

The Efficacy of Commercial Aerosol Insecticides to German Cockroaches (*Blattella germanica* L.) Populations from Two Places in Indonesia

Resti Rahayu^{1*}, Vivy Hermana Pratiwi¹, Anggia Safitri¹, Robby Jannatan²

Animal Physiology Laboratory, Department of Biology, Universitas Andalas, 25163, Indonesia¹
Animal Structure & Development Laboratory, Department of Biology, Universitas Andalas, 25163, Indonesia²

Corresponding Author: 1*



ABSTRACT— Aerosol spray insecticides are widely available in Indonesia's public market to control the German cockroach population, but the reports on their effectiveness are still limited. This study aimed to determine the efficacy of six pyrethroid insecticides in the form of aerosol sprays (By, Ht, Vp, Nm, Mt, and Fm) against field German Cockroaches populations in Indonesia (Palembang and Bukittinggi populations). Five insecticides effectively paralyzed the Bukittinggi population and ineffective to the Palembang population by the knockdown time (KT90) criteria. All aerosol insecticides were ineffective in killing Bukittinggi and Palembang Cockroaches populations by the lethal time (LT90) criteria. The pyrethroid insecticides sold in the public market were no longer effective in killing the German Cockroaches population. The results show a high level of resistance in two German cockroach populations in Indonesia.

KEYWORDS: urban pest, pyrethroid, chemical insecticide, resistance, Indonesia.

1. INTRODUCTION

The German cockroach (*Blattella germanica* L.) is the serious and most important pest in the urban area in many countries of the world [1], [2], [3] and also in Indonesia [4]. The German cockroach is also carrying 27 species of potential bacteria pathogens, such as *Klebsiella*, *Enterobacter*, *Serratia*, and *Streptococcus*. Almost all of the bacteria are multiple antibiotic resistant's [5]. Most people in Indonesia control the German cockroach population using chemical insecticides in the form of aerosol sprays. One of the many aerosol sprays sold on the public market is a pyrethroid insecticide. Still, most aerosol spray insecticide has been resistant to some German cockroach populations in Indonesia [6]. There is a specific character of resistance of the cockroach population. The characters can be identified from the different levels and patterns of the Cockroaches population's resistance mechanisms from each place [7]. Synthetic insecticides can quickly kill German cockroaches in some areas, but it may be ineffective in other areas [8]. The present study is monitoring the efficacy of aerosol sprays insecticide in the public market to control the German cockroach population, and this study may offer a new urban pest control management in Indonesia.

2. Material and Method

2.1 Provision of the German cockroach population

This study used two field populations of German cockroaches (*B. germanica* L.) were collected from the field. The populations were the Palembang population (PLZ-PLM) and Bukittinggi population (RMKN-BKT). A standard cockroach that is still susceptible to insecticides was obtained from the Vector Control Research Unit, University Sains Malaysia (VCRU-WHO) (Table 1). All cockroach populations were reared at the Animal Physiology Laboratory of the Biology Department, Andalas University, Indonesia. The

rearing of German Cockroaches populations refers to established method [9]. Cockroaches were reared in plastic containers with a volume of 16 liters. Cockroaches were fed and watered ad libitum. The feed given to cockroaches during the rearing process in the laboratory was cat food (pedigree). Cockroaches were bred at room temperatures between 25-28°C and humidity between 70-95%. The cockroaches used for treatment were adult male cockroaches aged 1-3 months and each treatment was replicated four times.

Table 1. Source and year of collection of german cockroach populations

Population	Place of collection		Year of collection
VCRU-WHO	Laboratory	Penang, Malaysia	2007
PLZ-PLM	Restaurant	Palembang, Indonesia	2017
RMKN-BKT	Restaurant	Bukittingi, Indonesia	2015

2.2 Provision of aerosol insecticides

Aerosol insecticide (active ingredient: pyrethroid) used in this study was a commercial insecticide sold to the public with the initials By, Ht, Vp, Nm, Mt, and Fm (Table 2).

