Vol. 11(3), pp. 36-43, May 2019
DOI: 10.5897/JEN2018.0205
Article Number: 985853F60976
ISSN 2006-9855

http://www.academicjournals.org/JEN

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Journal of Entomology and Nematology

Full Length Research Paper

Evaluation of residual effects of lambdacyhalothrin WP10 in different surfaces against *Anopheles stephensi*, in a malarious area, southern Iran

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Received 4 April, 2018; Accepted 14 June, 2018

Malaria is major vector-borne diseases in southern Iran. The main activity of vector control is indoor residual spraying using pyrethrpids. The study was conducted to evaluate the biological assays of lambdacyhalothrin WP10 at different surfaces of wall. The persistency of lambdacyhalothrin WP10 at 25 mg/m^2 was studied on different local surfaces of rooms such as plaster and mud surfaces (sorbent) as well as wooden and thatch roofs (as non-sorbent). Contact bioassays were carried out using world health organization (WHO) standard cones and lab-bred sugar-fed, 48-72 h old females of *Anopheles stephensi* (Iranshahr strain). In contact bioassays was carried out on sprayed surfaces for 150 days. Contact bioassay on surfaces treated with lambdacyhalothrin WP10 on sorbent surfaces caused 34 to 100% mortality and 76.32 to 100% on non-sorbent surfaces during 120 days evaluation period and the persistency of lambdacyhalothrin WP10 at 25 mg/m^2 was estimated about 2.5 months. Fumigant tests of lambdacyhalothrin WP10 revealed 50 to 93.83% mortality with one month persistency.

Key words: Lambdacyhalothrin, residual effects, fumigant efficacy, *Anopheles stephensi*, malaria, Iran.

INTRODUCTION

Malaria is the most important infectious disease with the major priority in the health sector. Malaria cases in Iran are reported from southern and southeastern areas of the country. The most routes of malaria cases are immigration from neighboring countries (WHO, 2017).

The latest number of autochthonous cases in the whole country is 42 including 23 local malaria patients, 7 relapsed cases, 12 imported from the other districts by the end of July 2016 (Badirzadeh et al., 2016). The last checklist of Iranian mosquitoes shows 31 Anopheles

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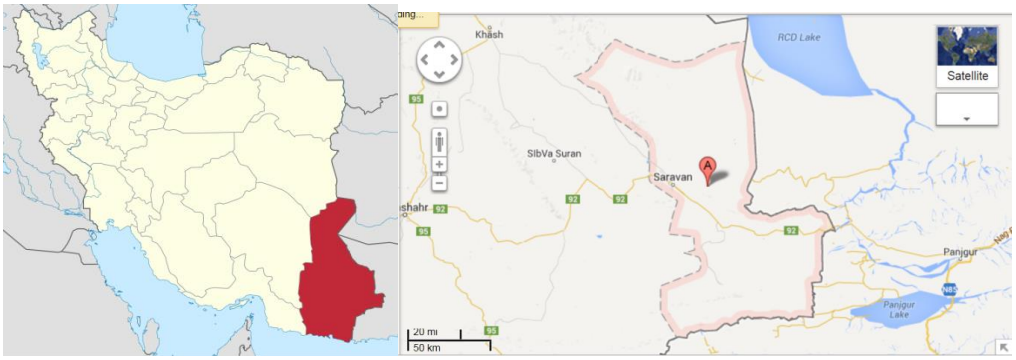

Figure 1. Map of study area, Saravan, Sistan and Baluchistan province, Iran.

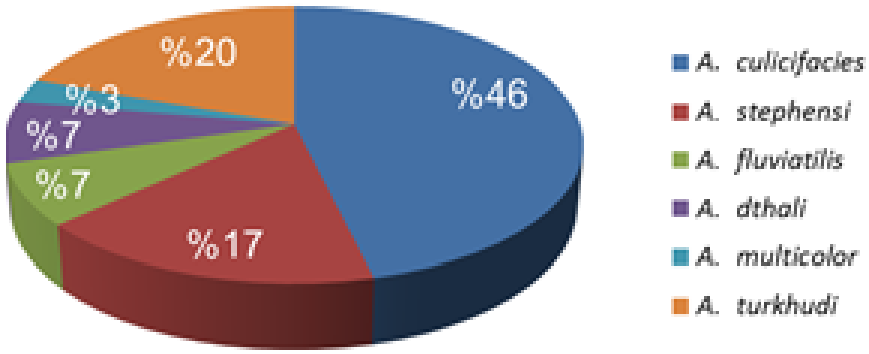

Figure 2. Composition of Anopheles species in study area.

species including sibling, biological forms and genotypes, 17 out of them are reported to be included in malaria transmission. These vectors are considered as sibling, genotype and type forms. *Anopheles stephensi, Anopheles culicifacies, Anopheles fluviatilis* and *Anopheles dthali* are the main vector species of south-eastern foci, while *Anopheles sacharovi and Anopheles maculipennis* are included in malaria transmission in northwest focus, and *Anopheles superpictus* has wide distribution in all malaria foci of the country.

