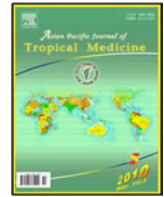


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Responsiveness of *Anopheles maculipennis* to different imagicides during resurgent malaria

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ABSTRACT

Objective: To determine the susceptibility of main malaria vector in Astra County, borderline of Iran and Republic of Azerbaijan for better control. **Methods:** Susceptibility of *Anopheles maculipennis* to diagnostic doses of DDT 4%, dieldrin 0.4%, malathion 5%, lambda-cyhalothrin 0.1%, and deltamethrin 0.025%, was tested according to method recommended by WHO. All the impregnated papers were provided by WHO. **Results:** It was shown that this species exhibited resistance to DDT, dieldrin, whereas susceptible to malathion, lambda-cyhalothrin and deltamethrin. **Conclusions:** Findings of susceptibility tests of this species provided a clue for control of malaria vector in the region.

1. Introduction

Malaria is the most important vector-borne disease in the world. The global strategy adopted by the WHO recommended an integrated management of the disease, including selective vector control^[1].

Over the past 50 years, it has been realized that *Anopheles maculipennis* (*An. Maculipennis*), was a common malaria associated vector. According to careful morphological, biological and hybridization experiments this species was composed of six sibling species including *Anopheles maculipennis* (*An. maculipennis*), *Anopheles masseae* (*An. Masseae*), *Anopheles atroparus* (*An. atroparus*), *Anopheles labranchia* (*An. labranchia*), *Anopheles melanon* (*An. melanon*) and *Anopheles sacharovi* (*An. sacharovi*). *An. maculipennis* complex has a wide distribution in the world: Europe, Southwest Asia, Persian Gulf and Siberia (*An. maculipennis*); Northern palearctic region (*An. messeae*); Holland, largely littoral of Europe (*An. atroparus*); Italy, Spain, Sardinia, Corsica, Balkans, Caucasin region (*An.*

melanon); Italy, Spain, Corsica, Sardinia, Sicily, Morocco, Algeria, Tunisia (*An. labranchiae*); Italy, Sardinia, Corsica, Greece, Syria, Iraq, Phalestine, Iran, Austria, Cyprus, Yugoslavia, Turkey, Lebanon, Jordan (*An. sacharovi*).

In Iran, prevalence mainly occurs in Caspian littoral, northern and southern slopes of Alborz mountains, Isfahan, Kermanshahan, Azerbaijan, Gilan and Mazandaran, Kordestan, Hamedan, Fars, Khorasan, Semnan, Tehran and Markazi provinces.

Slow moving streams, ditches, rice fields, pools, marshes, and other types of water with or without vegetation have been reported as the breeding sites. Clean stagnant and slow running water, with or without regulation also has been reported as breeding places of this species, *An. maculipennis* larvae. Adults of this species were found in human dwellings and animal shelters too, they rest indoor and outdoor shelters and actively bite man and animals. It has been a potential malaria vector in Europe, Turkey, Syria, morocco, Algeria and Tunisia.

An. maculipennis has been reported to resist to DDT and some of organophosphate, carbamate and pyrethroid compounds in Bulgaria, Greece, Romania, Turkey, Romania, Algeria, Morocco and Tunisia. *An. maculipennis* and *An. hyrchanus* are the most common anopheline species in the Gillan area of Iran. *An. superpicuts*, *An. claviger*, *An. plumbeus* the other known *Anopheles* in Iran, are also present in this area though in very small numbers.

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An. maculipennis, was regarded as the main vector of malaria[2–4].

Iran has been classified into four different strata according to the epidemiology of diseases[5]. A total of 14 000–20 000 malaria cases have been reported in Iran during the last two years. The disease is a major health problem in south–eastern Iran. It is unstable with two seasonal peaks mainly in spring and autumn. Outbreaks usually occur after rainy season. South–eastern Iran includes the provinces of Sistan & Baluchistan, Hormozgan and the tropical areas of Kerman provinces are characterized by refractory malaria[6]. In this part of the country six *Anopheline* mosquitoes including *Anopheline culicifacies* (*An. Culicifacies*), *Anopheline stephensi* (*An. Stephensi*), *Anopheline dthali* (*An. dthali*), *Anopheline fluviatilis* (*An. fluviatilis*), *Anopheline superpictus* (*An. superpictus*), and *Anopheline pulcherrimus* (*An. pulcherrimus*) are known as the malaria vectors[7–25]. In northern part of Iran only small imported cases of malaria were reported. After independence of southern countries of former Soviet Union and occurrence of Ghara– Bagh civil war, the malaria cases increased in these regions. Accordingly in some parts of West Azerbaijan and Gillan province of Iran several malaria foci were observed. Various factors can affect the malaria resurgence such as construction dam, people traveling from neighbor countries to Iran, socioeconomic factors, urbanization, lack of malaria vector control and shortage of drug supply. Epidemiological investigations approved the local transmission of malaria, which was mainly *Plasmodium vivax*. The major antimalarial activities of local authorities are increasing malaria case detection, prompt treatment, community education and focal insecticide application[26]. *An. sahacrovi* and *An. maculipennis* are considered as malaria vectors in northern part of the country[27–32]. An investigation was carried out for monitoring of insecticide resistance status on *An. maculipennis*.