Table 2. Aerosol insecticides and their active ingredients

No	Insecticide	Active ingredients
1	By	Cypermethrin (0.10) Pralethrin (0.10) Transfluthrin (0.10)
2	Ht	Transfluthrin (0.17) Pralethrin (0.05) Cypermethrin (0.10)
3	Vp	Dimefluthrin (0.04) Pralethrin (0.12) Cyfluthrin (0.03)
4	Fm	Transfluthrin (0.15) Permethrin (0.15)
5	Mt	Permethrin (0.06) Imiprothrin (0.03) Esbiothrin (0.11)
6	Nm	Transfluthrin (0.06) Cyfluthrin (0.03)

2.3 The efficacy test

The efficacy test refers to established protocols [10] using the spray method. Ten individuals of German cockroaches from each population were placed in a 30x20x20 cm test box (cardboard container). The top of the test box's inner side was coated with plastic tape and given a mixture of Vaseline and petroleum oil to prevent the German cockroaches from escaping from the test box. The aerosol insecticide was sprayed for one second with a spraying distance of one meter from the test box's bottom. The number of knockdowns and lethal German cockroaches were observed periodically for up to 96 hours. The knockdown of the cockroach was a condition no longer able to move from one point to another, but the legs still move if touched, while lethal was a condition of the cockroach cannot be moving at all.

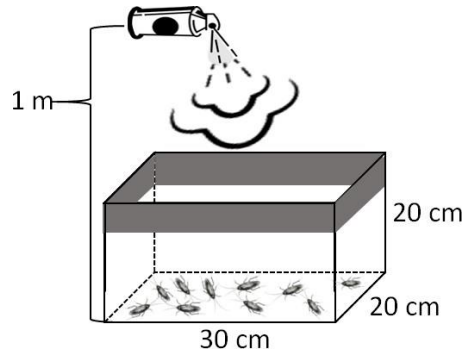


Figure 1. The efficacy test of aerosol insecticides against German cockroach population illustration

2.4 Data analysis

The knockdown time (KT) and Lethal Time (LT) from each treatment were analyzed by probit using the Minitab 18 program to obtain the KT90 and LT90 values. The criteria for aerosol insecticides' effectiveness were determined from the Efficacy Testing Method using a knockdown time of 90% (KT90) and lethal time of 90% (LT90) within a certain period. Aerosol insecticides were categorized as effective if the KT90 of the german cockroach population can be achieved for a maximum of 20 minutes after exposure to the insecticide and the LT90 of the german cockroach can be reached a maximum of six hours after exposure [10].

3. Result

Aerosol insecticides (By, Ht, Vp, Nm, Mt, and Fm) effectively paralyzed the standard population of German cockroaches (VCRU-WHO). The insecticides mentioned above were also effective in paralyzing the Bukittinggi population (RMKN-BKT) except the insecticide by. Meanwhile, none of them effectively paralyzed the Palembang population (PLZ-PLM) within ≤ 20 minutes after insecticide exposure. The insecticides were also ineffective in killing the field populations of german cockroaches within ≤ 6 hours (Table 3). The knockdown time of the Cockroaches population in the Palembang population (PLZ-PLM) was slower than the Bukittinggi population (RMKN-BKT) (Figure 1).

Table 3. The efficacy of aerosol insecticides to german cockroach populations by the knockdown time 90% (KT90) and lethal time 90% (LT90)

Insecticide	Population	KT90 (minutes)	LT90 (hours)
By	VCRU-WHO	8.69*	7.32
	RMKN-BKT	21.34	131.94
	PLZ-PLM	149.25	>192
Ht	VCRU-WHO	5.13*	4.16**
	RMKN-BKT	14.58*	176.52
	PLZ-PLM	174.2	>192
Vp	VCRU-WHO	8.31*	7.13
	RMKN-BKT	11.29*	240.75
	PLZ-PLM	185.5	>192
Nm	VCRU-WHO	11.44*	8.59
	RMKN-BKT	14.82*	180.08
	PLZ-PLM	203.18	>192
Mt	VCRU-WHO	11.44*	8.59
	RMKN-BKT	18.97*	216.65

