http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Pakistan Journal of Biological Sciences

ISSN 1028-8880
DOI: 10.3923/pjbs.2016.259.264

Research Article
Toxicity of Cypermethrin and Chlorpyrifos Against German Cockroach [*Blattella germanica* (Blattaria: Blattellidae)] Strains from Hamadan, Iran

[1]Mansour Nazari, [1]Behrouz Alipourian Motlagh and [2]Hassan Nasirian

[1]Department of Medical Entomology, School of Medicine, Hamadan University of Medical Sciences, Hamadan, Islamic Republic of Iran
[2]Department of Medical Entomology and Vector Control, School of Public Health, Tehran University of Medical Sciences, Tehran, Islamic Republic of Iran

Abstract

Background: German cockroach has relatively short life cycle and reproduce rapidly. It is the most common medically and public health pest. As a result, it is essential to combat this pest. Cypermethrin and chlorpyrifos are used by private companies in Hamadan to control *Blattella germanica*. It seems necessary to determine its susceptibility levels to these insecticides. **Objective:** The aim of this study was to determine the susceptibility levels of *B. germanica* strains to cypermethrin and chlorpyrifos in Hamadan. **Materials and Methods:** In this study, the German cockroach strains were collected from two hospitals (Fatemiyeh and Atiyeh) in Hamadan and transfered to the insectarium. The cockroach strains were reared under the same laboratory condition. Then their sensitivity levels were considered to 1, 2, 4, 8 and 16 mg m^{-2} for cypermethrin and 0.82, 1.65, 3.31, 6.63, 9.945 and 13.26 mg m^{-2} for chlorpyrifos using surface contact method. **Results:** Results based on insecticide treated doses, *B. germanica* strains showed different percent mortality to the insecticides ranged from 13.3-100. The LD_{50} and LD_{90} and regression lines of the treated insecticides against German cockroach strains indicate that Fatemiyeh Hospital strain is more susceptible to the treated insecticides than Atiyeh Hospital strain. The LD_{50} and LD_{90} of chlorpyrifos are also lower than cypermethrin, indicated that chlorpyrifos is more effective than cypermethrin against German cockroach. As the slopes of the regression lines are observed mild in this study indicate that the population of the cockroach strains is very heterogeneous. It can be a symbol of insecticides resistance to cypermethrin and chlorpyrifos. **Conclusion:** As chlorpyrifos and cypermethrin insecticides are also used for residual spraying by private companies and the doses which provide more than 90% mortality are below the WHO recommended insecticide doses. Therefore, chlorpyrifos and cypermethrin insecticides can be used for *B. germanica* control in Hamadan within regular monitoring and preventive measures of resistance.

Key words: German cockroach, chlorpyrifos, cypermethrin, *Blattella germanica*, toxicity

Received: April 24, 2016 Accepted: May 02, 2016 Published: May 15, 2016

Citation: Mansour Nazari, Behrouz Alipourian Motlagh and Hassan Nasirian, 2016. Toxicity of cypermethrin and chlorpyrifos against German cockroach [*Blattella germanica* (Blattaria: Blattellidae)] strains from Hamadan, Iran. Pak. J. Biol. Sci., 19: 259-264.

Corresponding Author: Hassan Nasirian, Department of Medical Entomology and Vector Control, School of Public Health, Tehran University of Medical Sciences, Tehran, Islamic Republic of Iran Tel: +982142933182 Fax: +982188951393

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

German cockroach [*Blattella germanica* (Blattaria: Blattellidae)] is the most common medically and public health pest[1,2]. German cockroach has relatively short life cycle and reproduce rapidly. *Blattella germanica* can infest homes, restaurants, hotels, hospitals and food storage. It can transmit pathogenic agents such as bacteria, viruses, fungi, protozoa and parasite eggs to human mechanically or through the digestive tract. Therefore, it is the most important vector of the diseases such as cholera, plague, leprosy, typhoid and diarrhea, etc. Moreover, German cockroach is the most important sources of allergen. So, it has a significant role in the development and exacerbation of allergic diseases and asthma[2]. As a result, it is essential to combat this pest and has a particular importance.

This is essential to use insecticides for German cockroach control. Repeat application and extensive use of insecticides has caused German cockroach resistant to insecticides in the world. In Iran, German cockroach is the most important public health problem. It has been resistant to different groups of insecticides and actually its control is very difficult[2-10].

