Original Article

High Insecticides Resistance in *Culex pipiens* (Diptera: Culicidae) from Tehran, Capital of Iran

Yaser Salim-Abadi [1], Mohammad Ali Oshaghi [1], Ahmad Ali Enayati [2], Mohammad Reza Abai [1], *Hassan Vatandoost [1], Mohammad Reza Eshraghian [3], Hossein Mirhendi [4], Ahmad Ali Hanafi-Bojd [1], Mohammad Amin Gorouhi [1,5], Fatemeh Rafi [1]

[1]Department of Medical Entomology and Vector Control, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[2]School of Public Health and Health Sciences Research Centre, Mazandaran University of Medical Sciences, Sari, Iran
[3]Department of Biostatistics, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[4]Department of Parasitology and Mycology, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[5]Department of Environmental Health and Medical Entomology, School of Health, Kerman University of Medical Sciences, Kerman, Iran

(Received 23 Nov 2014; accepted 04 Agu 2015)

Abstract

Background: During recent years transmission of *Dirofilaria immitis* (dog heart worm) by *Culex pipiens* and West Nile virus have been reported from Iran. The present study was preformed for evaluating the susceptibility status of *Cx. pipiens* collected from capital city of Tehran, Iran**.**

Methods: Four Insecticides including: DDT 4%, Lambdacyhalothrin 0.05%, Deltamethrin 0.05% and Cyfluthrin 0.15 % according to WHO standard methods were used for evaluating the susceptibility status of *Cx. pipiens* from Tehran moreover For comparison susceptibility status a Laboratory strain also was used. Bioassay data were analyzed using Probit program. The lethal time for 50% and 90% mortality (LT_{50} and LT_{90}) values were calculated from regression line.

Results: The susceptibility status of lab strain of *Cx. pipiens* revealed that it is susceptible to Lambdacyhalothrin, Deltamethrin, Cyfluthrin and resistant to DDT. Moreover cyfluthrin with LT_{50}=36 seconds and DDT with LT_{50}=3005 seconds had the least and most LT_{50}s. Field population was resistance to all tested insecticides and DDT yielded no mortality.

Conclusion: Highly resistance level against all WHO recommended imagicides were detected in field populations. We suggest more biochemical and molecular investigations to detect resistance mechanisms in the field population for further decision of vector control.

Keywords: Susceptibility status, *Culex pipiens*, Tehran

Introduction

Mosquitoes known as the main groups of arthropods in medical and public health due to their role in transmission of Malaria, filariasis, several types of encephalitis and also many arboviral diseases (Horsfall 1955, Service 2003, Mullen 2009). In the Culicidae Family, *Culex* genus and specifically *Cx. pipiens* complex members including: *Cx. pipiens pipiens*, *Cx. quinquefasciatus*, *Cx. p. pallens*, *Cx. pipiens* form molestus act as efficient vectors for Sindbis virus, West Nile virus, Equine encephalitis, St Louis, Oro-pouche, Rift Valley fever,moreover *Cx. pipiens* transmit *Plasmodium relictum* that

