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Evaluation of Resistance to Malathion and Pirimiphos Methyl in Strains of *Tribolium castaneum* (Herbst) collected in Indonesia.

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RINGKASAN

Lima puloh enam sampel Tribolium castaneum *yang diambil dari gudang BULOG dan gudang-maga padi unit-unit koperatif desa dan lain-lain tempat simpanan petani di kebanyakan tempat di Indonesia telah diuji untuk kekebalan terhadap racun serangga malathion dan pirimiphos methyl. Empat puloh sembilan dari sampel-sampel ini menunjukkan beberapa tingkatan kekebalan terhadap malathion sementara 7 sampel masih peka terhadap malathion. Semua sampel* T. castaneum *telah didapati peka terhadap pirimiphos methyl.*

Species yang utama dalam kumpulan Tribolium *spp. di Indonesia ialah* T. castaneum *(Herbst).*

SUMMARY

Fifty-six strains of Tribolium castaneum *(Herbst) collected from BULOG and commercial godowns of village co-operative units and farmers' padi storage units from many parts of Indonesia were tested for resistance to malathion and pirimiphos methyl. Forty-nine of these strains showed various degrees of resistance while seven showed a susceptible response to malathion. All the strains of* T. castaneum *were susceptible to pirimiphos methyl.*

The dominant species of Tribolium *spp. in Indonesia was found to be* T. castaneum *(Herbst).*

INTRODUCTION

Tribolium castaneum (Herbst) is a major pest of stored food commodities in Indonesia. After malathion came into general use as a protectant for rice in storage in the 1970's, outbreaks of *T. castaneum* were rarely found in rice storage warehouses in which malathion was used.

Malathion resistance in *T. castaneum* was first recorded in Nigeria in 1961 (Parkin *et al.*, 1962; Parkin, 1965) and subsequently by Spiers *et al.*, (1967) in Georgia and Florida in the United States of America.

Recent reports of malathion resistance in stored grain insects in many areas of the world (Dyte, 1974) suggest the need for an evaluation of the extent to which malathion resistance in Indonesian populations of stored grain insects exists.

Despite the widespread occurrence of insecticide resistance throughout the world, a thorough study on this aspect has not been carried out in Indonesia (Atmosudirdjo, 1978).

This study was conducted to determine the occurrence of resistant strains of *Tribolium castaneum,* and the predominant species of the *Tribolium* complex (*T. castaneum* (Herbst) and *T. confusum* J. du Val).

MATERIALS AND METHODS

Test Insects

This study was conducted at BIOTROP, Bogor, Indonesia from September 1978 to May 1979. The insect specimens were collected from various places in Java following methods recommended by FAO (1974). Insect specimens from Sumatra, Kalimantan, Sulawesi, Irian Jaya, Nusa Tenggara Timur, and Bali were provided by BULOG and its agencies by mail. Related information as to the locations and commodities from which various strains were collected, and the insecticidal background are presented in Table 1.

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TABLE 1

Information on the Field-collected strains of *Tribolium* spp. from various parts of Indonesia.

Sample Number	Locations	Type of[1] warehouse	Commodity	Insecticidal[2] history
1	Sukamerta (Krawang)	VCU	rice bran	M, PM
2	Sukamelang (Krawang)	FS	rice bran	NCS
3	Jatibarang	Commercial	milled rice	NCS
4	Gudang Kebulan (Jatibarang)	Commercial	milled rice	M, PM
5	Cirebon	New BULOG	milled rice	M, PM
6	Cirebon	Commercial	milled rice	PM
7	Cirebon	n.a.	n.a	n.a
8	Cianjur	FS	rice bran	NCS
9	Cianjur	Commercial	rice bran	PM
10	Bandung	New BULOG	milled rice	M, PM
11	Garut	VCU	rice bran	NCS
12	Ciamis	New BULOG	milled rice	PM
13	Banjar	Commercial	milled rice	PM
14	Gunungceri (Tasikmalaya)	FS	rice bran	NCS
15	Singaparna (Tasikmalaya)	FS	rice bran	NCS
16	Semarang	FS	milled rice	M, PM
17	Semarang	FS	padi	NCS
18	Semarang	FS	rice bran	NCS
19	Pati-Juana	Commercial	milled rice	M, PM
20	Pati	Commercial	padi	PM
21	Solo-Padjang (Solo)	Commercial	milled rice	PM
22	Solo-Klaten (Solo)	Commercial	milled rice	PM
23	Secang-Magelang (Magelang)	Commercial	milled rice	PM
24	Secang-Magelang (Magelang)	New BULOG	milled rice	PM
25	Temanggung	FS	rice bran	PM
26	Kabupattan Sari (Temenggung)	FS	milled rice	NCS
27	Nawang (Temenggung)	FS	rice bran	NCS
28	Wonosari	FS	cassava	NCS

