Study on insecticide resistance and irritability of malaria vector, Anopheles dthali in Iran

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Abstract
Background: A total of 228 million cases of malaria is reported by WHO in 2018. Using different insecticides is the main vector control measures. Regular monitoring and mapping of insecticide resistance is necessary for vector control.

Material and Methods: insecticide susceptibility of Anopheles dthali mosquitoes in Iran was evaluated according to WHO guideline: susceptible when mortality was 98% or higher, possible resistant when mortality was between 97 and 90%, and resistant when the mortality was lower than 90%.

Results: The results showed that this species is susceptible to all insecticides; there is a report on tolerant to DDT, malathion, propoxur and deltamethrin in malarious area of Iran. Irritability test in different parts of country revealed that this species showed more irritable to permethrin compared to other insecticides.

Conclusion: This species is exophile and secondary vector. Regular monitoring and mapping as well as detection of mechanisms of insecticide resistance will help for appropriate decision for vector control by authorities.

Keywords: Anopheles dthali, insecticide resistance, malaria, vector, Iran

Introduction
Malaria is the main vector borne diseases worldwide. According to the recent record of World Health Organization, 228 million cases have been reported in 2018 mainly in African region [1]. According to the report of Ministry of Health of Iran, less than 89 locally-transmitted cases in 2017 have been reported. The aim of country is to eliminate the disease by 2025 [2]. Malaria continues to be a main vector-borne public health problem in Iran. Anopheles dthali is a secondary vector species of southern foci of the country. Seasonal activity of Anopheline mosquitoes varies in different area due to environmental condition. It shows one peak in northwest especially in summer, however, there are two peaks of activity in coastal warm and humid region in the southern part of Iran with oriental epidemiological characteristics [3-8].

Figure1 shows the distribution of this vector in the country. Anopheles dthali is a malaria vector in some parts of the world. This species has been reported as a vector of malaria in Saudi Arabia [9]. It is widespread in north Ethiopia and Somalia, Socotra, north Africa to north west of Pakistan, Southwest of Saudi Arabia, around the Red sea and Adan Gulf [10-13]. Control malaria vectors started with DDT, dieldrin and BHC during the 1960’s, followed by malathion and pirimiphos-methyl) and continued with, propoxur during 1977-1990, and then with pyrethroids including lambda cyhalothrin and deltamethrin. Temephos, reldan and pirimiphos-methyl was used for larviciding from 1970 to 1992. Malaria control in the country is now based on use of deltamethrin (5% WP) and bendiocarb as an adulticide and Bacillus thuringiensis as a larvicide at volumes of about 15 and 5 tones respectively (14-15, CDC annual reports).

In this article we will present the status of insecticide resistance to different imagicides based on review of published data from 1957 to 2019. Knowledge on insecticide resistance in target species is a basic requirement to guide insecticide use in malaria control programmes in local and global scales. The main criteria for susceptibility status, which are recommended by WHO, were considered.
Materials & Methods

Data collection and analysis

Published data about insecticide susceptibility of Anopheles dthali mosquitoes in Iran (1999-2019) against DDT 4%, dieldrin 0.4%, malathion 5%, fenitrothion 1%, bendiocarb 0.1%, propoxur 0.1%, lambda-cyhalothrin 0.05 and 0.1%, deltamethrin 0.025 and 0.05%, cyfluthrin 0.15% and etofenprox 0.5% were searched from different sources. Within the collected documents, criteria for the bioassay tests (Figs 2-5) and results were followed as defined by WHO [16, 17, 1]: susceptible when mortality was 98% or higher, possible resistant when mortality was between 97 and 90%, and resistant when the mortality was lower than 90%. An excel sheet was created for insecticide resistance based on the applied insecticide at diagnostic dosage recommended by WHO. ArcGIS 10.5 used for mapping geographical distribution of An. dthali and spatial pattern of insecticide/larvicide resistance.