***Corresponding author:** Dr Hassan Vatandoost, E-mail: hvatandoost1@yahoo.com, vatando@tums.ac.ir

http://jad.tums.ac.ir
Published Online: October 04, 2016

causing bird malaria. Its distribution is wide so that this species approximately present in all continent of the world (Mitchell et al. 1980, Vinogradova 2000, Smith and Fonseca 2004, Savage et al. 2007, Mullen 2009, Strickman and Fonseca 2012). In Iran during recent years transmitting of *Dirofilaria immitis* (dog heart worm), West Nile and Sindbis viruses by *Culex* mosquitoes have been reported (Naficy and Saidi 1970, Azari-Hamidian et al. 2007, Azari-Hamidian et al. 2009). *Culex* Genus habituated capital city of Tehran in sewage system of the houses, where there are different insecticides which have been used for controlling of household and agricultural pests such as: permehrin, bioallethrin, dursban, pirimiphos-methyl, malathion, chlorpyrifos-methyl, allethrin, propoxur. I addition different reagents also exist in the sweage systems. we postulated that resistance to insecticides is as a result of continous exposure to Different group of insecticides which may indirectly cause selection pressure on the susceptibility of mosquitoes mainly breed in wastewater habitats (Horsfall 1955, Lotfi 1976, Golestani 1976, Lines 1988, Vatandoost et al. 2004, Calhoun et al. 2007). Here upon the evaluation of susceptibility level of mosquitos for monitoring of resistance to insecticides is necessary and for this approach in Iran in recent years the most studies about evaluating susceptibility level of mosquitos to common insecticides have been on *Anopheles* mosquitos (Enayati et al. 2003, Vatandoost and Borhani 2004, Vatandoost and Hanafi-Bojd 2005, Vatandoost et al. 2005, Hanafi-Bojd et al. 2006, Shahi et al. 2006, Abai et al. 2008, Hanafi-Bojd et al. 2010, Oshaghi et al. 2011, Hanafi-Bojd et al. 2012, Soltani et al. 2013) and there are just a limited study about susceptibility status of *Culex* genus in Iran for example in the performed studies in Caspian sea coast about susceptibility level of *Cx. pipiens* complex results indicated that this species is resistant to DDT and susceptible to Dieldrin (Lotfi et al. 1975). Nazari and Janbakhsh in 2000 reported that *Cx. pipiens* in the southern area of Tehran is resistance to DDT (Nazari and Janbakhsh 2000). In 2004 the susceptibility level of laboratory and field collected strains of *Cx. Quinquefasciatusin* a medically important member belong to *Cx. pipiens* complex to different insecticides evaluated, DDT resistant was observed in both laboratory and field collected strains (Vatandoost et al. 2004). According to the most performed study around the world it seems that this species approximately is resistant to many insecticides or have multiple insecticide resistances (Davidson 1964, Mukhopadhyay et al. 1993, Ben Cheikh et al. 1998, Bisset et al. 1999, Martinez-Torres et al. 1999, Corbel et al. 2007, Tantely et al. 2010, Toma et al. 2011, Jones et al. 2012, Pocquet et al. 2013). The present study was preformed for evaluating susceptibility status of *Cx. pipiens* of Tehran City. The result of this study can be useful for future chemical control programs in the study area.

Materials and Methods

Study area

This study was conducted in Tehran city (35° 41′ 46″ N, 51° 25′ 23″ E), Tehran Province, Iran. Tehran is the capital of Iran and also is Iran's largest city (Fig. 1).

Mosquito strains and adult susceptibility test

In this study four Insecticides including: DDT 4%, Lambdacyhalothrin 0.05%, Deltamethrin 0.05%, Cyfluthrin 0.15% were used for evaluating susceptibility status of *Cx. pipiens*. Moreover For comparison susceptibility status a Laboratory strain also was used. All tested species were reared in the insectary of School of Public Health, Tehran University of Medical Sciences under the standard condition.

Data analysis

Bioassay data were analyzed with Probit

http://jad.tums.ac.ir
Published Online: October 04, 2016

program (Finney 1971). For correction mortality, when control mortality is greater than 5% but less than 20%, then the observed mortality was corrected using Abbott's formula (Abbott 1965). By method of Finney the lethal Time for 50% and 90% mortality (LT_{50} and LT_{90}) values and their 95% confidence interval and Probit regression line parameters were determined for both strains (Lab and field population). The regression line belong to each Insecticides after different exposure times were plotted using Microsoft Excel (ver. 2013).

Results

The result of susceptibility test for lab and filed strains of *Cx. pipiens* has been summarized in Table 1 and 2. Lab strain exhibited different LT50 valuses to different insecticides. Cyfluthrin with LT_{50}=36Sec, Lambdacyhalothrin (LT_{50}=79), Deltamethrin ($LT_{50=}$ 326) and DDT ($LT_{50=}$3005) had the lowest to highest lethal time (Table 1 and 3). Although this result for field population indicated that DDT exhibited no mortality. Cyfluthrin with LT_{50}=27minutes, Lambdacyhalothrin (LT_{50}= 111 minutes) and Deltamethrin ($LT_{50=}$ 182 minutes) had lowest to highest LT50 (Table 2 and 3). The result also showed that among these insecticides, Lab strain is susceptible to Lambdacyhalothrin, deltamethrin, cyfluthrin and resistance to DDT according to WHO criteria that suggested (98-100% mortality indicates susceptibility, 90-97% mortality indicates resistance candidate (more investigation is needed or requires confirmation of resistance with other methods) and <90% mortality suggests resistance) (WHO 2013). And also cyfluthrin with LT50=45_{Sec} and DDT with LT50=3005 were the most and least effect (Table 1,3 and Fig. 2,3).