29	Pasar Wage (Purworkerto)	Commercial	milled rice	M, PM
30	Sukaraja (Purwokerto)	New BULOG	milled rice	M, PM
31	Purwokerto	FS	rice bran	NCS
32	Purwokerto	FS	milled rice	NCS
33	Sido Agung (Surabaya Utara)	Commercial	milled rice	M, PM
34	Surabaya Utara	Commercial	rice bran	M, PM
35	Sooko (Surabaya Selatan)	Commercial	padi	M, PM
36	Trowulan (Surabaya Selatan)	Commercial	rice bran	M, PM
37	Mojokerto	New BULOG	milled rice	M, PM
38	Pasuruan	New BULOG	milled rice	M, PM
39	Probolinggo	FS	rice bran	NCS
40	Lumajang	Commercial	rice bran	–
41	Jember	Commercial	rice bran	NCS
42	Prowogondo (Banyuwangi)	–	rice bran	M, PM
43	Banyuwangi	New BULOG	padi	M, PM
44	Genteng (Banyuwangi)	FS	milled rice	NCS
45	Kendari (Sulawesi Tengah)	New BULOG	milled rice	M, PM
46	Pontianak	New BULOG	milled rice	M, PM
47	Kandari (Denpasar)	New BULOG	milled rice	M, PM
48	Nusa Tenggara (Timur)	New BULOG	milled rice	M, PM
49	Irian Jaya	New BULOG	milled rice	M, PM
50	Balikpapan (Kalimantan Selatan)	New BULOG	milled rice	M, PM
51	Ujung Pandang (Sulawesi Selatan)	New BULOG	milled rice	M, PM
52	Banjarmasin (Kalimantan Selatan)	New BULOG	milled rice	M, PM
53	Palembang (Sumatra Selatan)	New BULOG	milled rice	M, PM
54	Jambi (Sumatra Selatan)	New BULOG	milled rice	M, PM
55	Ciawi	Animal Feed Unit	rice bran	NCS
56	Jakarta Utara	New BULOG	milled rice	M, PM

1: VCU = village co-operative unit
FS = farmers' storage

2: M = malathion
PM = pirimiphos methyl
NCS = no chemical sprayed

A total of 56 strains were tested, in a room 27 ± 2°C and 70% RH. Three replications of 40 insects each were used for each sample.

Determination of species of Tribolium.

The two different species of *Tribolium* spp. were separated by their antennal and eye characters (Hinton and Corbet, 1972). One hundred specimens were examined from each of the 56 specimens.

Resistance Test

The two insecticides used for resistance detection in *T. castaneum* were malathion and pirimiphos methyl; both were emulsifiable concentrates of 57 and 25% a.i. respectively. The discriminating doses used to detect resistance were: for malathion, 0.5% for 5 hours (FAO, 1974); and, for pirimiphos methyl, 0.6% for 5 hours (Morallo-Rejesus, unpublished data). Aliquots of 0.5 ml. of stock solution were evenly distributed on Whatman No. 1 filter papers of 7 cm. diameter which were then placed in petri dishes.

Based on the percentage mortality, the degree of resistance was categorized as: susceptible (99–100%), slightly resistant (90–98.9%), moderately resistant (80–89.9%), highly resistant (50–79.9%) and very highly resistant (<50%).

RESULTS AND DISCUSSION

Predominant species of Tribolium *and its distribution.*

A total of fifty-six samples of *Tribolium* spp. (100 specimens per sample) were examined to determine the predominant species present in Indonesia. There was only one sample that had a mixed population of *T. castaneum* and *T. confusum*. This sample was from Banyuwangi (East Java) and was composed of 65% *T. castaneum* and 35% *T. confusum*. The other 56 samples were all 100% *T. castaneum*. This seems logical for it is known that *T. castaneum* is widespread in the tropics, whereas *T. confusum* is predominant in temperate regions and cannot become established in this country. It is probable that the species came from imported rice since the sample was collected from a new BULOG godown at Banyuwangi.

