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EVALUATION OF INDONESIAN STRAINS OF *TRIBOLIUM CASTANEUM* (HERBST) FOR RESISTANCE TO MALATHION AND PIMIRIPHOS METHYL[1]

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Fifty-six strains of *Tribolium castaneum* (Herbst) collected from Bulog godowns and farmers storage houses from all over Indonesian islands were tested for resistance to malathion and pirimiphos methyl. Forty-seven of these strains showed variable degree of resistance while seven were susceptible to malathion. All strains were susceptible to perimiphos methyl.

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

Malathion resistance in *Tribolium castaneum* has been reported in Nigeria (Parkin 1965), USA (Speirs *et al.* 1967), Egypt (Toppozada *et al.* 1969), Australia (Champ & Campbell-Brown 1970) and from many areas of the world (Champ & Dyte 1976). Malathion has been used as a protectant for use in storage since the 1970's for the control of *T. castaneum* (Herbst), a major pest of stored food commodity in Indonesia.

Despite the widespread occurrence of insecticide resistance that has been detected from all over the world a thorough study on this aspect has not been carried out in Indonesia (Atmosudirdjo 1978).

This study was conducted to determine a) the predominant species of the *Tribolium complex (T. castaneum* and *T. confusum)* and the susceptibility of this species to chlorpyrifos methyl and permethrin, and b) the occurrence of resistant strains of *Tribolium castaneum* to malathion and pirimiphos methyl in Indonesia.

MATERIALS AND METHODS

Test Insects. This study was conducted at the insectarium and the chemical laboratory of BIOTROP, Tajur, Bogor, Indonesia from September 1978 to May 1979. The insect specimens were collected from various places

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in Java following the methods as recommended by FAO (1974). Insect specimens from Sumatra, Kalimantan, Sulawesi, Irian, Jaya, Nusa Tenggara Timur and Bali were provided by Bulog (Badan Urusan Logistik) and its agencies by mail. Related information as the locations, commodities from which various strains were collected and the insecticidal background are presented in Table 1. Fifty-six strains were tested. The locations from which insect samples were obtained for insecticide resistance and species of *Tribolium* is shown in Fig. 1

TABLE 1. **Information on the field collected strains of *Tribolium* spp. from certain parts of Indonesia.**

Sample Number	Locations	Type of Warehouse	Commodity	Insecticidal History
S–1	Sukamerta (Krawang)	VCU	rice bran	M, PM
S–2	Sukamelang (Krawang)	Private	rice bran	NCS
S–3	Jatibarang	Commercial	milled rice	NCS
S–4	Gudang Kebulan (Jatibarang)	Commercial	milled rice	M, PM
S–5	Cirebon	New Bulog	milled rice	M, PM
S–6	Cirebon	Commercial	milled rice	PM
S–7	Cianjur	Private	rice bran	NCS
S–8	Cianjur	Commercial	rice bran	PM
S–9	Bandung	New Bulog	milled rice	M, PM
S–10	Garut	VCU	rice bran	NCS
S–11	Ciamis	New Bulog	milled rice	PM
S–12	Banjar	Commercial	milled rice	PM
S–13	Gunungceri	Private	rice bran	NCS
S–14	(Tasikmalaya)			
	Singaparna	Private	rice bran	NCS
S–15	(Tasikmalaya)			
	Semarang	Private	milled rice	M, PM
S–16	Semarang	Private	padi	NCS
S–17	Semarang	Private	rice bran	NCS
S–18	Pati-Juana	Commercial	milled rice	M, PM
S–19	Pati	Commercial	padi	PM
S–20	Solo-Padyang	Commercial	milled rice	PM
S–21	Solo-Klaten	Commercial	milled rice	PM
S–22	Secang-Magelang	Commercial	milled rice	PM
S–23	Secang-Magelang	New Bulog	milled rice	PM
S–24	Temanggung	Private	rice bran	PM
S–25	Kb Sari (Temanggung)	Private	milled rice	NCS
S–26	Nawang-Temanggung	Private	rice bran	NCS
S–27	Wonosari	Private	cassava	NCS
S–28	Pasar Wage	Commercial	milled rice	M, PM
S–29	(Purworkerto)			
	Sukaraja	New Bulog	milled rice	M, Pm
S–30	(Purworkerto)			
	Purworkerto	Private	rice bran	NCS