There are several works in the country on different aspects of malaria including insecticide resistance monitoring (Vatandoost and Hanafi-Bojd, 2012) the use of plants for larval control (Vatandoost et al., 2012; Yousefbeyk et al., 2018) using bednets and long lasting impregnated nets (Vatandoost et al., 2013). There are several reports on different aspects of malaria vectors recently (Chavshin et al., 2014; Soleimani-Ahmadi et al., 2015; Ataie et al., 2015; Fathian et al., 2015; Soltani et al., 2015; Gorouhi et al., 2016).

Residual spraying history in the area

Campaign against malaria vectors started from 1952 by dichlorodiphenyltrichloroethane (DDT) spraying and then replaced by dieldrin, malathion, propoxur, lambdacyhalothrin and deltamethrin, respectively. The chemical control of vectors now is restricted to endemic malarious areas of south-eastern part of the country with deltamethrin and residual spraying and long lasting permethrin impregnated nets (Olyset) for personal protection, while biological control is conducted by bacillus thuringiensis as larvicide. Propoxur (1978 to 1991), Pirimphos methyl (1991 to 1993), Lambdacyhalothrin (1993 to 2000), Deltamethrin WP (2001 to 2010) and Deltamethrin WG (2011-2017) were used in the study area.

MATERIALS AND METHODS

Study area

The experiment was carried out in malarious areas in Saravan, Sistan and Baluchistan province, southern Iran. This city is bordered with Pakistan (Figure 1).

Composition of mosquitoes in the region

Figure 2 shows the composition of Anopheles mosquito in the study area. They *are A. stephensi, A. culicifacies, A. fluviatilis, A. dthali. A. multicolor* and *A. turkhudi.*

Figure 3. Bioassay test using conical exposure chamber.

Strain used for bioassay test

The adult females of *A. stephensi* (Iranshahr strain were used for bioassay tests) were used for bioassay test.

Residual spraying

A standard X-Pert® Hudson compression pump sprayer (10 liters capacity) as recommended by WHO for IRS operation fitted with HSS-8002 nozzle and a regulator-adjusted pressure gauge set at 25-45 psi pressure was used. The discharge rate of the insecticide was 757 ml/min. The operation carried out at Saravan, Sistan and Baluchistan province, southern Iran, was supervised by an expert.

Method of bioassay tests

Bioassay aspirator tubes especially narrow with glass arm were used. The conical exposure chamber was made of transparent polished plastic and then adhesive sponge plastic for lining rim of exposure chamber (Figure 3). At three different parts of wall, 3 conical were installed. The mosquitoes were exposed for 30 min, and then after 24 h recovery period the mortality rate was recorded.

Method of fumigant effects

3 cylindrical cages (14 x 20 cm) were employed. The number of mosquitoes per cage was 30 to 35, female, unfed, 2 to 3 days old. They were exposed 60 min in conical chamber and then the mortality was calculated after 24 h (Figure 4)

RESULTS

Result of contact bioassay lambdacyhalothrin WP10

The results of bioassay test on different surfaces are illustrated in Tables 1 to 3 and Figures 5 to 7. In contact bioassays was carried out on sprayed surfaces for 150 days. Contact bioassay on surfaces treated with lambdacyhalothrin WP10 on sorbent surfaces caused 34 to 100% mortality and 76.32 to 100% on non- sorbent surfaces during 120 days evaluation period, and the persistency of lambdacyhalothrin WP10 at 25 mg/m2 was estimated about 2.5 months. The fumigant effect of lambdacyhalothrin is shown Table 4 and Figure 8. Fumigant tests of lambdacyhalothrin WP10 revealed 50 to 93.83% mortality with one month persistency.