Resistance of T. castaneum *to Malathion.*

A total of fifty-six strains of *T. castaneum* were tested for resistance, 46 from the island of Java and 10 from outside Java.

Seven strains were found to be susceptible, while 49 strains showed varying degrees of resistance, ranging from slightly resistant to very highly resistant (Table 2). The seven susceptible

TABLE 2
Response of *T. castaneum* to a discriminating concentration of 0.5% malathion for 5 hours

Sample Number	Percent knockdown	Degree of Resistance
1	99.0	S
2	73.0	HR
3	93.3	SR
4	0.0	VHR
5	100.00	S
6	86.7	MR
7	84.0	MR
8	99.0	S
9	41.1	VHR
10	66.7	HR
11	100.0	S
12	82.2	MR
13	98.3	SR
14	92.2	SR
15	85.6	MR
16	34.7	VHR
17	94.7	SR
18	94.7	SR
19	100.0	S
20	80.0	MR
21	89.3	MR
22	90.7	SR
23	87.8	MR
24	94.4	SR
25	96.0	SR
26	95.6	SR
27	93.3	SR
28	95.0	SR
29	90.7	SR
30	73.3	HR
31	94.4	SR
32	90.0	SR
33	93.3	SR
34	85.0	MR
35	96.7	SR
36	96.7	SR
37	91.7	SR
38	73.3	HR
39	91.7	SR
40	95.0	SR
41	98.3	SR
42	100.0	S
43	100.0	S
44	95.0	SR
45	94.7	SR
46	58.3	HR
47	85.0	MR
48	97.8	SR
49	20.0	VHR
50	96.7	SR
51	73.3	HR
52	86.7	MR
53	96.7	HR
54	36.7	VHR
55	89.3	MR
56	76.7	HR

S – susceptible
SR – slightly resistant
MR – moderately resistant
HR – highly resistant
VHR – very highly resistant

strains were from Sukamerta, Cirebon, Cianjur, Garut, Pati-Juara, Prowogondo and Bunyuwangi. The strains from Cianjur and Garut were from private godowns and from the survey conducted during the collection, it was found that these two strains had no previous insecticidal treatment. The other five susceptible strains were collected from warehouses that had been spraying malathion as a control measure against insect infestation in rice. This means that malathion could still be effectively used against *T. castaneum* in these stores.

Out of the 49 strains resistant to malathion, five strains were very highly resistant and these were from Jatibarang, Cianjur, Semarang, Irian Jaya and Jambi. Eight strains were highly resistant and eleven were moderately resistant. Most of these strains were collected from new BULOG godowns in which insecticidal spraying practices were found to be very regular: once every two weeks.

Strains that were obtained from farmers' stores at Sukamelang, Jatibarang, Cirebon, Bianjur, Tasikmalaya, Semarang, Temanggung, Purwokerto, Probolinggo, Jember, Banyuwangi and Ciawi showed varying degrees of resistance despite the fact that these stores had no previous insecticidal operations. This could be explained by the fact that *T. castaneum* are strong and frequent fliers and are thus able to migrate actively, as well as the fact that they move passively with the stored commodities. Much evidence in the literature shows that resistant strains of storage insects are often found where the insecticides have not been used (Champ and Campbell-Brown, 1970; Pieterse *et al.*, 1972; Parkin, 1965 and Spiers *et al.*, 1967).

Resistance of T. castaneum *to pirimiphos methyl.*

The same strains of *T. castaneum* that were tested for resistance to malathion were also tested for resistance to pirimiphos methyl. All the fifty-six strains of *T. castaneum* showed a susceptible response to pirimiphos methyl. From the interviews conducted during the collection, it was found that the earliest date that pirimiphos methyl was first used in any of these warehouses was in May 1978. At the date of collection pirimiphos methyl had been used to control these storage insects in 37 stores during the previous five months, and had not been used in the remaining stores. Five months is probably too short a time for *T. castaneum* to develop resistance to pirimiphos methyl. This would probably explain the susceptible response of all the strains to pirimiphos methyl.

CONCLUSION

It can be safely concluded that resistance to malathion has been detected in many strains of *T. castaneum* collected from various parts of Indonesia, although the levels of resistance were found to vary. Only seven out of the fifty-six strains tested showed a susceptible response. All the strains were found to be susceptible to pirimiphos methyl, an insecticide which had only been used since May 1978.

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