Although, good food hygiene practices, including preventing access to food by sealing it in containers with close-fitting lids and preventing cockroaches from reaching water by repairing dripping taps and covering plug holes in sinks and drains are effective in restricting cockroach populations and the use of gel bait insecticides can be a strategy to control it[11-14]. Whereas it is commonly used residual insecticide spraying by private companies that are responsible for its fighting. Therefore, it is necessary to consider the susceptibility levels to the consumed insecticides such as chlorpyrifos and cypermethrin. So far, several studies have been done about susceptibility of German cockroach to cypermethrin[15-25] and chlorpyrifos[5,15,16,20,23,26-30] in the world. These insecticides are already used by private companies in Hamadan, a study design to consider the susceptibility levels of *B. germanica* to cypermethrin and chlorpyrifos in Hamadan. The aim of this study was to determine the susceptibility levels of *B. germanica* strains to cypermethrin and chlorpyrifos in two hospitals of Hamadan from Iran.

MATERIALS AND METHODS

Site of study: In this study, wild German cockroach strains were collected from Fatemiyeh and Atiyeh Hospitals in Hamadan, the Center of Hamadan province. Hamadan is one the oldest cities in the world and a metropolitan of Iran now. It composed an area about 4118 km^2 with two parts and 8 districts. Hamadan locates on the Alvand mountain ranges in the Western and mountainous of Iran with an elevation of 1820 m above the sea level. The city in terms of cultural heritage, history and handicrafts has abundant tourist attractions. Every year a large number of Iranian and foreign tourist visit Hamadan.

Fatemiyeh Hospital locates in the West of Hamadan and has 6,000 m^2 building space with 300 approved beds it has 158 active beds now. Fatemiyeh Hospital consists of different parts includes: Ten medical units, 9 clinical and diagnostic units and 12 specialized and ultra-specialized clinics. It is the first degree hospital and the first ones in Hamadan province which has received the 'ISO 9001-2000 certificate'. It is an already women top pole of health care, education and study in the West of Iran and provides the medical care to the people and educational and research services to the students.

Atiyeh Hospital locates in the North of Hamadan and has 2,400 m^2 building space with 256 approved beds, it has 116 active beds now. Atiyeh Hospital consists of different parts includes: 16 medical units, 16 clinical and diagnostic units and 13 specialized and ultra-specialized clinics. It provides the medical care to the people.

Cockroaches collecting and rearing: Cockroaches were collected by Nasirian *et al.*[4,31] methods. After collecting each cockroach strains were transferred into large glass jar, maintained and colonized at 24±2°C, 40±5% RH and a photoperiod of 12:12 (L:D) h in the insectary at Department of Medical Entomology, School of Medicine, Hamadan University of Medical Sciences. Cockroaches were provided with rodent diet, a cotton plugged water vial and a cardboard as a harborage.

Chemicals and reagents: Cypermethrin (technical grade, 93.0%) and chlorpyrifos (technical grade, 97.0% crystal) as insecticides, CO_2 as an anesthetic and acetone as a solvent were used.

Surface contact bioassay: In this study a glass jar was used for surface contact bioassay. It calculated the glass jars inner surface area, it was 188.4 cm^2. Technical grade of the insecticides were diluted by acetone solvent. So, this study designed to dilute insecticide concentrations which 1 mL volume contains considered insecticide doses. Then, 1 mL of diluted insecticide was pipetted into the glass jar. To deposit

the insecticide evenly over the inner surface of the glass jars, the glass jars were rolled horizontally over a flat surface until all of the acetone had evaporated. In a series of contact experiments, a concentration of technical grade at a 30 min exposure time was found to be a discriminating dose for male adults. Then adult male cockroaches were treated with 5-6 insecticide dose exposures at a 30 min time and each dose exposures were replicated 3 times (10 cockroaches for each replicate). This study used the insecticide doses of 1, 2, 4, 8 and 16 mg m^{-2} for cypermethrin and 0.82, 1.65, 3.31, 6.63, 9.945 and 13.26 mg m^{-2} for chlorpyrifos. Control groups received acetone alone. All insecticide dose exposures were given >0% and <100% mortality at 24 h after insecticide dose exposures. Insecticide exposured males were placed in plastic dishes, provided with food and water and monitored for mortality for 24 h under the same temperature and photoperiod as the colony. If insects on their backs were unable to right themselves, they were considered dead.

Statistical analysis: Mortality data from the replicates were pooled and the dose exposure mortality was assessed by probit regression analysis with a PASW statistics (18 version for windows) on a computer. Microsoft Office Excel (2007 version) were used to calculate equation and draw the regression lines.