Fig.1. The map of Iran and location of Tehran city

Table 1. Probit regression line parameters of lab strain of *Culex pipiens* exposed to different insecticides

Insecticides	A	B ± SE	LT_{50} , 95% C.I. (Second)	LT_{90}, 95% C.I. (Second)	X^2 (df)	P value
DDT 4%	-9.21	2.64± 0.31	2647 3005 3455	7061 9156 13701	3.56(3)	>0.05
Lambdacyhalothrin 0.05%	-2.50	1.31±0.18	43 79 120	510 752 1302	2.41(2)	>0.05
Deltamethrin 0.05%	-4.17	1.6± 0.16	255 326 406	1443 1937 2872	5.85 (4)	>0.05
Cyfluthrin 0.15%	-1.84	1.17±0.18	14 36 64	308 448 725	3.60(4)	>0.05

A= y-intercept, B= the slope of the line, SE= Standard error, CI= confidence interval, x^2= heterogeneity about the regression line, df= degree of freedom, P> 0.05 = represent no heterogeneity in the population of tested mosquitos.

http://jad.tums.ac.ir
Published Online: October 04, 2016

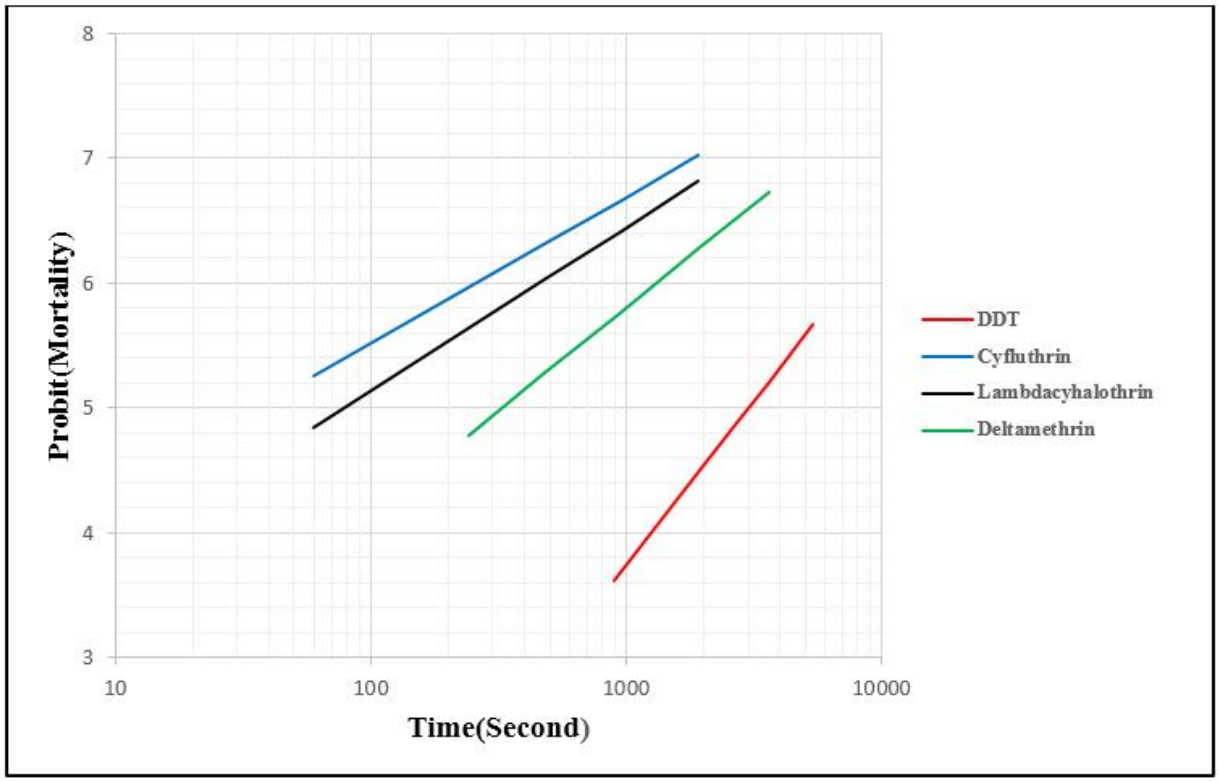

Fig. 2. Regression lines for lab strain of *Culex pipiens* exposed to different insecticides

Table 2. Probit regression line parameters of field population of *Culex pipiens* exposed to different insecticides