	PLZ-PLM	134.66	>192
Fm	VCRU-WHO	5.80*	5.13**
	RMKN-BKT	18.50*	233.41
	PLZ-PLM	173.10	>192

Note: * = effective (KT90 <20 minutes), ** = effective (LT90<6 hours)

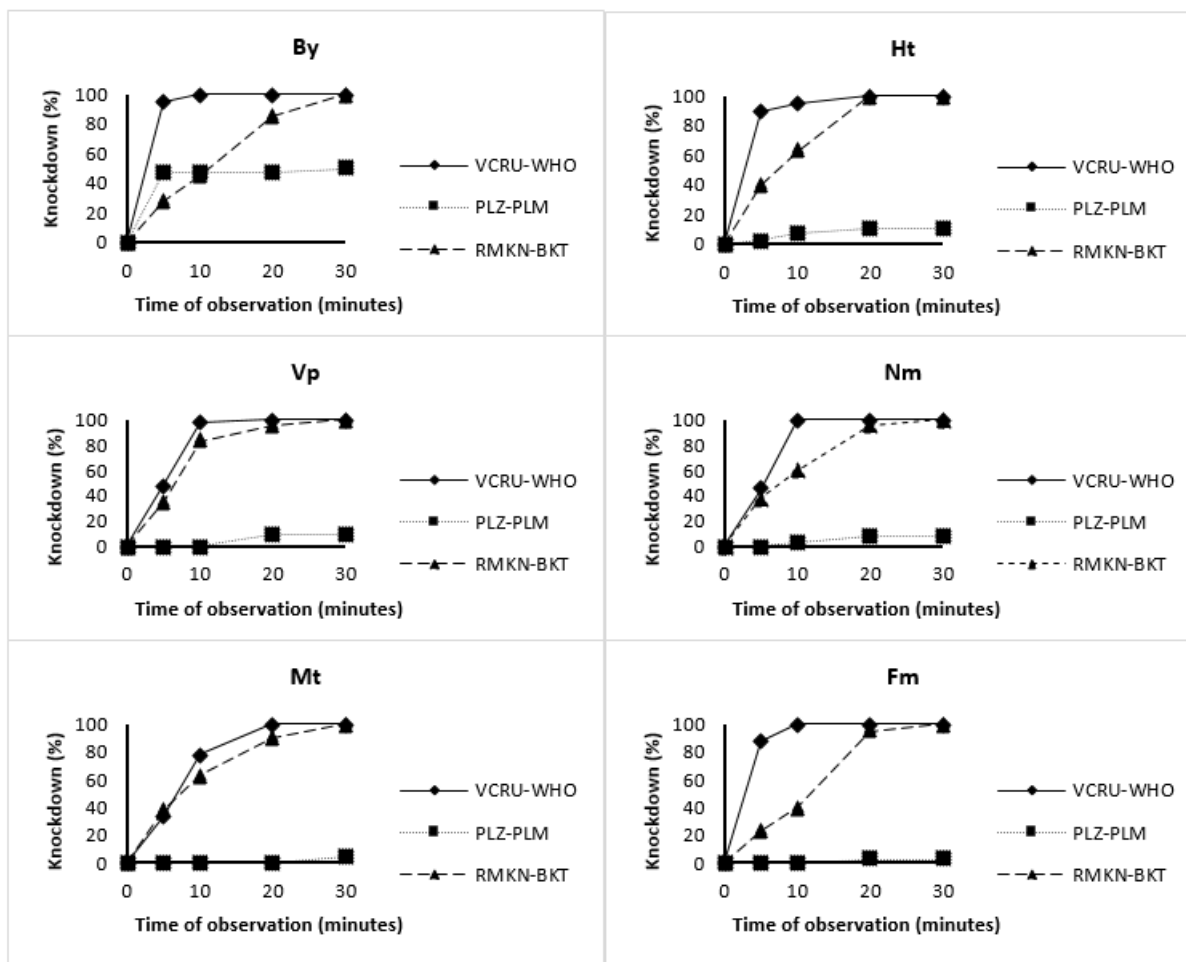


Figure 2. The German cockroach population knockdown rate by six pyrethroid insecticide in the form of aerosol sprays as long as 30 minutes of observation