RESULTS

Results based on the insecticide treated doses, German cockroach strains showed different percent mortalities to the insecticides ranged from 13.3-100 (Table 1).

The LD_{50} and LD_{90} of the treated insecticides against German cockroach strains indicate that Fatemiyeh Hospital strain is more susceptible to treated insecticides than Atiyeh Hospital strain (Table 2). The LD_{50} and LD_{90} of chlorpyrifos are lower than cypermethrin indicated that chlorpyrifos is more effective than cypermethrin against German cockroach (Table 2).

Regression lines of Fatemiyeh Hospital strain to the treated insecticides are also in front of Atiyeh Hospital strain that demonstrate Fatemiyeh Hospital strain is more susceptible than Atiyeh Hospital strain (Fig. 1). The slopes of the regression lines were observed mild (Fig. 2 and 3) indicate that the population of the cockroach strains is very heterogeneous.

DISCUSSION

German cockroach is the most common medically and public health pest[1,2]. It is commonly used residual insecticide spraying by private companies that are responsible for its fighting. Chlorpyrifos and cypermethrin insecticides are already used by private companies in Hamadan, the current study designed to consider the susceptibility levels of *B. germanica* strains to cypermethrin and chlorpyrifos in two hospitals of Hamadan from Iran. Results based on the insecticide treated doses German cockroach strains showed different percent mortality to the insecticides ranged from 13.3-100 (Table 1).

The slope of the regression line is a scale for the heterogeneity and genetic population variation. In this study, although the resistance of German cockroach was not studied but the slopes of the regression lines are mild (Fig. 2 and 3) indicate that the population of the cockroach strains is very heterogeneous. It can be a symbol of insecticides resistance to cypermethrin and chlorpyrifos. A degree of chlorpyrifos

Table 1: Toxicity of cypermethrin and chlorpyrifos against German cockroach strains by WHO glass jar method

Cypermethrin	Cockroach mortality (%)		Chlorpyrifos	Cockroach mortality (%)	
(mg m^{-2})	FH	AH	(mg m^{-2})	FH	AH
1	23.3	16.7	0.82	20.0	13.3
2	46.7	36.7	1.65	50.0	43.3
4	66.7	60.0	3.31	70.0	63.3
8	83.3	73.3	6.63	86.6	80.0
16	97.0	93.0	9.945	96.6	93.3
-	-	-	13.26	100	100

FH: Fatemiyeh Hospital strain and AH: Atiyeh Hospital strain

Table 2: Probit regression analysis of cypermethrin and chlorpyrifos against German cockroach strains by WHO glass jar method

Strain	n[a]	Intercept±SE	Slope±SE	χ^2	df	p	LD_{50}[b] (CI)	LD_{90}[b] (CI)
Cypermethrin								
FH	150	-0.53±0.18	0.18±0.03	4.9	3	0.18	3.03 (1.38-4.35)	10.36 (8.28-14.54)
AH	150	-0.69±0.17	0.15±0.03	5.2	3	0.16	4.49 (2.89-6.00)	12.81 (10.37-17.45)
Chlorpyrifos								
FH	180	-0.66±0.19	0.28±0.05	4.9	4	0.29	2.37 (1.34-3.21)	6.97 (5.78-9.02)
AH	180	-0.80±0.18	0.24±0.04	7.1	4	0.13	3.28 (0.91-5.13)	8.53 (6.35-14.71)

[a]No. of cockroach treated, [b]LD_{50} and LD_{90} values in mg m^{-2} (95% CI), FH: Fatemiyeh Hospital strain and AH: Atiyeh Hospital strain

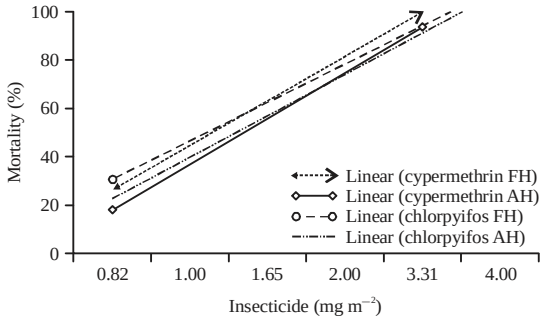

Fig. 1: Regression line of cypermethrin and chlorpyrifos against German cockroach strains by WHO glass jar method, FH: Fatemiyeh Hospital strain and AH: Atiyeh Hospital strain

