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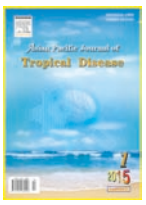

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Susceptibility status of *Culex pipiens* against deltamethrin and DDT, Urmia County, West Azerbaijan Province, northwestern Iran

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ABSTRACT

Objective: To determine the susceptibility status of *Culex pipiens* (*Cx. pipiens*) against two important and widely used insecticides (deltamethrin and DDT) in Urmia County, the main city of West Azerbaijan Province, northwestern Iran.
Methods: The susceptibility tests were carried out using the recommended method by World Health Organization (WHO). The sugar-fed 3-5 days old adult female *Cx. pipiens* were selected from reared larvae and/or from laid eggs. The female *Cx. pipiens* were transferred to holding tubes and after completing an hour of rest and removal of dead and damaged samples, the specimens were exposed for 60 min to toxicant tube containing insecticide impregnated papers which were supplied by WHO and specified discriminating concentration.
Results: The results of experiments reveals the higher mortality rate against both studied insecticides (deltamethrin and DDT). Considering the WHO criteria, the studied species, *Cx. pipiens*, is resistant to both deltamethrin and DDT.
Conclusions: Considering the notable role of this species in the transmission of several diseases and its wide range distribution across the Iran and neighboring countries and the probability of establishment of these diseases in this region Iran, further studies are needed regarding the study of resistance mechanisms of this species against insecticides using molecular and biochemical methods.

1. Introduction

Mosquitoes (Family: Culicidae) are the most important arthropods of medical importance, as they transmit malaria, lymphatic filariasis, dengue fever/dengue haemorrhagic fever, yellow fever and several types of encephalitis[1-4]. By transmitting major human diseases, mosquito species represent a serious threat worldwide in terms of public health, and pose a significant economic burden worldwide especially for developing tropical regions[5-7].

Among the different species of mosquitoes, the well-known *Culex pipiens* (*Cx. pipiens*), is one of the most medically-important species that transmit several notable diseases including lymphatic filariasis and wide range of arboviruses[2,8].

Despite the significant role of insecticides in mosquito control programs, the emergence of some problems such as vector resistance to insecticides, the harmful effects of pesticides and their residues on the environment and food chains, has led to growing challenges against the use of chemical insecticides[9]. Resistance to insecticides among a large number of vectors of diseases have been reported, including the *Cx. pipiens*[10-12].

Recently, several control measures have been employed against mosquitoes which the use of chemical insecticides is one of the most widely used methods[13]. In order to rational use of insecticides and decreasing the risk of the emerging resistant species, the monitoring of insecticide susceptibility status of medically important species against the routinely used compounds is highly recommended[14,15].

The geographical location of West Azerbaijan Province, northwestern Iran, its common border with several countries like Turkey, Azerbaijan and Iraq, the shared social and cultural relations among the countries and the possible political and humanitarian

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crises, necessitate the proper study of vectors and their control[16]. On the other hand, the knowledge on the status of the important mosquito species against insecticides would be of great importance to the selection and use of pesticides in case of potential emergency. The aim of this study was to determine the susceptibility status of *Cx. pipiens* against two important and widely used insecticides (deltamethrin and DDT) in Urmia County, the main city of West Azerbaijan Province, northwestern Iran.

2. Materials and methods

2.1. Study area

All samples were collected from different parts of Urmia County, the main city of West Azerbaijan Province (Figure 1). The geographical properties of collection sites have been given in Table 1.

Figure 1. The situation of West Azerbaijan Province and Urmia County.

Table 1
Sampling locations.

location	Latitude	Longitude	Altitude (m)
Naz-loo	37°39'24.39"N	44°59'0.39"E	1 358
Ghahraman-Loo	37°39'10.78"N	45°12'11.81"E	1 000
Koor-Abad	37°43'50.12"N	44°39'33.78"E	1 545
Issar	37°33'25.95"N	45°0'12.52"E	1 466

2.2. Sample collection and species identification

Larvae collection was carried out from different habitats using the standard (350 mL dipper) dipping method[17] in 4 localities (Naz-Loo, Koor-Abad, Ghahraman-Loo and Issar) during June–October of year 2014 and were allowed to mature into adults. The unfed 3-5 days old adult females were used for tests.

2.3. Adult susceptibility test

The susceptibility tests were carried out using the recommended method by World Health Organization (WHO)[18]. The sugar-fed 3-5 days old adult female *Cx. pipiens* were selected from reared larvae and/or from laid eggs. The female *Cx. pipiens* were transferred to holding tubes and after completing an hour of rest and removal of dead and damaged samples, the specimens were exposed for 60 min to toxicant tube containing insecticide impregnated papers which were supplied by WHO and specified discriminating concentration (deltamethrin: 0.05% and DDT: 4%).

2.4. Statistical analysis

Bioassay data were considered for each insecticide. The mortality rate was calculated as the percentage of individuals that died within 24 h after one hour of exposure. Bioassay outcomes were assessed according to WHO[18]. Those with an overall mortality ⩾98% were considered susceptible, those with mortality <98% but >90% were considered potentially resistant, and, those with mortality <90% were strongly suspected to be resistant.

3. Results

In this study totally 634 samples of *Cx. pipiens* were collected from different parts of Urmia County. Among collected samples 127 specimen were used as control group (four replicates of susceptibility tests) and 507 were divided in two groups (252/255) and each of batches were used for susceptibility tests against one of studied insecticides (deltamethrin and DDT). Each of the insecticides was evaluated at least four times .

The results of experiments have been shown in Table 2 that reveals the higher motality rate against both studied insecticides (deltamethrin and DDT). Considering the WHO criteria[18], the studied species, *Cx. pipiens*, is resistant to both deltamethrin and DDT.

Table 2
The results of susceptibility test of adult *Cx. pipiens* against DDT and deltamethrin collected from Urmia County, Northwestern Iran.

Group	Insecticide (Discriminating concentration, 1-h exposure period)	Replicates	No. of mosquito tested	No. of mosquito dead after 24 h exposure	Mortality rate
Pyrethroid	Deltamethrin (0.05%)	8	255	175	81.21%
Chlorinated hydrocarbon	DDT (4%)	8	252	37	15.62%
Control	Control	4	127	11	91.20%

4. Discussion

Considering the presence of *Cx. pipiens* in different parts of Iran[16,19], the present study is the first evaluation of susceptibility status of *Cx. pipiens* against two insecticides belongs to different chemical classes, in West Azerbaijan Province, northwestern Iran. The results of recent study in a southeastern part of Iran showed that *Cx. pipiens* was resistant to DDT and tolerant to deltamethrin[20]

whereas current results showed resistance against both DDT and deltamethrin.

One of the main facts which determines the susceptibility status of medically important arthropods against insecticides is the pattern of use of pesticides in agriculture[21,22]. Due to the geographical location of the region, its significant water resources and agricultural development, necessitates a logical cooperation between agriculture and health sections in order to improve the pattern of use of pesticides in each section and management of probable resistance.

As conclusion, considering the notable role of this species in the transmission of several diseases and its wide range distribution across the Iran and neighboring countries and the probability of establishment of these diseases in this region Iran, further studies are needed regarding the study of resistance mechanisms of this species against insecticides using molecular and biochemical methods.

Conflict of interest statement

We declare that we have no conflict of interest.

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