Insecticides	A	B ± SE	LT_{50} , 95% C.I. (Minute)	LT_{90}, 95% C.I. (Minute)	X^2 (df)	P value
Lambdacyhalothrin 0.05%	-7.58	3.71±0.36	99 111 122	214 245 293	5.34(2)	>0.05
Deltamethrin 0.05%	-4.36	1.9± 0.35	152 182 234	511 838 2322	0.37 (2)	>0.05
Cyfluthrin 0.15%	-2.29	1.59±0.23	21 27 33	117 172 336	3.47(2)	>0.05
DDT 4%*	-	-	-	-	-	-

*No mortality after 24 hours exposure

http://jad.tums.ac.ir
Published Online: October 04, 2016

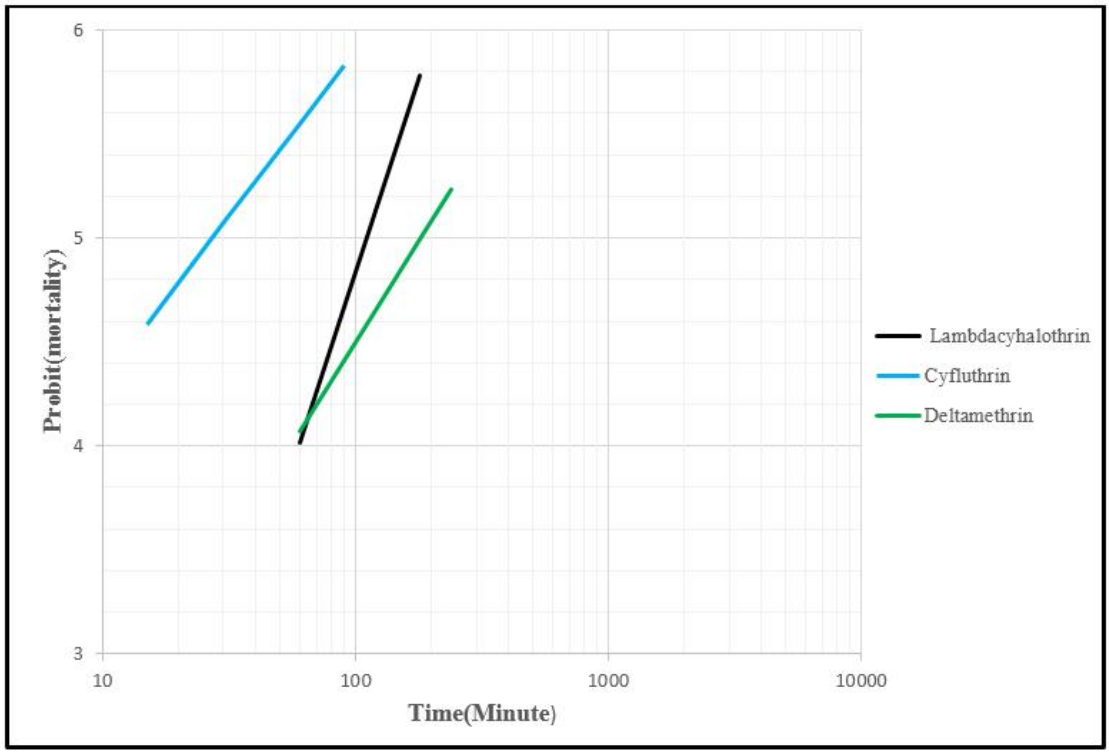

Fig. 3. Regression lines for field population of *Culex pipiens* exposed to different insecticides

Table 3. Mortality rate and susceptibility status of *Culex pipiens* (Lab and field population) exposed to different insecticides at one hour exposure and 24 hours recovery period

Insecticides	MR±EB*		Resistance status**	
	Lab strain	Field population	Lab strain	Field population
Lambdacyhalothrin 0.05%	100	20±**2**	S	R
Deltamethrin 0.05%	98±**1**	18±**3**	S	R
Cyfluthrin 0.15%	100	66±**3**	S	R
DDT 4%	55±**3**	0	R	R