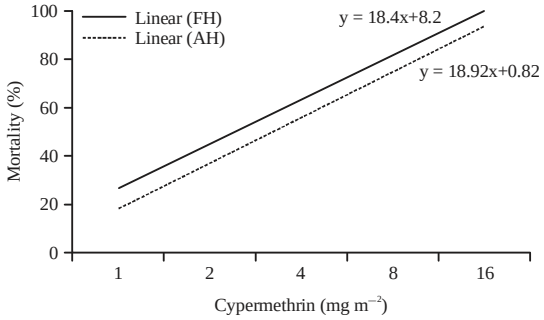

Fig. 2: Regression line of cypermethrin against German cockroach strains by WHO glass jar method, FH: Fatemiyeh Hospital strain and AH: Atiyeh Hospital strain

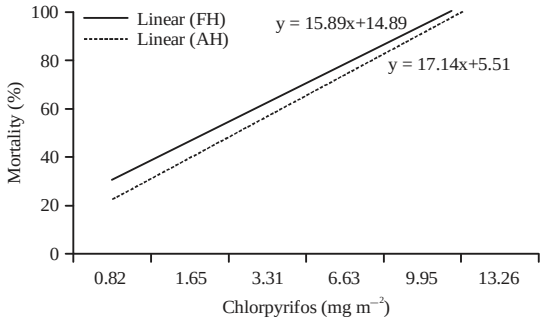

Fig. 3: Regression line of chlorpyrifos against German cockroach strains by WHO glass jar method, FH: Fatemiyeh Hospital strain and AH: Atiyeh Hospital strain

resistance was reported in *B. germanica*[30] in Iran. So far, worldwide cases of resistance were reported to cypermethrin[15-25,32,33] and chlorpyrifos[5,16,20,23,27-30,32].

Recently, it has been proved that the essential oil of *Pogostemon cablin* (Lamiales: Lamiaceae) leaves; *Artemisia arborescens* and *A. santolina* (Asterales: Asteraceae); Apiaceae (Apiales) plants and their major constituents have good potential as a source for natural insecticides or repellents[34-36] for German cockroach control, until they will be legally and officially used take a lot of time.

The use of gel bait insecticides can also be a strategy for control of the German cockroach[11-14]. Whereas, it is commonly used the residual insecticide spraying by private companies that they are responsible for German cockroach fighting. In this study, as the doses of chlorpyrifos and cypermethrin insecticides provide more than 90% mortality (Table 1) are below the WHO recommended insecticide doses. Therefore, they can be used for *B. germanica* control in Hamadan. But precautions such as using rotationally different group of insecticides, etc. must be observed.

CONCLUSION

The slope of the regression line is a scale for the heterogeneity and genetic population variation and they are observed mild in this study, indicate that the population of the cockroach strains is very heterogeneous. It can be a symbol of insecticides resistance to cypermethrin and chlorpyrifos. As chlorpyrifos and cypermethrin insecticides are commonly used for residual spraying by private companies and the doses which provide more than 90% mortality are below the WHO recommended insecticide doses. Therefore, they can be used for *B. germanica* control in Hamadan. But precautions such as using rotationally different group of insecticides, etc., must be observed.

SIGNIFICANCE STATEMENT

- The susceptibility levels of *B. germanica* strains to cypermethrin and chlorpyrifos in Hamadan determined
- The LD_{50} and LD_{90} and regression lines of the treated insecticides against German cockroach strains indicate that Fatemiyeh Hospital strain is more susceptible to treated insecticides than Atiyeh Hospital strain. The LD_{50} and LD_{90} of chlorpyrifos are also lower than cypermethrin indicated that chlorpyrifos is more effective than cypermethrin against German cockroach
- Chlorpyrifos and cypermethrin insecticides can be used for *B. germanica* control in Hamadan within regular monitoring and preventive measures of resistance

ACKNOWLEDGMENT

This study is the second author's M.Sc. Thesis in Medical Entomology and Vector Control from Department of Medical

Entomology, School of Medicine, supported by Hamadan University of Medical Sciences (Grant No: 9404302441), Hamadan, Iran.

