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Resistance monitoring of some commercial insecticides to German cockroach (*Blattella germanica* (L.) in Indonesia

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Abstract
The resistance to commercial insecticides has been developed to German cockroaches, it makes more difficulties to control all of them. The monitoring of insecticides resistance can be used as reference to evaluate the control of German cockroach population in the future. The aim of this study is to determine the resistance level of commercial insecticides by Tarsal Contact Test and Spray Test. The insecticides that used in this study were five commercial insecticides contain the active ingredient, Pyrethroid. The field cockroach populations were collected from Jakarta and Padang, the standard population cockroach is WHO standard. The resistance levels of German cockroach were from low until very high resistance to commercial insecticides. The German cockroach was high resistance used Tarsal Contact Test and very high resistance used Spray Test.

Keywords: Commercial insecticides, German cockroach, tarsal contact test, spray test, Indonesia

1. Introduction
The German cockroach was the most common household pests in Indonesia [1], it may served as vector of some diseases and played major role in transmission of pathogens in the human foods [2, 3]. Recently, the synthetic commercial insecticides were the most commonly used methods in controlling cockroaches. It was used individually at home. The resistance of the German cockroach was caused by uncontrolled and overused of the insecticides [4]. The resistance cases of insecticides to German cockroach have studied in several countries: German cockroach resistant to Malathion in Malaysia [5]; DDT in Europe [6]; Pyrethroid from Iran [7], USA, Panama, Denmark, Dubai [8], Singapore [4], and South Korea [9].
In Indonesia, many people used synthetic commercial insecticides to control the German cockroaches, because it can be applied easily and kill quickly. Therefore, monitoring the level of synthetic commercial insecticide resistance of German cockroaches in Indonesia was important information for controlling the German cockroaches in the future. Most of all commercial insecticides in Indonesia were insecticide sprays which were it still negative effect and leaved many residues in the environment. The aims of this study were to determine the level of commercial insecticides resistance to the German cockroaches by spray method and the effect of insecticide residual resistance in the German cockroaches.

2. Materials and Methods
2.1 Time of Monitoring. Monitoring of some commercial insecticides to German cockroaches was conducted from August to December 2013 at Laboratory of Animal Physiology Department of Biology, University of Andalas, Padang, West Sumatra, Indonesia.

2.2 Cockroaches: The male cockroaches of *Blattella germanica* (L.) were used in this study from three strains. The VCRU-WHO (Vector Control Research Unit, World Health Organization) strain was used as susceptible strain. This strain is pure population that has never exposed to the insecticides and belongs to School of Biological Sciences, University Sains Malaysia. The field strains cockroaches were collected from two cities in Indonesia (Table 1). The collected strains of the cockroaches were reared in Laboratory of Animal Physiology Department of Biology, University of Andalas, Indonesia. The rearing method [10] was carried out at the temperature between 24 °C and 28 °C and the Photoperiod 12:12.

Table 1: The information of German cockroaches population sources

Populations	Collection sites	Collection years
VCRU-WHO	Penang, Malaysia	2007
GFA-JKT	Jakarta, Indonesia	2007
PLZ-PDG	Padang, Indonesia	2010

2.3 Insecticides: Insecticides that used in this study were top five commercial insecticides which have been widely using in the field. The insecticides are sold to the public and obtained from several outlets in Padang city, West Sumatra. The active compounds of insecticides were shown in Table 2.

Table 2: The percentage of active compounds of insecticide products that tested

Insecticide Products	Active compounds	Percentage (%)
By	Cypermethrin	0.10
	Imiprothrin	0.03
Vp	Prallethrin	0.03
Ht	Prallethrin	0.20
	d-allethrin	0.15
Rd	Transfluthrin	0.06
	Cyfluthrin	0.06
Mt	Esbiothrin	0.11
	Permethrin	0.06
	Imiprothrin	0.03

2.4 Bioassay of Insecticides: To method were used to determine the effect of insecticide to the German cockroach. First, Contact Method (modified from Tarsal Contact Test [11]). The Petri dish (9 cm diameter) was filled with one ml of insecticide which its edges smeared with the dilution of baby oil and petroleum oil to prevent cockroach escape during observation. The insecticide was dried at room temperature for 1-2 hours, and then 10 individuals of cockroaches were placed into a Petri dish. The second method is Spray Method and also uses Petri dishes (9 cm diameter) which are its edges smeared with oil like the Contact Method procedure. The Petri dish was place into a plastic box, 30x30x60 cm (length x width x height). Ten individuals of cockroaches were placed into a Petri dish and sprayed it with insecticide for 1 second. The each treatment has done with three replications. The Lethal time of cockroaches on Contact and Spray Methods were observed every hour until the entire cockroach individuals died 100%.