S–31	Purworkerto	Private	milled rice	NCS
S–32	Sido Agung	Commercial	milled rice	PM
S–33	(North Surabaya)			
	North Surabaya	Commercial	rice bran	PM
S–34	Sooko	Commercial	padi	M, PM
S–35	(South Surabaya)			
	Trowulan	Commercial	rice bran	M, PM
S–36	(S. Surabaya)			
	Mojokerto	New Bulog	milled rice	M, PM
S–37	Pasuruan	New Bulog	milled rice	M, PM
S–38	Probolinggo	Private	rice bran	NCS
S–39	Lumajang	Commercial	rice bran	–
S–40	Jember	Commercial	rice bran	NCS
S–41	Prowogondo	–	rice bran	M, PM
S–42	(Banyuwangi)			
	Banyuwangi	New Bulog	padi	M, PM
S–43	Genteng	Private	milled rice	NCS
S–44	(Banyuwangi)			
	Kendari	New Bulog	milled rice	M, PM
S–45	(Sulawesi Teng.)			
	Pontianak	New Bulog	milled rice	M, PM
S–46	Kendari	New Bulog	milled rice	M, PM
S–47	(Denpasar)			
	Nusa Tenggara	New Bulog	milled rice	M, PM
S–48	(Timur)			
	Irian Jaya	New Bulog	milled rice	M, PM
S–49	Balikpapan	New Bulog	milled rice	M, PM
S–50	Ujong Pandang	New Bulog	milled rice	M, PM
S–51	Banjarmasin	New Bulog	milled rice	M, PM
S–52	Palembang	New Bulog	milled rice	M, PM
S–53	Jambi	New Bulog	milled rice	M, PM
S–54	Ciawi	Animal Feed Unit	rice bran	NCS
S–55	Jakarta N.	New Bulog	milled rice	M, PM

M – malathion
PM – pirimiphos methyl
NCS – no chemical sprayed

Species Determination. The specimens (100 individuals per strain) used for the resistant test was subsequently examined for determining the species. The two different species of *Tribolium* was separated based on their antennal and eye character (Fig. 2).

Resistance Tests. The suscpetibility of the strains to malathion (0,0 dimethyl–S–[1,2 dicarbethoxyethyl] phosphorothionate) and pirimiphos methyl (2–[diethylamino–6 methyl–4–pyrimidinyl] 0,0–dimethyl phosphorothionate) were tested during the recommended paper impregnation and malathion discriminating concentration (0.5%) by FAO (1974) except for pirimiphos methyl which was taken from Morallo-Rejesus and Virrey (1978). Exposure time for both insecticides was 5 hours.