DISCUSSION

In the present study, contact bioassay on surfaces treated with lambdacyhalothrin WP10 on sorbent surfaces caused 34 to 100% mortality and 76.32 to 100% on non- sorbent surfaces during 120 days evaluation period and the persistency of lambdacyhalothrin WP10 at 25 mg/m2 was estimated about 2.5 months. Fumigant tests of lambdacyhalothrin WP10 revealed 50 to 93.83% mortality with one month persistency. Surface: Plaster, Mud, Thatch.

The maximal residual time of these three insecticides of lambdacyhalothrin, deltamethrin and cyfluthrin on plaster and cement walls was estimated to be similar (about 90 days). There was no significant difference between the mortalities of *A. stephensi* on different sprayed surfaces in southern part of Iran (Azizi et al., 2014). There are several reports on bioefficay of lambdacyhalothrin against different malaria vectors worldwide. With lambdacyhalothrin CS, the knockdown rates against susceptible strain of *A. gambiae* remained 100% on wood surfaces during the 26 weeks trial. However, it significantly decreased on concrete and mud surfaces from the 11th (83%) and the 20th (88%) weeks respectively ($P < 0.05$) in south Cameroon (Etang et al., 2011).

The mud slabs sprayed with lambda-cyhalothrin in the

Figure 4. Methods of fumigant test.

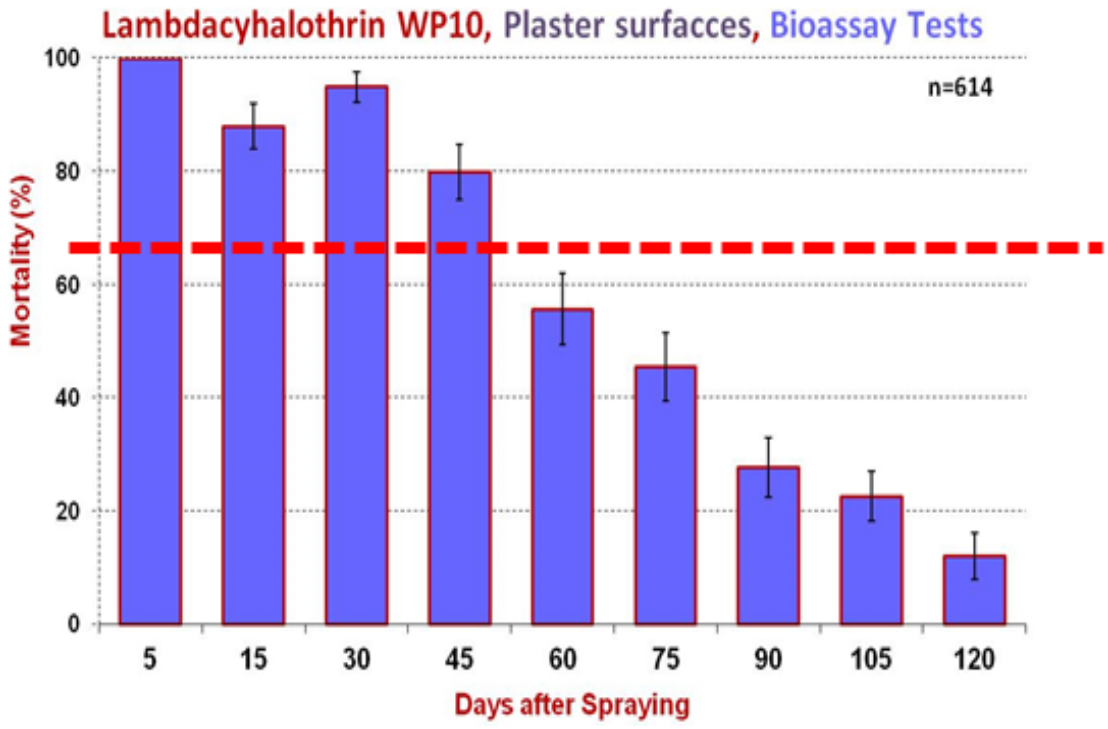

Figure 5. Contact bioassay test of lambdacyhalothrin on plaster surface.