2.5 Data analysis. The analysis of lethal time of cockroaches was observed every hour used the Probit analysis by POLO-PC computer program [12] to get the lethal time 50 (LT_{50}) values. Resistance level was obtained from the value of Ratio Resistance (RR_{50}). RR_{50} was compared between LT_{50} of field strain and LT_{50} susceptible strain. The level of resistance [13] was modified, as follow: $RR_{50} \leq 1$: absence of resistance, $1 < RR_{50} \leq 5$: low resistance, $5 < RR_{50} \leq 10$: moderate resistance, $10 < RR_{50} \leq 50$: high resistance, $RR_{50} \geq 50$: very high resistance, $RR_{50} \geq 1000$: extremely high resistance.

3. Results and Discussion

The lethal time (LT) and resistance level of German cockroach to commercial insecticides that used Contact Method were shown in table 3. The Lethal Time (LT_{50}) of cockroaches to insecticides is ranged from 0.73 to 8.77 hours on standard strain cockroaches and from 6.17 to 99.85 hours on the field strain cockroaches. The resistance level of cockroaches is high to the Rd insecticide product with RR_{50} values ranged from 1.64 to 13.33 folds and Mt insecticide product with 9.20 to 29.74 folds. The insecticide resistance levels from higher to lower is Rd>Mt>By>Vp>Ht. The German cockroach has highest resistance level to Rd insecticide product and the lowest resistance level to Ht insecticide product.

The resistance level is higher in PLZ-PDG population than the GFA-JKT population. This condition may be cause by overused of insecticides in Padang if compare with Jakarta, but this hypothesis need to confirm with the total sales of product in each city. The Mt and Rd insecticide products may be widely used by house owner in the Padang city than others insecticide products. The Rd was used commonly and dominant in both city, but in Jakarta only cause moderate resistance. The possible way of the resistance happens to cockroaches by the contact method which its residue left in the field, and this hypothesis was confirmed in this study that the spray insecticide product leave many residues in the environment and made the levels of resistance was very high.

Table 3: Lethal times and Resistance levels of German cockroach to some commercial insecticide products that used Tarsal Contact Test

Insecticide Products	Active Compounds (%)		Populations	Levels of Resistance		
				LT_{50}(hours)	RR_{LT50}(Folds)	Levels
By	Cypermethrin	0.10	VCRU-WHO	2.31	1	Absence of resistance
	Imiprothrin	0.03	GFA-JKT	6.40	2.76	low resistance
			PLZ-PDG	17.46	7.55	Moderate resistance
Ht	Prallethrin	0.20	VCRU-WHO	8.77	1	Absence of Resistance
	d-allethrin	0.15	GFA-JKT	10.36	1.18	Low resistance
			PLZ-PDG	12.19	1.39	Low resistance
Mt	Esbiothrin	0.11	VCRU-WHO	7.48	1	Absence of Resistance
	Permethrin	0.06	GFA-JKT	12.34	1.64	Low resistance
	Imiprothrin	0.03	PLZ-PDG	99.85	13.33	High resistance
Rd	Transfluthrin	0.06	VCRU-WHO	0.73	1	Absence of Resistance
	Cyfluthrin	0.06	GFA-JKT	6.78	9.20	Moderate resistance
			PLZ-PDG	21.91	29.74	High resistance
Vp	Prallethrin	0.03	VCRU-WHO	3.12	1	Absence of Resistance
			GFA-JKT	6.17	1.97	Low resistance
			PLZ-PDG	8.91	2.85	Low resistance

Note: LT_{50}: Lethal Time 50% cockroach

RR_{50}: Ratio Resistance 50%, LT_{50} of field population cockroach/LT_{50} of standard population cockroach

The Lethal Time (LT_{50}) of German cockroaches to insecticides that used Spray Method is ranged from 0.05 to 11.57 hours on the standard strain of cockroaches and 4.37 to 28.72 hours on the field strain of cockroaches. The German

cockroaches have very high resistance to the Rd insecticide products with RR_{50} ranged from 107.13 to 165.98 folds. The insecticide resistance level from higher to lower is Rd> Mt> By> Ht> Vp. The Rd insecticide product has very high level of resistance against cockroaches than the Vp insecticide product.