4. Discussion

Field population cockroaches (PLZ-PLM and RMKN-BKT populations) have been resistant to pyrethroid insecticides compared to standard population cockroaches (VCRU-WHO). There are differences in KT and LT values between field and standard populations of cockroach, indicating the difference in each cockroach population's ability to respond to insecticides. According to [11], there is a difference of insecticides' detoxification rate in resistant and susceptible insects, depends on the amount of detoxification enzyme. The time to paralyze and kill field cockroach population is very long than the standard population (table 3). The field German Cockroaches population has been resistant to commercial aerosol insecticides tested. Aerosol insecticides are very effective in killing cockroaches compared to other types of insecticides. According to [12], aerosol insecticides are suitable for killing fast-moving insects such as cockroaches. Aerosol insecticides leave the residues on sprayed surfaces in the cockroach's home range, it will kill the cockroaches later. Therefore, people use aerosol insecticides often than the standard dosage because it is easily to apply and have many formula variations. Based on the interviews with the owners of the location

that field German cockroach was collected, the insecticide used to control German cockroach is aerosol insecticides. The factors that cause aerosol insecticides ineffective control the field cockroaches population because of the insecticides overuse and affect the resistance of German cockroach. The use of insecticide continuously could cause resistance in insect pests [8]. One of the factors driving the rapid development of insects' resistance is the frequency and dosage of insecticide that increase continuously [13]. [14] reported in Korea that insecticides' overuse causes failures in the control of cockroach populations in the field because of the growing resistance in field cockroaches. Field population cockroaches that have been resistant to the insecticides have an improved self- defense system against insecticides. The first self-defense in the cockroaches is recognizing and identifying the toxic compounds and leaving the area with residues of the insecticide exposed. This ability is called behavioral resistance. Resistant insects can change their behavior to detect the toxins contained in the insecticides, insects develop other resistance mechanisms such as improving the detoxification ability of toxins and thickening their cuticle that can slowing the absorption of chemicals into his body [15]. [16] also reported that behavioral resistance is the performance of resistant insects that can detect or recognize and avoid toxins. The present study result showed two types of aerosol insecticides can kill standard cockroach population within <6 hours. It's have a higher percentage of pyrethroid substance than other types insecticides. An insecticide's efficacy can be influenced by intrinsic and extrinsic factors. Intrinsic factors are the active ingredients, dosage, concentration, formulation, and sensitivity of insect species, while extrinsic factors are temperature, sunlight, wind and influenced by the application of insecticides (the way, time, tools used, and methods of storage) [17].

5. Conclusion

All aerosol insecticides (By, Ht, Vp, Nm, Mt, and Fm) are ineffectively paralyze and kill field population of German cockroach.

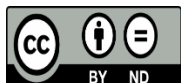
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7. References

- [1] Rust, M. K., Owens, J. M., & Reiersen, D. A. Understanding and controlling the German cockroach. Oxford University Press on Demand, 1995.
- [2] Dingha, B., Jackai, L., Monteverdi, R. H., & Ibrahim, J. "Pest control practices for the German cockroach (Blattodea: Blattellidae): a survey of rural residents in North Carolina" Florida Entomologist, Volume 96, Issue 3, 2013, pp. 1009-1015, <https://doi.org/10.1653/024.096.0339>
- [3] Shahraki, G.H., Parhizkar, S. & Nejad, A.R.S. "Cockroach infestation and factors affecting the estimation of cockroach population in urban communities" International Journal of Zoology, 2013.
- [4] Ahmad, I., Astari, S., Putra, R. E., & Permana, A. D. "Monitoring pyrethroid resistance in field collected *Blattella germanica* Linn. (Dictyoptera: Blattellidae) in Indonesia" Entomological Research, Volume 39, Issue 2, 2009, pp. 114–118, <https://doi.org/10.1111/j.1748-5967.2009.00205.x>
- [5] Elgderi, R. M., Ghenghesh, K. S., & Berbash, N. "Carriage by the German cockroach (*Blattella germanica*) of multiple-antibiotic-resistant bacteria that are potentially pathogenic to humans, in hospitals and households in Tripoli, Libya" Annals of Tropical Medicine & Parasitology, Volume 100, Issue 1, 2006, pp. 55-62. <https://doi.org/10.1179/136485906X78463>