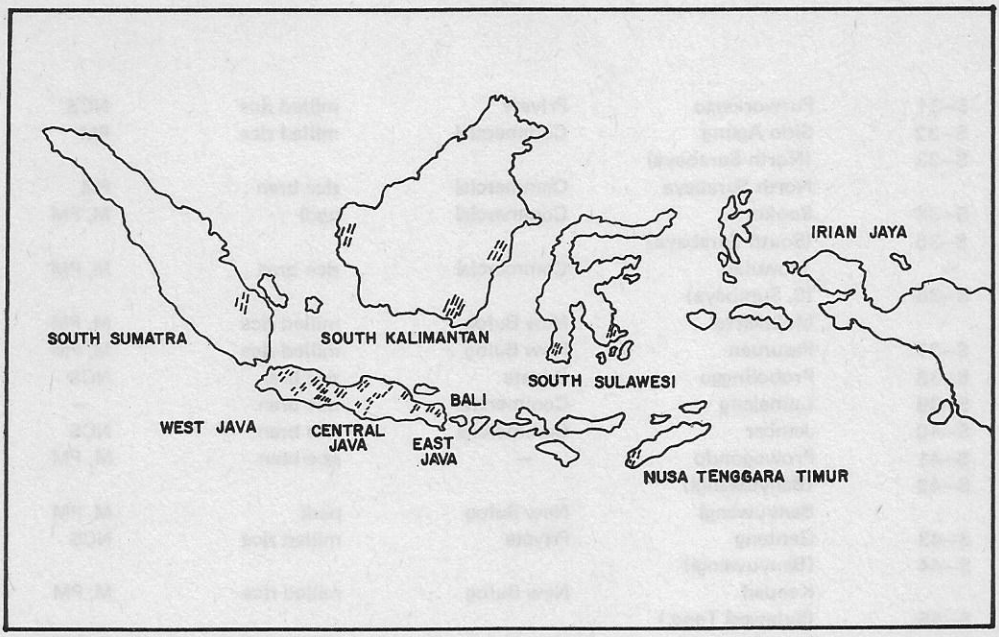
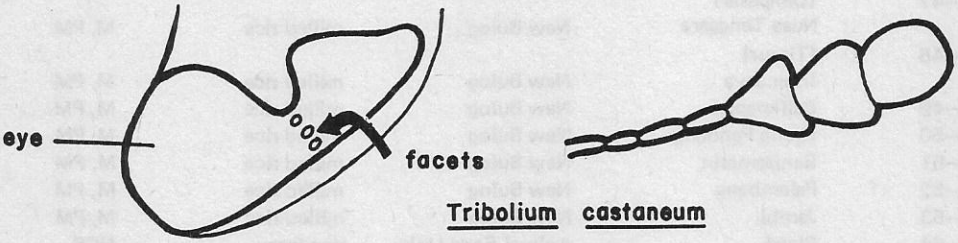


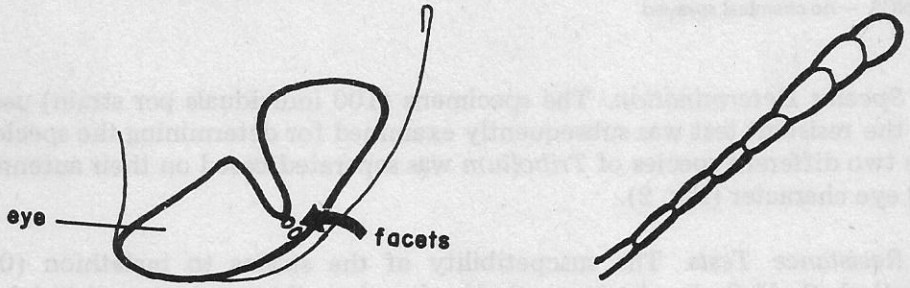
Fig. 1. Map of Indonesia showing locations from which insect samples were obtained for survey of insecticide resistance and species of Tribolium spp. (shaded area).



Tribolium castaneum

a. Eye- partly divided by backwardly produced side margin of head and having 3-4 facets at the narrowest point.

C. Antennae – with distinct three segmented club



Tribolium confusum

b. Eye- more strongly divided than in T. castaneum and having not more than 2 facets at the narrowest point.

d. Antennae - gradually thickened towards apex

Figure 2. Antennal and eye characters used in separating the Tribolium spp.

Based on the present mortality, the degree of resistance was categorized as: susceptible (99-100%): slightly resistant (90-98%); moderately resistant (80-89%); highly resistant (50-79%), and highly, highly resistant (50%).