The resistance level of the Rd insecticide product that used spray method is highest resistance on the GFA-JKT and PLZ-PDG populations. The possibility of using the Rd insecticide product is predominantly high by the public in the city of Padang and Jakarta than other insecticide products. The spray insecticide application affects the development of higher resistance level than contact insecticide application. The contact insecticide application is relied solely on the residue of the insecticide. The insecticide product was using a direct spray to German cockroach can be enter the body through the cuticle and trachea.

Table 4: Lethal times and Resistance levels of German cockroaches to some commercial insecticides that used Spray Method

Insecticides Products	Active Compounds (%)		Populations	Level of Resistance		
				LT_{50}(hours)	RR_{LT50}(Folds)	Levels
By	Cypermethrin	0.10	VCRU-WHO	11.57	1	Absence of resistance
	Imiprothrin	0.03	GFA-JKT	12.56	1.09	Low resistance
			PLZ-PDG	28.27	2.44	Low resistance
Ht	Prallethrin	0.20	VCRU-WHO	3.88	1	Absence of resistance
	d-allethrin	0.15	GFA-JKT	6.51	1.68	Low resistance
			PLZ-PDG	4.37	1.13	Low resistance
Mt	Esbiothrin	0.11	VCRU-WHO	4.22	1	Absence of resistance
	Permethrin	0.06	GFA-JKT	4.80	1.14	Low resistance
	Imiprothrin	0.03	PLZ-PDG	20.91	4.95	Low resistance
Rd	Transfluthrin	0.06	VCRU-WHO	0.05	1	Absence of resistance
	Cyfluthrin	0.06	GFA-JKT	8.63	165.98	Very high resistance
			PLZ-PDG	5.57	107.13	Very high resistance
Vp	Prallethrin	0.03	VCRU-WHO	9.37	1	Absence of resistance
			GFA-JKT	15.62	1.67	Low resistance
			PLZ-PDG	11.58	1.24	Low resistance

Note: LT_{50}: Lethal Time 50% cockroach

RR_{50}: Ratio Resistance 50%, LT_{50} of field population cockroach/LT_{50} of standard population cockroach

The development of resistance to Rd insecticide product is likely caused its product containing the active ingredients. The active ingredients in Rd insecticide product are Transfluthrin and Cyfluthrin. Transfluthrin and Cyfluthrin, and these compound not found in the others insecticide which is used in this study. The commercial insecticides in Singapore also have very high levels of resistance to German cockroaches with containing the active ingredients Beta-Cyfluthrin [4]. The active compound in insecticides was tested is class of Pyrethroid. The Pyrethroid is one of the classes of insecticide that has been used generally in Indonesia, so it's caused faster development of resistance to pyrethroid class insecticides [1]. The result of the resistance level containing Cypermethrin was higher than Prallethrin and D-Allethrin in German cockroaches from Bandung population [1]. The Cypermethrin has extremely high resistance in German cockroaches from Jakarta population [13]. The Cypermethrin, Prallethrin, and D-Allethrin were providing the same level of resistance in this study. The resistance level of insecticide containing Cypermethrin and D-Allethrin compound is caused by using these compounds for long time in Indonesia since the early 1990s [1].

4. Conclusions

This study was confirmed of the using the synthetic commercial insecticide product will caused the low to high resistance level on the Contact Method and low to very high resistance level on Spray Method. The level of resistance in German cockroaches to insecticides from higher to lower is Rd>Mt>By>Vp>Ht on the Contact Method and slightly different on Spray Method, Rd>Mt>By>Ht>Vp.

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