*Mortality Rate±Error Bar
**R Resistance, S Susceptible

Discussion

In the present study four Insecticides including: DDT 4%, Lambdacyhalothrin 0.05%, Deltamethrin 0.05% and Cyfluthrin 0.15% were used for evaluatin the susceptibility status of *Cx.pipiens* According to WHO criteria lab starin was resistant to DDT and Filed strain exhibited resistant to all insecticides used. In the both strains a highly level of resistance to DDT were determined and also the LT_{50} for DDT >Deltamethrin > Lambdacyhalothrin >Cyfluthrin respectively. In the two previous studies conducted in Tehran, resistant to DDT have been reported in *Cx. pipiens* and *Cx. quinquefasciatusin* and these results was in parallel to our finding (Nazari and Janbakhsh 2000, Vatandoost et

http://jad.tums.ac.ir
Published Online: October 04, 2016

al. 2004). It seems that *Cx. pipiens* in the most part of the world has been resistant to DDT (Mukhopadhyay et al. 1993, Nazni et al. 2005, Corbel et al. 2007, Sarkar et al. 2009, Jones et al. 2012, Pocquet et al. 2013). In the study conducted by Nazni et al. (2005) mosquitoes from two field sites in Kuala Lumpur exhibited resistance to DDT with no mortality 24h after exposure, and this result was same to our result about field population (Nazni et al. 2005). In another study, high frequencies of resistance to DDT in *Cx. quinquefasciatus* from Benin have been reported and mortality rate ranged from 5 to 54% (Corbel et al. 2007). In northeastern India *Cx. quinquefasciatus* which caught from 7 different field sites of study area this species was resistance to DDT in all sites and its mortality rate varied from 11.9 to 50.0% (Sarkar et al. 2009). Result of susceptibility test in northwest and southeastern part of Iran indicated that this species is highly resistant to DDT (Ataie et al. 2015, Fathian et al. 2015). In the current study, Field population also was resistance to Lambdacyhalothrin, Deltamethrin and Cyfluthrin and in some same studies this result also reported, for example resistance to Lambdacyhalothrin and Cyfluthrin reported in the Southeastern part of Iran and resistance to Lambdacyhalothrin in Northwestern part of Iran (Ataie et al. 2015, Fathian et al. 2015). In *Cx. quinquefasciatus* from Wete on Pemba Island in Zanzibar resistance to Deltamethrin and Lambdacyhalothrin also have been reported (Jones et al. 2012). In Thailand, *Cx. quinquefasciatu*s belong to The Baan Suan strain was highly resistant to Deltamethrin even its mortality was very lower than our results (Sathantriphop et al. 2006). Resistance to Deltamethrin also reported by Chen et al. (2010), so that all the six surveyed *Cx. pipiens pallens* populations strains were resistance to Deltamethrin and also their mortality Ranged from 20.2% to 78.6% (Chen et al. 2010). In some studies resistance to the others group of insecticides like organophosphates and Carbamate also have been reported (Bisset et al. 1999, Corbel et al. 2007, Tantely et al. 2010, Toma et al. 2011, Ataie et al. 2015 Fathian et al. 2015). for example in the both study that performed in Northwestern and Southern part of Iran, *Cx. pipiens* showed resistance to Propoxur (Ataie et al. 2015, Fathian et al. 2015). Tolerance to Deltamethrin (with mortality=86%) in Culex populations from Kilimani, Unguja Island in Zanzibar also reported by Jones et al. (2012). Although this populations was susceptible to Lam-bdacyhalothrin. Moreover in this study *Culex* from the nearby site of Tibirinzi in Pemba was relatively susceptible to Deltamethrin and also Lambdacyhalothrin (Jones et al. 2012). In the same previously study that performed by Vatandoost et al in 2004, field population of *Cx. Quinquefasciatus* which collected from Sewage System of Tehran after evaluating their susceptibly status to insecticides result showed that this species is susceptible to Cyfluthrin and also have tolerance to Lambdacyhalothrin and Deltamethrin. Routine use of pesticides in Household and agricultural pest control might have developed this Enhanced Tolerance to insecticide in the wastewater mosquito, *Cx. Quinquefasciatus* (Vatandoost et al. 2004).

Conclusion

In the present study, in the population whitch collected from field highly resistance to all insecticides exhibited it might be due to pollution of wastewater with chemical substances Findings of this research could provide a clue for logical operations of future chemical control program. Next step of this research will focus on the biochemical and molecular investigation.

Acknowledgements

This article is a part of the first author's

http://jad.tums.ac.ir
Published Online: October 04, 2016

dissertation for fulfillment of a PhD degree in Medical Entomology and Vector Control from Department of Medical Entomology and Vector Control, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran. This study was financially supported by the Deputy of Research, Tehran University of Medical Sciences. The authors declare that there is no conflict of interest.

