distribution. In sampling the materials for insecticide bioassay tests, however, usually uninfested berries would in practice be ommited from collection. Consequently, the assumed Poisson distribution may be truncated at the lower end because the true number of observations in the class unit zero measurement cannot be obtained. Using the method developed by David and Johnson (1952), a spatial distribution data of the fruit fly larvae grown on coffee berry was first analysed to fit to the truncated Poisson distribution.

Materials and methods: In early November, 1971, coffee berries infested by fruit flies were collected at random in the coffee plantation in the yard of the Biological Institute of São Paulo. The materials were kept one by one in a tightly covered plastic cup (8 cm in diameter and 3 cm in height) and placed under an insectary condition of ca 25°C and 60% R.H. At the 14th day, total number of larvae coming out from each berry was counted and recorded.

Results and discussion: The first and second columns of Table 1 show the number of fruit fly larvae frequency f for each unit of coffee berry x omitting the frequency for the unit of 0 count. In these 196 coffee berries, the number of larvae totalled $\Sigma(fx)=637$, averaging $\bar{x}=\bar{m}=\Sigma(fx)/N=3.25$ larvae per berry. David and Johnson have shown a table for approximating

Table 1. Estimation of expected frequencies ϕ by interpolation and their comparison with observed frequencies f by χ^2

Larvae per berry	Observed frequency	Proportionate frequency for		Expected frequency ϕ for		
x	f	$\hat{m}=3.1$	$\hat{m}=3.2$	$\hat{m}=3.104$	$f-\phi$	$\frac{(f-\phi)^2}{\phi}$
0	—	0.0450	0.0408	(9.19)		
1	29	0.1397	0.1304	28.59	0.41	0.006
2	37	0.2165	0.2087	44.36	−7.36	1.221
3	56	0.2237	0.2226	45.89	10.11	2.227
4	36	0.1734	0.1781	35.58	0.42	0.005
5	20	0.1075	0.1140	22.11	−2.11	0.201
6	11	0.0555	0.0679	11.49	−0.49	0.021
7, 8, 9	2, 3, 2	+0.0387	+0.0375	7.98	−0.98	0.012
Factor		196.98	8.21			
Total	196			196.00		$3.693=\chi^2$

the mean of the complete Poisson distribution $\hat{\lambda}$ from the mean value $\bar{m}$ of the truncated Poisson distribution. Using their table, the value of $\hat{\lambda}$ corresponding to $\bar{m}=3.25$ was interpolated as 3.104. The agreement of the observed data with that expected by Poisson series with an estimated mean $\hat{m}=\hat{\lambda}=3.104$ has been tested for goodness of fit. The tabular proportionate frequencies for $\hat{m}=3.1$ and $\hat{m}=3.2$ have been copied in the third and fourth columns of Table 1 from a table of the Poisson distribution. Proportionate frequency for $m=3.104$ corresponding $x=0$ class interpolated as 0.0448. Consequently the total number of frequencies in the complete Poisson distribution is estimated as

$$\hat{N}=N/(1-0.0448)$$
$$=205.19.$$

To obtain the expected frequencies by linear interpolation, each value of ϕ for $\hat{m}=3.1$ was multiplied by $(1-0.04)\times 205.19=196.98$ and added to the products of the corresponding value for $\hat{m}=3.2$ multiplied by $0.04\times 196.98=8.21$. These factors have been entered at the first foot of each column. The expected frequency for $x=0$, for example, was computed as

$$\phi_0=196.98\times 0.0450+8.21\times 0.0408$$
$$=9.19,$$

and others were calculated similarly.

The expected frequencies ϕ were then compared with the observed values f, computing from each pair its distribution to χ^2. The sum of the seven entries gave $\chi^2=3.698$ with $7-2=5$ degrees of freedom, indicating good agreement with Poisson.

A laboratory method for evaluating the insecticide effectiveness on the immature stage of the Mediterranean fruit fly

In the previous section, the spatial distribution of larvae of the Mediterranean fruit fly on coffee berries was proved to follow the Poisson distribution. This information tells us that a series of survival count record of the fruit fly larvae from the insecticide-treated coffee berries could be analysed by the standard probit method of Wadley and Finney, and the determination of LC_{50} and other characteristics of the concentration-mortality curve could be estimated. The applicability of Wadley's problem will be discussed.