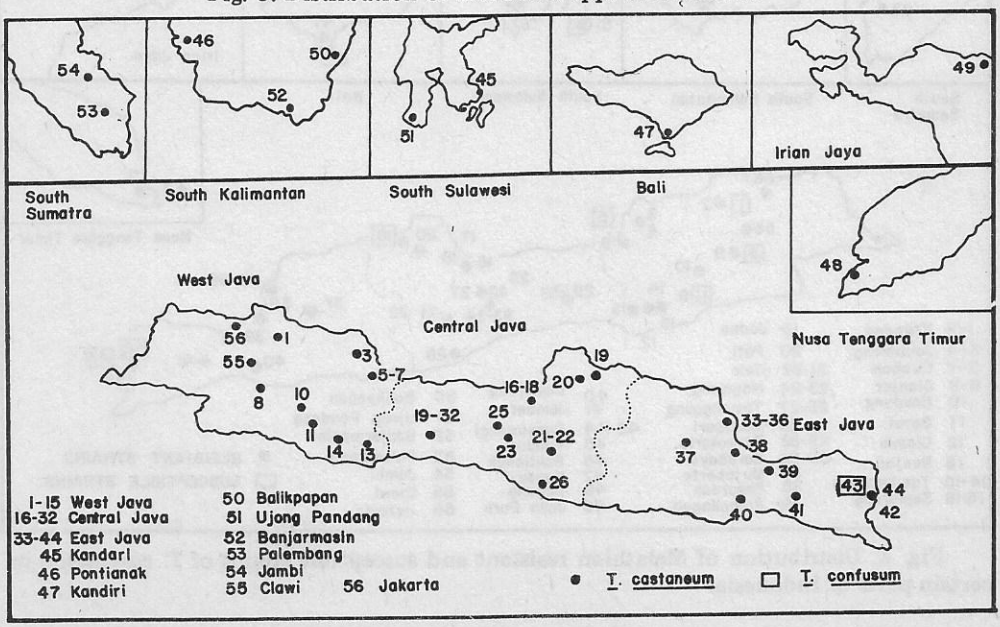
Toxicity Test. The toxicity of pirimiphos methyl, chlorpyrifos methyl (0,0 dimethyl—0—[3,5,6—trichloro—2—pyridinyl] phosphorothionate) and permethrin (3—phonexybenzyl—cis trans [+]—2,2 dimethyl—3—] 2,2, dichloro vinyl—cyclo—Propane—1—carboxylate) was determined by filter paper impregnation method. Stock solution of 10 mg/ml for each insecticide was prepared, from which a serial dilutions of the following dosages 1.0, 0.5, 0.1, 0.05 and 0.01 were made during the solvent system of petroleum ether acetone-olive oil (FAO 3:1:1).

The criteria used for toxicity for both the resistance and the susceptibility tests were mortality and knockdown. The discriminating concentrations were calculated from the toxicity tests.

RESULTS AND DISCUSSIONS

Predominant Species of Tribolium and Its Distribution. The predominant *Tribolium* species in Indonesia is *castaneum.* Its distribution is shown in Fig. 3. There was only one location that has a mixed population of *T. castaneum* and *T. confusum.* This strain was from Banyuwangi (East Java) and composed of 65% *castaneum* and 35% *confusum.* This seems logical for it is known that *T. castaneum* is widespread in the tropics while *T. confusum* is predominant in the temperate region. It is possible that the species came from imported rice to Indonesia since the strain was collected from New Bulog godown, Banyuwangi, East Java. Perhaps a follow-up study should be conducted to determine the establishment of *T. confusum* in the country.

Fig. 3. Distribution of *Tribolium* spp. in Indonesia.



Resistance of T. castaneum to Malathion. The distribution of the fifty-six strains of *T. castaneum* tested for malathion resistance (46 from the island of Jave and 10 from outside Java) is shown in Fig. 4. Seven strains were found to be susceptible, while 49 strains showed a variable degree of resistance, ranging from slight resistant to highly, highly resistant (Table 2). The seven susceptible strains were from Sukamerta, Cirebon, Cianjur, Garut, Pati, Juana and Bunyuwangi. Strains from Ganjur and Garut were from private dodowns and had no previous exposure to insecticides. It is obvious therefore that the two strains were susceptible to malathion. The other five susceptible strains were collected from warehouses that had been spraying malathion against insect infestation in rice. This means that the insect has not developed resistance to malathion and can still be used against this strain.

Out of the 49 resistant strains to malathion, three strains were highly, highly resistant and these were from Jatibarang, Cianjur and Semarang. Seven strains were highly resistant and eleven were moderately resistant. Most of these strains were collected from New Bulog godowns, where insecticides were sprayed very frequently at two weeks intervals.

It is expected that strains obtained from private godowns where there has been no or with limited spraying operations would show susceptible response to malathion. This was not the case with strains collected from private godowns of Sukamelang, Jatibarang, Cirebon, Cianjur, Tasikmalaya, Semarang, Temanggung, Purwokerto, Probolinggo, Jember, Banyuwangi and Ciawi. This could be due to the incorrect information obtained from the farmers during the interview.