References

Abai MR, Mehravaran A, Vatandoost H, Oshaghi MA, Javadian E, Mashayekhi M, Mosleminia A, Piyazak N, Edallat H, Mohtarami F, Jabbari H, Rafi F (2008) Comparative performance of imagicides on *Anopheles stephensi*, main malaria vector in a malarious area, southern Iran. J Vector Borne Dis. 45(4): 307–312.

Abbott WS (1965) A method of comparing the effectiveness of an insecticide. J Econ Entomol. 18: 265–267.

Ataie A, Moosa-Kazemi SH, Vatandoost H, Yaghoobi-Ershadi MR, Bakhshi H, Anjomruz M (2015) Assessing the Susceptibility Status of Mosquitoes (Diptera: Culicidae) in a Dirofilariasis Focus, Northwestern Iran. J Arthropod-Borne Dis. 9(1): 7–21.

Azari-Hamidian S, Yaghoobi-Ershadi MR, Javadian E, Abai MR, Mobedi I, Linton YM, Harbach RE (2009) Distribution and ecology of mosquitoes in a focus of dirofilariasis in northwestern Iran, with the first finding of filarial larvae in naturally infected local mosquitoes. Med Vet Entomol. 23(2): 111–121.

Azari-Hamidian S, Yaghoobi-Ershadi MR, Javadian E, Mobedi I, Abai MR (2007) Review of dirofilariasis in Iran. J Med Fac Guilan Univ Med Sci. 15(60): 102–113 (In Persian).

Ben Cheikh H, Ben Ali-Haouas Z, Marquine M, Pasteur N (1998) Resistance to organophosphorus and pyrethroid insecticides in *Cx. pipiens* (Diptera: Culicidae) from Tunisia. J Med Entomol. 35: 251–260.

Bisset JA, Rodriguez MM, Diaz C, Alain Soca L (1999) Characterization of resistance to organophosphate insecticides, carbamates, and pyrethroids in *Culex quinquefasciaus* from the State of Miranda, Venzuela. Rev Cubana Med Trop. 51(2): 89–94.

Bisset J, Rodríguez M, Díaz C, Ortiz E, Marquetti M, Hemingway J (1990) The mechanisms of organophosphate and carbamate resistance in *Culex quinquefasciatus* (Diptera: Culicidae) from Cuba. Bull Entomol Res. 80(3): 245–250.

Calhoun LM, Avery M, Jones L, Gunarto K, King R, Roberts J, Burkot TR (2007) Combined sewage overflows (CSO) are major urban breeding sites for *Culex quinquefasciatus* in Atlanta, Georgia. Am J Trop Med Hyg. 77: 478–484.

Chen L, Zhong D, Zhang D, Shi L, Zhou G, Gong M, Zhou H, Sun Y, Ma L, He J, Hong S, Zhou D, Xiong C, Chen C, Zou P, Zhu C, Yan G (2010) Molecular ecology of pyrethroid knockdown resistance in *Culex pipiens pallens* mosquitoes. PloS one. 5(7): e11681.

Corbel V, N'Guessan R, Brengues C, Chandre F, Djogbenou L, Martin T, Akogbéto M, Hougard JM, Rowland M (2007) Multiple insecticide resistance mechanisms in *Anopheles gambiae* and *Culex quinquefasciatus* from Benin, West Africa.Acta Trop. 101: 207–216.

Davidson G (1964) DDT resistance and dieldrin resistance in *Cx. pipiens* fatigans. Ann Trop Med Parasitol. 58: 180–188.

Enayati AA, Vatandoost H, Ladonni H, Townson H, Hemingway J (2003) Molecular evidence for a kdr-like pyrethroid resistance mechanism in the malaria

http://jad.tums.ac.ir
Published Online: October 04, 2016

vector mosquito *Anopheles stephensi*. Med Vet Entomol. 17(2):138–144.

Fathian M, Vatandoost H, Moosa-Kazemi SH, Raeisi A (2015) Susceptibility of Culicidae Mosquitoes to Some Insecticides Recommended by WHO in a Malaria Endemic Area of Southeastern Iran. J Arthropod-Borne Dis. 9(1): 22–34.

Finney DJ (1971) Probit analysis, III edn. Cambridge University Press, Cambridge.