Materials and methods: An emulsifiable concentrate sample labelled 60% methyl parathion content used for the present experiment was a commercial product offered from a chemical company in São Paulo. Test solutions of eighteen levels of concentration were prepared by dilution in water in logarithmic scale starting from 10% formulation.

The coffee berries infested by the fruit fly were obtained at the coffee plantation in the yard of the Biological Institute of São Paulo. A part of the materials was used for the determination of spatial distribution type of larvae developed per unit of berry. The result obtained has been mentioned in the previous section. The rest of materials was randomly assigned to eighteen levels of concentration and to the control in which only water was used. The infested berry materials were enough to assign 30 berries to each concentration and the control.

Table 2. Concentration (%) of methyl parathion emulsifiable concentrate used for dipping coffee berries and number of larvae of the Mediterranean fruit fly that survived and developed

Concentration	Number of larvae	Concentration	Number of larvae	Concentration	Number of larvae
10	0	10×0.5^{6}	0	10×0.5^{12}	19
10×0.5^{1}	0	10×0.5^{7}	0	10×0.5^{13}	34
10×0.5^{2}	0	10×0.5^{8}	1	10×0.5^{14}	47
10×0.5^{3}	0	10×0.5^{9}	0	10×0.5^{15}	58
10×0.5^{4}	0	10×0.5^{10}	2	10×0.5^{16}	59
10×0.5^{5}	0	10×0.5^{11}	9	10×0.5^{17}	63

Insecticide treatment of berries was made by dipping in the test solution for one minute. After the dipping, treated berries were transferred on paper and excessive solution was dried for 24 hours. Then berries were transferred to a glass container of 9 cm in diameter and 5 cm in height. Containers were covered with cotton cloth, then kept for two weeks under an insectary condition of ca 25°C and 60% R.H. On the 14th day after treatment, the number of larvae which survived and developed was counted and recorded.

Results and discussion: The result of experiment was shown in Table 2 as the relation between the concentration (%) of formulation and number of larvae coming out from treated berries. The number of larvae from the control batch was 62. It could be said from the result shown in Table 2 that no larvae can survive from dipping at higher concentrations than about $10\times0.5^8\%=390.625$ ppm. The data obtained for the range of concentrations from 10×0.5^9 to $10\times0.5^{17}\%$ will be used for the present discussion.

For analysing the data statistically, N was first provisionally estimated as 62, then concentrations in term of ppm were transformed to logarithms x and per cent mortality $p=1-s/N$ was converted to probits. The relation between both variables were calculated by the standard probit estimation method of parameters of tolerance distribution (Wadley 1949, Finney 1949).

The revised estimate of N obtained was $N'=60.85$, and the concentration-mortality regression equation was $Y=0.2184+2.2071x$. Using the figures of N' and Y obtained in the first cycle of approximation, the second cycle of approximation was carried out in the same way. The detailed pattern of calculation shown in Table 3 has been given elsewhere (Nagasawa, *et al.* 1965). To the sum of squares of deviations of x' was added N, and to the sum of products of deviation of x' and y was added (s_0-N), or 1.15.

Equation for obtaining b and δN then become

$$\left.\begin{aligned}12.5614\ b+25.955\ \frac{\delta N}{N}&=27.45,\\ 25.955\ b+190.27\ \frac{\delta N}{N}&=56.69.\end{aligned}\right\}$$

The inverse matrix of the coefficients of b and $\frac{\delta N}{N}$ is

$$V=\begin{pmatrix}0.110854 & -0.015122\\ -0.015122 & 0.007318\end{pmatrix}$$

whence were derived

$b=2.1816,$

Table 3. Calculation of experimental data on the lethal effect of methyl parathion emulsifiable concentrate on the Mediterranean fruit fly larvae

x	s	P (N=60.85)	Emp. probits	Y	Nw	x'	y	Nwx	Nwx'	Nwy
3.291	0	1.000	$+\infty$	7.5	3.01	−0.354	7.854	9.906	−1.066	23.64
2.990	2	0.963	6.79	6.8	10.56	−0.455	6.786	31.574	−4.805	71.66
2.689	9	0.852	6.05	6.2	19.94	−0.593	6.031	53.619	−11.824	120.26
2.388	19	0.688	5.49	5.5	24.45	−0.876	5.490	58.387	−21.418	134.23
2.087	34	0.441	4.85	4.8	16.06	−1.481	4.852	33.517	−23.785	77.92
1.786	47	0.228	4.25	4.2	6.48	−2.721	4.256	11.573	−17.632	27.58
1.485	58	0.047	3.33	3.5	1.09	−7.205	3.347	1.619	−7.853	3.65
1.184	59	0.031	3.13	2.8	0.08	−27.797	3.282	0.095	−2.224	0.26
0.882	63	0.000	$-\infty$	2.2	0.00	−126.020	1.877	0.000	−0.000	0.00
Controls	62	—	—	—	81.67	—	—	200.290	−90.607	459.20