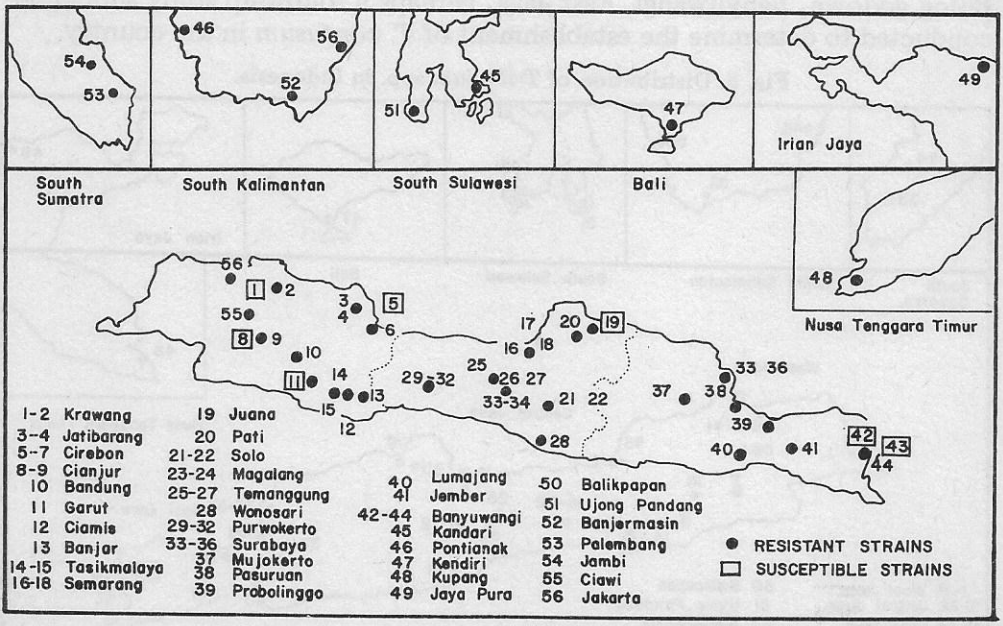


Fig. 4. Distribution of Malathion resistant and susceptible strains of *T. castaneum* in certain parts of Indonesia.

TABLE 2. **Response of *T. castaneum* to a discirminating concentration of 0.5% malathion.**

Sample Number	Percent Mortality	Degree of Resistance
S–1	99.0	S
S–2	73.0	HR
S–3	93.3	SR
S–4	0	HHR
S–5	100.0	S
S–6	86.7	MR
S–7	84.0	MR
S–8	98.9	S
S–9	41.1	HHR
S–10	66.7	HR
S–11	100.0	S
S–12	82.2	MR
S–13	98.3	SR
S–14	92.2	SR
S–15	85.6	MR
S–16	34.7	HHR
S–17	94.7	SR
S–18	94.7	SR
S–19	100.0	S
S–20	80.0	MR
S–21	89.3	MR
S–22	90.7	SR
S–23	87.8	MR
S–24	94.4	SR
S–25	96.0	SR
S–26	95.6	SR
S–27	93.3	SR
S–28	95.0	SR
S–29	90.7	SR
S–30	73.3	HR
S–31	94.4	SR
S–32	90.0	SR
S–33	93.3	SR
S–34	85.0	MR
S–35	96.7	SR
S–36	96.7	SR
S–37	91.7	SR
S–38	73.3	HR
S–39	91.7	SR
S–40	95.0	SR
S–41	98.3	SR
S–42	100.0	S
S–43	100.0	S
S–44	95.0	SR
S–45	94.7	SR
S–46	58.3	HR
S–47	85.0	MR
S–48	97.8	SR
S–49	20.0	HHR

S–50	96.7	SR
S–51	73.3	HR
S–52	86.7	MR
S–53	76.7	HR
S–54	36.7	HR
S–55	89.3	MR
S–56	76.7	HR

S – susceptible
SR – slightly resistant
MR – moderately resistant
HR – highly resistant
HHR – highly, highly resistant

TABLE 3. **Toxicity of three insecticides by filter paper impregnation[1] method to** *T. castaneum.*

Insecticides	KD_{50}	Confidence Limit		$KD_{99.9}$	Confidence Limit	
		Lower	Upper		Lower	Upper
Pirimiphos methyl	.0045	.003	.15	.17	.54	.533
Chlorpyrifos	.0016	.0009	.006	.04	.0095	.167
Permethrin	.13	.02	.227	1.0	.068	1.56

[1]Response taken 24 hours after exposure.