Golestani J (1967) The methods of the mosquito *Culex* control in Tehran City. J General Med Tehran Univ Med School. 6: 376–379. (In Persian).

Hanafi-Bojd AA, Vatandoost H, Jafari R (2006) Susceptibility status of *Anopheles dthali* and *An. fluviatilis* to commonly used larvicides in an endemic focus of malaria, southern Iran. J Vector Borne Dis. 43(1): 34–38.

Hanafi-Bojd AA, Vatandoost H, Oshaghi MA, Haghdoost AA, Shahi M, Sedaghat MM, Yeryan M, Pakari A (2012) Entomological and epidemiological attributes for malaria transmission and implementation of vector control in southern Iran. Acta Trop. 121: 85–92.

Hanafi-Bojd AA, Vatandoost H, Philip E, Stepanova E, AI Abdi A, Safari R, Mohseni GH, Bruhi MI, Peter A, Abdulrazag SH, Mangal G (2010) Malaria situationanalysis and stratification in Bandar Abbas County, Southern Iran, 2004– 2008. Iran J Arthropod-Borne Dis. 4: 31–41.

Horsfall WR (1955) Mosquitoes: Their Bionomics and Relation to Disease. Hafner publishing, New York, pp.723.

Jones CM, Machin C, Mohammed K, Majambere S, Ali AS, Khatib BO, Kelly-Hope LA (2012) Insecticide resistance in *Culex quinquefasciatus* from Zanzibar: implications for vector control programmes. Parasit Vectors. 5: 78.

Lines JD (1988) Do agricultural insecticides select for insecticide resistance in mosquitoes: A look at the evidence. Parasitol Today. 4(7): S17–20.

Lotfi MD (1976) Key to Culicinae of Iran, genus *Culex* and their biology (Diptera: Culicidae). Iranian J Publ Health. 5: 71–84.

Lotfi MD, Manouchehri AV, Yazdanpanah H (1975) Resistance of *Cx. pipiens pipiens* to DDT in Northern Iran, 1973. Bull Soc Pathol Exot Filiales. 68(1): 91–93.

Martinez-Torres D, Chevillon C, Brun-Barale A, Berge JB, Pasteur N, Pauron D (1999) Voltage-dependent Na+ channels in pyrethroid-resistant *Cx. pipiens L* mosquitoes. Pestic Sci. 55: 1012–1020.

Mitchell CJ, Francy DB, Monath TP (1980) Arthropod vectors. In: Monath TP, Reeves WC, editors. St. Louis Encephalitis. Washington: American Public Health Association. 313–379.

Mukhopadhyay AK, Sinha SN, Yadav RL, Narasimham MV (1993) Susceptibility status of *Culex quinquefasciatus* in Patna to insecticides. Indian J Public Health. 37(2): 57–60.

Mullen GR, Durden L (2009) Medical and Veterinary Entomology, Mosquitoes (Culicidae) Woodbridge A. Foster and Edward D Walter. Vol. 2. Elsevier, Burlington, pp. 207–260.

Naficy K, Saidi S (1970) Serological survey on viral antibodies in Iran. Trop Geogr Med. 22(2): 183–188.

Nazari M, Janbakhsh B (2000) a survey of the susceptibility level of *Culex theileri* and *Cx. pipiens* to DDT, Dieldrin, Propoxur and Malathion in the southern area of Tehran. J Uromia Univ Med Sci. 11(1): 13–19.

Nazni WA, Lee, HL, Azahari AH (2005) Adult and larval insecticide susceptibility status of *Culex quinquefasciatus* (Say) mosquitoes in Kuala Lumpur, Malaysia. Trop Biomed. 22: 63–68.

Oshaghi MA, Vatandoost H, Gorouhi A, Abai

http://jad.tums.ac.ir
Published Online: October 04, 2016

MR, Madjidpour A, Arshi S, Mehravaran A (2011) Anopheline species composition in borderline of Iran, Azerbaijan. Acta trop. 119(1): 44–49.

Pocquet N, Milesi P, Makoundou P, Unal S, Zumbo B, Atyame C, Darriet F, Dehecq J, Thiria J, Bheecarry A, Iyaloo D, Weill M, Chandre F, Labbé P (2013) Multiple Insecticide Resistances in the Disease Vector *Culex quinquefasciatus* from Western Indian Ocean. PLoS One. 8(10): e77855.