$\bar{x}=2.4524,$ $\bar{x}'=-1.1094,$ $\bar{y}=5.6226.$

$SNwx^2$	$SNwxx'$	$SNwx'^2$	$SNwxy$	$SNwx'y$	$SNwy^2$
503.7526	−196.250	229.94	1153.59	−453.90	2642.68
491.1912	−222.205	100.52	1126.14	−509.44	2581.90
12.5614	25.955	129.42	27.45	55.54	60.78
		60.85		1.15	0.00
		190.27		56.69	60.78

and

$$\frac{\delta N}{N} = -0.0002.$$

Substituting the provisional value of N

$$\delta N = -0.01,$$

and the revised estimates of N is therefore

$$N' = 60.84.$$

The remaining parameter for the regression line is

$$a = 0.2624.$$

The revised equation is therefore

$$Y = 0.2624 + 2.1856x.$$

The iterative calculation could be continued from these results, but the new equation is so nearly the same as that of the first cycle of approximation that further calculation is not worth while.

The heterogeneity χ^2 is found as

$$\chi^2_{(7)} = 0.80$$

since 7 degrees of freedom remained after the estimate of three parameters. The result of χ^2 is not significant. Therefore the variances and covariance of b and $\frac{\delta N}{N}$ are directly the diagonal elements of the matrix V.

From the first diagonal element

$$V(b) = 0.110854,$$

whence

$$b = 2.1856 \pm 0.3329,$$

and from the second diagonal element

$$V(N) = 0.007318 \times 60.85^2$$
$$= 20.096523,$$

and therefore

$$N' = 60.84 \pm 4.483.$$

The log median lethal concentration is

$$m = 2.1677.$$

At the 5% probability level

$$g = 0.09$$

is less than 0.1; for most practical purpose the variance of m can be approximately calculated by the simpler equation,

$$V(m) = 0.002686,$$

and therefore

$$m = 2.1677 \pm 0.0518.$$

Fiducial limits to m are set at 2.2692, 2.0662. It could be concluded that the median lethal concentration of methyl parathion emulsifiable concentrate tested is 147.12 ppm, and true value is likely to lie between 185.86 and 116.46 ppm.

The method of analysis of dosage-mortality curves from counts of survivors was first discussed by Wadley (1949) based on the data for the control test of immature stages of fruit flies. The same data was again used by Finney (1949) in his generalized discussion of the estimation method of parameters of tolerance distributions. Both authors found an equally great indication of heterogeneity in their analysis of the data. Concerning this result, Finney states "Genuine heterogeneity of the experimental material, as judged by the standard of the Poisson and binomial distribution used in the derivation of the statistical technique, seems the most likely explanation. Non-normality of the distribution of log tolerances would show itself as a curvature of the probit regression line, but departure from a Poisson distribution, in the number of flies per fruit—a situation very likely to obtain in reality—might reduce the true weights of observations and so permit erratic deviations from the the regression line which would appear to be significant when the Poisson weights were used".

Effectivenees evaluation of an insecticide emulsifiable concentrate using coffee berry samples from different trees

Even in a plantation, infestation of coffee berries by fruit flies varies among trees, parts of a tree or among parts of the plantation in flowering time and ripening of the berries, since environmental conditions are not always uniform. Coffee berry samples collected from different trees, parts of a tree or of a plantation are therefore considered to be the samples from Poisson distributed population mean N_i. An effectiveness evaluation test of an insecticide emulsifiable concentrate was carried out in which the coffee berry samples from different trees were compared with expectation of an equal effective concentration within a sampling error.

Materials and methods: The emulsifiable concentrate used for the present experiment was a test sample supplied by a manufacturer in São Paulo. Test solutions at ten levels of concentration were prepared by dilution in water in logarithmic scale starting from 500 ppm. In late November, 1971, seven batches of coffee berries infested by fruit flies were collected separately from seven trees in the yard of the Biological Institute of São Paulo. Each batch of coffee berries was randomly assigned to ten levels of concentration and to the control in which only water was used. Number of berries assigned to each concentration and the control was 30. Evaluation of results was carried out following the same method mentioned in the previous section.