REFERENCES

1. Mutebi, J.P., 2001. Book review. J. Med. Entomol., 38: 769-769.
2. Nasirian, H., 2010. An overview of German cockroach, *Blattella germanica*, studies conducted in Iran. Pak. J. Biol. Sci., 13: 1077-1084.
3. Nasirian, H., H. Ladonni and H. Vatandoost, 2006. Duration of fipronil topical application toxicity in *Blattella germanica* field population strains. Pak. J. Biol. Sci., 9: 800-804.
4. Nasirian, H., H. Ladonni, M. Shayeghi and M.S. Ahmadi, 2009. Iranian non-responding contact method German cockroach permethrin resistance strains resulting from field pressure pyrethroid spraying. Pak. J. Biol. Sci., 12: 643-647.
5. Limouei, M., M. Shayeghi, H. Javad, H. Nasirian and H. Ledani, 2010. Susceptibility level of hospital-collected strains of German cockroach *Blattella germanica* (L.) to carbamate and organophosphorous insecticides using surface contact method in Tehran (2007-2008). Behbood, 13: 337-343.
6. Paksa, A., H. Ladonni and H. Nasirian, 2011. Detection of malathion and chlorpyrifos resistance mechanism in German cockroaches (*Blattella germanica*, Insecta: Blattodea: Blattellidae) using piperonyl butoxide and tributyl phosphorotrithioate. Hormozgan Med. J., 15: 243-253.
7. Paksa, A., H. Ladonni and H. Nasirian, 2012. Comparison of PBO and DEF effects on creating bendiocarb and carbaryl insecticide resistance in German cockroach. Kurdistan Univ. Med. Sci. J., 17: 91-101.
8. Nasirian, H., H. Ladonni, B. Davari, M. Shayeghi, M.R.Y. Ershadi and H. Vatandoost, 2006. Effect of fipronil on permethrin sensitive and permethrin resistant strains of *Blattella germanica*. Scient. J. Kurdistan Univ. Med. Sci., 11: 33-41.
9. Nasirian, H., H. Ladonni, M. Shayeghi, H. Vatandoost and Y. Rassi *et al*., 2006. Duration of Fipronil WHO glass jar method toxicity against susceptible and feral German cockroach strains. Pak. J. Biol. Sci., 9: 1955-1959.
10. Gondhalekar, A.D. and M.E. Scharf, 2012. Mechanisms underlying fipronil resistance in a multiresistant field strain of the German cockroach (Blattodea: Blattellidae). J. Med. Entomol., 49: 122-131.
11. Nasirian, H., 2008. Rapid elimination of German cockroach, *Blatella germanica*, by fipronil and imidacloprid gel baits. Iran. J. Arthropod-Borne Dis., 2: 37-43.
12. Nasirian, H., 2007. Duration of fipronil and imidacloprid gel baits toxicity against *Blattella germanica* strains of Iran. Iran. J. Arthropod-Borne Dis., 1: 40-47.
13. Nasirian, H., H. Ladonni, H. Vatandoost, M. Shayeghi and A. Poudat, 2006. Laboratory performance of 0.05% fipronil and 2.15% imidaclporid gel baits against German cockroach *Blattella germanica*. Med. J. Hormozgan Univ., 10: 157-166.
14. Anikwe, J.C., F.A. Adetoro, J.A. Anogwih, W.A. Makanjuola, K.A. Kemabonta and K.L. Akinwande, 2014. Laboratory and field evaluation of an indoxacarb gel bait against two cockroach species (Dictyoptera: Blattellidae, Blattidae) in Lagos, Nigeria. J. Econ. Entomol., 107: 1639-1642.
15. Scott, J.G., D.G. Cochran and B.D. Siegfried, 1990. Insecticide toxicity, synergism and resistance in the German cockroach (Dictyoptera: Blattellidae). J. Econ. Entomol., 83: 1698-1703.
16. Moss, J.I., R. Patterson and G. Koehler, 1992. Detection of insecticide resistance in the German cockroach (Dictyoptera: Blattellidae) with glue-toxin traps. J. Econ. Entomol., 85: 1601-1605.
17. Zhai, J. and W. Robinson, 1991. Pyrethroid resistance in a field population of German cockroach, *Blattella germanica* (L.). Jpn. J. Sanit. Zool., 42: 241-244.
18. Zhai, J. and W.H. Robinson, 1992. Measuring cypermethrin resistance in the German cockroach (Orthoptera: Blattellidae). J. Econ. Entomol., 85: 348-351.
19. Ladonni, H., 1993. Susceptibility of *Blattella germanica* to different insecticides in different hospitals in Tehran-Iran. J. Entomol. Soc. Iran, 12-13: 23-28.
20. Lee, C.Y., H.H. Yap, N.L. Chong and R.S.T. Lee, 1996. Insecticide resistance and synergism in field collected German cockroaches (Dictyoptera: Blattellidae) in Peninsular Malaysia. Bull. Entomol. Res., 86: 675-682.
21. Cochran, D.G., 1997. Misuse of the tarsal-contact method for detecting insecticide resistance in the German cockroach (Dictyoptera: Blattellidae). J. Econ. Entomol., 90: 1441-1444.
22. Scharf, M.E., W. Kaakeh and G.W. Bennett, 1997. Changes in an insecticide-resistant field population of German cockroach (Dictyoptera: Blattellidae) after exposure to an insecticide mixture. J. Econ. Entomol., 90: 38-48.
23. Valles, S.M., 1998. Toxicological and biochemical studies with field populations of the German cockroach, *Blattella germanica*. Pestic. Biochem. Physiol., 62: 190-200.
24. Valles, S.M., K. Dong and R.J. Brenner, 2000. Mechanisms responsible for cypermethrin resistance in a strain of German cockroach, *Blattella germanica*. Pestic. Biochem. Physiol., 66: 195-205.
25. Limoee, M., H. Ladonni, A.A. Enayati, H. Vatandoost and M. Aboulhasani, 2006. Detection of pyrethroid resistance and cross resistance to DDT in seven field-collected strains of the German cockroach, *Blattella germanica* (L.) (Dictyoptera: Blattellidae). J. Biol. Sci., 6: 382-387.
26. Abd-Elghafar, S.F., A.G. Appel and T.P. Mack, 1990. Toxicity of several insecticide formulations against adult German cockroaches (Dictyoptera: Blattellidae). J. Econ. Entomol., 83: 2290-2294.
27. Hemingway, J., G.J. Small and A.G. Monro, 1993. Possible mechanisms of organophosphorus and carbamate insecticide resistance in German cockroaches (Dictyoptera: Blattelidae) from different geographical areas. J. Econ. Entomol., 86: 1623-1630.