Results

Susceptibility status of An. dthali against different insecticides including DDT, Dieldrin, Malathion, Propoxur, Lambda-cyhalothrin and permethrin in Bandar Abbas County, Hormozgan Province, Southern Iran showed susceptible to all insecticides. (Fig.2). Susceptibility status of this species against different insecticides including: DDT, Dieldrin, Malathion, Fenitrothion, Bendiocarb Propoxur, Deltamethrin, Lambda-cyhalothrin, Permethdin, Cyfluthrin, Etofenprox in Kazeroun County, Fars Province, Southern Iran revealed complete susceptibility to these insecticides. (Fig.3). Susceptibility status of this species against different insecticides including: DDT, Dieldrin, Malathion, Fenitrothion, Bendiocarb Propoxur, Deltamethrin, Lambda-cyhalothrin, Permethdin, Cyfluthrin in Bandar Abbas County, Hormozgan Province, Southern Iran was evaluated again later on, The results also showed again susceptibility (Fig.4). Some years later this species showed tolerant (resistant candidate) for Malathion and Deltamethrin in the malarious area, Hormozghan province (Fig.5). The results for Kerman province was complete susceptible to all insecticides (Fig.6). Susceptibility status of species against different insecticides in Chabahar, Sistan and Baluchistan Province, borderline of Iran and Pakistan showed tolerant to DDT and Propoxur (Fig.7). Irritability of species to different insecticides including DDT, Permethrin, Deltamethrin and Lambda-cyhalothrin revealed more irritable to Permethrin in both populations (Figs, 8, 9).
Fig 3: Susceptibility status of *Anopheles dthali* against different insecticides in Kazeroun County, Fars Province, Southern Iran.

Fig 4: Susceptibility status of *Anopheles dthali* against different insecticides in Bandar Abbas County, Hormozgan Province, Southern Iran.

Fig 5: Susceptibility status of *Anopheles dthali* against different insecticides in Kahnouj County, Kerman Province, Southern Iran.

Fig 6: Susceptibility status of *Anopheles dthali* against different insecticides in Bashagard County, Hormozgan Province, Southern Iran.
Discussion

*Anopheles dthali* has been found in southern parts of the Zagros chain, and coastal area of the Persian Gulf up to 1410 m [8, 14, 18]. This species is a secondary vector in some parts of southern Iran especially in mountainous areas of Hormozgan Province. Precipitin tests on this species, showed anthropophilic index depends on the area, varying from 1% in Izeh, a sheep rearing area southwestern Iran, to 25% in Bandar Abbas in south [6, 19]. This species is known as a secondary vector in some parts of southern Iran especially in mountainous areas of Hormozgan Province. Results of current studies show this species is susceptible to all tested insecticides from 4 groups of Organochlorine, Organophosphate, Carbamates, and Pyrethroids [6, 19, 20]. There is also a noticeable point: tolerance to DDT, malathion, propoxur and deltamethrin in this species (21) (Table 1, Figs 2-7). Irritability test in different parts of country revealed that this specie showed more irritable to permethrin compared to other insecticides (Figs 8-9).
Table 1: Status of insecticide resistance in malaria vectors of Iran, 1957-2019

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Mortality (%)</th>
<th>An. dthali</th>
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<tbody>
<tr>
<td>DDT 4%</td>
<td>96.8</td>
<td>RC</td>
</tr>
<tr>
<td>Dieldrin 0.4-4%</td>
<td>100</td>
<td>S</td>
</tr>
<tr>
<td>Malathion 5%</td>
<td>95.1</td>
<td>RC</td>
</tr>
<tr>
<td>Fenitrothion 1%</td>
<td>100</td>
<td>S</td>
</tr>
<tr>
<td>Propoxur 0.1%</td>
<td>96.9</td>
<td>RC</td>
</tr>
<tr>
<td>Bendiocarb 0.1%</td>
<td>100</td>
<td>S</td>
</tr>
<tr>
<td>Permethrin 0.25-0.75%</td>
<td>100</td>
<td>S</td>
</tr>
<tr>
<td>Lambda cyhalothrin 0.025-0.1%</td>
<td>100</td>
<td>S</td>
</tr>
<tr>
<td>Deltamethrin 0.025-0.05%</td>
<td>95.5</td>
<td>RC</td>
</tr>
<tr>
<td>Cyfluthrin 0.15%</td>
<td>100</td>
<td>S</td>
</tr>
<tr>
<td>Etofenprox 0.5%</td>
<td>100</td>
<td>S</td>
</tr>
</tbody>
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S = Susceptible, RC = Resistant candidate, R = Resistant

Conclusion
There are several reports on resistant status of malaria vectors including *An. stephensi* [22, 23], *An. maculipennis* [24], *An. sacharovi* [25], *An. culicifacies* [26, 27, 28], *An. fluviatilis* [29]. There is a widespread tolerant to Organochlorines, organophosphates, carbamates and pyrethroids insecticides in *An. dthali*. In this study It is found that species is tolerant to DDT, propoxur, malathion and deltamethrin. More studies on detection of insecticide resistance should be carried out to prevent the resistance of species to insecticides.

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References