Sarkar M, Bhattacharyya I, Borkotoki A, Goswami D, Rabha B, Baruah I, Srivastava RB (2009) Insecticide resistance and detoxifying enzyme activity in the principal bancroftian filariasis vector, *Culex quinquefasciatus*, in northeastern India. Med vet entomol. 23(2): 122–131.

Sathantriphop S, Paeporn P, Supaphathom K (2006) Detection of insecticides resistance status in *Culex quinquefasciatus* and *Aedes aegypti* to four major groups of insecticides. Trop Biomed. 23: 97–101.

Savage HM, Aggarwal D, Apperson CS, Katholi CR, Gordon E, Hassan HK, Unnasch TR (2007) Host choice and West Nile virus infection rates in blood-fed mosquitoes, including members of the *Cx. pipiens* complex, from Memphis and Shelby County, Tennessee, 2002–2003. Vector Borne Zoonotic Dis. 7(3): 365–386.

Service MW (2003) Medical Entomology for Students. Vol. 3. United Kingdom: Cambridge. University Press, Cambridge.

Shahi M, Vatandoost H, Abaei MR, Hanafi-Bojd AA (2006) Susceptibility of *Anopheles fluviatilis* James to different insecticides in Bandar Abbas township, 2003. Hormozgan Med J. 10(4): 321–328.

Smith JL, Fonseca DM (2004) Rapid assays for identification of members of the *Culex* (*Culex*) *pipiens* complex, their hybrids, and other sibling species (Diptera: Culicidae). Am J Trop Med Hyg. 70: 339–345.

Soltani A, Vatandoost H, Oshaghi MA, Enayati AA, Raeisi A, Eshraghian, MR,Rafi F (2013) Baseline Susceptibility of Different Geographical Strains of *Anopheles stephensi* (Diptera: Culicidae) to Temephos in Malarious Areas of Irana J Arthropod-Borne Dis. 7(1): 56–65.

Strickman D,Fonseca DM (2012) Autogeny in *Cx. pipiens* complex mosquitoes from the San Francisco bay area. Am J Trop Med Hyg. 87(4): 719–726.

Tantely ML, Tortosa P, Alout H, Berticat C, Berthomieu A, Rutee A, Weill M (2010) Insecticide resistance in *Cx. pipiens quinquefasciatus* and *Aedes albopictus* mosquitoes from La Reunion Island. Insect Biochem Mol Biol. 40: 317–324.

Toma L, Menegon M, Romi R, De Matthaeis E, Montanari M, Severini C (2011) Status of insecticide resistance in *Culex pipiens* field populations from north-eastern areas of Italy before the withdrawal of OP compounds. Pest Manag Sci. 67(1): 100–106.

Vatandoost H, Borhani N (2004) Susceptibility level and irritability of synthetic pyrethroids against main malaria vectors in the endemic areas of Iran. Acta Med Iran. 42: 247–255.

Vatandoost H, Hanafi-Bojd AA (2005) Current Resistant Status of *Anopheles stephensi* Liston to Different Larvicides in Hormozgan Province, Southeastern Iran, 2004. Pak J Biol Sci. 8: 1568–1570.

Vatandoost H, Mashayekhi M, Abaie MR, Aflatoonian MR, Hanafi-Bojd AA, Sharifi I (2005) Monitoring of insecticides resistance in main malaria vectors in a malarious area of Kahnooj district, Kerman Province, southeastern Iran. J Vector Borne Dis. 42(3): 100–108.

http://jad.tums.ac.ir
Published Online: October 04, 2016

Vatandoost H, Ezeddinloo L, Mahvi AH, Abai MR,Kia EB, Mobedi I (2004) Enhanced tolerance of house mosquito to different insecticides due to agricultural and household pesticides in sewage system of Tehran, Iran. Iranian J Environ Health Sci Eng. 1(1): 42–45.

Vinogradova EB (2000) *Cx. pipiens pipiens* Mosquitoes: Taxonomy, Distribution Ecology, Physiology, Genetics and Control. Pensoft Publisher, Sofia.

WHO (1981) Instruction for determining the susceptibility or resistance of adult mosquitoes to organochlorine, organphosphate and carbamate insecticides. Diagnostic test. WHO/VBC.81.806.

WHO (2013) Test procedures for insecticide resistance monitoring in malaria vector mosquitoes. World Health Organization, Geneva, Switzerland.

http://jad.tums.ac.ir
Published Online: October 04, 2016