- [6] Rahayu, R., Madona, W. R., Bestari, W., & Jannatan, R. "Resistance monitoring of some commercial insecticides to German cockroach (*Blattella germanica* (L.)) in Indonesia" *Journal of Entomology and Zoology Studies*, Volume 4, 2016, pp. 709-712.
- [7] Brogdon, W.G. & McAllister, J.C. "Synopsis Insecticide resistance and vector control" *Emerging Infectious Disease*, Volume 4, Issue 4, 1998, pp. 605–613.
- [8] Rahayu, R., Ahmad, I., Sri Ratna, E., Tan, M. I. & Hariani, N. "Present Status of Carbamate, Pyrethroid dan Phenylpyrazole Insecticide Resistance to German Cockroach, *Blattella germanica* (Dictyoptera: Blattellidae) in Indonesia" *Journal of Entomology*, Volume 9, Issue 6, 2012, pp. 361-367.
- [9] Rahayu, R., Mairawita & Jannatan, R. "Efficacy and residual activity of lemongrass essential oil (*Cymbopogon flexuosus*) against German cockroaches (*Blattella germanica*)." *Journal of Entomologi*, Volume 15, Issue 3, 2018, pp. 149-54.
- [10] Directorate of Fertilizer and Pesticide of Indonesia. *Metode Pengujian Efikasi Hygene Lingkungan*. Departeman Pertanian Republik Indonesia; Jakarta, 2004.
- [11] Hudayya, A. & H. Jayanti. *Pengelompokan Pestisida Berdasarkan Cara Kerjanya (Mode of Action)*. Yayasan Bina Tani Sejahtera Lembang; Bandung, 2012.
- [12] Raini, M. *Toksikologi insektisida rumah tangga dan pencegahan keracunan. Media penelitian da pengembangan kesehatan*; Jakarta, 2009.
- [13] Lasbudi, Pahlepi R.I., Tavip, Y., Budiyanto, A., Sitorus, H. & Febriyanto "Tingkat kerentanan *Aedes aegypti* (Linn) terhadap malation di Provinsi Sumatera Selatan" *Buletin Penelitian Kesehatan*, Volume 43, Issue 2, 2015, pp.97-104
- [14] Chang, K. S., Shin, E. H., Jung, J. S., Park, C., & Ahn, Y. J. "Monitoring for insecticide resistance in field- collected populations of *Blattella germanica* (Blattaria: Blattellidae)" *Journal of Asia-Pacific Entomology*, Volume 13, Issue 4, 2010, pp. 309-312.
- [15] Baehaki, S. E., E. H. Iswanto, dan D. Munawar, "Resistensi Wereng Coklat terhadap Insektisida yang Beredar di Sentra Produksi Padi" *Jurnal Penelitian Pertanian Tanaman Pangan*, Volume 35, Issue 2, 2016, pp. 99-108.
- [16] Dono, D., Ismayana, S., Prijono, D. & Muslikha, I. "Status dan Mekanisme Resistensi Biokimia *Crocidolomia pavonana* (F.) (Lepidoptera: Crambidae) terhadap Insektisida Organofosfat serta Kepekaannya terhadap Insektisida Botani Ekstrak Biji *Barringtonia asiatica*" *Jurnal Entomologi Indonesia*, Volume 7, Issue 1, 2010, pp 9-27.
- [17] Djojosumarto, P. *Panduan lengkap pestisida & aplikasinya*. Agromedia. 2008.



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