Results and discussion: The result of experiment was shown in Table 4 as the relation between the concentration of test solution and number of larvae coming out from berries. As is seen in the table, the rate of infestation by fruit flies was the highest in tree C and the lowest in tree D. These data were analysed separately by the method described in the previous chapter using the population mean N_i of each Poisson distribution estimated from the number of larvae at the zero concentration. The revised Poisson distributed population mean N', position a and slope b of the calculated concentration-mortality regression equation and the result of heterogeneity test are shown for each tree and for the total in Table 5. There is no indication of heterogeneity for any set of data, and the estimated concentrations expecting 50% mortality of fruit fly larvae are in very good agreement, occuring the largest difference of the median lethal concentration m between samples from trees F and E. The difference between these two m's may be tested for heterogeneity. The method for comparing two m's of two samples from Poisson-distributed population of mean N_1 and N_2 has been proposed by Nagasawa and Nakayama (1972) using the chemosterilant test data.

For comparing the median lethal concentration, some statistics obtained in the analysis of the concentration-mortality data for trees F and E are shown in Table 6. Suffixes 1 and 2 naturally

Table 4. Relation between concentrations of a methyl parathion emulsifiable concentrate and number of fruit fly larvae coming out from treated coffee berries of trees A-F.

Concentration ppm	Number of larvae							
	A	B	C	D	E	F	G	Total
500	1	1	2	0	1	0	2	7
500×0.5	2	1	2	0	2	1	0	8
500×0.5^2	2	1	4	2	4	2	4	19
500×0.5^3	5	6	4	2	11	5	5	38
500×0.5^4	8	8	13	3	13	5	16	66
500×0.5^5	11	12	19	4	18	14	19	97
500×0.5^6	19	18	29	6	24	17	30	143
500×0.5^7	23	29	40	9	29	26	35	191
500×0.5^8	25	30	44	11	32	25	42	209
500×0.5^9	29	32	48	9	33	33	43	227
Control	28	33	47	10	35	31	47	231

Table 5. Results of the maximum likelihood estimation of the data shown in Table 4.

Term	A	B	C	D	E	F	G	Total
N	31	32	53	10	34	32	45	230
N'	30.06	35.13	48.63	10.17	34.60	32.09	47.48	243.94
a	3.7779	3.4746	3.6236	3.2647	3.2644	3.5170	3.5649	3.6293
b	1.1853	1.3409	1.3170	1.4814	1.3421	1.4628	1.3574	1.3096
m	1.0310	1.1376	1.0451	1.1714	1.2932	1.0137	1.0572	1.0467
χ^2	2.54	4.28	6.03	1.54	1.13	2.54	0.07	2.06
n	8	8	8	8	8	8	8	8

Table 6. Maximum likelihood analysis of the data for trees F and E shown in Table 4.

F		E	
N_1	32	N_2	34
$\bar{x}_1$	1.4118	$\bar{x}_2$	1.7020
$\bar{x}'_1$	−1.0563	$\bar{x}'_2$	−1.1168
$\bar{y}_1$	5.5793	$\bar{y}_2$	5.5291
S_1xx	28.7149	S_2xx	19.4525
S_1xx'	28.529	S_2xx'	29.197
$S_1x'x'$	70.88	$S_2x'x'$	117.00
S_1xy	42.08	S_2xy	26.62
$S_1x'y$	41.92	$S_2x'y$	41.24
S_1yy	64.20	S_2yy	37.58
δN_1	0.09	δN_2	0.60
N'_1	32.09	N'_2	34.60
a_1	3.5170	a_2	3.2644
b_1	1.4628	b_2	1.3421
χ_1^2	2.54	χ_2^2	1.13
n_1	8	n_2	8

refer to the two sets of data. To fit parallel probit lines to two sets of data from Poisson-distributed population of mean N_1 and N_2, the coefficients of equations are read from Table 6 to give

$$\left.\begin{aligned} &b\ (28.7149+19.4525)+\frac{\delta N_1}{N_1}28.529 + \frac{\delta N_2}{N_2}\ 29.197=42.08+26.62,\\ &b\ 28.529 \qquad +\frac{\delta N_1}{N_1}70.88 =41.92,\\ &b\ 29.197 \qquad +\frac{\delta N_2}{N_2}117.00=41.24. \end{aligned}\right\}$$