2. Material and methods

2.1. Study area

The investigation was carried out in Astara area and Gillian province during 1998–1999 over a 12–month period. Astara area with a total population of about 67 584 in the malarious area located in 48° 51' N longitude, 38° 26' E latitude in the northern parts of Gilan province, borderline with Azerbaijan Republic, Ardabil Province as well as Caspian sea, where the annual incidence of malaria average is about 0.5 per thousand population. Three villages with a total population of 2 956 were selected randomly for this study. The average maximum and minimum temperature in summer was 32.4 °C and 24.2 °C and in winter 23.2 °C and 10.4 °C respectively. This area are growing rice and vegetable also lemon and orange, irrigated by Astarachi and Taleseyfi rivers and irrigation canals, which the major sources of mosquito breeding places.

The average annual rainfall is about 320 mm. Antimalaria

measures such as residual spraying started by DDT 75% with the rate of 2 mg. a. i./m² from 1950 to 1954 and was stopped following the decrease of malaria cases but foci residual spraying with lambda-cyhalothrin 10% with the rate of 50 mg a.i./m², active and passive case detection and drug distribution as prevention and treatment of malaria are still going on.

2.2. Mosquito collection

Field population of blood fed or semi–gravid of female *An. maculipennis* were collected from 6.00 till 9.00 A.M. during May and June. The *An. maculipennis* to be tested were caught by aspirator tubes and were kept in paper cups during the transportation to the laboratory; sufficient humidity was carried out by placing pieces of damp cotton wool on the cups.

2.3. Adult susceptibility test

The adult susceptibility tests were carried out use method recommended by WHO[10]. Papers impregnated with DDT 4%, dieldrin 0.4%, malathion 5%, deltamethrin 0.025% and lambda-cyhalothrin 0.1%, supplied by WHO[33] were used in this study. The female *Anopheles* were transferred to clean holding tube after 60 minutes exposure to the toxicant tube and the mortality was calculated after 24 hours maintenance in insectarium (26 °C, 60% RH).

3. Results

The history of malaria during 1992–1999 showed that an increase of annual parasite incidence (API) was due to malaria epidemics from 0.033 to 0.350 per 1 000 population. Because of the importance of malaria in that region, antimalaria measures such as indoor residual spraying with lambda-cyhalothrin were done through the whole period. July–August seems to be the peak of *Plasmodium vivax*. Adult susceptibility test was carried out according to the method recommended by WHO. Female mosquitoes were exposed at the diagnostic dose of different insecticides for one hour. Results of this study were presented in table 1. By applying WHO criteria (98–100% mortality indicates susceptibility, 80–97% mortality requires confirmation of resistance with other methods and < 80% mortality suggests resistance), it was found that field samples, this species exhibited resistance to DDT, dieldrin and susceptible to malathion, lambda-cyhalothrin and deltamethrin.

4. Discussion

Malaria continues to be a major public health problem in South–East of Iran. Despite the considerable research and control efforts, it is still the most prevalent disease and forms a public health problem. In Gillian province, malaria control started with residual spraying by DDT from 1945

Table 1Mortality of *An. maculipennis*, wild strain exposed to different diagnostic dose of insecticides in Astara area, Gillan province.

Insecticides	Replicates	No. mosquito tested	No. mosquito dead	Mortality rate	Error bar
DDT 4%	10	251	211	84	± 2
Dieldrin 4%	4	100	79	79	± 4
Malation 5%	6	148	148	100	0
Lambdacyhalothrin 0.1%	4	100	100	100	± 0
Deltamethrin 0.025%	4	100	97	97	± 2
Control	18	425	9	2	± 1

and stopped following the decreased malaria cases in 1950. Following the emergence Azerbaijan and Armenia republics in borderline of Gillian province and Astara area, Annual parasite incidence (API) has been increasing.

There was a new focus such as Astara, Pars-Abad, Kaleybar, Maco, in relation to malaria epidemic. *An. maculipennis*, the main vector of malaria in this area was endophagic and endophilic. Adults susceptibility test using diagnostic dose of different insecticides showed that this species exhibits resistance to DDT and dieldrin, whereas susceptible to malathion, lambdacyhalothrin and deltamethrin. Resistance to DDT was also reported previously, but resistance to dieldrin has been reported for the first time during this study.

Results of adult test of *An. maculipennis* with DDT, malathion and deltamethrin in Turkey revealed different responses of strains to adulticides^[34]. They determined low mortality with the diagnostic dosage of DDT in all strains. In some localities, mortality was even lower than 30%. The diagnostic dosage mortality of the other adulticides varied widely. Insecticide susceptibility tests on *An. sachrovi* in Ardebil province, northwestern Iran showed that the species is susceptible to malathion and propoxur but resistant to DDT and dieldrin^[35]. Kasap et al^[36] reported different levels of susceptibility of *An. sachrovi* to malathion, pirimiphos-methyl, dieldrin, lambda-cyhalothrin, etofenprox; fenitrothion and cyfluthrin. This phenomenon depends on the location of mosquito collection. Monitoring of insecticide resistance in *An. sacharovi* in borderline of Iran, Armenia, Naxcivan and Turkey, showed that this species is still resistant to DDT, tolerant to dieldrin but susceptible to other insecticides such as bendiocarb, propoxur, malathion, fenitrothion, deltamethrin, permethrin, cyfluthrin, lambdacyhalothrin, and etofenprox with low frequency of tolerant gene in some population to some above mentioned insecticides^[26]. Results of this investigation provided a guideline for authorities for control of malaria epidemics.

Conflict of interest statement

We declare that we have no conflict of interest.

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