28. Park, N.J. and S.T. Kamble, 2001. Decapitation impacting effect of topically applied chlorpyrifos on acetylcholinesterase and general esterases in susceptible and resistant German cockroaches (Dictyoptera: Blattellidae). J. Econ. Entomol., 94: 499-505.
29. Pai, H.H., S.C. Wu and E.L. Hsu, 2005. Insecticide resistance in German cockroaches (*Blattella germanica*) from hospitals and households in Taiwan. Int. J. Environ. Health Res., 15: 33-40.
30. Ladonni, H., A. Paksa, H. Nasirian, A. Doroudgar and M.R. Abaie, 2013. Detection of carbamat and oregano phosphorus susceptibility levels in german cockroach *in vivo*. J. Toloo-e-Behdasht, 12: 95-105.
31. Nasirian, H., H. Ladonni, M. Shayeghi, H. Vatandoost and M.R. Yaghoobi-Ershadi *et al*., 2006. Comparison of permethrin and fipronil toxicity against German cockroach (Dictyoptera: Blattellidae) strains. Iran. J. Public Health, 35: 63-67.
32. Limoee, M., B. Davari and S.H. Moosa-Kazemi, 2012. Toxicity of pyrethroid and organophosphorous insecticides against two field collected strains of the German cockroach *Blattella germanica* (Blattaria: Blattellidae). J. Arthropod-Borne Dis., 6: 112-118.
33. Gholizadeh, S., B. Nouroozi and H. Ladonni, 2014. Molecular detection of knockdown resistance (kdr) in *Blattella germanica* (Blattodea: Blattellidae) from Northwestern Iran. J. Med. Entomol., 51: 976-979.
34. Yeom, H.J., J.S. Kang, G.H. Kim and I.K. Park, 2012. Insecticidal and acetylcholine esterase inhibition activity of Apiaceae plant essential oils and their constituents against adults of German cockroach (*Blattella germanica*). J. Agric. Food Chem., 60: 7194-7203.
35. Yeom, H.J., C.S. Jung, J. Kang, J. Kim and J.H. Lee *et al*., 2015. Insecticidal and acetylcholine esterase inhibition activity of Asteraceae plant essential oils and their constituents against adults of the German cockroach (*Blattella germanica*). J. Agric. Food Chem., 63: 2241-2248.
36. Liu, X.C., Q. Liu, H. Chen, Q.Z. Liu, S.Y. Jiang and Z.L. Liu, 2015. Evaluation of contact toxicity and repellency of the essential oil of pogostemon cablin leaves and its constituents against *Blattella germanica* (Blattodae: Blattelidae). J. Med. Entomol., 52: 86-92.