TABLE 4. **Discriminating concentration and exposure time of three different insecticides to** *T. castaneum.*

Insecticides	Discriminating Concentration (%)	Exposure Time (hr.)
Pirimiphos methyl	0.6	5
Chlorpyrifos methyl	0.1	12
Permethrin	1.8	12

Resistance of T. castaneum to Pirimiphos Methyl. The same number of strains of *T. castaneum* that were tested for resistance to malathion were also tested for resistance to pirimiphos methyl. All strains were susceptible to pirimiphos methyl. Based on the interview conducted during the collection, it was found that pirimiphos methyl was first used in these warehouses sometime in May, 1978. At the date of collection, pirimiphos methyl had been used to control those storage insects barely five months which was probably too short a time for selection to occur in *T. castaneum* with pirimiphos methyl

Toxicity Test. The KD_{50} and $KD_{99.9}$ of chlorpyrifos methyl, pirimiphos methyl and permethrin in a susceptible strain of *Tribolium castaneum* were determined from the eye-fitted log probit response lines in Fig. 5. Among these insecticides, chlorpyrifos methyl was the most toxic and permethrin, the least toxic (Table 3).

Both pirimiphos methyl and chlorpyrifos methyl had a lower discriminating concentration (Table 4) to *T. castaneum* than malathion as recommended by FAO (Anonymous 1974). However, chlorpyrifos methyl was slow acting, the reliable time for determining knockdown was 12 hours as compared to only 5 for pirimiphos methyl.

The discriminating concentration (0.18%) found in the present study for pirimiphos methyl was lower than the concentration (0.5%) reported by Morallo-Rejesus and Virrey (1978) which was the concentration used for the resistance test in present study. It is suggested that another resistance test be conducted for pirimiphos methyl on same strains using the discriminating concentration found in the present study. It seemed that the susceptible strains used by Morallo-Rejesus and Virrey (1978) in the Philippines were slightly tolerant to pirimiphos methyl.

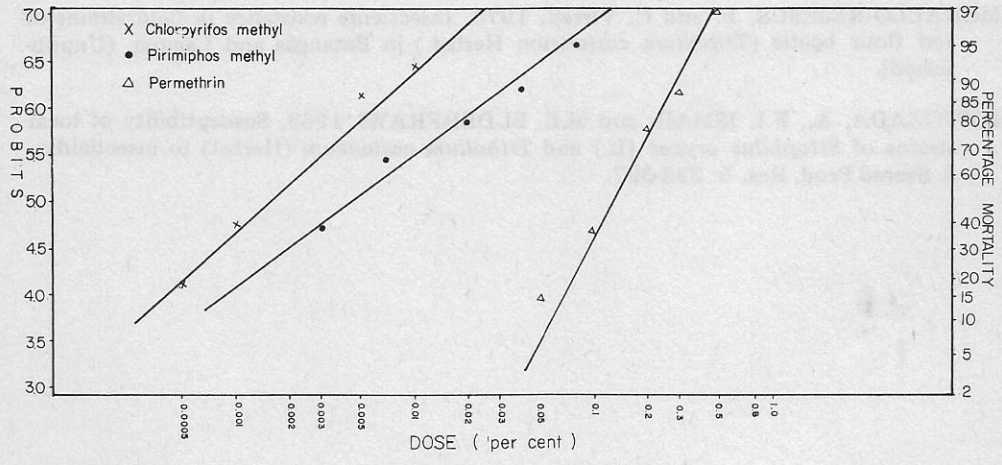


Fig. 5. Dose-response line of *T. castaneum* to three insecticides by filter paper impregnation method.

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