The inverse matrix of coefficients is found as

$$V=\begin{pmatrix} v_{11} & v_{12} & v_{13}\\ v_{12} & v_{22} & v_{23}\\ v_{13} & v_{23} & v_{33}\end{pmatrix} =\begin{pmatrix} 0.0340153 & -0.0136911 & -0.0084884\\ -0.0136911 & 0.0196190 & 0.0034166\\ -0.0084884 & 0.0034166 & 0.0116653\end{pmatrix}.$$

Therefore

$$b=1.4129,$$

$$\frac{\delta N_1}{N_1}=0.02275,$$

$$\frac{\delta N_2}{N_2}=-0.00009.$$

From Table 6, the remaining parameters for the concentration-mortality regression lines are

$$a'_1=3.6087,$$

and

$$a'_2=3.1245.$$

The revised regression equations are therefore

$$Y_1=3.6087+1.4129x,$$

$$Y_2=3.1245+1.4129x.$$

The heterogeneity χ^2 is found as

$$\chi^2_{cal}=3.762.$$

There were 22 concentration levels tested including controls, and five parameters a_1, a_2, b, δN_1, δN_2 have been estimated, leaving 17 degrees of freedom. Clearly there is no indication of heterogeneity, and therefore the matrix V mentioned above gives the variance and covariance b, $\frac{\delta N_1}{N_1}$ and $\frac{\delta N_2}{N_2}$. In particular

$$V(b)=0.0340153,$$

whence

$$b=1.4129\pm 0.1844,$$

and

$$V(N'_1)=0.0106190\times 32^2=20.089856,$$

whence

$$N'_1=32.73\pm 4.48,$$

and

$$V(N'_2)=0.0106653\times 34^2=12.329087,$$

whence

$$N'_2=34.00\pm 3.51.$$

The median lethal concentration in logarithms are found as

$$m_1=0.9848,$$

$$m_2=1.3276.$$

For the 5% level of probability, $t=1.96$, and

$g=0.065<0.1$.

The logarithm of the ratio of equally effective concentration is

$M=0.34281$

and the variance of M is

$V(M)=0.02847$.

Hence $M=0.34281 \pm 0.16872$. The t-test shows that the difference between two median lethal concentrations is not significant at $P=0.01$. The effectiveness evaluation of insecticide emulsifiable concentrate for fruit fly larvae in coffee berries would be possible by this method using coffee berries at any rate of infestation. Of course, in the case of lower infestation, it would be necessary to use a larger number of berries than that collected from trees of heavy infestation.

Effectiveness evaluation of some insecticide emulsifiable cancentrates

In the previous section, it was verified that the effectiveness of insecticide emulsifiable concentrate on fruit fly larvae in coffee berries could be evaluated by a dipping method of infested berries. Thereupon an effectiveness evaluation experiment of some commercial insecticide emulsifiable concentrates was performed following the same method of experiment and analysis.

Materials and methods: Insecticide emulsifiable concentrates tested are all commercial products brought into the Biological Institute of São Paulo from manufacturers for effectiveness evaluation. These samples are denoted as I~VI. Coffee berries moderately infested by the fruit fly were collected in the yard of the institute and mixed uniformly before using. The details concerning the materials and methods are all the same as described in the preceding sections.

Results and discussion: The result of experiment was shown in Table 7. The number of larvae at the zero concentration was 31. With

Table 7. Relation between concentrations of some commercial emulsifiable concentrates I-VI and number of fruit fly larvae coming out from treated coffee berries. The number of larvae at the zero concentration was 31.

Concentration ppm	Number of larvae					
	I	II	III	IV	V	VI
500	3	1	0	1	0	0
500×0.5	5	0	3	2	0	2
500×0.5^2	12	2	8	8	3	4
500×0.5^3	24	4	17	17	5	10
500×0.5^4	27	5	23	23	8	19
500×0.5^5	31	6	28	28	10	27
500×0.5^6	29	12	29	29	15	30
500×0.5^7	30	14	29	29	14	31
500×0.5^8	31	19	30	31	17	30
500×0.5^9	32	24	29	30	23	32

Table 8. Results of the maximum likelihood estimation of the data shown in Table 7