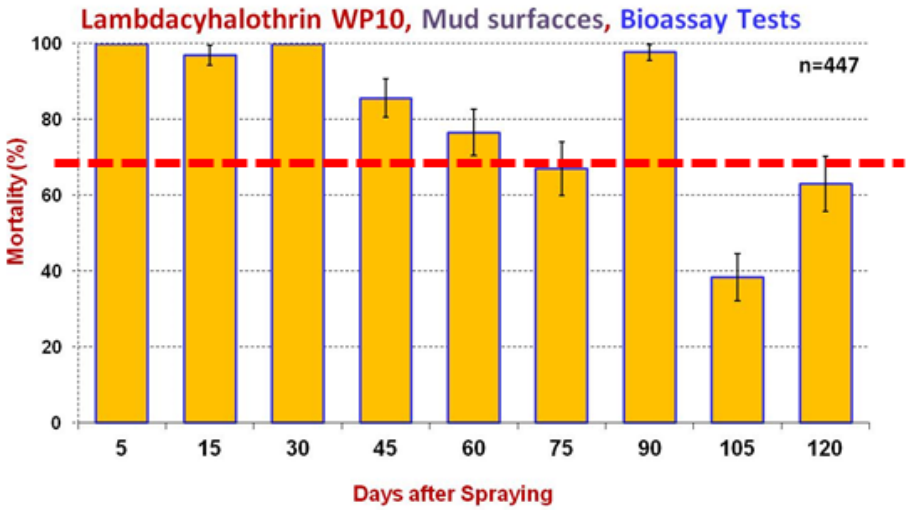

Figure 6. Contact bioassay test of lambdacyhalothrin on mud surface.

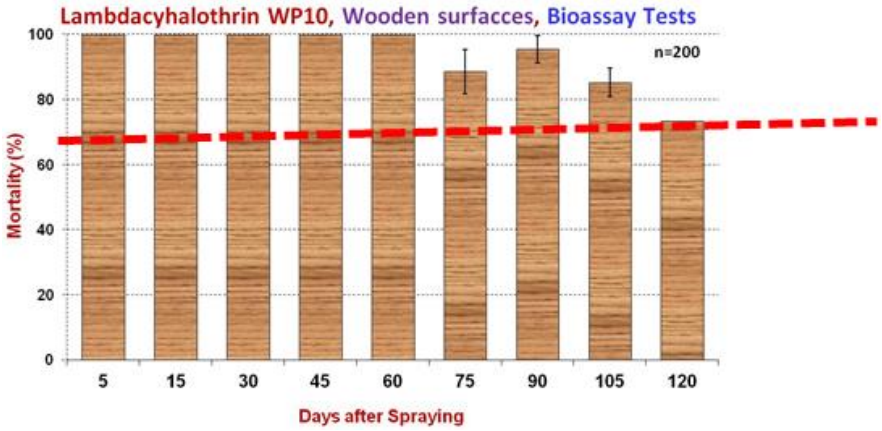

Figure 7. Contact bioassay test of lambdacyhalothrin on wooden surface.

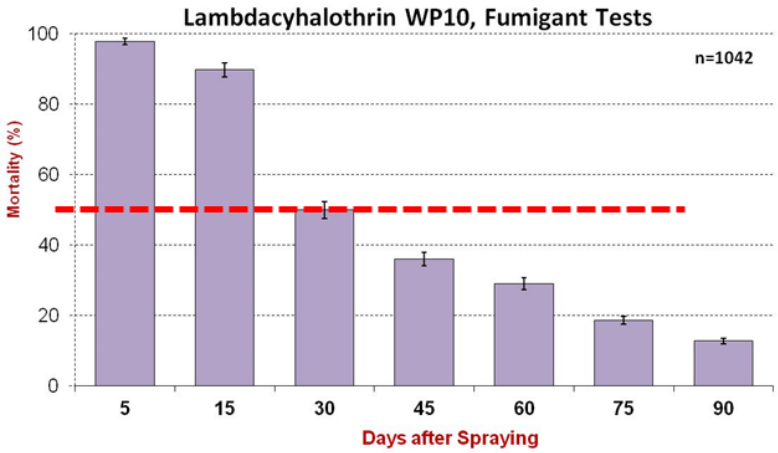

Figure 8. The fumigant effect of lambdacyhalothrin.

Table 1. Contact bioassay test of lambdacyhalothrin on plaster surface.

Relative humidity (%)	Temperature (°C)	Error bar	Corrected mortality rate	Average mortality rate	Mortality in control	No. mosquito tested (treatment)	No. of mosquito tested (control)	Day after spraying
33.45	25.00	0.00	100	100	17.14	64	24	5
28.00	22.50	4.06	87.99	90	19.97	67	23	15
27.00	21.50	2.72	94.92	87.5	9.09	65	22	30
24.50	21.00	4.90	79.91	60.0	19.71	62	24	45
27.00	24.50	6.31	55.65	66.67	18.27	62	22	60
25.50	25.00	6.04	45.47	41.67	19.09	68	21	75
24.00	19.50	5 .20	27.74	20	10.24	74	29	90
20.50	17.50	4.36	22.63	20	19.73	92	22	105
19.00	17.00	.20	12.03	25	19.11	60	19	120

Table 2. Contact bioassay test of lambdacyhalothrin on mud surface.