Term	I	II	III	IV	V	VI
N	30	30	30	30	30	30
N'	32.25	31.61	29.65	30.32	29.82	31.50
a	1.1233	4.4573	0.3293	0.8242	4.2708	1.4742
b	1.9641	1.0309	2.5210	2.2914	1.0147	2.1980
m	1.9738	0.5264	1.8329	1.8224	0.7186	1.6041
χ^2	1.45	2.47	0.47	0.26	3.05	1.06
n	4	7	4	5	7	5
LC_{50} (ppm)	94.12	3.36	68.06	66.44	5.23	40.2

the provisionally estimated population mean N=30, the maximum likelihood analysis was then performed for each data. The revised Poisson population mean N', position a and slope b of the calculated concentration-mortality regression line and the result of the heterogeneity test are shown in Table 8. At the level of 50 per cent mortality, samples II and V were most and I was least effective on fruit fly larvae in coffee berries.

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Summary

The spatial distribution of larvae of the Mediterranean fruit fly growing on coffee berries could well be fitted to the trunctated Poisson series. Consequently, Wadley's problem for estimating the paramefers of tolerance distribution was applicable to a series of survival count records of the fruit fly larvae from the insecticide-treated coffee berries. Effectiveness evaluation of an insecticide emulsifiable concentrate was possible using any batch of coffee berries collected from different trees at various infestation rates. Effectiveness evaluation test results with some commercial products was shown as a numerical example.

References

1) David, F. N. and N. L. Johnson: *Biometrics* 8, 275-285 (1952).
2) Finney, D. J.: *Biometrika* 36, 239-256 (1949).
3) Nagasawa, S., H. Shinohara and M. Shiba: *Botyu-Kagaku* 30, 91-95 (1965).
4) Nagasawa, S. and I. Nakayama: *Appl. Ent. Zool.* 7, 1-8 (1972).
5) Wadley, F. M.: *Ann. Appl. Biol.* 36, 196-202 (1949).

抄 録

カツオブシムシ *Anthrenus flavipes* LeConte の性フェロモン：

Identification of the Sex Pheromone of the Furniture Carpet Beetle, *Anthrenus flavipes* LeConte. H. Fukui, F. Matsumura, M. C. Ma, W. E. Burkholder, *Tetrahedron Letters* (40) 3563 (1974).

カツオブシムシ科の1種 *Anthrenus flavipes* LeConte の雌は，明期のはじめに，前脚をたてて頭をもたげた姿勢でコーリングを行なう．雌虫体の有機溶媒抽出物が雄を誘引し，交尾行動を誘発するので，フェロモンの化学構造の検索を行なった．蛹で雌雄をわけ，雌は成虫羽化後10日間濾紙上で飼育し，濾紙，虫体を合わせて *n*-ヘキサンで抽出した．

カラムクロマトグラフ，薄層クロマトグラフで精製後，ジアゾメタンでメチル化しガスクロマトグラフで分取した．もう一つのカツオブシムシ *Trogoderma inclusm* LeConte の雄は，このフェロモンのメチルエステルに反応を示すので，著者らの考案したオルファクトメーターで検索し活性部を集めた．メチルエステルは，水素添加で methyl decanoate を与えることがわかり GC-Ms でもこれが確認された．さらに，フェロモンのメチルエステルは，LAH で還元し，ペンタフロロプロピオン酸エステルとし，オゾン分解後，GLC (ECD) で $OHC(CH_2)_2OC(=O)$-C_2F_5 を確認した．

そこで，3-decenoic acid がフェロモンの化学構造で，その(E)体か(Z)体かは，合成した(Z)体が(E)体の20倍も活性が高いことから(Z)体と決定された．

（高橋正三）

オオカバマダラの hairpencil 分泌物の揮発成分の化学構造について：

Isolation, Tentative Identification, and Synthesis Studies of the Volatile Components of the Hairpencil Secretion of the Monarch Butterfly. T. E. Bellas, R. G. Brownlee, R. M. Silverstein. *Tetrahedron*, 30, 2267 (1974).

今まで，マダラチョウ科の2，3の種の雄の hairpencil の成分についての研究が報告されているが，今回はオオカバマダラの hairpencil の分泌物の揮発成分を検索した．一つは，Benzyl caproate で，他の成分はおそらく1,5,5,9-tetramethyl-10-oxabicyclo-[4,4,0]-3-decen-2-one かあるいは，2,2,6,8-tetramethyl-7-oxabicyclo-[4,4,0]-4-decen-3-one のいづれかであろう．IR, NMR, UV 等の研究では解決できず，合成的手法で確認しようとしているが，まだ明らかではない．

（高橋正三）