Relative humidity (%)	Temperature (°C)	Error bar	Corrected mortality rate	Average mortality rate	Mortality in control	No. mosquito tested (treatment	No. mosquito tested (control)	Day after spraying
33.45	25.00	0.00	100.00	100.00	17.14	51	24	5
28.00	22.50	2.65	96.95	90.00	19.97	47	23	15
27.00	21.50	0.00	100.00	100.00	9.09	56	22	30
24.50	21.00	5.11	85.68	76.92	19.71	47	24	45
27.00	24.50	6.18	76.60	60.00	19.27	47	22	60
25.50	25.00	7.01	67.04	61.54	19.09	45	21	75
24.00	19.50	2.13	97.73	93.33	10.24	49	29	90
20.50	17.50	6.23	38.48	93.33	19.73	61	22	105
19.00	17.00	7.27	63.09	30.77	19.11	44	19	120

IRS program killed all susceptible *A. gambiae* for at least 7 months after the spray in the cone bioassay. Significant decay in insecticidal activities was observed 6 months after spray for most populations (72.5 to 80.7 %, $P < 0.05$) (Wanjala et al., 2015). The study was conducted in public housing unities in the city of Belem, Northern Brazil, in 2003. Twelve houses were randomly chosen, three in each of the four established areas. Pyrethroids cypermethrin wettable powder, deltamethrin suspension concentrate, lambda-cyhalothrin wettable powder, and etofenprox wettable powder, were sprayed on the indoor wall surface of local houses. There was no statistical difference between the effect of deltamethrin and cypermethrin in all surfaces tested, and the duration of the residual effect was satisfactory up to three months after spraying (La Corte dos Santos et al., 2007)

Conclusion

The results of study revealed that lambdacyhalothrin as recommended dosage as residual spraying could control the malaria vector during the transmission season. Monitoring and

Table 3. Contact bioassay test of lambdacyhalothrin on wooden surface.

Relative humidity (%)	Temperature (°C)	Error bar	Corrected mortality rate	Average mortality rate	Mortality in control	No. mosquito tested (treatment	No. mosquito tested (control)	Day after spraying
33.45	25.00	0.00	100.00	100.00	17.14	32	24	5
28.00	22.50	0.00	100.00	100.00	19.97	18	23	15
27.00	21.50	0.00	100.00	100.00	9.09	28	22	30
24.50	21.00	0.00	100.00	100.00	19.71	22	24	45
27.00	24.50	0.00	100.00	100.00	19.27	22	22	60
25.50	25.00	6.77	88.64	83.33	18.00	22	21	75
24.00	19.50	4.13	95.54	92.31	10.24	25	29	90
20.50	17.50	4.36	85.30	83.00	10.56	21	19	105
19.00	17.00	0.00	73.59	76.11	19.11	10	19	120

Table 4. The fumigant effect of lambdacyhalothrin.

Relative humidity (%)	Temperature (°C)	Error bar	Corrected mortality rate	Average mortality rate	Mortality in control	No. mosquito tested (treatment)	No. mosquito tested (control)	Day after spraying
33.45	25.00	1.32	95.74	97.87	20.00	235	190	5
28.00	22.50	3.67	84.30	89.80	19.00	97	60	15
27.00	21.5	3.81	23.08	50.00	20.00	122	40	30
24.50	21.00	4.42	25.43	36.08	14.29	93	42	45
27.00	24.50	0.00	25.75	29.03	19.50	93	32	60
25.50	25.0	0.00	15.94	18.60	12.90	93	31	75
24.00	19.50	0.00	9.78	12.78	5.41	108	37	90

mapping of insecticide resistance to WHO recommended adulticide is recommended periodically. Factors influencing degradation of insecticides includes; type of surfaces, chemical reaction of active ingredients with alkaline and soil alkaline of surface, and effect of climate.

Recommendation

Evaluation of new insecticides as alters for malaria vector control program, use of Whatman papers as routine program in IRS program of Ministry of Health, entomological evaluation of routine and new insecticides against malaria vectors.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENTS

The study was supported partially by the Ministry of Health and Medical Education of Iran. Tehran University of Medical Sciences provided grant to do the research. The code number is 92-02-27-23550.

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